PILOT PROJECT REPORT

APPENDICES

Regional Infiltration and Inflow Control Program
King County, Washington

October 2004

King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

Pilot Project Report Appendices

Regional Infiltration and Inflow Control Program

King County, Washington

October 2004

Prepared for King County by
Earth Tech Team, Seattle, WA

King County
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alternative formats on request at
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List of Appendices

Appendix A

I/I Pilot Project Candidate Nomination Forms

Description:

This appendix contains the nomination forms that were prepared by the respective local agencies and used in the pilot project selection workshops.

Reference Chapter:

Chapter 2 – I/I Pilot Project Selection

I/I W orkshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: <u>Blanket Contract Manhole Rehabilitation – (Consolidated Effort of CCR002, NUD038 & VAL019)</u>

Local Agency: <u>Joint Project (Coal Creek, Northshore, Val Vue)</u> ■ **Project** □ **Basin #:** <u>CCR002, NUD038, VAL019</u>

Contact Person: <u>Barry Scott</u> **Phone #:** <u>206-625-1053</u>

Proposed Project Management & Contracting Method:
□ **Local Agency** ■ **King County**

Geographic Area: ■ **North** ■ **East** ■ **South**

I/I Source Info (if known): □ Inflow □ Infiltration ■ Both □ Unknown
■ Public □ Private □ Both □ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
*	*	*

*** = see individual component Agency sheets**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	*
Meets Time Frames for the I/I Program	✔	*
Geographic Representation	✔	*
"Do No Harm" + Geologic Conditions OK	✔	*
System Age	✔	*
Environmental Benefits	✔	*
Addresses Private Sewer Issues		*
Provides Regional Impact	✔	*
Model for Future Projects	✔	*
Representative of Typical I/I Problems Region-wide	✔	*

Wild Card	✔	*

*** = see individual component Agency sheets**

Project Title: Blanket Contract Manhole Rehabilitation

Key Facts & Information:

Proposed Pilot is a cooperative joint effort by the Coal Creek Utility District, the Northshore Utility District and the Val Vue Sewer District. Pilot would allow for the trial of multiple types of rehabilitation techniques in a variety of field conditions. The Pilot will provide a good geographic representation for the total Service Area with one basin located in the North, East and South Regions of the County.

I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: CCR002 (Consolidated with NUD038 & VAL019)

Local Agency: Coal Creek Utility Dist. ☐ **Project** ☐ **Basin #:** CCR002

Contact Person: Tom Peadon **Phone #:** 425-235-9200

Proposed Project Management & Contracting Method:
☐ **Local Agency** ■ **King County**

Geographic Area: ☐ **North** ■ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ☐ Both ■ Unknown
■ Public ☐ Private ☐ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 4,202 gpad	7.9 (11/13/01 storm)	Peak: 22.5 gplfd

Selection Criteria:

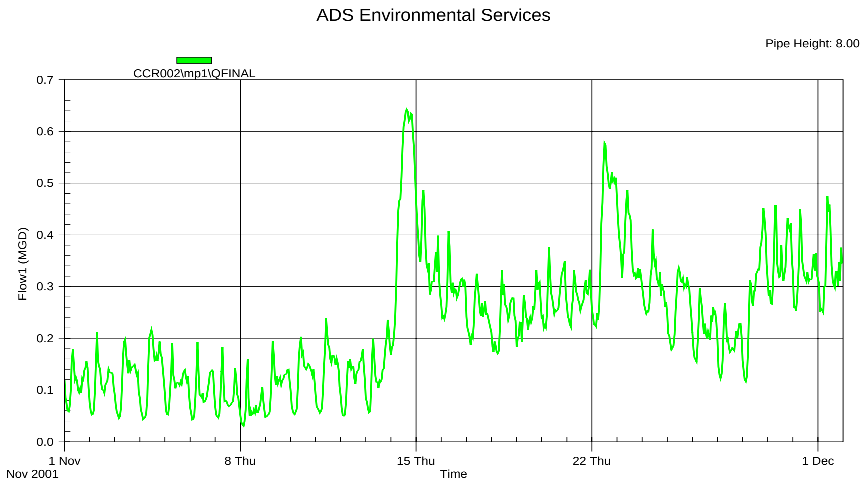
Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	MH repair
Meets Time Frames for the I/I Program	✔	
Geographic Representation	✔	East
"Do No Harm" + Geologic Conditions OK	✔	Gravel lenses, fairly flat terrain. Known artesian springs / seeps nearby.
System Age	✔	1967-69 (30+ years)
Environmental Benefits	✔	Stream enhancement, ESA on Coal Creek. Wetlands NA, all Newcastle.
Addresses Private Sewer Issues		
Provides Regional Impact		
Model for Future Projects		
Representative of Typical I/I Problems Region-wide		
Wild Card		

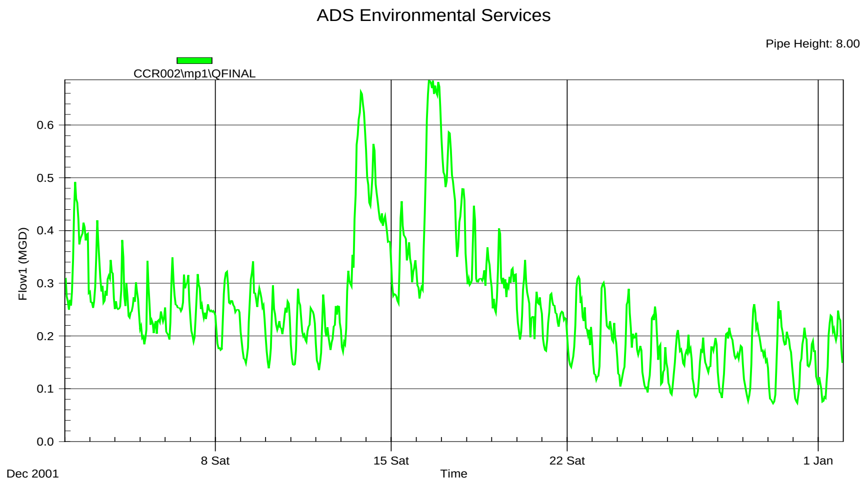
Project Title: CCR002

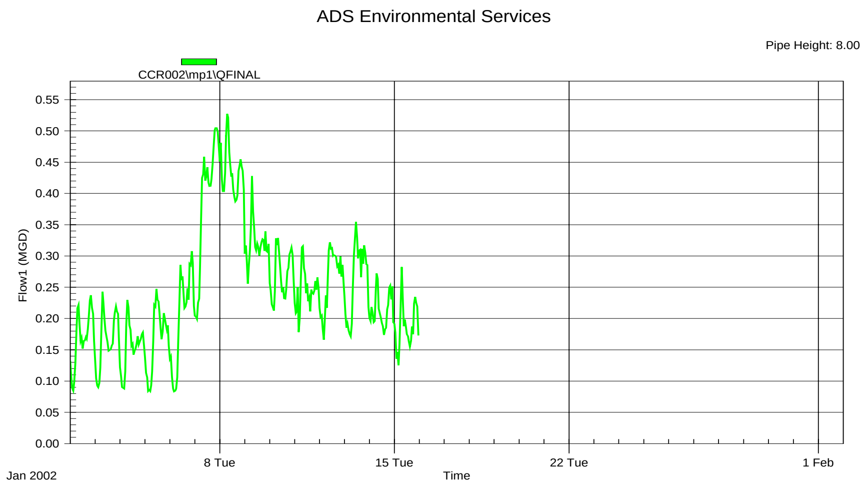
Key Facts & Information:

Infiltration through seams and pipe penetrations at large number of manholes, clear water flowing, erosion in manhole channels. 6”/8” all AC (rubber gasketed) bad manholes. Shallower sewers than 007. Approx. 40-50 MH’s are found to be leaking, additional SSES work will determine the total number.

Coal Creek Utility District
CCR002







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: NUD038 (Consolidated with CCR002 & VAL019)

Local Agency: Northshore Utility Dist. ☐ Project ☐ **Basin #:** NUD038

Contact Person: Matt Everett **Phone #:** 425-398-4428

Proposed Project Management & Contracting Method:
■ Local Agency ☐ King County

Geographic Area: ■ North ☐ East ☐ South

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
■ Public ☐ Private ☐ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 6,025 gpad	**9.0 (12/15/01 storm)**	**Peak: 27.0 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Manhole grouting/sealing/lining using various materials and techniques
Meets Time Frames for the I/I Program	✔	No anticipated problems.
Geographic Representation	✔	North-end (King County).
"Do No Harm" + Geologic Conditions OK	✔	No anticipated problems.
System Age	✔	Post 1961 System – About 75% newer D.I. & P.V.C. pipe and 25% concrete & A.C. pipe.
Environmental Benefits	✔	Less sewer flow to north end of Lake Washington – reduce sewer overflow events.
Addresses Private Sewer Issues		Primarily public.
Provides Regional Impact	✔	Increases capacity in regional conveyance and treatment systems. Reduces overflows into Lake Washington.
Model for Future Projects	✔	Good project to learn how to reduce I/I in manholes. All sewer agencies can benefit.
Representative of Typical I/I Problems Region-wide	✔	All sewer agencies have leaking manholes.

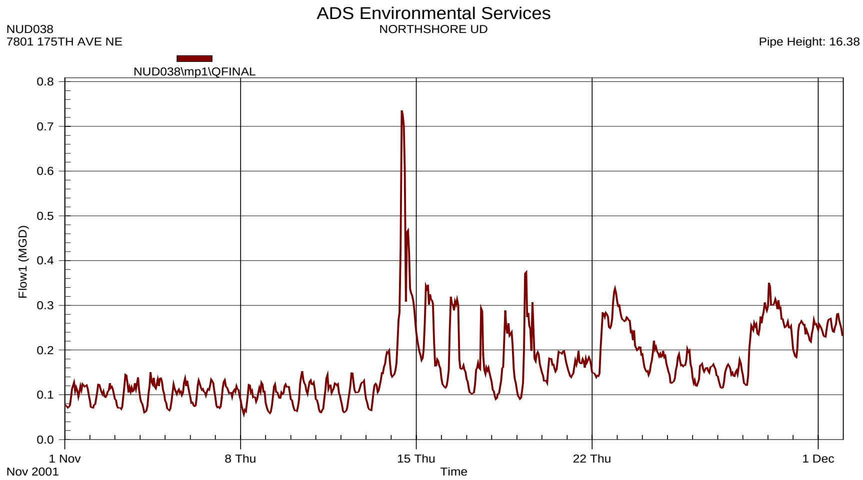
Wild Card	✔	Northshore is willing to consolidate efforts with Coal Creek and Val Vue Districts to maximize benefits for the dollars spent.

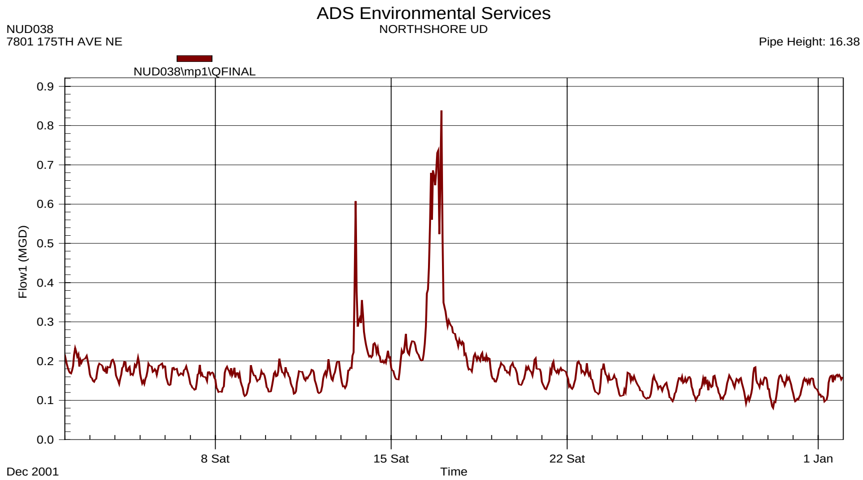
Project Title: NUD038

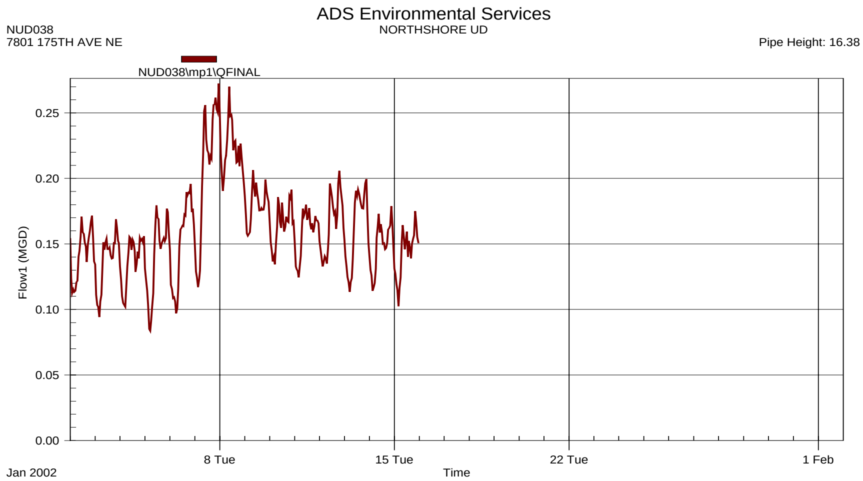
Key Facts & Information:

- Upstream sewer basin. Easily monitored; No subtraction errors.
- Total I/I as high as 6,025 gpad.
- 10 (3-day) storm events had cumulative I/I volume of 4,808,000 gallons.
- About 75% of the sewer basin is comprised of newer D.I. and P.V.C. sewer pipes.
- The District has T.V.'d most of the area and found no notable problems in the sewer mainlines.
- In March, 2002 District staff found 33 out of 145 manholes obviously leaking. This was during a non-rain event, but higher than average water table. Many manholes in the basin are installed in wetland areas. A more thorough investigation will find additional manholes requiring rehabilitation.
- SSES work can be completed quickly – concentrating solely on the condition of manholes.
- Consolidating efforts with two other sewer agencies will allow us the ability to use a variety of manhole rehabilitation technologies and enhance learning.
- Consolidating efforts with two other sewer agencies will provide maximum I&I reduction for minimum dollars. "The most bang for the buck."

Northshore Utility District
NUD038







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: VAL019 (Consolidated with CCR002 & NUD038)

Local Agency: Val Vue Sewer District Project/Basin #: VAL019

Contact Person: Dana Dick Phone #: 206-242-3236

Proposed Project Management & Contracting Method:

☐ **Local Agency** ■ **King County**

Geographic Area: ☐ **North** ☐ **East** ■ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown

■ Public ☐ Private ☐ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 4,307 gpad	**10.4 (11/13/01 storm)**	**Peak: 22.7 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Manhole grouting/sealing/lining using various materials and techniques
Meets Time Frames for the I/I Program	✔	Right-of-Way Use Permit
Geographic Representation	✔	South 3
"Do No Harm" + Geologic Conditions OK	✔	No geographic harm. All work will be done in right-of-ways or on previously established easements.
System Age	✔	Post 1961 System – 27 yrs. Mainlines are all PVC pipe. Manholes were constructed in 1973 and some of the most serious contributors have been grouted but need to be readdressed due to grout failures. Alternative grout/sealing/lining materials are needed to address high fluctuations in the groundwater table, which damage typical grout.
Environmental Benefits	✔	Increase capacity and reduce overflows, ESA benefits, and minimize public impacts by trenchless rehabilitation, when appropriate.
Addresses Private Sewer Issues		Public.

Provides Regional Impact	✔	Increase capacity in regional system by reducing flows to go to King County-Metro
Model for Future Projects	✔	Results are expected to be significant and will be closely monitored and provided for modeling
Representative of Typical I/I Problems Region-wide	✔	Very representative, most agencies have some leaking manholes.
Wild Card	✔	This sub basin flows through a single pump station. Comparing station pump times to rainfall shows a direct correlation. During rain events the pumps run 24/7. There is also a direct correlation between seasonal ground water and pump run times.

Project Title: McMicken Basin Manhole Rehabilitation

Key Facts & Information:

I/I Confirmed:

- Upstream basin, easily monitored.
- Total I/I as high as 4,307 gpad
- 10 storm cumulative volume = 1,598,326 gallons.
- Flow monitoring by ADS indicates a peaking factor of 10.4.
- Val Vue's flow monitoring confirms this peaking factor.
- Pump Station run times confirm I/I.

Source of I/I confirmed:

- PVC mainlines have been inspected and are not leaking.
- Laterals do not show signs of high I/I.
- In the past when the manholes have been grouted there has been an immediate reduction in I/I.
- Recent evaluation found 30 out of 75 manholes leaking.

SSES can be quickly completed:

- Most manholes connected to this basin have been recently evaluated (March of 2002). Location of I/I inside each evaluated manhole is known.

Variety of Technologies Available:

- Grouting (different grout materials on the market)
- Lining (different lining materials on the market)
- Complete rebuild.

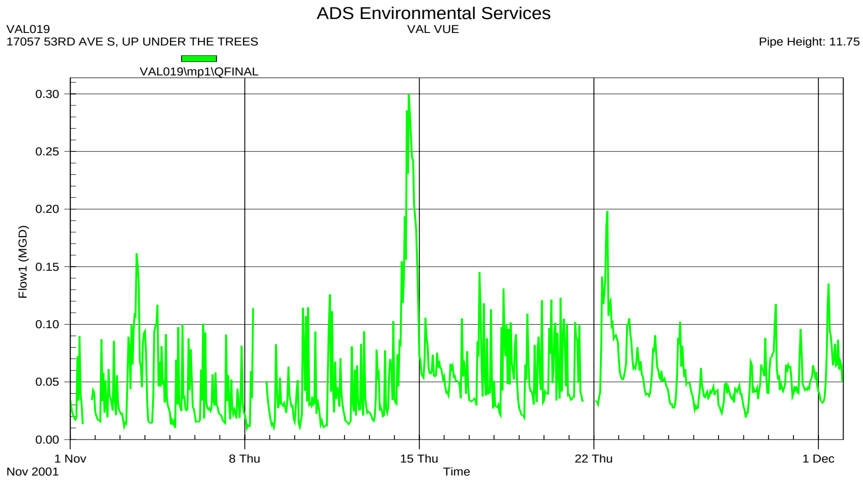
Consolidated project:

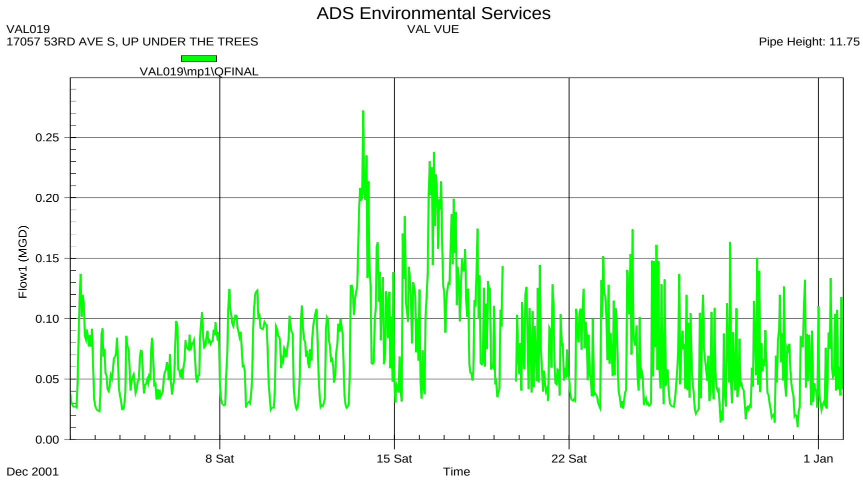
- Scalable Size: Val Vue/Coal Creek/Northshore = 120-240 manholes.
- Agencies involved have already held coordinating meetings.

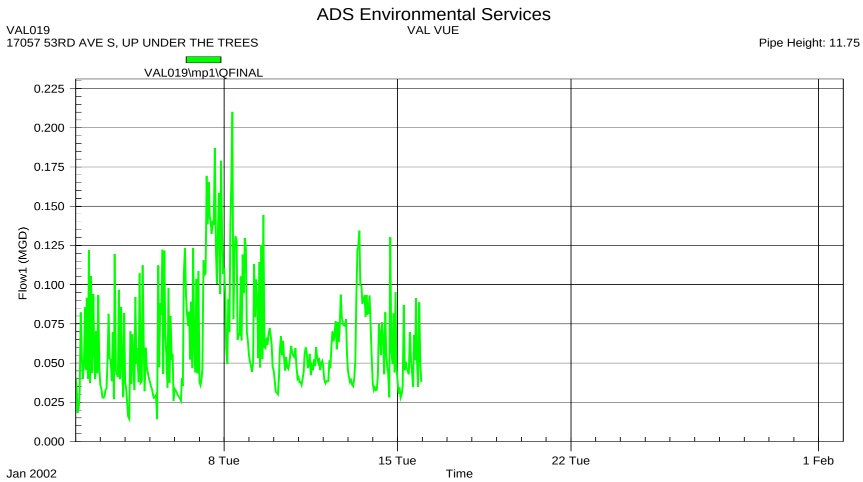
Possible volume discount for other agencies:

- Extended quantity based price from contractors can be made available to any agency planning manhole rehab projects.

Val Vue Sewer District
VAL019







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: Auburn Academy

Local Agency: City of Auburn ☐ **Project** ☐ **Basin #:** ABN002

Contact Person: Jeff Roscoe **Phone #:** 253-931-4008

Proposed Project Management & Contracting Method:
■ **Local Agency** ☐ **King County**

Geographic Area: ☐ **North** ☐ **East** ■ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 10,030 gpad	5.3 (11/4/01 storm)	Peak: 58.9 gplfd

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Whatever will get the job done
Meets Time Frames for the I/I Program	✔	No known issues exist that would present a problem.
Geographic Representation	✔	Flat terrain, residential area with rocky soil. Located upon a plateau.
"Do No Harm" + Geologic Conditions OK	✔	No impact to sensitive areas.
System Age	✔	1965 – 35 years approximately (1966)
Environmental Benefits	✔	MIT system is shut off if this line surcharges.
Addresses Private Sewer Issues	✔	Private systems contribute to the problem.
Provides Regional Impact	✔	Main line has capacity concerns. Correcting the line will allow continued economic growth for Auburn and the MIT.
Model for Future Projects	✔	Auburn sees this as a typical situation with residential and public concerns.
Representative of Typical I/I Problems Region-wide	✔	Concrete main line and side sewers that need to be replaced. Seems to be a typical situation.

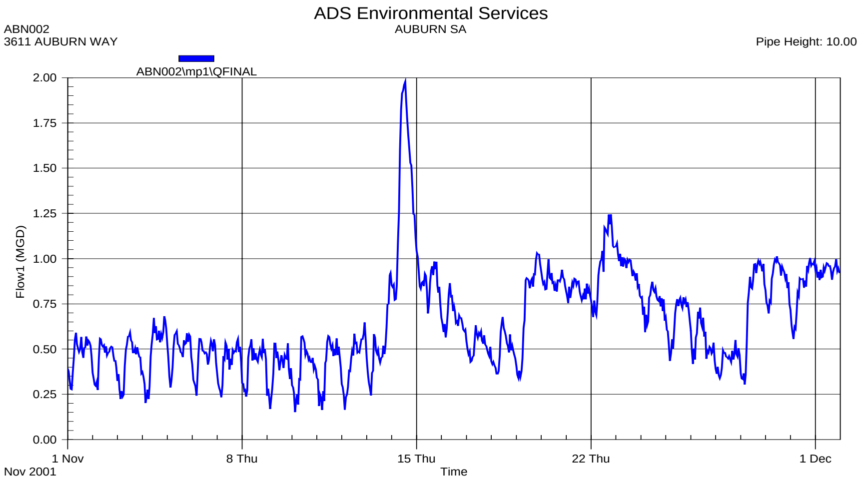
Wild Card		Auburn is willing to participate financially. The MIT may also be willing to participate.

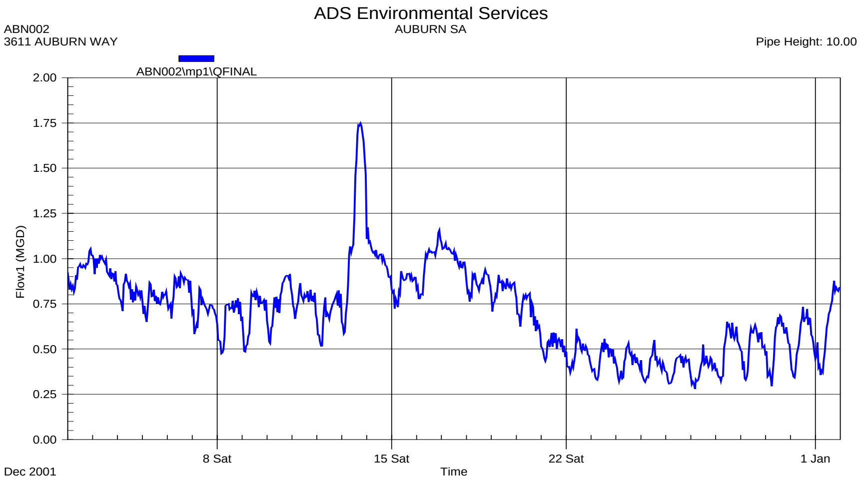
Project Title: Auburn Academy

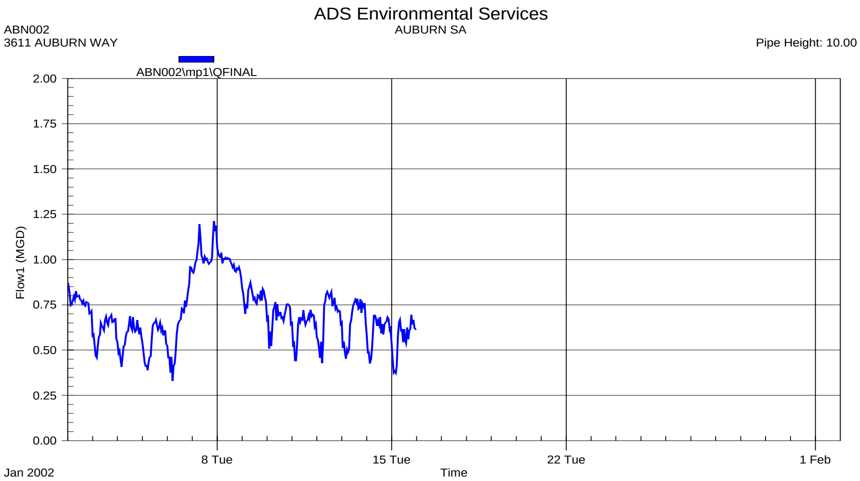
Key Facts & Information:

- Line has surcharged in the past during rain events. Auburn has an agreement with the Muckleshoot Indian Tribe that shuts off the flow from their pump stations when Auburn's system becomes surcharged. This can create a sewage spill at the Tribe's sewage pump station, resulting in a health problem. The MIT is not the likely source of the I/I problem, just a component of this equation.
- Smoke test information and some improvements were done in 1998-99. The system is still showing signs of excessive flows.
- City has a desire to replace a portion of the main trunk line with larger pipe in the future. The City improvement will not address side sewers and a large portion of public main line that runs behind the Auburn Adventist Academy (private high school). I see this as an ideal opportunity to participate with King County for the complete removal of I/I from this sewer basin.

City of Auburn
ABN002







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: Fairweather Basin #1

Local Agency: City of Bellevue ☐ **Project** ☐ **Basin #:** BEL077

Contact Person: Randy Thompson **Phone #:** 425-452-6800

Proposed Project Management & Contracting Method:
■ **Local Agency** ☐ **King County**

Geographic Area: ☐ **North** ■ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 7,342 gpad	**9.4 (11/13/01 storm)**	**Peak: 46.0 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Potential for joint repair, pipe bursting, slip lining, insituform, etc.
Meets Time Frames for the I/I Program	✔	Basin is in the City of Medina. Bellevue has a good working relationship with Medina.
Geographic Representation	✔	East
"Do No Harm" + Geologic Conditions OK	✔	No known issues
System Age	✔	Pre 1961 System – 40+ years. Almost all 8" concrete pipe installed in 1960.
Environmental Benefits	✔	Will reduce the volume and frequency of storm related local pump station overflows to Lake Washington via a small creek.
Addresses Private Sewer Issues	✔	Publicly owned side sewers in the right-of-way – no unusual circumstances associated with side sewer rehabilitation on private property.
Provides Regional Impact	✔	Flows to King County's Medina PS, Eastside Interceptor, and Renton Treatment Plant.
Model for Future Projects	✔	Typical of older construction during a period of "construction boom". Common pipe material

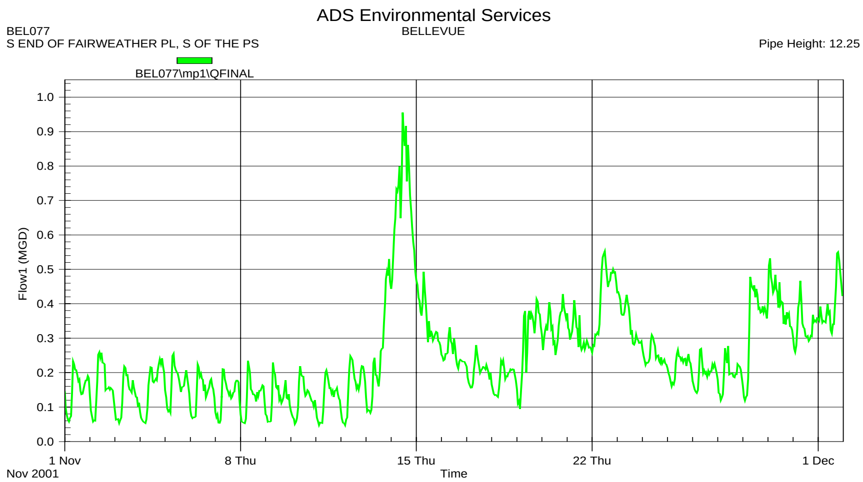
		(concrete) that frequently has high I/I.
Representative of Typical I/I Problems Region-wide	✔	I/I flow pattern is typical of many locations in the region. I/I flow volume and peaking factor are high but also relatively common (not among the few worst I/I problem areas in the region).
Wild Card		

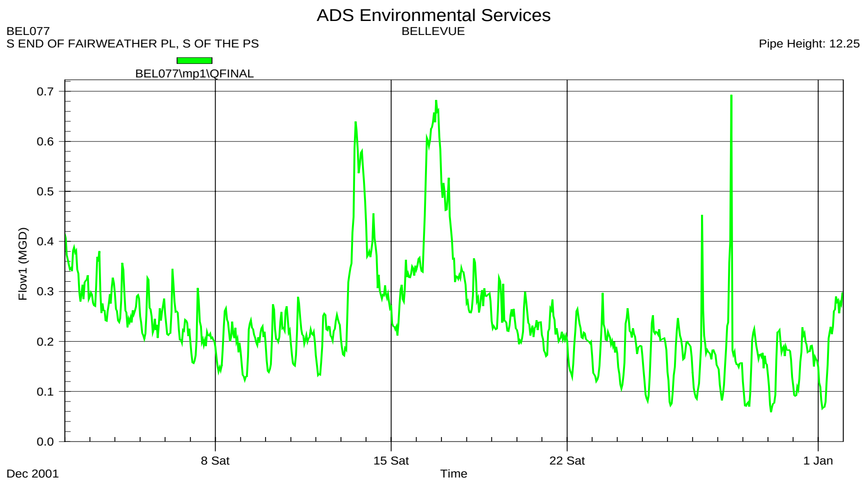
Project Title: Fairweather Basin #1

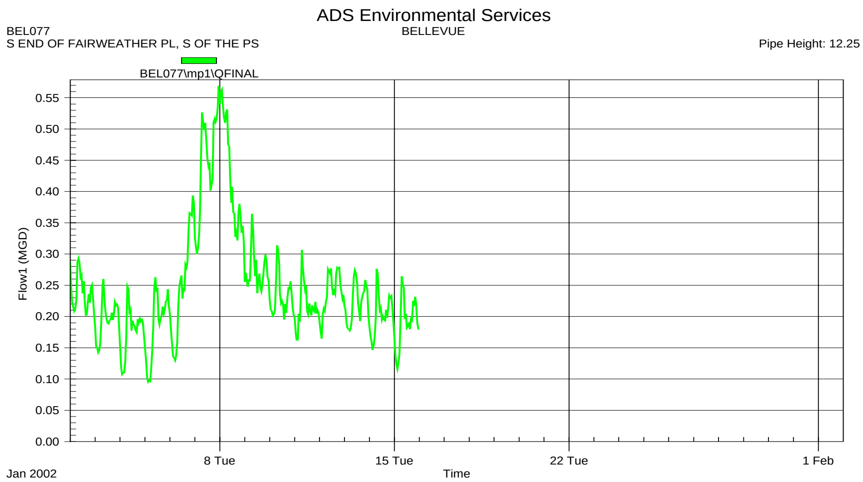
Key Facts & Information:

- City flow monitoring conducted in 1997 at four locations within this mini basin indicates the problem is uniform & widespread.
- This mini-basin has very uniform pipe material and installation date.
- Approximately 70% of these pipes have been video inspected with pipe defects and observations well documented in a computer database.
- The Area is tributary to Bellevue's Fairweather P.S. but does not include any areas along the lakeshore.
- Fairweather PS records show rapid response to storm events.
- Exhibits some evidence of infiltration.
- Reduced I/I will reduce pumping costs for both Bellevue and King County pump stations.

City of Bellevue
BEL077







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: BLA001

Local Agency: City of Black Diamond **Project/Basin #:** BLA001

Contact Person: Jason Paulsen **Phone #:** 360-886-2560

Proposed Project Management & Contracting Method:

☐ **Local Agency** ☐ **King County**

Geographic Area: ☐ **North** ☐ **East** ■ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown

☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 3,311 gpad	**3.8 (11/13/01 storm)**	**Peak: 17.7 gplfd**

Selection Criteria:

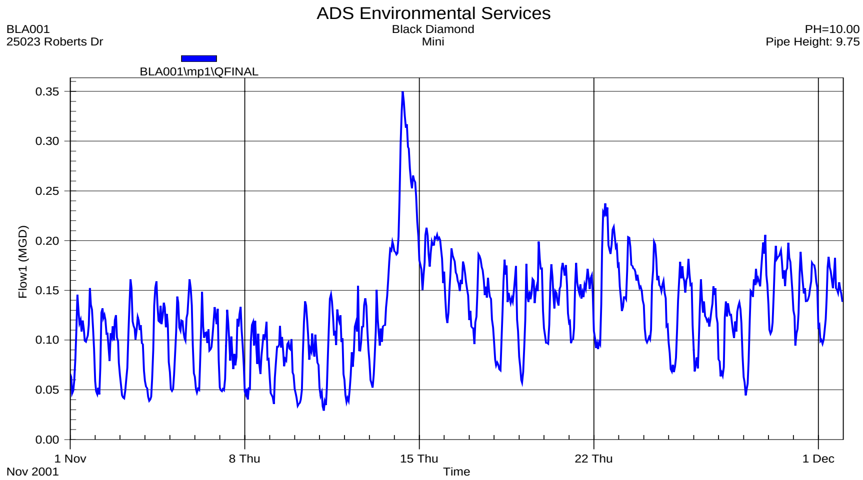
Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	
Meets Time Frames for the I/I Program	✔	
Geographic Representation	✔	
"Do No Harm" + Geologic Conditions OK	✔	
System Age	✔	Before 1980
Environmental Benefits		
Addresses Private Sewer Issues		
Provides Regional Impact	✔	
Model for Future Projects	✔	
Representative of Typical I/I Problems Region-wide	✔	
Wild Card		

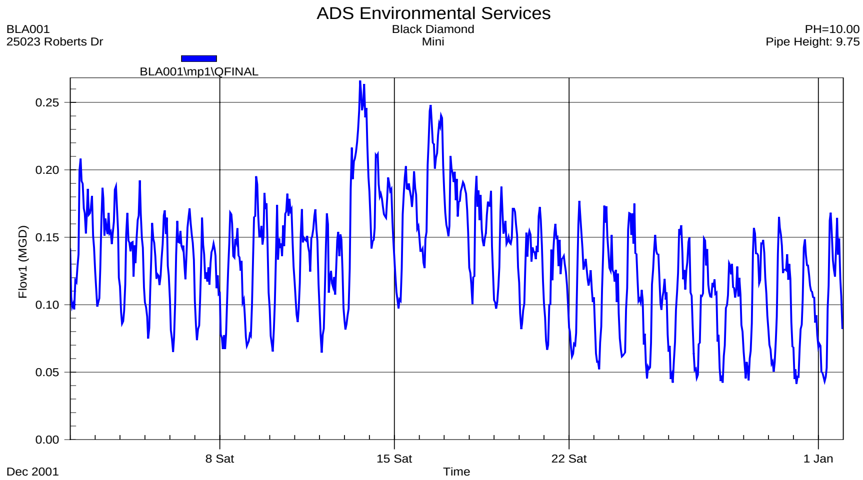
Project Title: BLA001

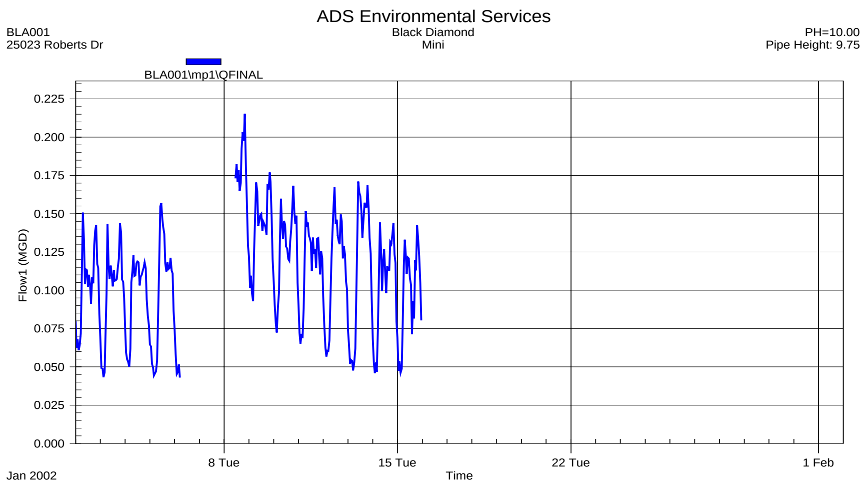
Key Facts & Information:

Pilot project provides an opportunity to determine system deficiencies that were constructed with very little oversight during original construction.

City of Black Diamond
BLA001







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: BOT004

Local Agency: City of Bothell ☐ **Project** ☐ **Basin #:** BOT004

Contact Person: Mac McDonald **Phone #:** 425-488-0118

Proposed Project Management & Contracting Method:
■ **Local Agency** ☐ **King County**

Geographic Area: ■ **North** ☐ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ☐ Both ■ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 5,938 gpad	**8.3 (11/21/01 storm)**	**Peak: 31.5 gplfd**

Selection Criteria:

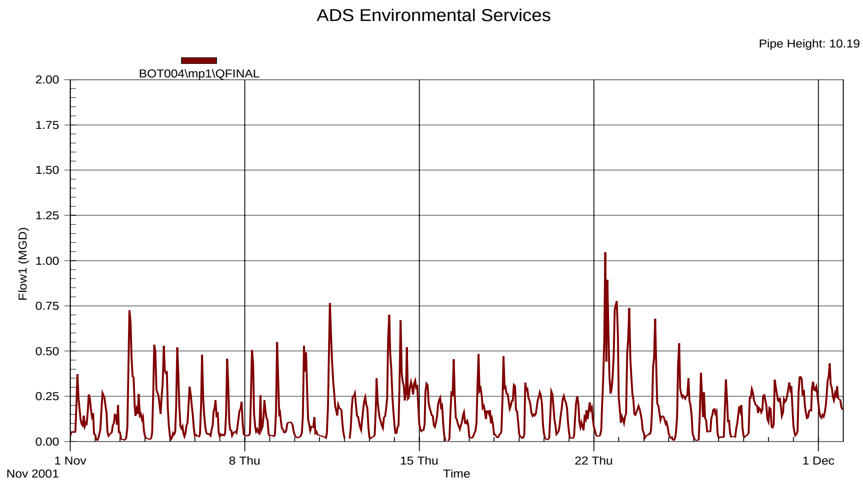
Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Good candidate for use of opoen trenc
Meets Time Frames for the I/I Program		May need to coordinate with other utilities to improve water services to the area.
Geographic Representation	✔	North
“Do No Harm” + Geologic Conditions OK	✔	
System Age	✔	Primarily post 1970
Environmental Benefits	✔	Basin flows into overloaded Kenmore pump station.
Addresses Private Sewer Issues	✔	
Provides Regional Impact	✔	
Model for Future Projects	✔	Opportunity for participation in costs with Water and Storm utilities.
Representative of Typical I/I Problems Region-wide	✔	
Wild Card		

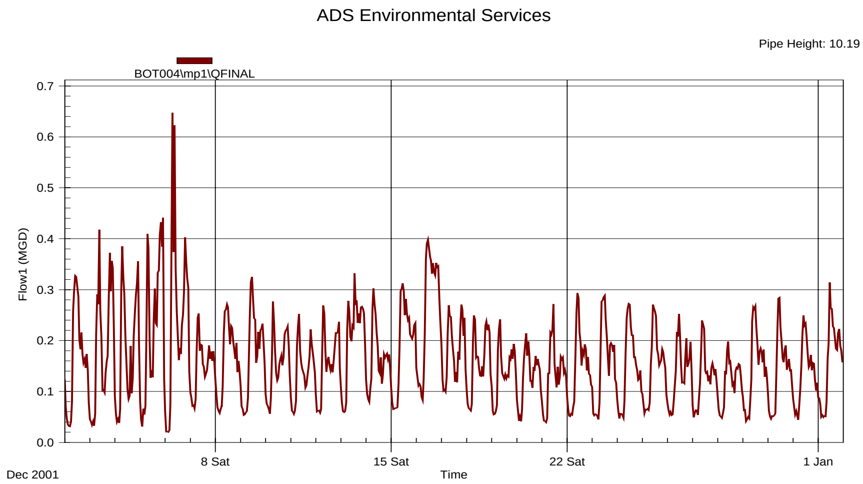
Project Title: BOT004

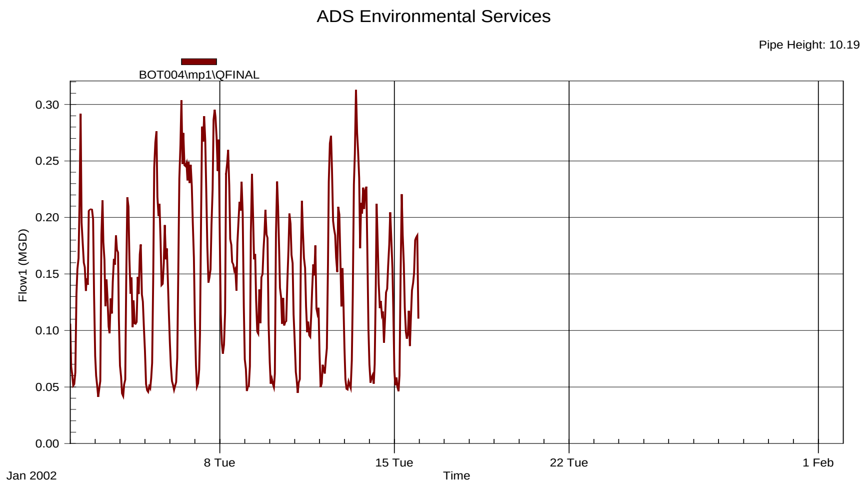
Key Facts & Information:

Based on the November readings, it appears that significant inflow – in the neighborhood of .6 MGD – during a storm event occurs. We believe this inflow is primarily in the Woodcrest Mobile Home park, where several problems with combined and confusing storm lines have been identified as a result of 2 separate developers installing separate systems. There is a timing issue in resolution of some water service conflicts, as water services in the area are spaghetti lines, and determination of responsibility for replacement and "rationalization" of those lines will need to be undertaken. These issues can be resolved in a timely manner if no serious objection from homeowners is encountered. Project costs may be shared to some extent with the water and storm utilities, where appropriate, which could extend the scope of the overall project.

City of Bothell
BOT004







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: BOT011

Local Agency: City of Bothell ☐ **Project** ☐ **Basin #:** BOT011

Contact Person: Mac McDonald **Phone #:** 425-488-0118

Proposed Project Management & Contracting Method:
☐ **Local Agency** ■ **King County**

Geographic Area: ■ **North** ☐ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ☐ Both ■ Unknown
☐ Public ■ Private ☐ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 2,947 gpad	4.1 (12/15/01 storm)	Peak: 16.3 gplfd

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Excellent candidate for pipe-bursting – many streets have been recently resurfaced
Meets Time Frames for the I/I Program	✔	
Geographic Representation	✔	
“Do No Harm” + Geologic Conditions OK	✔	
System Age	✔	Varies from 70’s to early 50’s – some of the oldest pipe in the system.
Environmental Benefits	✔	System drains to overloaded Kenmore pump station.
Addresses Private Sewer Issues	✔	Suspect many roof drains tied into older sanitary sewer lines – older sections of storm may also.
Provides Regional Impact	✔	
Model for Future Projects	✔	Opportunity to complete a project in a “core” area, with attendant traffic & congestion.
Representative of Typical I/I Problems Region-wide	✔	Older neighborhood with mixed development – potential for some roof drain/combined systems

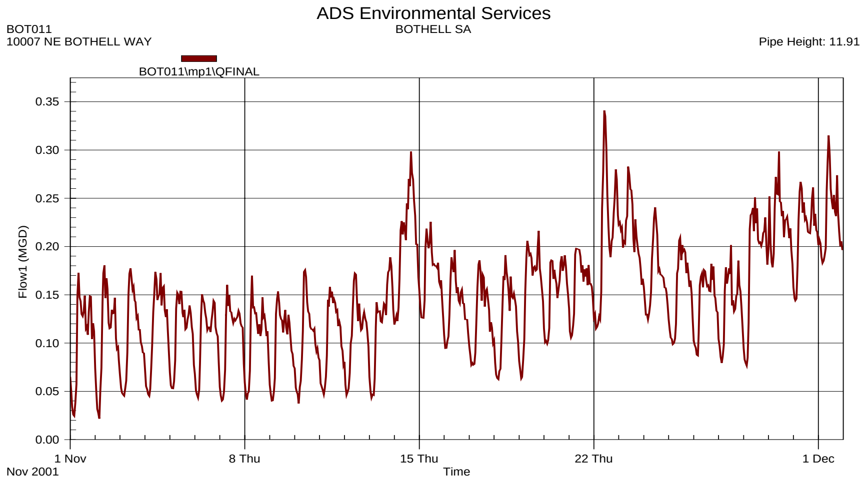
Wild Card		

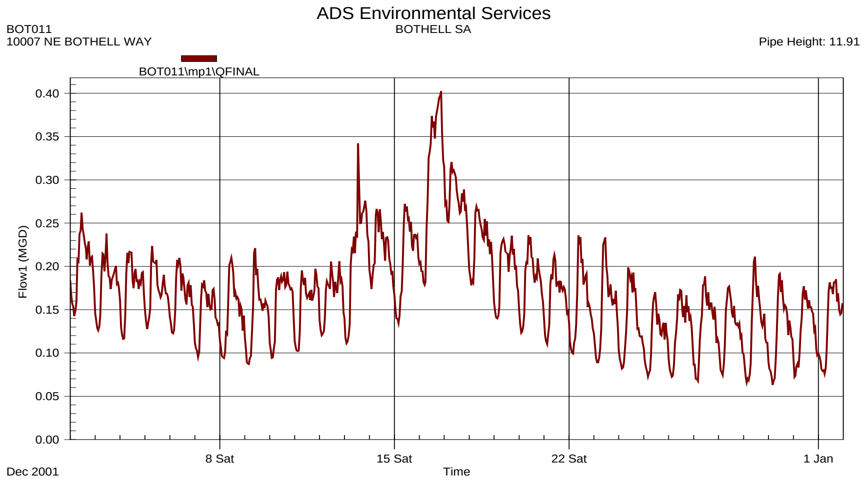
Project Title: BOT011

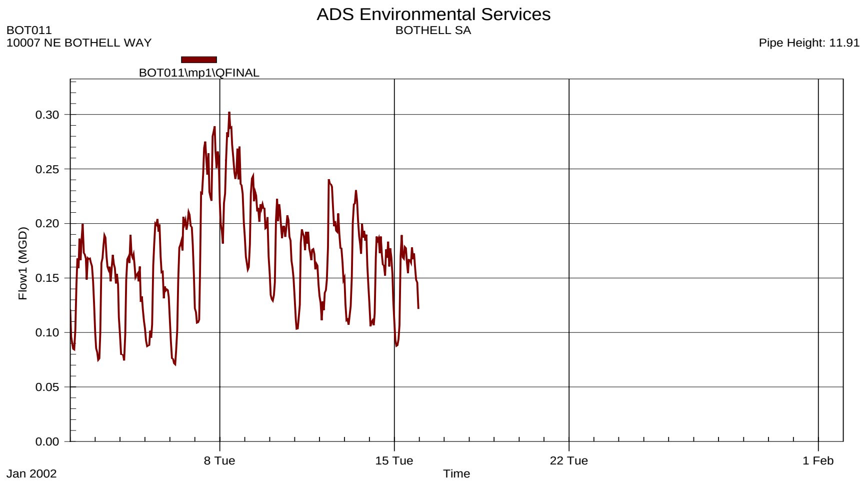
Key Facts & Information:

This project includes considerable areas of older (pre 1950) development, where loose enforcement and customary usage had homeowners connecting roof and footing drains to any convenient discharge. Further testing may indicate a relatively small area where the majority of the inflow is concentrated, consisting of the area south of 192nd. Due to recent resurfacing of many of these streets, pipe bursting or another trenchless technology would be the preferred method of mitigation.

City of Bothell
BOT011







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: **BRR004-Dundee**

Local Agency: **City of Brier** ☐ **Project** ☐ **Basin #:** **BRR004**

Contact Person: **Dick Russell** **Phone #:** **425-775-5440**

Proposed Project Management & Contracting Method:

■ **Local Agency** ☐ **King County**

Geographic Area: ■ **North** ☐ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown

☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 6,338 gpad	**11.2 (12/12/01 storm)**	**Peak: 57.3 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Trenchless in pipe rehab. Manholes: Raise lids & frames, interior lining
Meets Time Frames for the I/I Program	✔	Meets 1 yr time frame
Geographic Representation	✔	North
"Do No Harm" + Geologic Conditions OK	✔	No harm
System Age	✔	Post 1961 System – Concrete pipe in '67 (2/3 area); PVC pipe in '96 (1/3 area)
Environmental Benefits	✔	Lyon Creek – High water
Addresses Private Sewer Issues	✔	Get side sewer easements
Provides Regional Impact	✔	Will reduce water volumes 1100% from base flow
Model for Future Projects	✔	High water table – will provide measurable reduction of I/I
Representative of Typical I/I Problems Region-wide	✔	Older concrete pipe – 1967
Wild Card	✔	Can complete TV of system in 60 days – no flow

		from upstream basin

Project Title: BRR004

Key Facts & Information:

We believe this candidate is a good representative project as a model for I/I Problems.

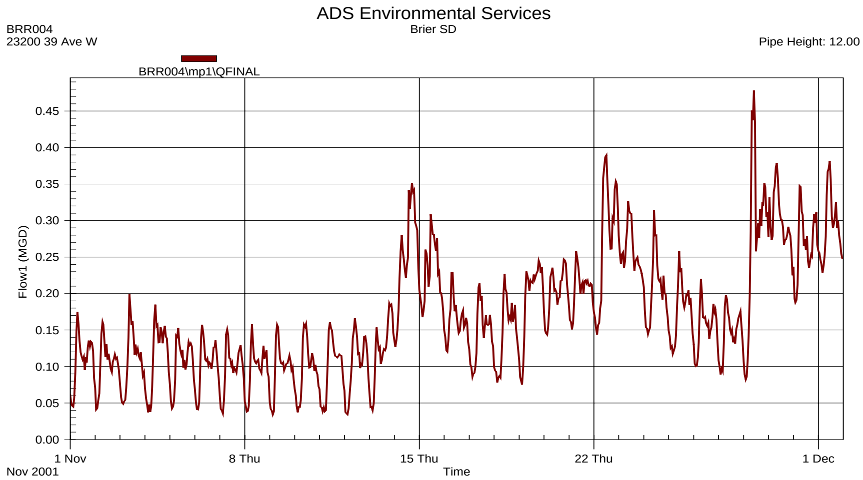
- This candidate has a combination of pipe types ranging from 1967 vintage concrete pipe (the oldest in the city) in the South and East portions of the basin, 1982 vintage PVC pipe to the immediate North and 1997 PVC to the extreme North.
- The South portion of the basin sewer line parallels the headwaters of the East fork of Lyon Creek and the elevation is approximately at creek level. With the probable repairs required near the creek and the proximity to Brier Elementary School (which is located in the basin), it may be possible to consider this as a "WILDCARD" and to enhance the streambed and use the creek as an "adopt a stream" for the Elementary School students.
- We believe that geographically this candidate is the furthest north of the proposed Pilot Program Projects. The vehicular traffic is generally low, which would allow easy access for construction. The basin also contains a Middle School that was built at the time of the original sewer construction and it may be that patio drains are connected to the sanitary sewer system. If this candidate is selected, we will immediately contact the School District Administration for assistance and permission to test their on-site sewage system.
- Some of them manholes as well as the sewer lines are on farily steep slopes (30-40%), private property, and heavily vegetated with native vegetation.
- The sewers in the basin have been TV'ed and if this candidate is selected we will also complete smoke testing.
- There are storm systems in all the plats within the basin; however, with the age, materials, and questionable level of inspection in the 1967 construction period, it is our opinion that many faults in the system may exist that could be corrected without total re-construction. We are also of the opinion that both the 1982 and 1997 sewers constructed in those periods are in good condition which could limit the overall work to be accomplished and assist in not requiring as much as a year to complete the rehabilitation.
- As the City of Brier is a small jurisdiction that is primarily a bedroom community, we have a small staff and limited budget; however, we find it challenging, rewarding and mandatory to be as innovative as possible in accomplishing our given responsibilities.

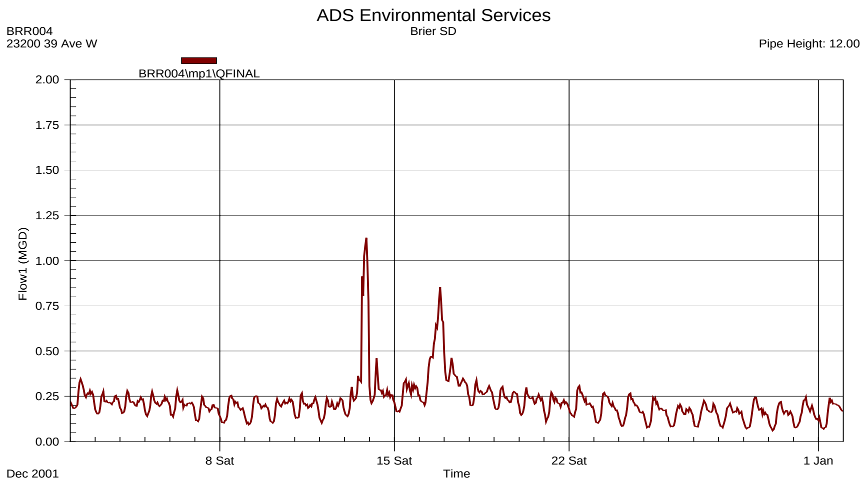
- We try to work "Out of the Box" rather than assuming that "It should be done this way because it's always been done this way." We are not limited or hindered by bureaucracy since our Community Development Staff and the Mayor are the decision-makers.
- Since this basin is located at the Headwaters to Lyon Creek, any correction to exfiltration would definitely enhance the positive effect on downstream ESA.

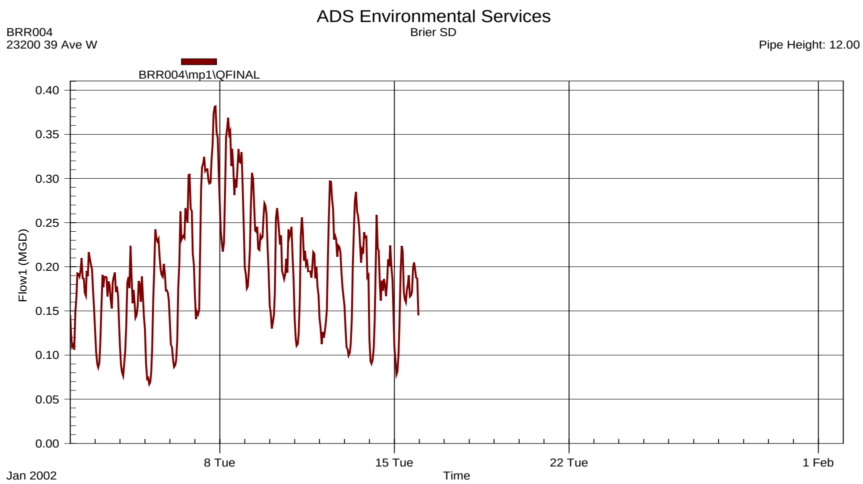
Please consider this as additional information to the Pilot Basin/Project Worksheets:

1. If the City of Brier is selected as a candidate for a Pilot Basin Project at the March 21, 2002 meeting, we will assure you that the selected basin will have TV work completed within 60 days.
2. The City of Brier has a naturally occurring high groundwater table typically at the 2' to 3' depth.
3. The City of Brier candidates are post 1961.
4. The City of Brier would prefer to administer and manage the pilot project; however, if the County has a particular reason to undertake administration that is feasible.
5. The City of Brier will use the proven technology that best suits the I/I correction requirements and follow King County I/I Program Guidelines.
6. The City of Brier geology is predominately glacial till with some steep slopes; however, there are no slide areas.
7. The City of Brier will complete the project within one year.
8. The City of Brier is of the opinion that the candidates represent typical I/I program conditions.
9. The City of Brier candidates do not have flow from upstream basins.
10. The City of Brier candidates will not create any hazards or danger to shorelines, streams, wetlands or steep slopes.

City of Brier
BRR004







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: BRR006

Local Agency: City of Brier ☐ **Project** ☐ **Basin #:** BRR006

Contact Person: Dick Russell **Phone #:** 425-775-5440

Proposed Project Management & Contracting Method:
■ **Local Agency** ☐ **King County**

Geographic Area: ■ **North** ☐ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 2,408 gpad	**4.8 (12/15/01 storm)**	**Peak: 16.6 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Illegal Conn. Spot repairs. Manholes – interior linings.
Meets Time Frames for the I/I Program	✔	1 yr time
Geographic Representation	✔	North
"Do No Harm" + Geologic Conditions OK	✔	No harm. Near Scriber Creek.
System Age	✔	1982
Environmental Benefits	✔	Enhanced stream flow. Reduced exfiltration.
Addresses Private Sewer Issues	✔	Get side sewer easements
Provides Regional Impact	✔	Will reduce wastewater volumes
Model for Future Projects	✔	With existing high water table, will be measurable I/I reduction
Representative of Typical I/I Problems Region-wide	✔	Typical PVC pipe grouted at M.H. with illegal connections
Wild Card	✔	Measurable reduction of 700% and I/I

Project Title: BRR006

Key Facts & Information:

We believe this is a good representative project as a model for I/I problems.

- This candidate was constructed in 1982 with PVC pipe.
- This plat was constructed in an area that would probably have been designated as a wetland based on the standards used today. Scriber Creek runs through the plat from west to east and there is a designated wetland along most of the north boundary of the plat.
- Due to poor soil conditions and probable poor construction practices, sections of the plat infrastructure have failed and it is our opinion that the failing curb, gutter and sidewalk are an indication that the subsurface sanitary sewer and storm drainage are in similar condition. The ground water table is extremely high and there are underground springs so that in some areas water flows from private property across the sidewalks. Manhole infiltration has also been observed.
- We are suspicious that there may be multiple illegal connections to the sanitary sewer system even though there is a piped storm system.
- Much of the main line is on private property (in backyards) and roughly parallels Scriber Creek.

Please consider this as additional information to the Pilot Basin/Project Worksheets:

11. If the City of Brier is selected as a candidate for a Pilot Basin Project at the March 21, 2002 meeting, we will assure you that the selected basin will have TV work completed within 60 days.
12. The City of Brier has a naturally occurring high groundwater table typically at the 2' to 3' depth.
13. The City of Brier candidates are post 1961.
14. The City of Brier would prefer to administer and manage the pilot project; however, if the County has a particular reason to undertake administration that is feasible.
15. The City of Brier will use the proven technology that best suits the I/I correction requirements and follow King County I/I Program Guidelines.
16. The City of Brier geology is predominately glacial till with some steep slopes; however, there are no slide areas.

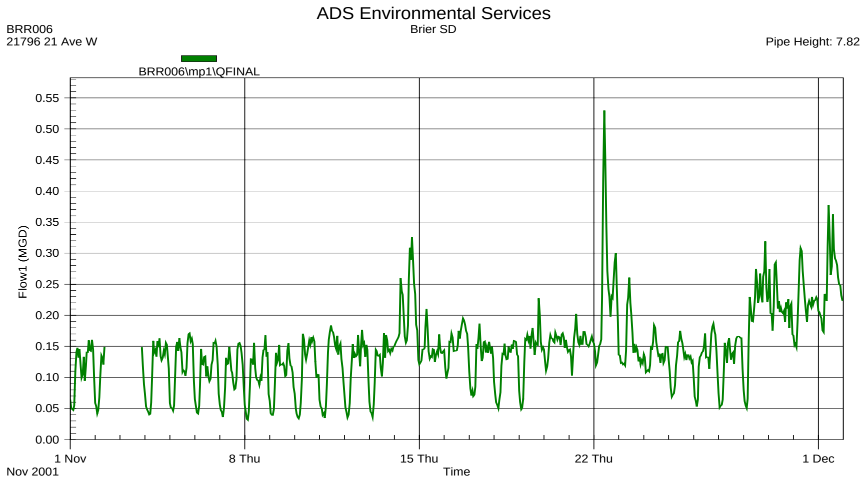
17. The City of Brier will complete the project within one year.

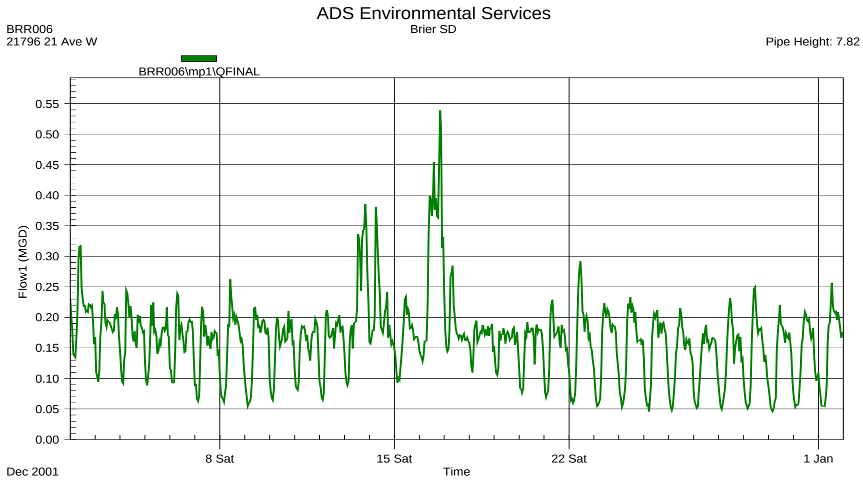
18. The City of Brier is of the opinion that the candidates represent typical I/I program conditions.

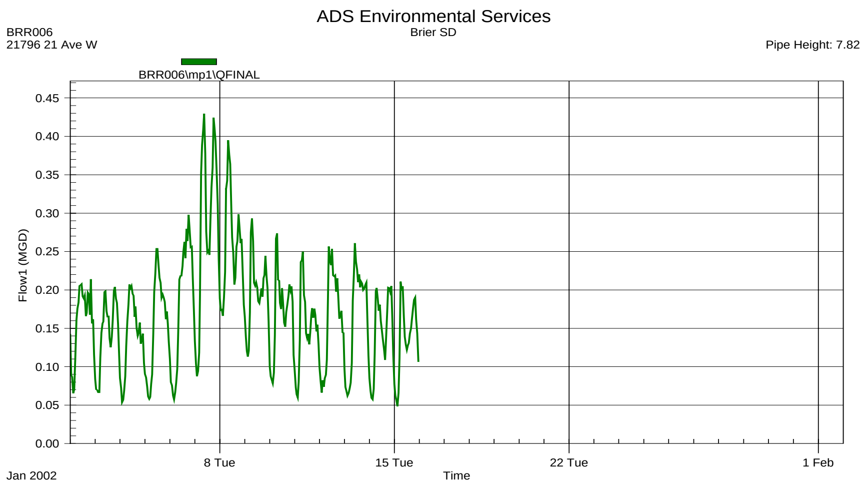
19. The City of Brier candidates do not have flow from upstream basins.

20. The City of Brier candidates will not create any hazards or danger to shorelines, streams, wetlands or steep slopes.

City of Brier
BRR006







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: **Basin 6 (From Bryn Mawr I/I Project Identification Dated 1998 – Side Sewer and Main Line Rehabilitation/Replacement)**

Local Agency: **Bryn Mawr-Lakeridge** **Project/Basin #:** **BLS002**

Contact Person: **Cheryl Scheuerman** **Phone #:** **206-772-7343**

Proposed Project Management & Contracting Method:
■ **Local Agency** ☐ **King County**

Geographic Area: ☐ **North** ☐ **East** ■ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 27,167 gpad	**16.6 (12/12/01 storm)**	**Peak: 130.1 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	The various techniques used in this project will be dependent on the characteristics of each specific private property and side sewer involved. Techniques could include traditional digging, pipe bursting, lining or some combination.
Meets Time Frames for the I/I Program	✔	This project can be completed within one year. Because the side sewer portion of the project was actually a 1998 King County/District I/I pilot project that was never realized, a good portion of it has already been completed. Side sewer topographic survey, base mapping and design is complete. Mainline design would need to be added. Private property “Right of Entry” agreements were obtained in 1998 from all properties owners. These agreements are still valid and only need to be updated for properties that have changed ownership in the last 4 years. Possible permits: King County Grading and Right of Way; DOE Approval.
Geographic Representation	✔	Southwest region – Bryn Mawr-Lakeridge Water

		and Sewer District (Lakeridge Area)
"Do No Harm" + Geologic Conditions OK	✔	No harm. There are no slopes, wetlands or creek-beds in project area.
System Age	✔	40+ years. Most all of system was constructed in 1960's and prior.
Environmental Benefits	✔	This project will reduce the amount of storm water entering the sewers, bringing reductions in sewer collection and treatment/disposal costs. It will help eliminate potential storm event overflows/backups and reduce the potential for periodic, seasonal downstream overflows into Lake Washington.
Addresses Private Sewer Issues	✔	This project involves both private and public issues. Any issues, however, are expected to be minimal and easily resolved. With the exception of ownership changes since 1998, private right of entry agreements have already been obtained and are still valid. Only updating and customer communication is needed.
Provides Regional Impact	✔	Since Bryn Mawr-Lakeridge's Basin #6 was previously documented to be King County's #1 I/I contributor, this project was determined to have regional benefit. As indicated above, King County actually approved it as a "pilot" project in 1998 when it agreed to share in its funding because of the significant regional benefit expected. The project was fully designed and put out to bid twice – once in the summer of 1998 and again in the winter of 1999. Due to a myriad of complex cost and funding circumstances, however, bid was not awarded and the project was abandoned. Its need and regional benefit remain to date.
Model for Future Projects	✔	Side sewer replacement model. As indicated above, this project was established as a 1998 pilot in which King County agreed to share in funding because of the significant modeling potential and regional benefit that it was expected to provide. While funding issues led to the project's abandonment, the positive modeling potential of this project remains to date. Old faulty side sewers have been determined to be a major I/I contributor. Prior project bids confirm contractor and cost efficiencies to be realized if main line is replaced at the same time as side sewers. This project will help quantify the benefit of side sewer and mainline replacement together.
Representative of Typical I/I Problems Region-wide	✔	Old and faulty side sewers have been determined to be the major I/I contributor in prior studies. This area is no exception. This project will help quantify the benefit of side sewer replacement coupled with main line replacement.

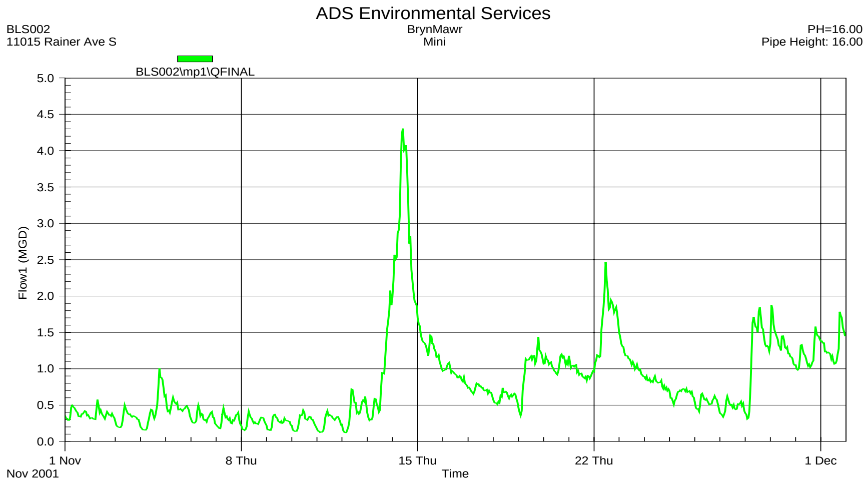
Wild Card	✔	As indicated above, this project was originally established as a King County pilot project in 1998. It was fully designed and private property rights of entry were obtained. Public education and hearings were accomplished. The project was bid twice, but both bids came in significantly higher than estimated, due to two reasons: 1) the underestimating of street overlay costs; 2) low contractor efficiency and cost efficiency in replacing only side sewers without mainline replacement at the same time. The project was subsequently abandoned due to increased costs and funding restrictions. With just a bit of "tweaking", this project can be accomplished on an extremely "fast tract" basis. Side sewer design has already been completed. Only main line design would need to be added. The Basin's residents are already educated with regard to the District's and King County's I/I reduction program and are cooperative. All private property rights of entry agreements were obtained and are still valid. They only need updating for ownership changes. Regional benefit and participation were previously confirmed. All of the reasons it was considered a great pilot project in 1998 remain the same to date. Given technology improvements over the past four years and the current economy, construction bids would be expected to be extremely competitive. The funding issues that halted the 1998 project should not apply in 2002. Any costs in excess of King County's pilot project allocation would be borne by the District.

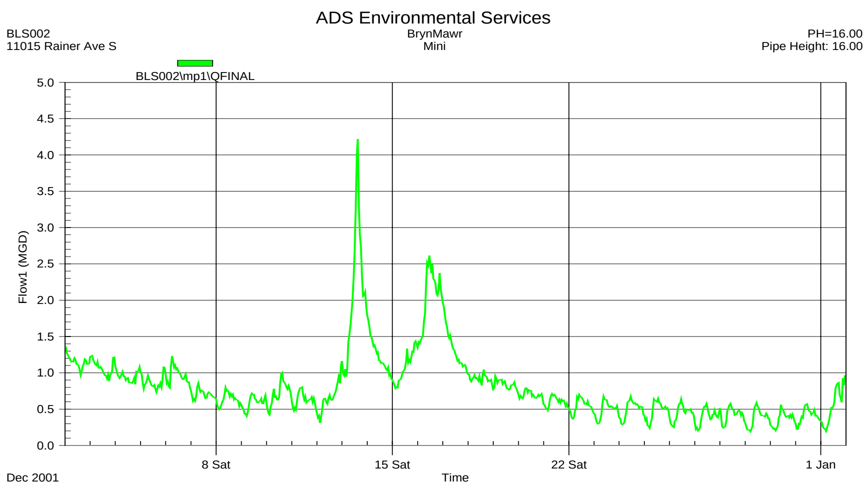
Project Title: Basin 6 Side Sewer and Mainline Replacement

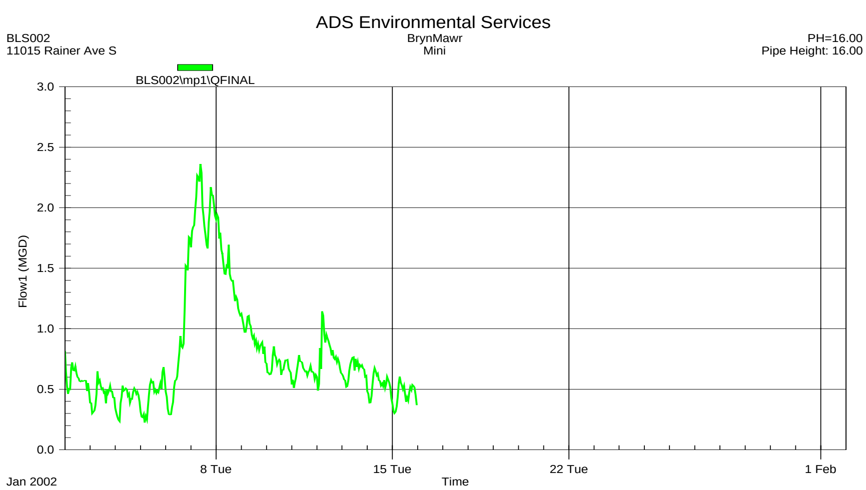
Key Facts & Information:

Rehabilitation and replacement of 169 side sewers (4"-6"), including installation of cleanouts at the house, replacement of sewer main tee sections, and replacement of approximately 9,962 lineal feet of 8" sewer mainline with 39 associated manholes. This basin was designated as King County's #1 I/I area in 1996.

Bryn Mawr – Lakeridge Water & Sewer District
BLS002







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: ISS014

Local Agency: City of Issaquah ☐ **Project** ☐ **Basin #:** ISS014

Contact Person: Kerry Ritland **Phone #:** 425-837-3400

Proposed Project Management & Contracting Method:
■ **Local Agency** ☐ **King County**

Geographic Area: ☐ **North** ■ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 3,572 gpad	**7.6 (11/13/01 storm)**	**Peak: 17.3 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Pipe lining (Insituform) and in-situ lining/repair of problematic side sewer connections
Meets Time Frames for the I/I Program	✔	City has extensive experience with reline projects
Geographic Representation	✔	East
"Do No Harm" + Geologic Conditions OK		Residential development on hillside terrain
System Age	✔	1960's installation period by developer
Environmental Benefits		Reduced likelihood of surcharging to surface waters
Addresses Private Sewer Issues		Public. Although side sewers are private ownership according to City code, lining of lower 5 feet at connection to main will likely solve most infiltration problems associated with side sewer because of poorly constructed connections to main
Provides Regional Impact	✔	May reduce need for downstream capacity improvements on regional system, including interceptor serving Issaquah and Sammamish that was identified by Metro as potentially needing capacity upgrade

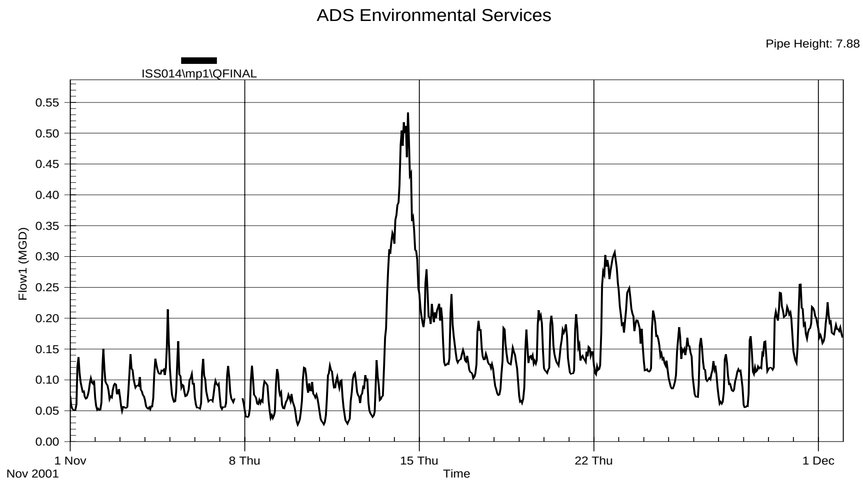
Model for Future Projects	✔	Tests feasibility of repairing side sewers, which were poorly constructed, along with in-situ lining of concrete mains that are deteriorating due to exposure to acidic water
Representative of Typical I/I Problems Region-wide	✔	Typical of installations on hilly terrain with shallow soils over hard till. Substantial interflow in soils contributes to infiltration along mains and side sewer connections
Wild Card		

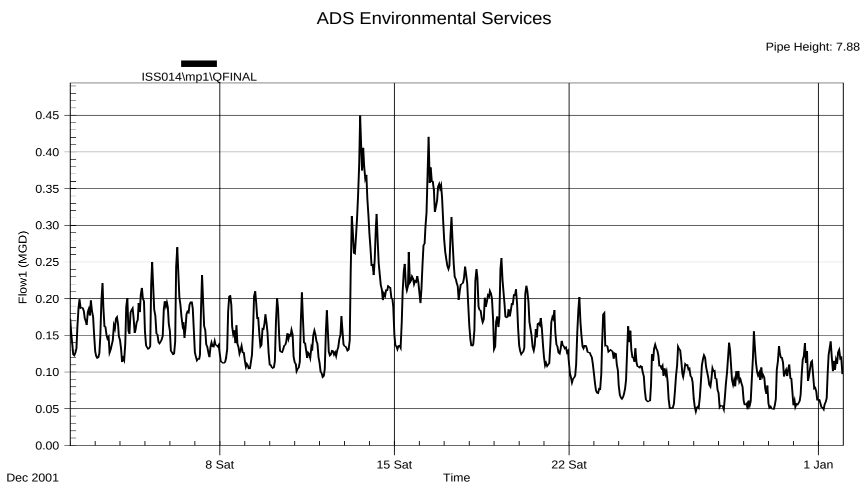
Project Title: ISS014

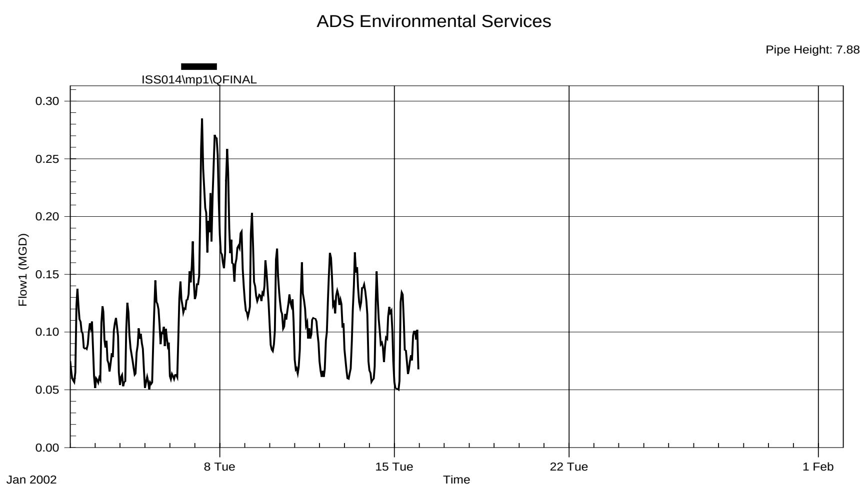
Key Facts & Information:

1960's era 8" concrete sewer lines on Squak Mt. (ISS002 is nearly identical)

City of Issaquah
ISS014







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: KNT014

Local Agency: City of Kent ☐ **Project** ☐ **Basin #:** KNT014

Contact Person: Dave Brock **Phone #:** 253-856-5658

Proposed Project Management & Contracting Method:
■ **Local Agency** ☐ **King County**

Geographic Area: ☐ **North** ☐ **East** ■ **South**

I/I Source Info (if known): ■ Inflow ☐ Infiltration ☐ Both ☐ Unknown
☐ Public ■ Private ☐ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 7,709 gpad	**9.9 (11/13/01 storm)**	**Peak: 52.4 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Project is a candidate for side sewer repairs, deform and form within side sewers, removal/dig/replace existing side sewers.
Meets Time Frames for the I/I Program	✔	It is anticipated the only permits required for this project are SEPA and a Street Use Permit. The City of Kent has existing staff available to design, bid, obtain permits, perform SSES evaluations, and provide construction inspection for this proposed pilot project by the fall of 2003.
Geographic Representation	✔	The proposed project is within the South geographic area and will provide valuable I/I removal data for all 34 collection agencies.
"Do No Harm" + Geologic Conditions OK	✔	The proposed project is within the area which does not have a high groundwater table or steep slopes. The soil type within project area "hard pan."
System Age	✔	The majority of the collection system for the proposed project was constructed between 1959 – 1962.
Environmental Benefits	✔	Historically sewer overflows have occurred at the Linda Heights PS during significant rain fall events

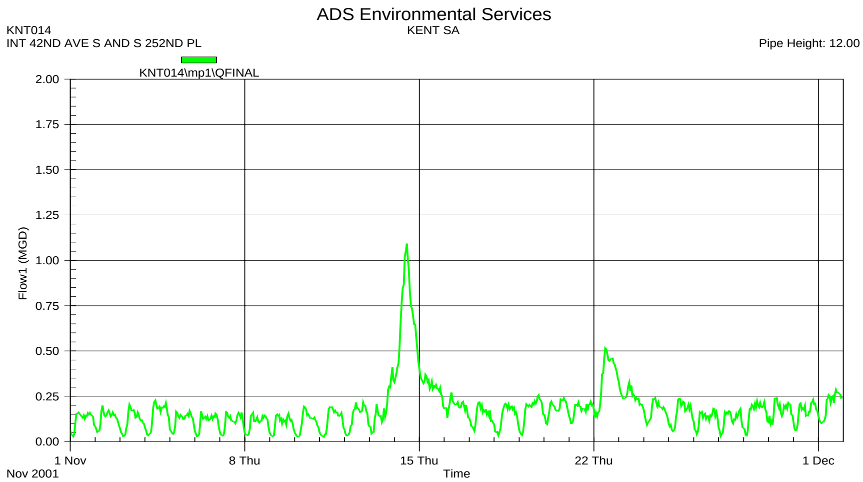
		(1-2 times per year). Elimination of the inflow connections and installation of appropriate infiltration systems (where feasible) with overflows to the existing storm water collection systems, will promote aquifer recharge and reduce/eliminate sewer overflows at the PS. The majority of the rehabilitation work associated with this project is anticipated to be on private side sewers. Therefore, this project will provide the opportunity to educate the public of the importance of the regional I/I reduction program and evaluating the political impacts of performing work on private property and systems.
Addresses Private Sewer Issues	✔	The proposed project is a model project for side sewer I/I reduction evaluation.
Provides Regional Impact	✔	The collection system within the pilot project basin is tributary to METRO's interceptor and is conveyed to the Renton Treatment Plant.
Model for Future Projects	✔	The proposed project is a model project for side sewer I/I reduction evaluation.
Representative of Typical I/I Problems Region-wide	✔	Please see Key Facts & Information section.
Wild Card		

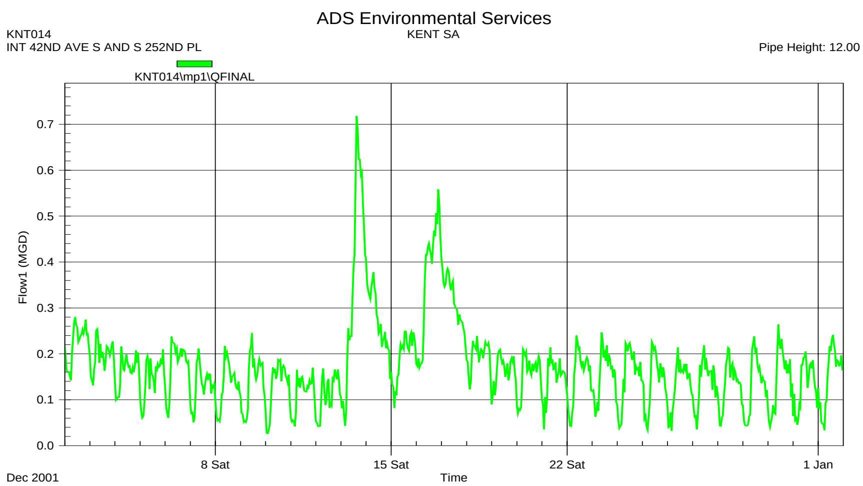
Project Title: KNT014

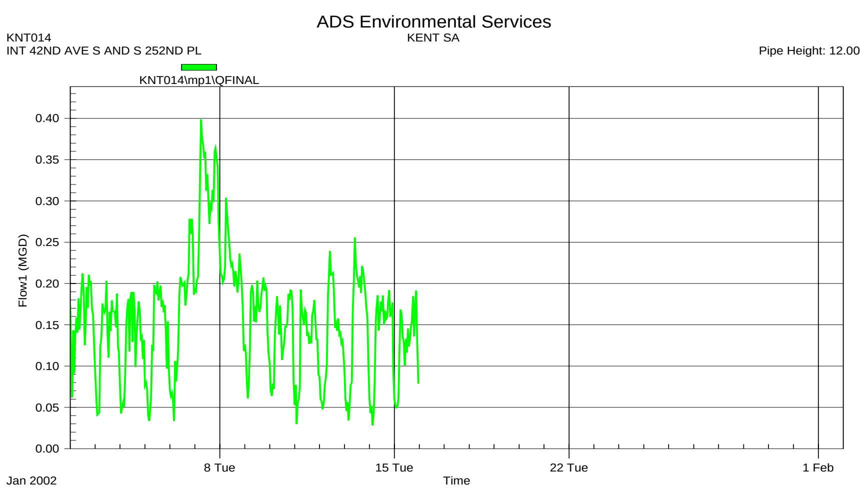
Key Facts & Information:

The proposed KNT014 Pilot Project is located on the West Hill of Kent. The collection system consists of approximately 19,138 feet of 8-inch and 10-inch concrete pipe with concrete manholes. The 8-inch and 10-inch pipe lengths range from 4-6 feet and have rubber gasket joints. There are approximately 230 active side sewers that connect to the main lines (additional side sewers connect directly to manholes). The City of Kent Sewer Division completed TV inspecting all publicly maintained lines during the winter of 2000/2001. Results from the TV reports (available upon request) indicate the main lines are in good condition with a few areas of root intrusion and a couple of holes (potential infiltration). This leads the City to believe the inflow within this basin is a result of illicit roof / foundation drain connections to side sewers. It is the City's position this project would provide an educational benefit to the public, politicians, the 34 sewerage collection agencies, provide environmental benefits, and meets all 10 selection criteria. In addition the project would require the establishment of a methodology/procedure for working with the public to obtain access to private property to perform rehabilitation work. This methodology/procedure would be valuable to all 34 collection agencies.

City of Kent
KNT014







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: **KRK006 Central Way Sub-Basin**

Local Agency: **City of Kirkland** ☐ **Project** ☐ **Basin #:** **KRK006**

Contact Person: **Greg Kremer** **Phone #:** **425-828-1137**

Proposed Project Management & Contracting Method:
☐ **Local Agency** ■ **King County**

Geographic Area: ☐ **North** ■ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 6,745 gpad	**12.9 (12/15/01 storm)**	**Peak: 36.1 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	SS repairs, illegal connections – foundation drains, dig & repair R&R side sewer from main to house
Meets Time Frames for the I/I Program	✔	
Geographic Representation	✔	East
"Do No Harm" + Geologic Conditions OK		N/A
System Age		1941
Environmental Benefits	✔	Removal of I/I will enhance stream flow, reduce sewer overflow @ KC 3 St. & Parklane pump station, & minimal public impacts.
Addresses Private Sewer Issues	✔	Private. In Kirkland Private=main to house/structure. Roof & foundation drains, & side sewer infiltration.
Provides Regional Impact	✔	This sub-basin flows to KC 3 St. & Parklane pump station, I/I reduction will aid in the station's planned rehabilitation & gen-set project.
Model for Future Projects	✔	

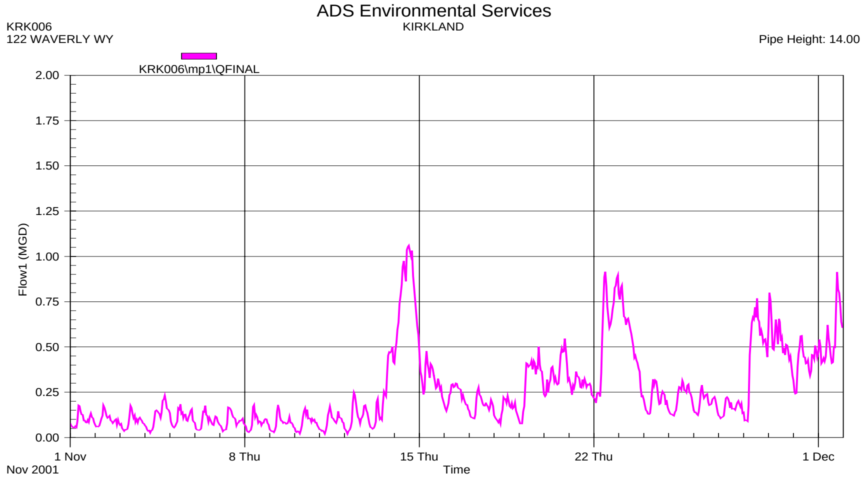
Representative of Typical I/I Problems Region-wide	✔	Removal of I/I on private side sewer/lateral
Wild Card	✔	City of Kirkland has funded $1.1 million for I/I reduction in 5 year period. Smoke testing has been conducted.

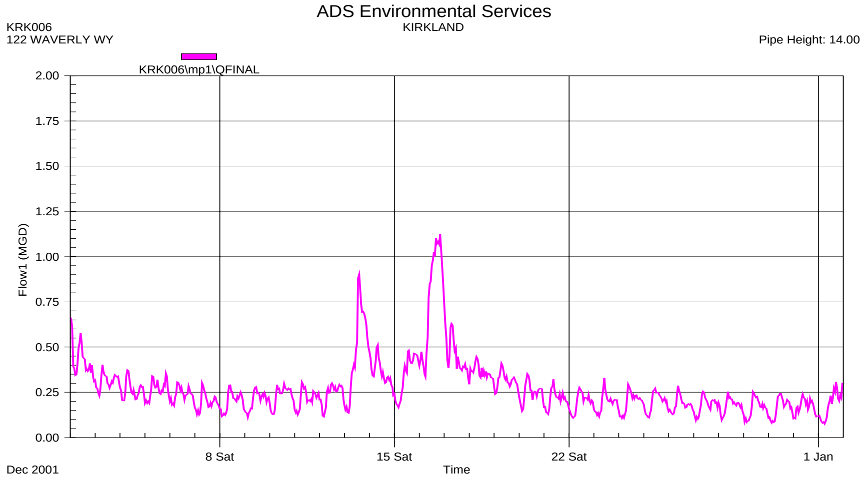
Project Title: KRK006

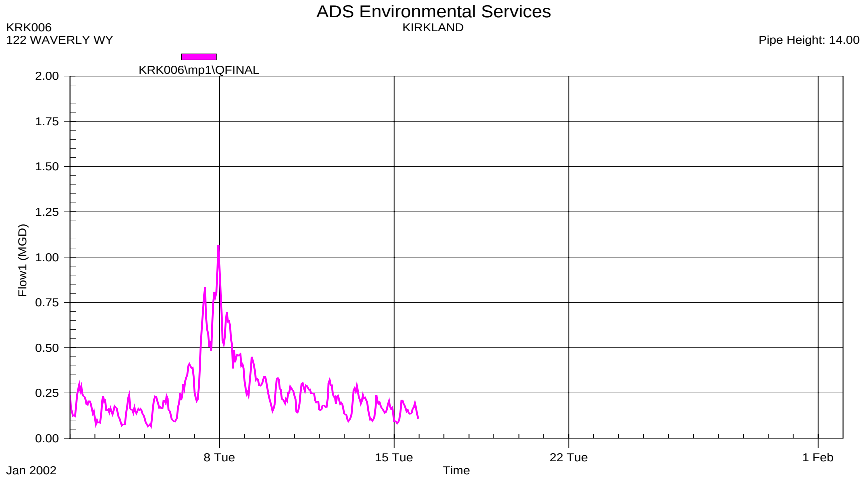
Key Facts & Information:

- All basin sewage flows into King County's 3 st & Parklane pump station, overflows occur and discharge at the Marina park boat launch ramp. Reduction of I/I would reduce pumping operation (power consumption) and K.C.'s pump station is considering rehabilitation and generator installation.
- Pipe age 1941, with 75% of pipe 6" diameter.
- Sewer trunk line replaced in 2001, 6,500 lineal feet.
- Smoke tests were conducted 1996 & 1997, @ 23 locations, photo's & video are available.
- Sewer mains have not been video inspected.
- Service area has springs throughout.
- Not fully developed storm drainage system, opportunity for joint sewer/storm drain project.
- Clear water flowing observed by maintenance staff.
- City of Kirkland owns sewer main only, residents own from home to City main.
- No manhole I/I is known.
- City of Kirkland has $1.1 million in I/I reduction funds available.

City of Kirkland
KRK006







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: KRK011 Central Way Sub-Basin

Local Agency: City of Kirkland ☐ **Project** ☐ **Basin #: KRK011**

Contact Person: Greg Kremer **Phone #: 425-828-1137**

Proposed Project Management & Contracting Method:
☐ **Local Agency** ■ **King County**

Geographic Area: ☐ **North** ■ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 7,289 gpad	**3.4 (11/13/01 storm)**	**Peak: 53.3 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	SS repairs, illegal connections – foundation drains, dig & repair R&R side sewer from main to house
Meets Time Frames for the I/I Program	✔	
Geographic Representation	✔	East
"Do No Harm" + Geologic Conditions OK		N/A
System Age		1941
Environmental Benefits	✔	Removal of I&I will enhance stream flow, reduce sewer overflow @ KC 3 St. & Parklane pump station, & minimal public impacts.
Addresses Private Sewer Issues	✔	Private. In Kirkland Private=main to house/structure. Roof & foundation drains, & side sewer infiltration.
Provides Regional Impact	✔	This sub-basin flows to KC 3 St. & Parklane pump station, I/I reduction will aid in the station's planned rehabilitation & gen-set project.
Model for Future Projects	✔	

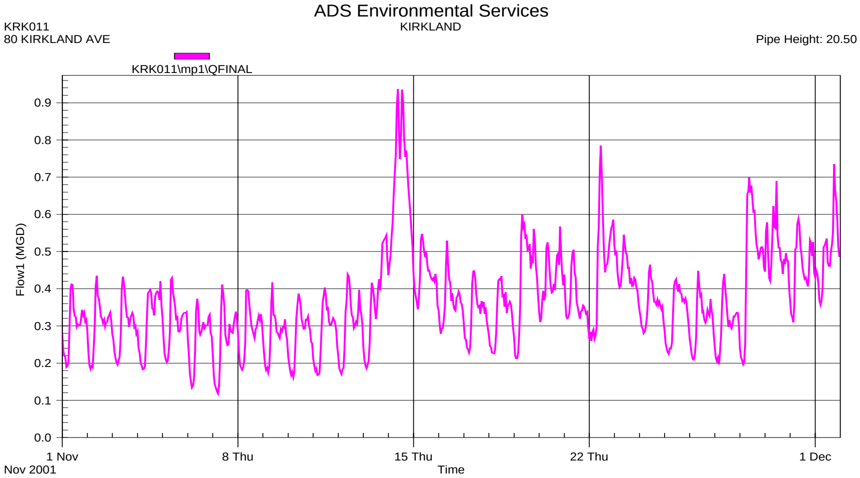
Representative of Typical I/I Problems Region-wide	✔	Removal of I/I on private side sewer/lateral
Wild Card	✔	City of Kirkland has funded $1.1 million for I&I reduction in 5 year period. Smoke testing has been conducted. LBBVLD trunk line was replaced, 50% reduction of I/I from that project.

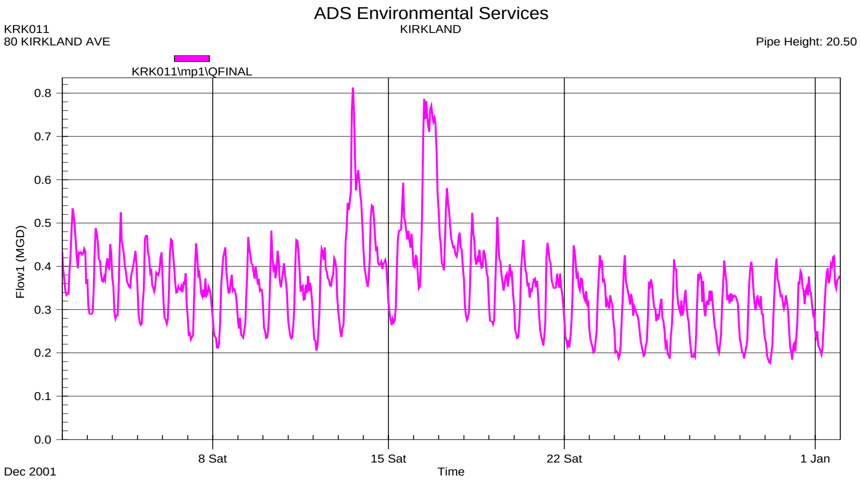
Project Title: KRK011

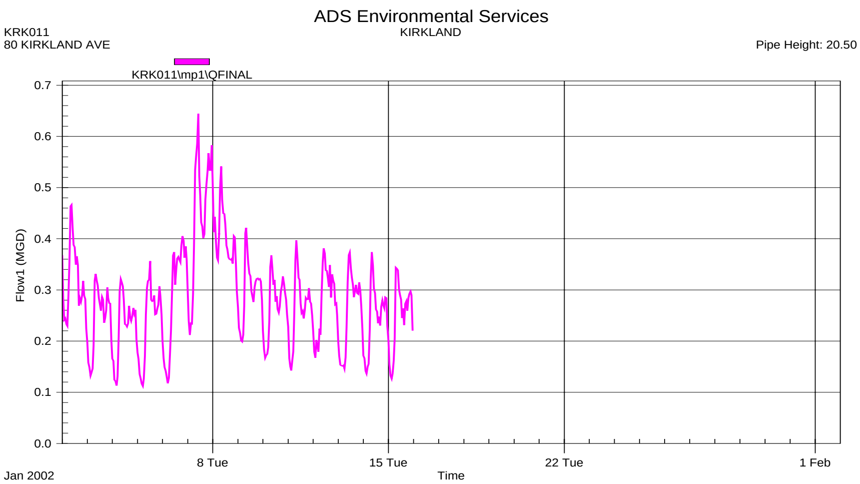
Key Facts & Information:

- All basin sewage flows into City of Kirkland's Plaza pump station, which flows to King County's 3 St & Parklane pump station, overflows occur and discharge at the Marina park boat launch ramp. Reduction of I/I would reduce pumping operation (power consumption) and K.C.'s pump station is considering rehabilitation and generator installation.
- City's sewer trunk line was replaced in 1993-1995, 8,461 lineal feet, adjacent to Lake Washington.
- Pre-trunk line replacement I/I was in excess of 1800 gpm, afterwards 800 gpm
- Pipe age 60% 1941
- Smoke tests were conducted 1996 & 1997, @ 16 locations, photo's & video are available.
- Sewer mains have not been video inspected.
- Service area has severe springs throughout.
- Not fully developed storm drainage system, opportunity for joint sewer/storm drain project.
- Clear water flowing observed by maintenance staff.
- City of Kirkland owns sewer main only, residents own from home to City main.
- No manhole I/I is known.
- City of Kirkland has $1.1 million in I/I reduction funds available.

City of Kirkland
KRK011







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: RON041 (LFP)

Local Agency: City of Lake Forest Park ☐ **Project** ☐ **Basin #:** RON041

Contact Person: Doug Jacobson (LFP) **Phone #:** 206-368-5440

Proposed Project Management & Contracting Method:
■ **Local Agency** ☐ **King County**

Geographic Area: ■ **North** ☐ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 7,962 gpad	14.0 (12/15/01 storm)	Peak: 48.3 gplfd

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Trenchless and in-pipe rehab. Direct stormwater connections and driveway drains. Old mainline repair or replacement.
Meets Time Frames for the I/I Program	✔	Permits required: Right-of-Way, Right-of-Entry (ROE) (for work on private property, no environmental sensitivity)
Geographic Representation	✔	Northern King County
"Do No Harm" + Geologic Conditions OK	✔	No streams or known wetlands. Easily accessible.
System Age	✔	Generally 40+ years, however there are some lines that are reported to be over 70 years old.
Environmental Benefits	✔	Reduces sewer overflows and capacity issues in the Lake Washington Interceptor Line
Addresses Private Sewer Issues	✔	Public & Private. Project will require ROE.
Provides Regional Impact	✔	Significant reduction potential from a system that exhibits sever I/I
Model for Future Projects	✔	Post repair monitoring will identify the benefit

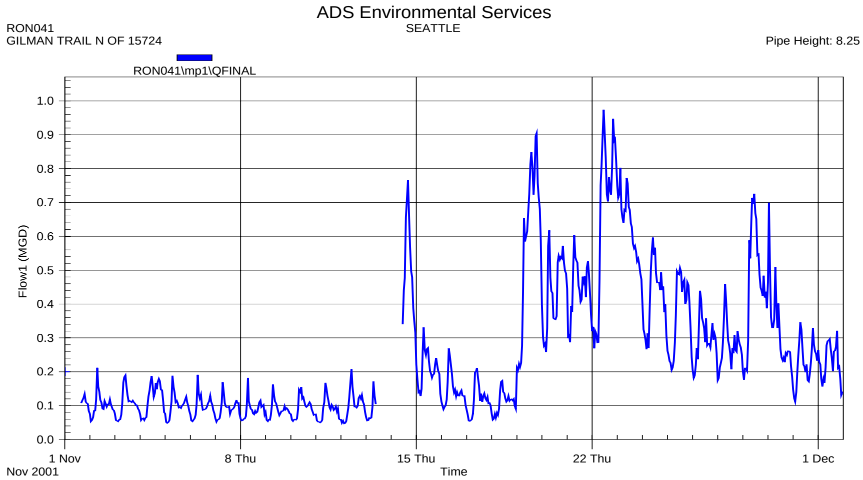
Representative of Typical I/I Problems Region-wide	✔	Typical of the older SPU system which has shown some signs of neglect over the years.
Wild Card		No upstream flow component, some TV work and MH inspection has taken place.

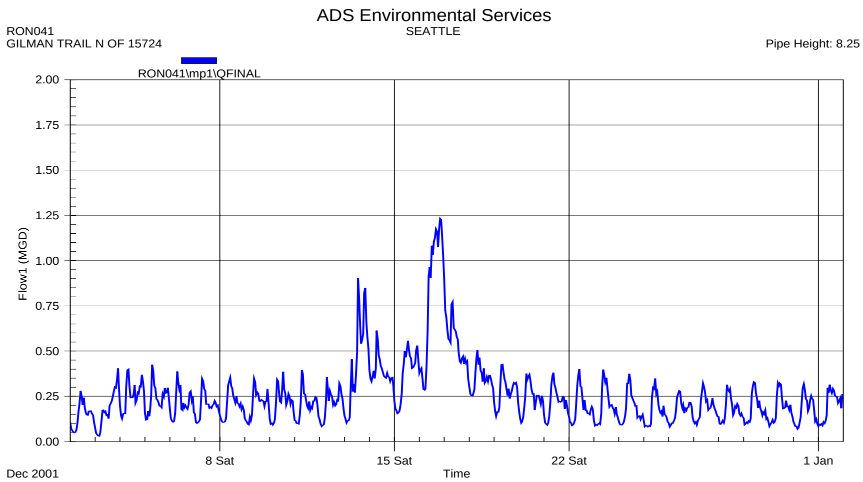
Project Title: RON041

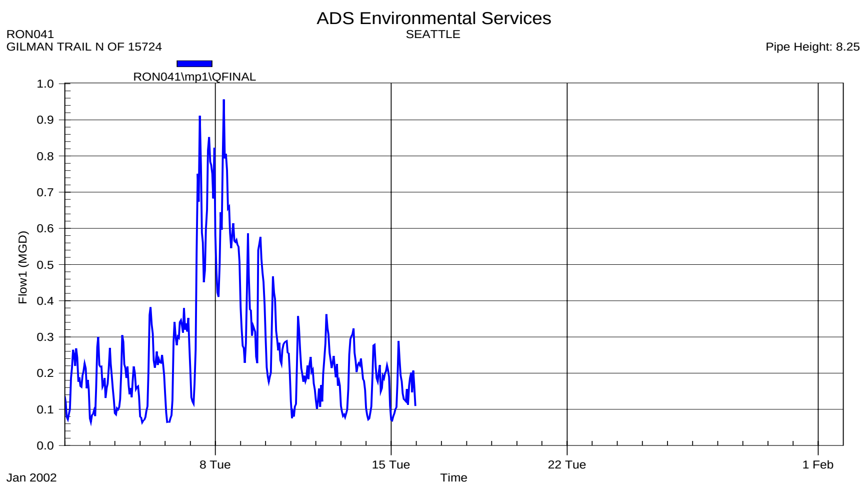
Key Facts & Information:

- Objective: Suspected direct connections and sources of inflow.
- Mainline structural integrity has been reported to be in jeopardy. Reported joint displacement, longitudinal cracking and sagging.
- Estimated age is greater than 40 years and as much as 70 years old in some locations
- No Upstream flow contribution
- Directly connects to the Lake Washington Interceptor line which has a history of capacity problems
- This pilot will be representative of the Seattle Utilities (SPU) system north of 145th which contributes a significant volume of I/I to the King County system

City of Lake Forest Park
RON041







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: MRC012

Local Agency: City of Mercer Island ☐ Project ■ **Basin #:** MRC012 (East Seattle Grid #54)

Contact Person: Pat White & Patrick Y. **Phone #:** 206-236-3620

Proposed Project Management & Contracting Method:
☐ Local Agency ■ King County

Geographic Area: ☐ North ■ East ☐ South

I/I Source Info (if known): ■ Inflow ☐ Infiltration ☐ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 13,719 gpad	21.4 (11/13/01 storm)	Peak: 67.6 gplfd

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Use of trenchless rehabilitation (pipe bursting, lining, joint sealing), and open cut methods to control inflow from roof & yard drains and infiltration from pipe joints.
Meets Time Frames for the I/I Program	✔	Not in shoreline or critical areas.
Geographic Representation	✔	East region
"Do No Harm" + Geologic Conditions OK	✔	Flat to Moderate Slopes, some large lots. Mainly single family with a few multifamily developments. Fully developed. Pilot project would not affect slope stability.
System Age	✔	46 years old. Constructed in 1956. Public system constructed mostly of concrete. Side sewers are mostly concrete and clay.
Environmental Benefits	✔	• Reduce likelihood of over flows to Lake Washington. • Reduce sewer back ups and claims.
Addresses Private Sewer Issues	✔	• Majority of inflow expected from private property based on smoke testing.

		• Work on private property would be accomplished by agreement with property owner. • May need to improve the public drainage system in some locations as part of roof drain disconnection if public drainage system is not available or is too high. Stormwater utility could fund a portion of public drainage improvements.
Provides Regional Impact	✔	Will reduce the local flows conveyed to the regional conveyance system and Renton treatment plant via KC's north Mercer Island pump station.
Model for Future Projects	✔	Private Sewer Issues – downspout disconnection and other work on private property (smoke test data available).
Representative of Typical I/I Problems Region-wide	✔	Inflow and some infiltration on private property.
Wild Card		

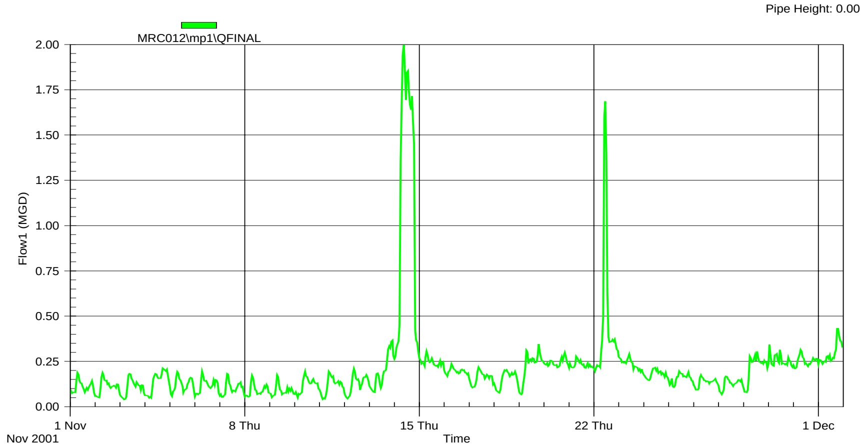
Project Title: MRC012

Key Facts & Information:

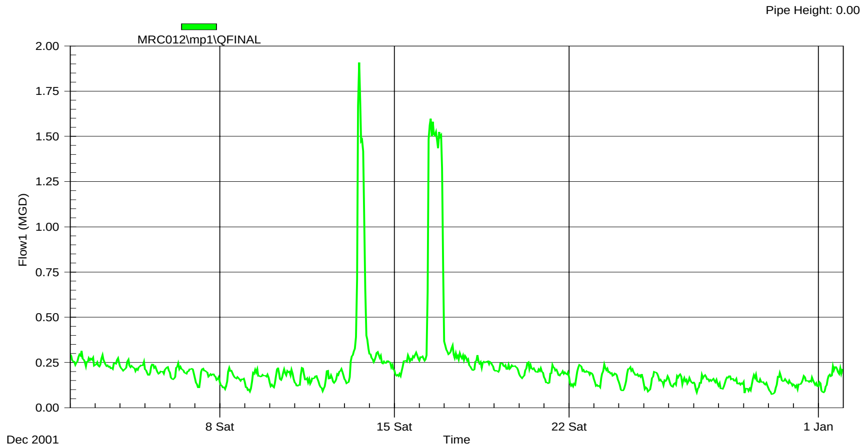
Peaking factor in this basin exceeds 20. This basin was the first area developed on Mercer Island. Development began in the early 1900's as Seattleites built weekend and vacation cabins. Most of Mercer Island's public sewer system was constructed in the 1950's and 1960's by three sewer LIDs. The sewers in this basin were constructed by LID #1 in 1956 and are typical of what exists in the region (8-inch diameter concrete). Available system information includes GIS maps and as-builts of mains, many side sewer as-builts, CCTV records (40% of the basin) and smoke test results. Direct sources of inflow from the public drainage system were removed following smoke testing of the basin in late 1980's. Smoke testing also revealed several sources of inflow on private properties.

City of Mercer Island
MRC012

ADS Environmental Services



ADS Environmental Services



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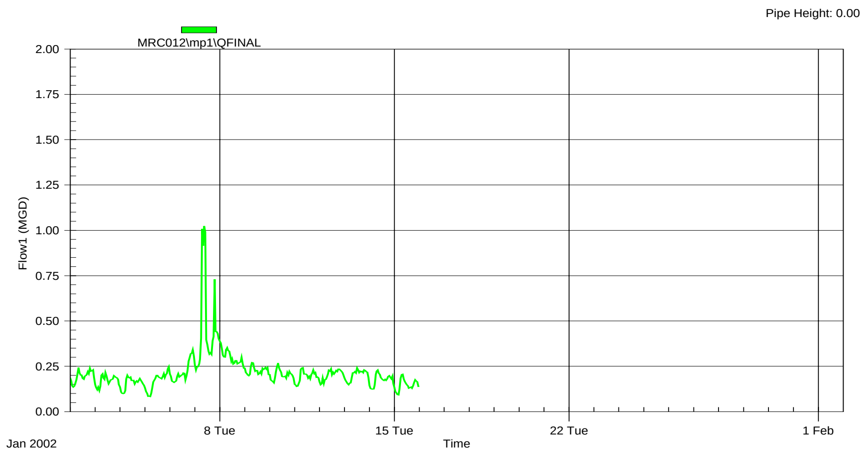


I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: MRPS24

Local Agency: City of Mercer Island ■ **Project** ■ **Basin #:** MRPS24
(Mercerwood Grid #40)

Contact Person: Pat White & Patrick Y. **Phone #:** 206-236-3620

Proposed Project Management & Contracting Method:
☐ **Local Agency** ■ **King County**

Geographic Area: ☐ **North** ■ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 2,797 gpad	9.7 (12/15/01 storm)	Peak: 17.5 gplfd

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Use of a combination of trenchless rehabilitation techniques (pipe bursting, lining, joint sealing, MH sealing) and open cut to control high infiltration on mains and I/I from some side sewers
Meets Time Frames for the I/I Program	✔	Not in shorelines or critical areas.
Geographic Representation	✔	East region
"Do No Harm" + Geologic Conditions OK	✔	Flat to Moderate Slopes, some large lots. Mainly single family residential. Fully developed. Moderate to high winter water table in 30-40 percent of the basin. Pilot project should not affect slope stability. Most mains are in public right of way.
System Age	✔	Constructed during the 1960's sometime as part of East Mercer Sewer District. Taken over by Mercer Island in 1988.
Environmental Benefits	✔	• Provide aquifer recharge. • Reduce likelihood of over flows to Lake Washington

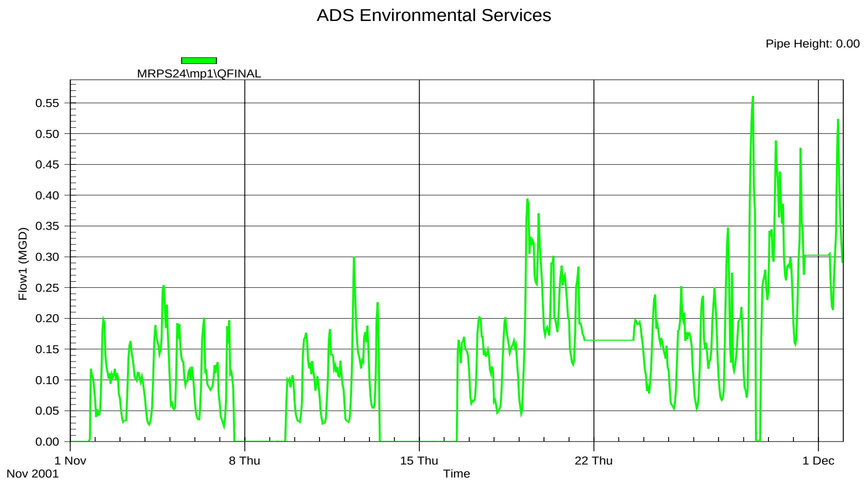
		• Reduce likelihood of sewer back ups and claims. • Reduce conveyance of I/I flows to KC conveyance system and Renton treatment plant. • Reduction of pumping and O & M costs (flows from this basin are conveyed through three Mercer Island lift stations and KC's south Mercer Island pump station).
Addresses Private Sewer Issues	✔	Some I/I sources were observed on private property during previous SSES effort. Work would be accomplished by agreement with property owner.
Provides Regional Impact	✔	Will reduce the local flows conveyed to the regional conveyance system and Renton treatment plant via KC's south Mercer Island pump station.
Model for Future Projects	✔	Trenchless rehabilitation/replacement of mains and open cut replacement of side sewer connections. Removal of infiltration from public sewer mains in right of way and connections between mains and side sewers. Also some I/I removal from side sewers on private property (extensive SSES performed in 1990s).
Representative of Typical I/I Problems Region-wide	✔	Infiltration in public mains and connections to mains.
Wild Card		

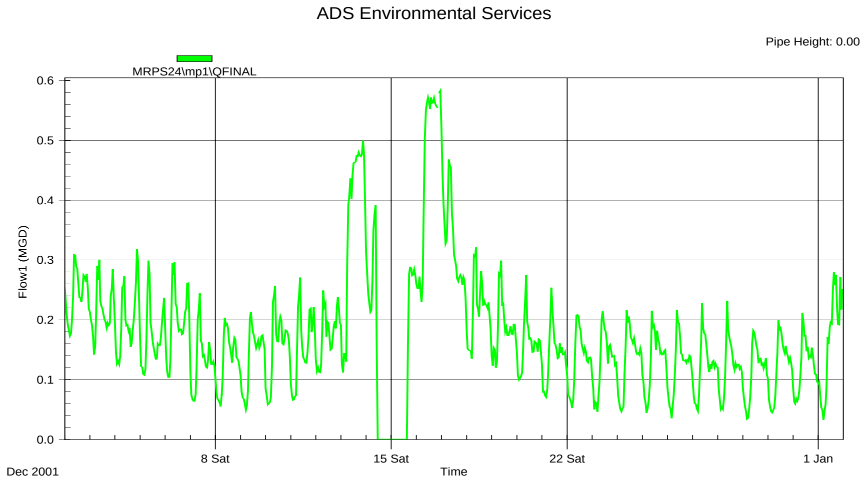
Project Title: MRPS24

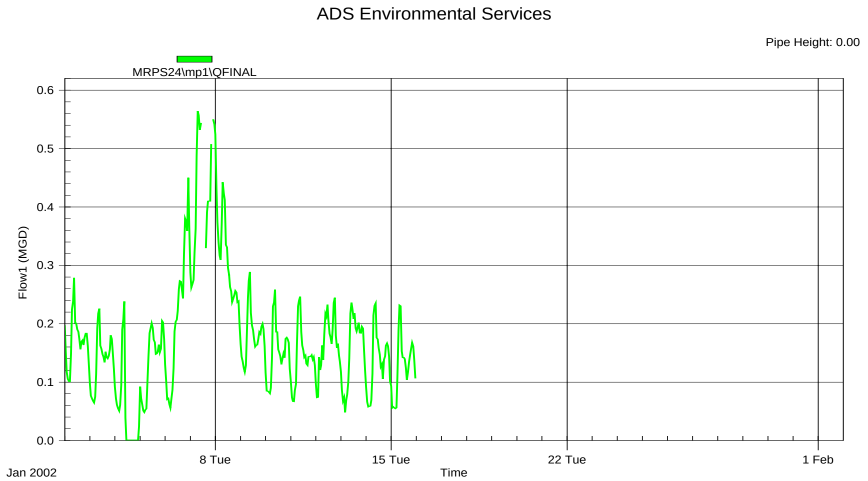
Key Facts & Information:

The sewers in this basin were constructed by the East Mercer Sewer District in the 1960s and were taken over by Mercer Island in 1988. The area is fully developed. The system was smoke tested in 1995 and CCTV performed in 1998. The SSES results showed that the winter water table is higher than the main in many locations. The age and material of the main is typical of what exists in the region (8-inch diameter concrete, 3-foot lengths). SSES information includes smoke test results. CCTV records, and GIS map of sewer system. Flows from basin are conveyed through three Mercer Island lift stations and KC's south Mercer Island pump station. System capacity is a concern during major storm events.

City of Mercer Island
MRPS24







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: NUD024

Local Agency: Northshore Utility Dist. ☐ **Project** ☐ **Basin #:** NUD024

Contact Person: Matt Everett **Phone #:** 425-398-4428

Proposed Project Management & Contracting Method:
■ **Local Agency** ☐ **King County**

Geographic Area: ■ **North** ☐ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 2,860 gpad	**5.4 (12/15/01 storm)**	**Peak: 16.8 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Until SSES work has been completed, we are not sure where the I/I is originating. The District is open to various types of proven technologies and rehabilitation techniques.
Meets Time Frames for the I/I Program	✔	No apparent wetlands, rivers, lakes or steep slopes in sewer basin. Permitting should not be a problem.
Geographic Representation	✔	North-end (King County)
"Do No Harm" + Geologic Conditions OK	✔	No problems/No rivers or lakes. Relatively flat. Easily accessible.
System Age	✔	All post-1961. Pipe is 50% concrete (35 yrs. old) and 50% PVC (20 yrs. old & newer).
Environmental Benefits	✔	Able to reduce I/I into Juanita Pump Station.
Addresses Private Sewer Issues	✔	Most problems in laterals; District responsible to R.O.W. line and customers responsible on private property.
Provides Regional Impact	✔	Ability to reduce 280,000 gal/day I/I into K.C.'s Juanita Pump Station, which is already at capacity.

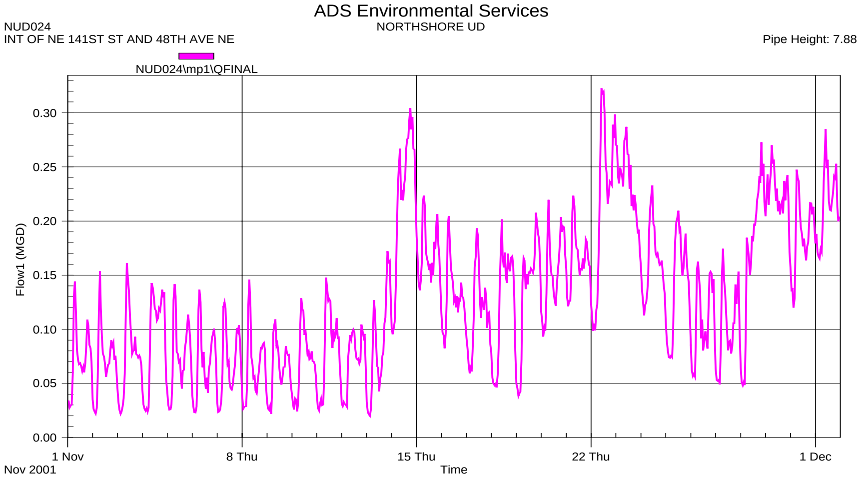
Model for Future Projects	✔	The pilot project would provide information on how to best rehab older concrete pipes and manholes. Would entail some lateral work.
Representative of Typical I/I Problems Region-wide	✔	Failed concrete pipe joints and leaky manholes are typical region-wide problems.
Wild Card		

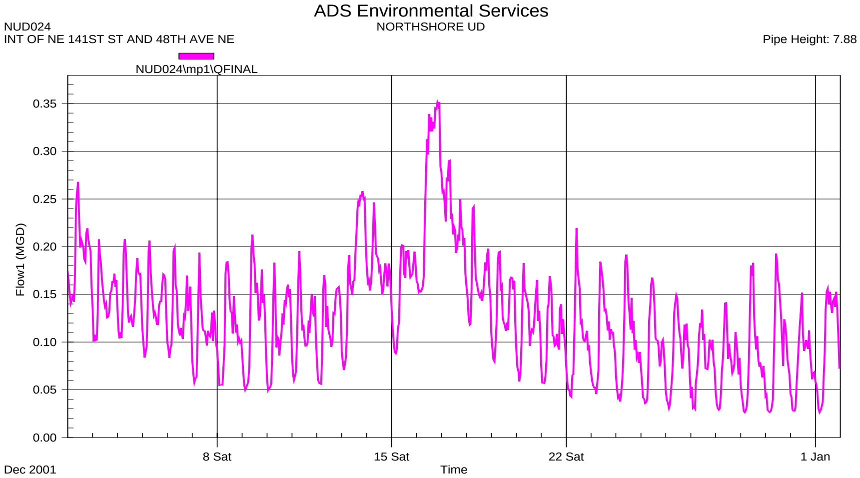
Project Title: NUD024

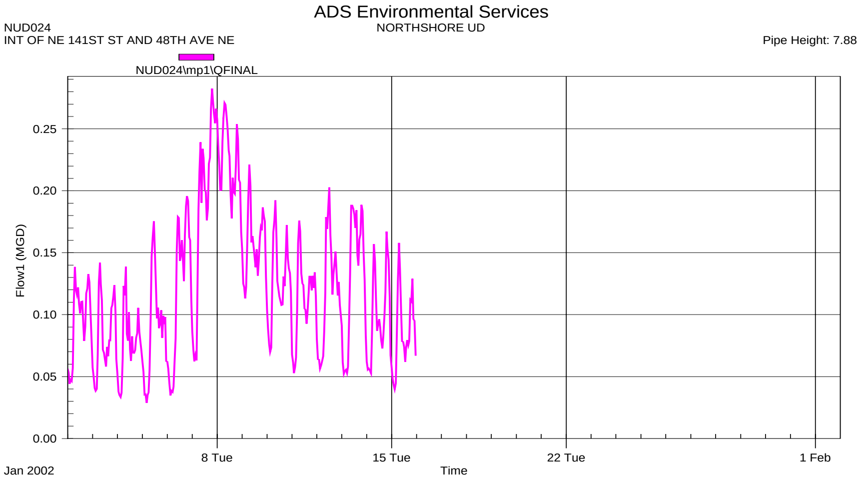
Key Facts & Information:

- Upstream sewer system. Easily monitored; No subtraction errors.
- Total I/I as high as 2,860 gpad.
- 10 (3-day) storm events had cumulative I/I volume of 3,290,000 gallons.
- About 50% of sewer basin is comprised of post-1961 concrete pipe.
- The sewer basin is in a relatively flat area with no sensitive areas, therefore problems associated with obtaining permits should be minimized.
- The District has T.V.'d most of area and found a few leaking manholes, but no significant problems in the sewer mainlines. Most I/I is coming from District laterals on Right-of-Way and side-sewers on private property.
- This sewer basin flows into King County's Juanita Pump Station, which is at capacity. Reducing I/I could reduce overflow events in Lake Washington.

Northshore Utility District
NUD024







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: PAC005

Local Agency: City of Pacific/Algona ☐ **Project** ☐ **Basin #:** PAC005

Contact Person: John Walsh **Phone #:** 253-929-1113

Proposed Project Management & Contracting Method:
☐ **Local Agency** ■ **King County**

Geographic Area: ☐ **North** ☐ **East** ■ **South**

I/I Source Info (if known): ■ Inflow ■ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ☐ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 4,320 gpad	**3.0 (11/13/01 storm)**	**Peak: 37 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Rehabilitation techniques appropriate for concrete sewers.
Meets Time Frames for the I/I Program	✔	Yes. City will dedicate resources necessary to meet one-year criterion within its control.
Geographic Representation	✔	Yes. Pilot would also be joint project with the City of Algona.
"Do No Harm" + Geologic Conditions OK	✔	No steep slopes in project vicinity.
System Age	✔	33 years
Environmental Benefits	✔	No steep slopes in project vicinity.
Addresses Private Sewer Issues		Not known. Would need to perform SSES to determine I&I private property sources.
Provides Regional Impact	✔	In general, I/I removal in Pacific reduces conveyance capacity requirements all the way to Renton WWTP.
Model for Future Projects	✔	This project represents a good opportunity to remedy I/I in a basin with older pipe and high groundwater.

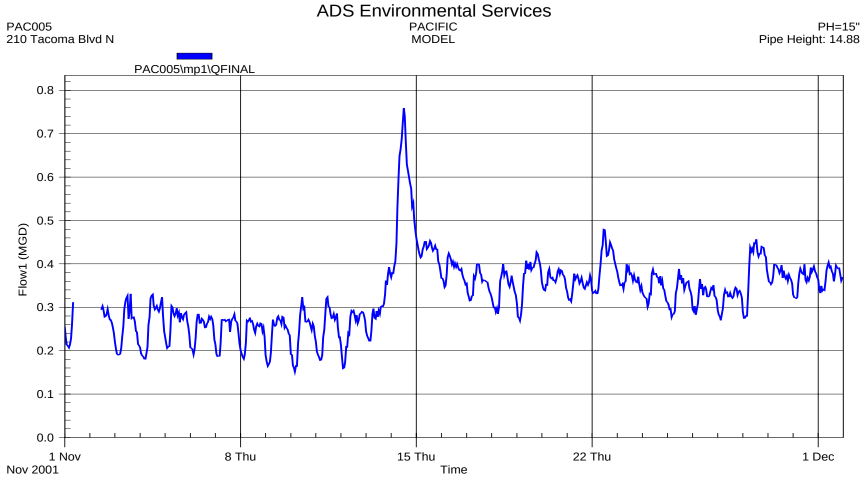
Representative of Typical I/I Problems Region-wide	✔	Yes
Wild Card		

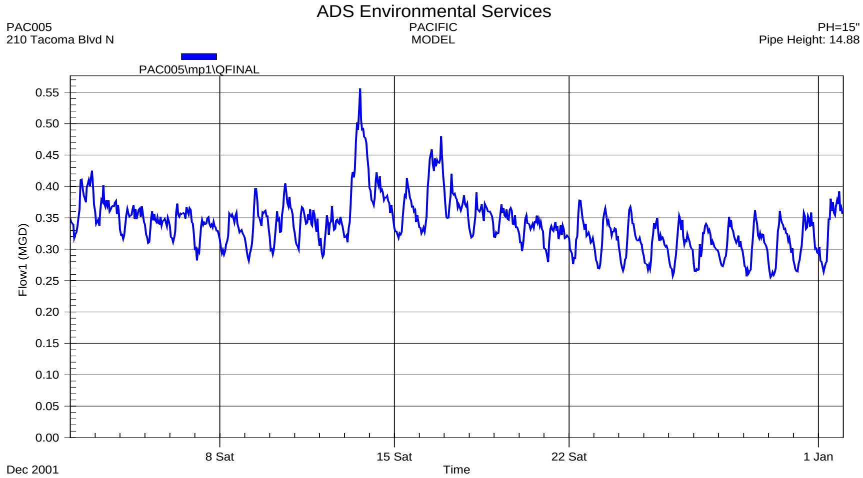
Project Title: PAC005

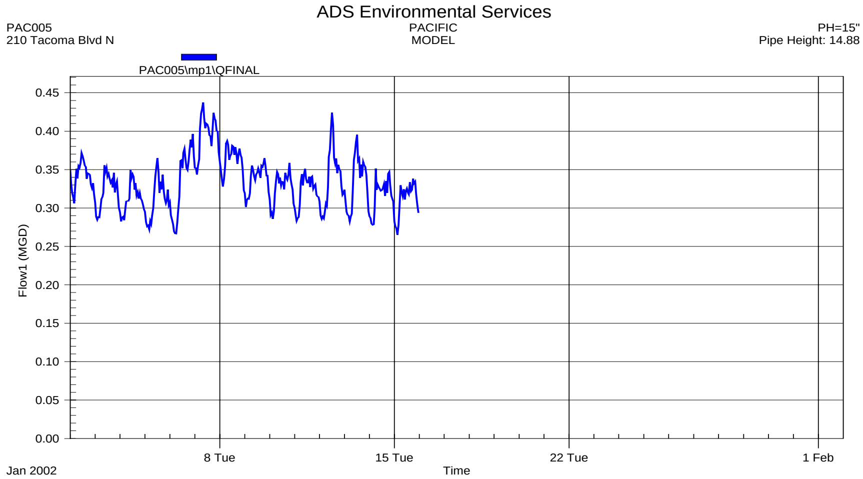
Key Facts & Information:

- As-built plans available for majority of area
- The city is willing to assist in preliminary investigation including video and smoke testing upon assurance of project award
- According to base line trends, this area is likely to have high level of infiltration from ground water. See flows after Nov. 14 rain fall event
- This project would be shared among joint jurisdictions City of Pacific & City of Algona

City of Pacific/City of Algona
PAC005







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: RDM009 – City Center

Local Agency: City of Redmond ☐ **Project** ☐ **Basin #:** RDM009

Contact Person: Scott Thomasson **Phone #:** 425-556-2829

Proposed Project Management & Contracting Method:
☐ **Local Agency** ■ **King County**

Geographic Area: ☐ **North** ■ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ■ Infiltration ☐ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 5,250 gpad	**4.3 (12/15/01 storm)**	**Peak: 30.9 gplfd**

Selection Criteria:

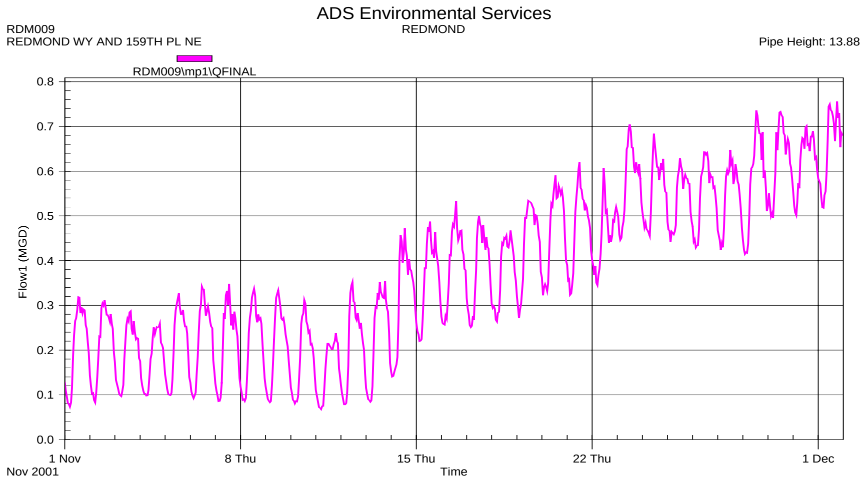
Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	
Meets Time Frames for the I/I Program	✔	
Geographic Representation	✔	Eastern region
"Do No Harm" + Geologic Conditions OK	✔	
System Age	✔	Pre 1961 System – Core of the system is pre-'61. Outlying areas are more recent. City has near-term plans for upsizing existing mains for future growth.
Environmental Benefits	✔	Lessen likelihood for sewer overflows
Addresses Private Sewer Issues	✔	In the event an SSES demonstrates that private side sewers are a significant source of I/I, the Water and Sewer Utility Supports work on private property to remedy.
Provides Regional Impact		
Model for Future Projects	✔	Excellent candidate for pipe bursting as some of the pipe will need to be upsized for future growth.

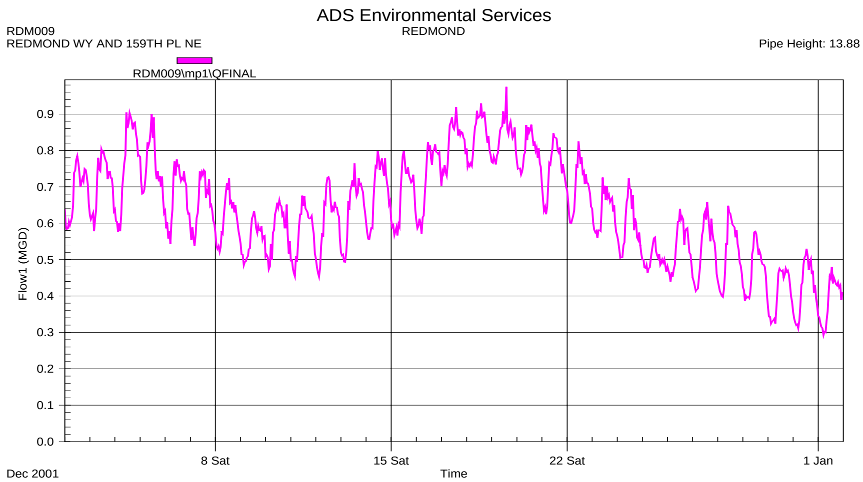
Representative of Typical I/I Problems Region-wide	✔	Basin currently includes pipe from 8 to 14 inches. Near term, growth driven plans call for upsizing the downstream pipes in the basin. A successful I/I removal project here could demonstrate the cost effectiveness of I/I removal by eliminating the need for some costly upsizing of downstream mains. Basin also is an excellent example of valley floor area w/ high winter water table and resultant high infiltration. Variety of opportunities to address pre-'61 concrete pipe as well as more recent pvc pipe.
Wild Card		

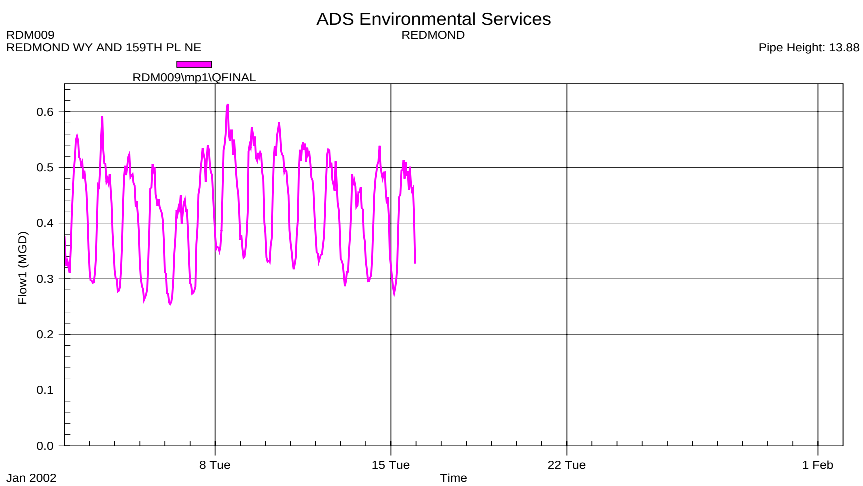
Project Title: RDM009

Key Facts & Information:

City of Redmond
RDM009







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: RNT021

Local Agency: City of Renton **Project/Basin #:** RNT021

Contact Person: Dave Christensen **Phone #:** 425-235-2500

Proposed Project Management & Contracting Method:
■ **Local Agency** □ **King County**

Geographic Area: □ **North** □ **East** ■ **South**

I/I Source Info (if known): □ Inflow □ Infiltration □ Both ■ Unknown
□ Public ■ Private □ Both □ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 4,355 gpad	**5.2 (12/12/01 storm)**	**Peak: 26.5 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	This project would primarily consist of sidesewer work on private property, due to past work performed by City in this subbasin.
Meets Time Frames for the I/I Program	✔	City has already performed extensive work on mainline system including TV work, smoke testing, manhole and mainline rehabilitation. The City performed a City-Wide I/I evaluation in 1995 that included this subbasin. In 1996 the City rehabilitated all manholes that were identified to have significant I/I. In 1997 we relined sewer mains that indicated severe leakage as part of previous investigation work. No external permits required. City permits issued by this Department. City staff is currently performing additional TV Taping and manhole evaluation within this subbasin. This work will be performed during low or no use periods and during a rain event to try and identify key portions of the private system to concentrate on.
Geographic Representation	✔	Located in Renton Highlands in a perched groundwater situation.

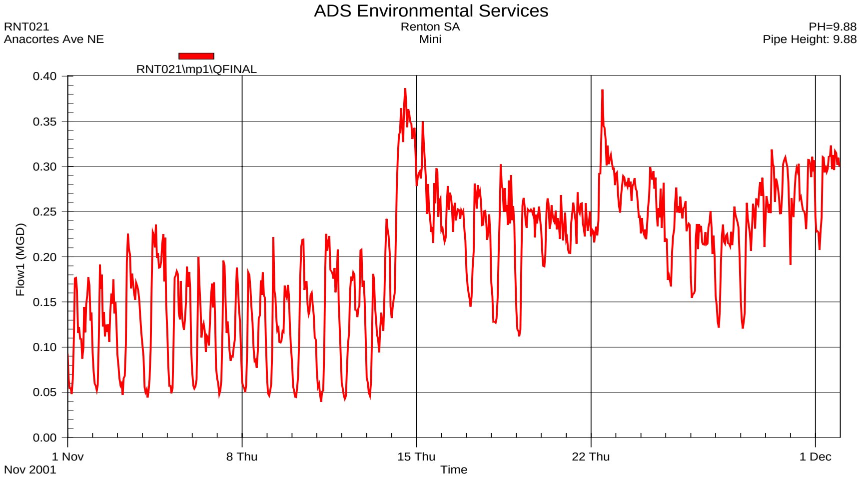
"Do No Harm" + Geologic Conditions OK	✔	This area is not listed on the City's geologic hazards mapping.
System Age	✔	1967-1998; Primarily concrete pipe installed in late 1960's. Small sections of PVC added. Post 1961 System – see attached map.
Environmental Benefits	✔	This area is located in the City's aquifer recharge area for its water supply. Repairing leaky sidesewers would have the benefit of reducing exfiltration of contaminates within the aquifer.
Addresses Private Sewer Issues	✔	The City has performed extensive work in the subbasin on the mainline systems, and we feel that it is relatively tight. As such, we propose to concentrate the work on the private sidesewers for further flow reduction. Homeowner owns sidesewer from main to house.
Provides Regional Impact		Not to our knowledge.
Model for Future Projects	✔	Excellent opportunity to focus on private property issues with sidesewers.
Representative of Typical I/I Problems Region-wide	✔	The majority of this subbasin was installed in the mid to late 1960's with concrete pipe and concrete sidesewers. The majority of the area is single family residential.
Wild Card	✔	Again, this location is a ready example to test sidesewer technologies.

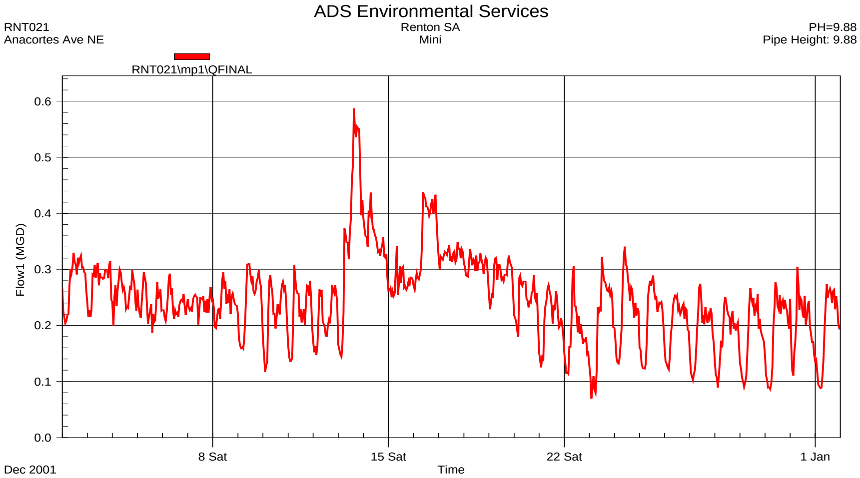
Project Title: RNT021

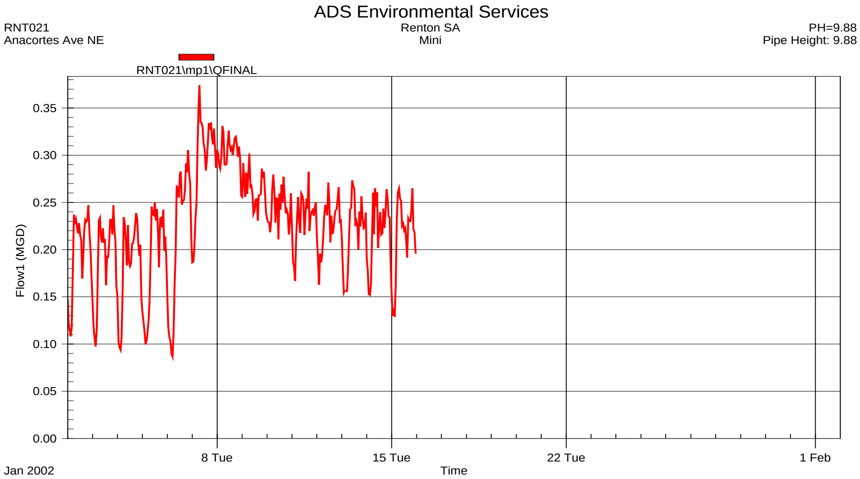
Key Facts & Information:

Primarily residential neighborhood consisting of 8-inch pipe, mostly concrete.

City of Renton
RNT021







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: **RON002 (RWD Sub-Basin 14-10)**

Local Agency: **Ronald Wastewater Dist.** ☐ **Project** ☐ **Basin #:** **RON002**

Contact Person: **Scott Christensen (CHS)** **Phone #:** **425-637-3693**

Proposed Project Management & Contracting Method:
■ **Local Agency** ☐ **King County**

Geographic Area: ■ **North** ☐ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 11,279 gpad	**11.1 (11/28/01 storm)**	**Peak: 81.9 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Replace side sewers by pipebursting, open cut or repair by cured in place lining
Meets Time Frames for the I/I Program	✔	• Mainline video inspection has already been completed – 1998 through 2000 • Permits required: Right-of-Way, Right-of-Entry (ROE) (for work on private property, District has successfully obtained on past similar project)
Geographic Representation	✔	NW King County, City of Shoreline
"Do No Harm" + Geologic Conditions OK		Excavations are in developed areas and previously disturbed
System Age	✔	43 years
Environmental Benefits	✔	• Reduces sewer overflows (see facts & info) • Returns ground water to Boeing Creek • Minimum impact repairs by pipebursting or cured in place lining as much as feasible
Addresses Private Sewer Issues	✔	Public & Private. Project involves side sewer replacement from mainline to house connection

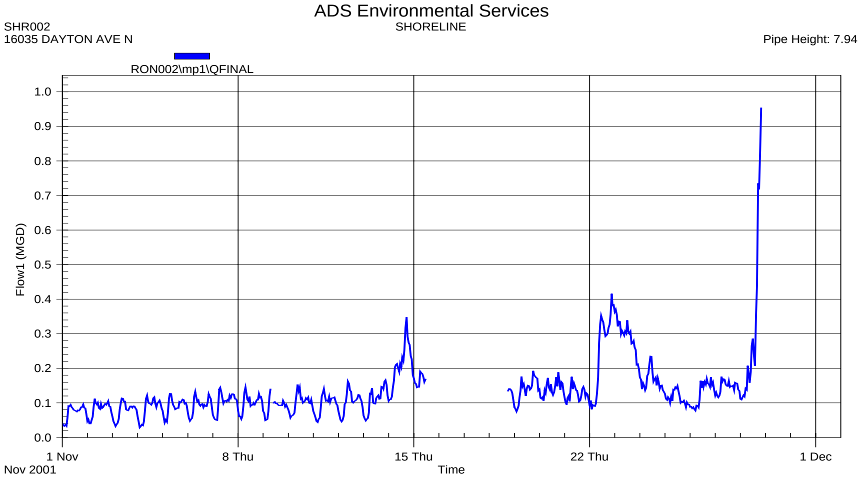
Provides Regional Impact	✔	Reduces flows to King County facilities (Hidden Lake/Richmond Beach Pump Stations) and Edmonds WWTP via "Flow Transfer" agreement
Model for Future Projects	✔	Determines the benefit of replacing side sewers in a basin
Representative of Typical I/I Problems Region-wide	✔	Side sewers are typically a significant source of I/I
Wild Card	✔	Sanitary Sewer Evaluation Survey (Flow Monitoring, Smoke Testing, Mainline TV Inspection) work already completed; District currently working on similar project.

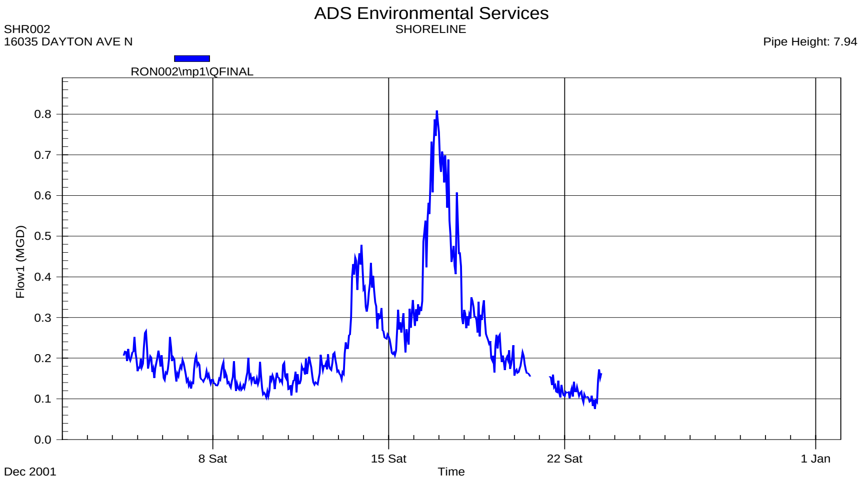
Project Title: RON002

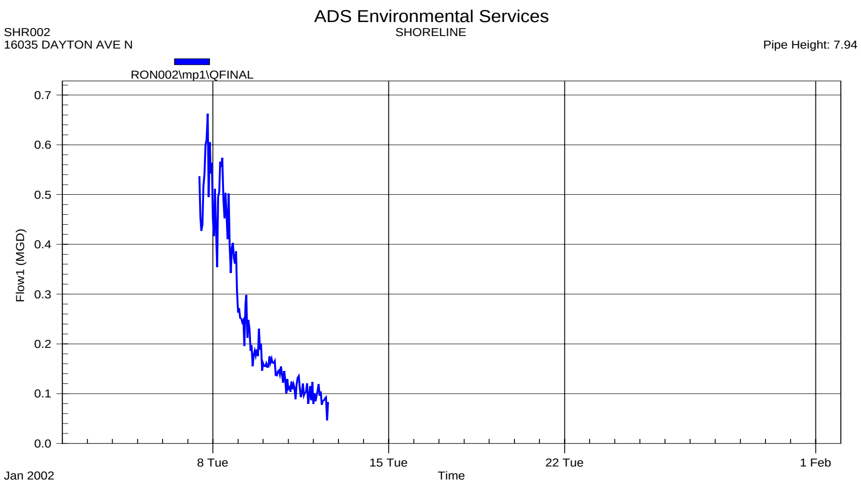
Key Facts & Information:

- Project cost approx. $1.8m, District will fund approx. $0.9m +/-
- Objective: To assess impact of replacement of side sewers on private property, TV and repair those in Right of Way as required, plus repair the identified mainline faults. We believe there are faults in side sewers that cannot be easily identified by smoke testing and Tving.
- Smoke testing and mainline TV inspection already complete
- Approximately 43 year old concrete pipe system
- Most Upstream basin
- Only 8 mainline faults evident from TV inspection (Basin Area = 85+ acres, 322 Homes) which indicates I/I is coming from side sewers
- Tributary to Hidden Lake and Richmond Beach Pump Stations which are in the pre-design stage of upsizing. Project may reduce size of King Co. Hidden Lake Project if successful, basin suffers periodic overflows
- Project can be ready for construction in the summer of 2002 and completed within one year
- Consistent indication of I/I over all rain storms and verification of King Co. data by District flow monitoring in years 1999 through 2001
- Area tributary to Boeing Creek, District has a Salmon/Stream monitoring program here, so it can document summer flow
- This project encompasses the entire basin

Ronald Wastewater District
RON002







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: <u>RON032 (former SPU/LCSD)</u>

Local Agency: <u>Ronald Wastewater Dist.</u> ☐ **Project** ☐ **Basin #:** <u>RON032</u>

Contact Person: <u>Scott Christensen (CHS)</u> **Phone #:** <u>425-637-3693</u>

Proposed Project Management & Contracting Method:

■ **Local Agency** ☐ **King County**

Geographic Area: ■ **North** ☐ **East** ☐ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown

☐ Public ☐ Private ■ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 7,303 gpad	**17.5 (12/15/01 storm)**	**Peak: 48.0 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	TBD, but presumed to be mostly side sewer replacement by pipebursting or cured in place lining
Meets Time Frames for the I/I Program	✔	District prepared to smoke test and TV summer of 2002 and prepare project for winter 2003
Geographic Representation	✔	NW King County, City of Shoreline
"Do No Harm" + Geologic Conditions OK		Excavations are in developed and previously disturbed areas
System Age	✔	43 yrs.
Environmental Benefits	✔	Minimum impact by pipebursting & cured in place as much as feasible
Addresses Private Sewer Issues	✔	Public & Private. Project will involve side sewer replacement from mainline to house connection
Provides Regional Impact	✔	Reduces flows to King County facilities (via Seattle sewers)
Model for Future Projects	✔	Fast track SSES and TV of side sewers
Representative of Typical I/I Problems Region-wide	✔	The significant I/I in this basin is presumed to be mostly from side sewers

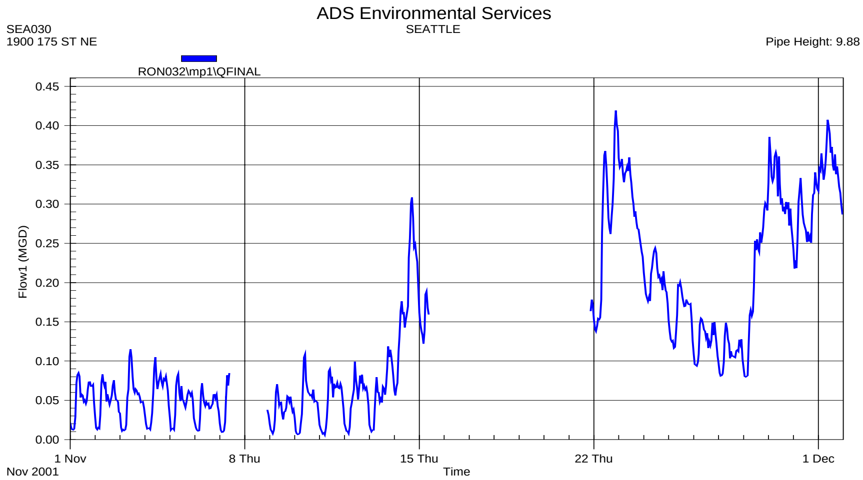
Wild Card	✔	District currently working on similar side sewer and mainline repair project

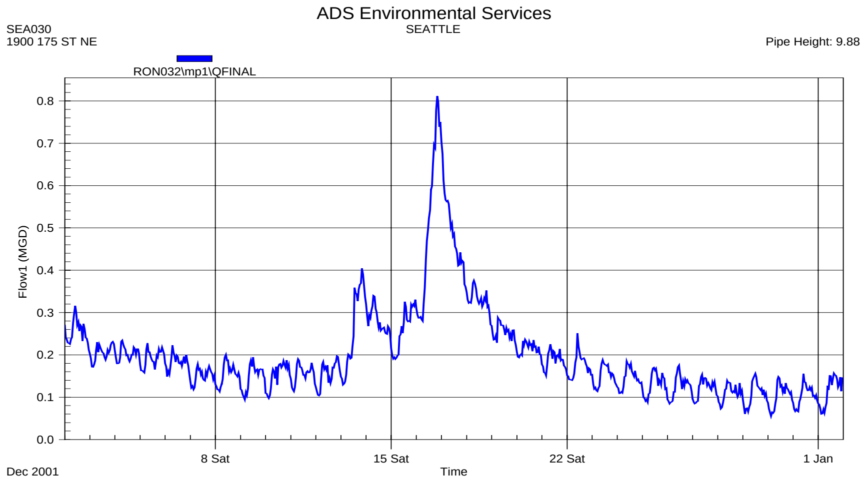
Project Title: RON032

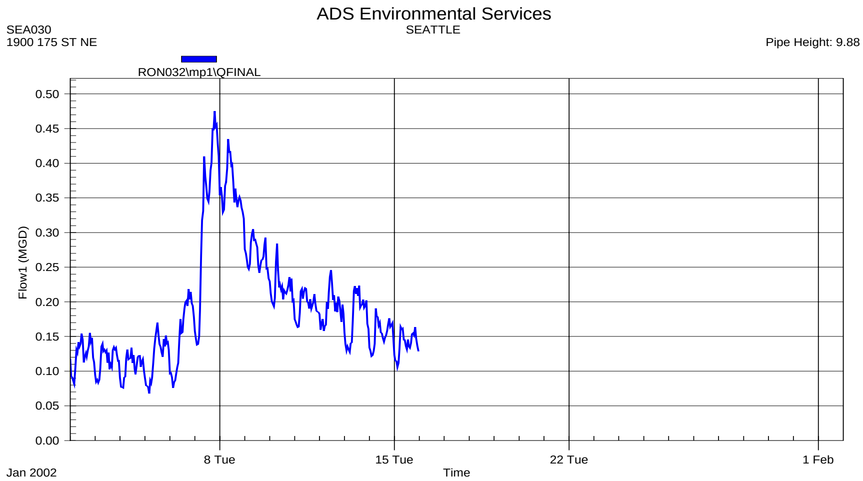
Key Facts & Information:

- District is willing to participate financially above King County's level of participation
- Objective: To assess impact of repairing identified faults in side sewers and mainline
- District committed to smoke testing and TV work summer of 2002 and preparation of construction contract for winter/spring 2003
- Approximately 43 year old concrete pipe
- Most Upstream basin
- Basin Area = 100+ acres, 340 Homes
- District has current project in construction where contractor is Tving side sewers and doing replacement, also making mainline repairs
- System acquired from Seattle Public Utilities (SPU) 10/1/01
- This project encompasses the entire basin

Ronald Wastewater District
RON032







I/I Workshop #8 – Pilot Project/Basin Selection
Worksheet for Proposed Pilot Project or Basin

Pilot Basin or Project Title: Subbasin 13 Rehabilitation

Local Agency: Val Vue Sewer District **Project/Basin #:** VAL016

Contact Person: Dana Dick **Phone #:** 206-242-3236

Proposed Project Management & Contracting Method:
■ **Local Agency** ☐ **King County**

Geographic Area: ☐ **North** ☐ **East** ■ **South**

I/I Source Info (if known): ☐ Inflow ☐ Infiltration ■ Both ☐ Unknown
☐ Public ■ Private ☐ Both ☐ Unknown

Flow Data (where known):

Gallons per Acre per Day	Ratio of Peak Flow to Average Flow	Gallons per Day per Lineal Foot Pipe
Peak: 3,726 gpad	**4.6 (12/12/01 storm)**	**Peak: 26.5 gplfd**

Selection Criteria:

Item	Check	Comments
Uses a Variety of Proven Technologies & Rehabilitation Techniques	✔	Pipe bursting and slip-lining of side sewers and stubs only; Trenchless Technology
Meets Time Frames for the I/I Program	✔	Right-of-Way Use Permit, Local Agency to acquire private property right-of-entry form.
Geographic Representation	✔	South 3
"Do No Harm" + Geologic Conditions OK	✔	No geographic harm. All work will be done in right-of-ways or residential yards
System Age	✔	Post 1961 System – 37 yrs.
Environmental Benefits	✔	Increase capacity and reduce overflows, ESA benefits, and minimize public impacts by trenchless rehabilitation, when appropriate
Addresses Private Sewer Issues	✔	Project is for private side sewers only and District owned stubs only – video inspection indicated mainline is sound
Provides Regional Impact	✔	Increase capacity in regional system by reducing flows to go to King County-Metro
Model for Future Projects	✔	Results are expected to be significant and will be closely monitored and provided for modeling

Representative of Typical I/I Problems Region-wide	✔	Video inspection indicates problems are primarily in the laterals, a typical problem for many systems.
Wild Card	✔	Visual observations indicate manhole surcharging and overflows in storm events. Basement flooding also has resulted from major storm events. All, or part, of this basin can become a pilot project.

Project Title: Subbasin 13 Rehabilitation

Key Facts & Information:

I/I Confirmed:

- Upstream basin, easily monitored
- Total I/I as high as 3,726 gpad.
- 10 storm cumulative volume = 7,001,616 gallons
- Flow monitoring by ADS indicates a peaking factor of 4 to 5.
- Val Vue's flow monitoring confirms this peaking factor.

Video Inspection Complete, Source of I/I Confirmed:

- 90% of the mainline has already been video inspected to confirm its condition.
- Mainline in good condition, Laterals and side sewers are source of I/I.

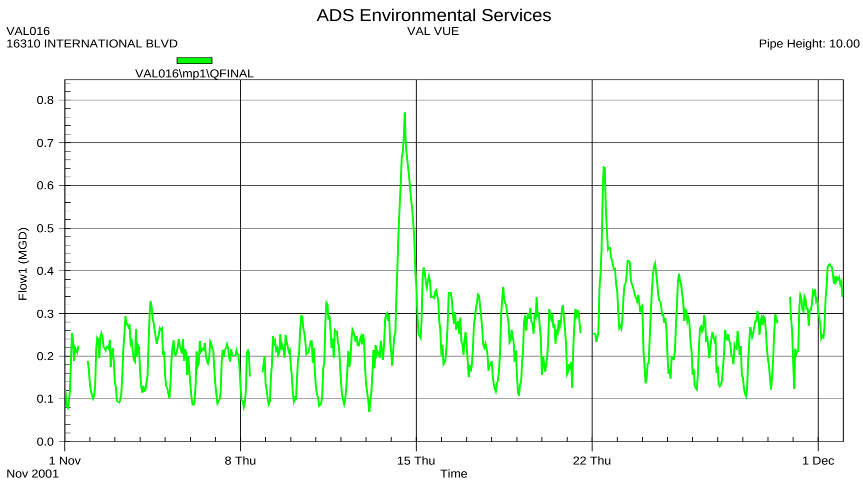
Scalable Project Size:

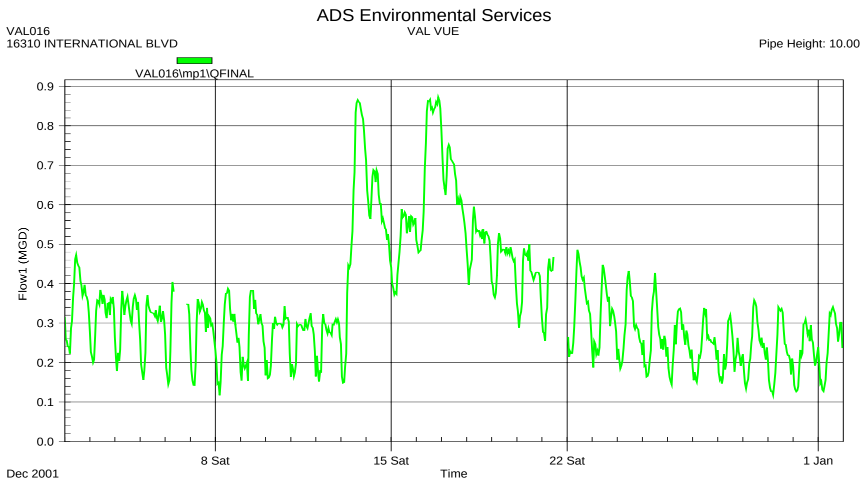
- 20,000 to 30,000 linear feet of laterals.
- Entire basin, or a part of it can become a project.

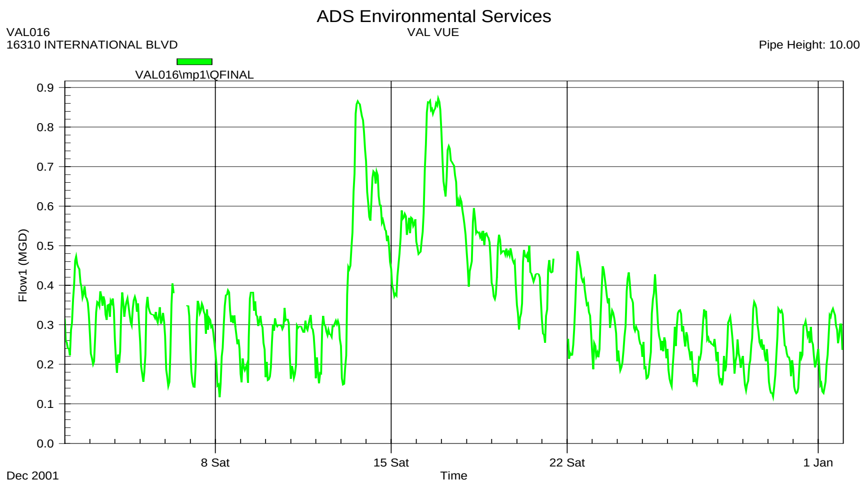
Val Vue has experience with projects of this kind:

- In the past eight years Val Vue has completed five projects involving private property rehab of side sewers.
- Another project is currently out to bid.

Val Vue Sewer District
VAL016







Appendix B

I/I Ronald Pilot Project Report

Description:

This appendix contains a summary report prepared by Ronald Wastewater District's consultant to document the experiences of the Ronald I/I Pilot Project.

Reference Chapters:

All chapters

Author:

CHS Engineers, Inc.

Project Report

Basin RON002 I/I Removal Pilot Project
Ronald Wastewater District

Prepared by CHS Engineers

This report summarizes the activities, findings and recommendations for the subject inflow and infiltration (I/I) removal pilot project. This serves as the project closeout report and follows the project plan used for the five quarterly project monitoring reports. The project was divided into six elements and each element was further subdivided to varying levels of detail as appropriate for planning and monitoring the corresponding work. The six project elements are: project management, predesign, public relations, design, bidding/contracting, and construction. In this report, the activities, observations, or findings for this project and recommendations for future similar projects are discussed for each project element. This report focuses on those activities specifically related to I/I removal projects, with emphasis on the challenges associated with working on side sewers and private property, with only minimal attention to more common aspects of public works design and construction projects. The I/I removal resulting from this work is not addressed in this report but will be addressed in a separate report to be prepared by King County.

The project's objective was to determine the effectiveness of replacing side sewers as a means to reduce I/I. The project area included approximately 290 single family residential properties in a sanitary sewer basin in the southwestern portion of Ronald Wastewater District (herein referred to as RWD or District). Figure 1 is a map of the project area.

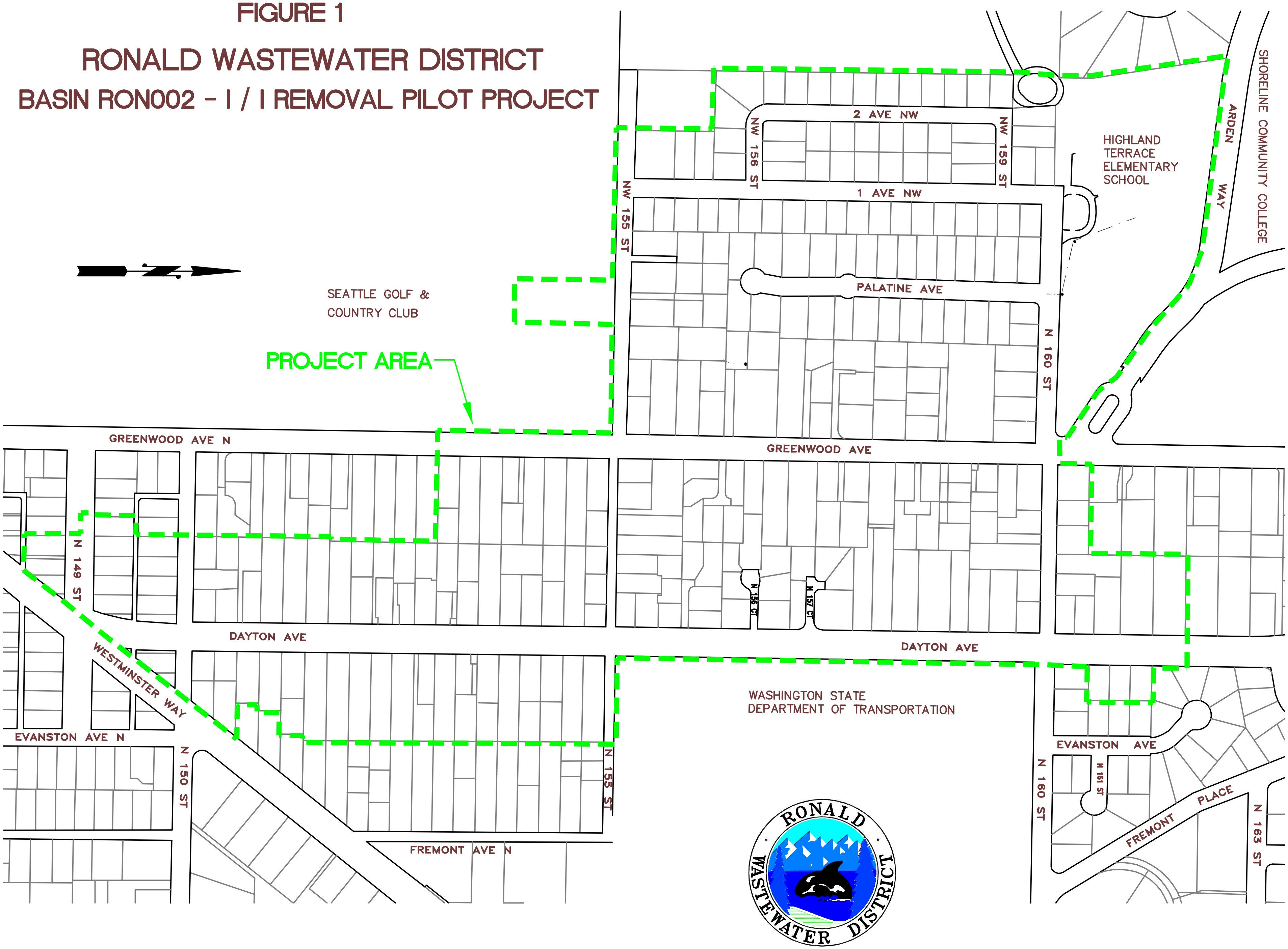
The project was one of ten pilot projects selected by King County Department of Natural Resources Wastewater Treatment Division (herein referred to as KCWTD, KC or the County) as part of their Inflow/Infiltration control program, an element of the County's Regional Wastewater Services Plan (RWSP).

Prior to this pilot project, KCWTD completed flow monitoring throughout its conveyance system and within the collection systems of each of the component agencies served by the County's wastewater system. I/I rates were estimated for each monitored basin and the results shared with the component agencies.

In late 2001, the County issued a Request for Proposal to component agencies for selection and funding of $900,000 for pilot projects that use any combination of trenchless technologies to decrease I/I. RWD, being a component agency and already having an I/I program in place since the 1990s (information was readily available), proposed pipebursting all side sewers and providing an additional $900,000 of its own funds.

FIGURE 1

RONALD WASTEWATER DISTRICT
BASIN RON002 - I / I REMOVAL PILOT PROJECT



The project began in May 2002 and was substantially complete in December 2003. The District's engineer, CHS Engineers, served as project manager, designer and construction manager with support from District Managers and staff, and oversight by KCWTD. The construction was performed by BUNO Construction of Snohomish, Washington.

Prior to beginning this project, KCWTD completed flow monitoring throughout its conveyance system and within the collection systems of each of the component agencies served by the County's wastewater system. I/I rates were estimated for each monitored basin and the results shared with the component agencies. As an element of the RWSP, funding was allocated for I/I removal pilot projects. Component agencies proposed pilot projects in specific basins, utilizing various I/I removal techniques. Ten basins/projects were selected for implementation and each was funded by KCWTD. RWD provided additional funds to complete the proposed work throughout the selected basin. Following completion, flow monitoring and hydraulic/hydrologic modeling will be performed by KCWTD to estimate the amount of I/I removed in each basin (i.e. corresponding to each I/I removal technique). Comparing the cost of such removal to the cost of conveyance and treatment will help the County determine the effectiveness of each technique.

The effectiveness conclusions and other information gathered in all the pilot projects will support decision-making and future efforts for I/I removal by RWD and KCWTD.

RWD's pilot project basin is approximately 100 acres in area and primarily consists of single family residential properties. There is also one commercial property, one apartment building, a few duplexes and one public elementary school. The basin does not receive wastewater from an upstream sewer basin, and all wastewater leaves the basin at a single point (RWD Manhole A70). The basin includes approximately 12,500-feet of 8-inch diameter sewer main and approximately 23,000-feet of four and six-inch diameter side sewer and stub piping.[1] Approximately 500-feet of the sewer main is PVC pipe with the remainder constructed of concrete pipe.

Flow monitoring indicated that this basin had significant I/I: approximately 11,000 gallons per acre per day. However, previous RWD sanitary sewer evaluation work in this basin (sewer main inspection and smoke testing) revealed relatively few faults. Only seven sewer main faults were noted and about 10 faults on private property were noted which could allow I/I. None of the observed faults contributed to significant I/I. Therefore, the supposition was made that the source of I/I must be in the side sewers and stubs, so those were identified as the focus for the work of the pilot project.

As indicated above, this report summarizes the activities and observations for each of the six project elements. Recommendations are then presented after discussion of activities and observations. Project cost summary information is presented at the end of the report.

[1] For this project, the "side sewer" is defined as the private pipe between the building connection and the right of way or public sewer easement and the "stub" is defined as the public pipe extending from the sewer main to the right of way or public sewer easement.

1. Project Management

The first element of the project was project management. Project management includes the work of planning, implementing, monitoring, controlling, and closing a project. A project plan was developed, including a project scope, schedule and budget. The scope described the work in each project element, the details thereof, the schedule, and the budget for each task. Project management activities are summarized as follows:

1.1. Activities

1.1.1. Quarterly Monitoring Reports. Five quarterly reports were prepared by CHS to report progress and activity to RWD and KCWTD. For each of the six project elements, the reports described the work of the prior quarter, work for the upcoming quarter, budget and schedule status and identified changes or challenges in the project implementation. Budget and schedule were monitored using the "earned value" method of project monitoring. This method compares actual cost and progress to planned or budgeted costs and schedule to quantify cost and schedule variances at each monitoring milestone.

1.1.2. Monthly Review. CHS updated the budget and schedule element of the quarterly monitoring report each month to regularly monitor progress and costs. This monthly review allowed adjustment in effort or resources to adhere to the planned budget and schedule or to allow prompt adjustment of the original schedule or budget as appropriate.

1.1.3. King County Coordination. This task included meeting and corresponding with KCWTD regarding the interlocal agreement between the County and RWD, and included design and construction phase coordination and review.

1.2. Observations

The effort for monthly and quarterly monitoring was somewhat underestimated, and the scope of KCWTD reporting requirements changed during project implementation. For example, only one County plan review was anticipated yet two reviews at two stages of design completion were required: one each by the County and one each by their consultant. Once construction began, more specific progress reporting and project document sharing was requested by the County (e.g. copies of shop drawings, daily reports, etc.). Additionally, KCWTD indicated they would prepare the SEPA checklist but requested significant support from RWD and CHS to complete the checklist for this project. These changes resulted in higher than anticipated costs in the King County Coordination task. Also, because the engineering and construction work was combined in the construction element of the budget monitoring tool, another challenge was distinguishing construction budget status from engineering budget status during each monthly review.

2. Predesign

The goal of this element was to collect and manage data that was to be used in the design phase.

2.1. Activities

2.1.1. Review Sewer Main CCTV Records. The District had inspected almost all the sewer mains in previous years and any outstanding inspections were completed by District crews. Once all the inspections were gathered, the faults were prioritized according to Table 1. Only Priority 1 & 2 faults were considered for repair. Typical main line faults/conditions found were roots, cracks, gaps, and unused side sewers stubs.

Table 1: Main Line Fault Priority

Priority	*Description*
1	*Inflow sources, including heavy flows*
	Structural faults (main line, side sewers or manhole) (>1-inch opening)
	Stub tee fault, main line fault
	Heavy, moderate I/I
2	*Structural faults, cracks (<1-inch)*
	Manhole joint
	Light I/I
3	*Hairline cracks*
	Belly
4	*Roots/grease/debris*
	Mineral deposits
	Manhole not accessible
5	*No faults identified - Reinspect within 5 years*
E	*Investigate source of flow - possible fault?*
	-District camera could not fit
	-flow too heavy to complete inspection

Manhole inspection was an additional related task required by KCWTD after project initiation. Although District staff had completed general manhole condition assessments with their closed-circuit television (CCTV) work, KCWTD wanted more specific and better-documented inspections. An inspection form developed with guidance from KCWTD, and RWD staff completed the inspections accordingly. CHS reviewed and summarized the findings, including recommendations to raise one (1) manhole to grade and to reinstall one (1) offset frame and cover. This work was completed by RWD staff.

2.1.2. Records Research. Various records were gathered from County and District files. Each type of record was reviewed and compared to other records for use in the predesign and design work:

- T-sheets, side sewer as-builts, quarter sections (CAD drawings), and white cards were obtained from the District. White cards show similar information as the quarter sections.

- The latest versions of King County Assessors' maps were obtained. The maps were used in conjunction with parcel search information from King County's eReal Property System (http://www.metrokc.gov/Assessor). Property lines, right-of-way (ROW) lines, easements, etc. on quarter section maps were compared against Assessors' map information. Property ownership was verified with parcel searches to determine tract ownership (e.g. easement vs. shared tracts).
- Kroll Maps were obtained, but were not used because they were older than quarter sections.
- An aerial photo (circa. 2001) was obtained. It was used as a visual aid only.
- A U.S. Soils Survey was obtained. It revealed that area is underlain by Alderwood gravelly sandy loam, rolling (6-15% slope) – considered to be moderately well-drained soil.
- FEMA Flood Insurance Maps were obtained and revealed that entire basin is outside the 500-year floodplain.
- King County provided a preliminary environmental review for the project area. The review indicated the potential for petroleum-contaminated soils and/or groundwater in the vicinity of a commercial property (presently unused) formerly occupied by a service station. The existing side sewer and stub had been completely inspected by CCTV, with only one fault at the ROW line (6-inch to 4-inch transition). It was decided to avoid work in this area due to potential cost of pollution prevention and the undetermined use of the subject property.

2.1.3. Base Map Development. The CAD quarter sections were used to develop the contract drawing base map. Through a combination of site visits, comparison of side sewer as-builts (some properties had since been remodeled or redeveloped), field observations, and CCTV records (some stubs had since been abandoned while others had since been constructed), corrections were made to stationing and alignment on the quarter sections. Property lines, easements, addresses, etc. were also updated following review of Assessors' maps and District records.

2.1.4. Side Sewer and Stub CCTV Inspection. Pipe Experts LLC was contracted to inspect side sewers and/or stubs and to mark stub locations at the edge of the ROW. A side-launch (main line) camera equipped with a sonde was used. The side launch camera had a cable length of 80-feet. They produced video tapes (VHS) with inspections of all nearby stubs, inspection logs documenting observations (and corresponding stub/side sewer stationing), depth at locates and main line stationing, and marked with wooden stakes, nails, or paint to mark the location of the stub at the estimated edge of ROW.

2.1.5. Review Construction Method. The primary method selected for side sewer replacement was pipebursting because of its generally lower level of surface disturbance compared to open-cut restoration. Therefore, the efforts of this activity focused on confirming the feasibility and cost-efficiency of pipebursting for the variety of side sewer alignments and conditions in the project area. The primary questions were: replace stub and/or side sewer, feasible/cost-efficient depth for pipebursting, and how to pay for pipebursting with varying conditions on each property.

Concrete side sewers/stubs were designated for replacement, regardless of condition and/or knowledge of any faults. PVC and ABS side sewers/stubs were specified for "Inspect Only" assuming a much lower prevalence of faults resulting in infiltration. Each stub/side sewer inspection was reviewed to decide if the pipeburst should originate from the main or from the property line. If faults were found in the stub within 3-feet of the main, then a "pipeburst from main" (Type C replacement for 4-inch, Type D replacement for 6-inch) was specified. Otherwise, a "pipeburst from property line" (Type A replacement for 4-inch, Type B for 6-inch) was specified. Multiple Type A's or B's were specified for each property if it had a side sewer with bends greater than 45 degrees because another insertion pit was assumed to be required. For Type C's and D's, 12-feet deep was assumed to be the limit of practical excavation, in which case a cured-in-place (CIP) stub/side sewer lining (T-Liner®) was specified. T-Liner® was chosen for its ability to line the stub and around the stub opening into the main line. The data was summarized in a spreadsheet.

2.2. Observations

2.2.1. In general, T-Sheets were the least accurate and the District's CCTV logs were the most accurate in terms of side sewer stationing. Pipe Experts' stationing was reasonably close to the District's records, accounting for calibration and start point. Some analysis was required to verify or deduce if a side sewer existed, given the variety of sources.

2.2.2. Sharp bends and constraints in pushing the camera upstream with limited directional control (side-launch camera) and only 80-feet of cable limited the extent of stub and side sewer inspection. Pipe Experts' three-man crew (one camera operator, two laborers) completed inspection of about two or three main lines (manhole-manhole) in one day (approx. 14 stubs/day). The laborers traced and marked the camera position and read the depth at the ROW line.

2.2.3. The knowledge of the ROW line location, inconsistent mark placement, electrical interference (of sonde reading), and depth of main limited the accuracy of, or in some cases the ability to obtain, the horizontal and vertical location reading of the side sewer.

3. Public Relations

The goal of this element was to involve and educate the public, secure permission to work on private property, and to coordinate with the City of Shoreline.

3.1. Activities

3.1.1. Public Meetings. Three public meetings were held at the Highland Terrace Elementary School gymnasium. The purpose of the meetings was to provide information to property owners and offer a forum for questions, answers, and discussions during the design process. The first meeting introduced the topic of I/I, what the County and District were doing about it, and why the attention is focused on this basin. The agenda for the second and third meetings was to both provide background information (as presented in the first meeting) and to build on the first meeting. Computer slide presentations and display maps were used at each meeting. Also at the second and third meetings, a video was presented to show the pipebursting process. Coffee was provided for attendees and coloring/educational materials were available for their children. The following are types of communications that were attempted prior to, during, and following the public meetings.

- Informational flyers. Notices were mailed to each property owner two weeks prior to each of the public meetings. The first notice was a letter-sized colored flyer identifying the project boundary. King County paid for the copies and mailing of the first flyer. The second flyer was on an 8½-inch x 5½-inch bright colored flyer announcing the meeting and referencing the Right of Entry (ROE) Mailing (see ROE discussion below). Two different postcards were mailed depending on whether the owner's ROE had been received or not. A final colored flyer was sent out prior to the third meeting. The District paid for the copying and mailing of the flyers for the second and third meetings.
- Internet. A web site was developed prior to the first meeting and was updated following each of the public meetings. The web site was developed and maintained by King County with information provided by the District. The site included: project boundary, a construction schedule, and frequently asked questions (FAQ), which were developed from the public meeting discussions. A point of contact at both Ronald Wastewater District and King County was included on the website. Photos of the construction project were added once the construction was underway. The website was modified as more King County I/I projects got underway. The website was again updated following completion of construction to reflect the work that was performed.
- Questionnaires. A questionnaire was handed out at public meetings. Owners were asked basic questions: if there were previous sewer problems; if there was a basement or sump pump on the property; if the gutter, downspouts and yard drains were connected to the sewer; if the side sewer had every been modified; and if there were any manholes or cleanouts on the property.

  The District mailed a simple post-construction questionnaire to the participating property owners. Seventy-six (76) responses were received. It asked property owners' input by responding to eight (8) questions on a scale of 1 to 5:

  1 – Very Unsatisfied
  2 - Unsatisfied
  3 – Satisfied
  4 – Very Satisfied
  5 – Does Not Apply

  The questions, along with satisfaction ratings (i.e. "3" and "4" responses) are presented in Table 2. (Not every respondent answered all questions. The percentages presented below are based only on answers provided.)

Table 2:Questionnaire Satisfaction Results

Question	Satisfied	Very Satisfied
Meetings conveyed project description	23%	35%
Meetings were conveniently timed	33%	27%
Meetings were at a convenient location	29%	33%
Advance notice was adequate	36%	42%
Work was completed promptly	23%	51%
Contractor was responsive to feedback	25%	44%
Disturbance level was reasonable	39%	44%
Work performed was understood	35%	43%

- Door hangers. The District staff placed door hangers two days prior to the second meeting on all the properties that had not yet turned in their ROE (see ROE discussion below). A second set of door hangers was distributed prior to the contract going to bid to the few properties that had yet to sign a ROE.
- Project signs. A total of 5 project signs were installed prior to construction by the Contractor at different access routes into the basin. It included: project name, contact name and number, District logo and King County logo. The City of Shoreline reviewed the sign layouts. King County paid for the sign fabrication.

3.1.2. Rights-of-Entry. Included in the second mailing to each homeowner in the project area was a ROE form, handout from the first public meeting, questionnaire, a list of FAQ, a District-addressed and stamped envelope, and a cover letter explaining what the District was asking of each resident. The District paid for this mailing.

3.1.3. Stormwater Management. Early in the project the District and County met with the City of Shoreline Public Works Director regarding stormwater management. The primary issue was the impact of I/I removal from the sanitary sewer system on private property and/or the existing storm drainage system. The District's position was that runoff is a City or property owner responsibility but that the District would consider some level of support to the property owner if the side sewer replacement and/or disconnection of illegal connections results in drainage problems. The parties recognized the challenge of knowing whether drainage problems are directly related to the side sewer replacement work

3.1.4. Right of Way Permit. CHS consulted with the City ROW inspector early in the design process to coordinate the permitting procedures and standards for road restoration. Contract language and restoration details were drafted for the City's review prior to bidding the work.

3.2. Observations

3.2.1. Attendance at the first two public meeting was about fifty (50) people each meeting. Fewer residents were in attendance at the final meeting. Very few children attended.

3.2.2. Although property owners were told that the project was 100% funded by RWD and KCWTD, their main concerns were out-of-pocket expense and property damage/restoration. Of particular concern was the area of disturbance of concrete or asphalt surfacing and mature vegetation.

3.2.3. Many property owners claimed they had not been notified about this project. For those properties that had not signed their ROE forms prior to the third meeting, the District personally contacted the residents. Contact with property owners was attempted a total of six (6) times.

3.2.4. A total of 153 questionnaire responses were received prior to the predesign report. The results were tabulated by the District for use in the predesign element.

3.2.5. Approximately 116 of the 290 (40%) of potential properties' ROEs were received prior to the second public meeting. Prior to the project going to bid, a total of approximately 246 ROEs had been received, or 85 percent of the total number of residents in the area. Although it was not, in the end, an issue on this project with the high level of participation, there is the potential issue of participation by less than all parties to a jointly used side sewer. The District's attorney concluded work could not be performed on a joint side sewer unless the right-of-entry was executed for the property on which the joint side sewer was physically located.

3.2.6. The contract was bid with 247 properties having signed ROEs. Additional property owners signed their ROEs after start of construction, other parcels dropped out during construction, bringing the total to 261 of the 290 properties (90% participation) in the project area.

3.2.7. Stormwater Management. Late in the design process and again early in construction, CHS and the District discussed potential reasons why a property owner may not sign a ROE, particularly owners that knew of, or suspected, illegal connections to their side sewer and were reluctant to participate in the project. Although stormwater connections to the sewer are prohibited under District code, they have not been enforced in the past because of a number of unresolved enforcement issues. (Educating the public was the primary means of enforcement in the past.) A potential conclusion is that there may be more unknown illegal connections. A challenge of such a project is obtaining permission to find and remove illegal connections.

3.2.8. Right of Way Permit. The pre-bid coordination with the City resulted in timely approval of the ROW permit, without unexpected conditions.

4. Design

The goal of this element was to analyze the data gathered during predesign, make informed design decisions and complete contract documents under KCWTD oversight.

4.1. Activities

4.1.1. Plan Preparation. Due to the large quantity and variety of side sewer replacement work, drawings had to be as clear and concise as possible. A detailed field survey was not completed, assuming it would be too expensive (and time-consuming) to obtain ROEs for such survey (not all ROEs for construction had even been obtained yet). Furthermore, the private side sewer alignment was unknown. Therefore District quarter section maps (includes ROW, property line, house footprint and sanitary sewer system) were used as the drawing base map. Participating properties were shaded and all proposed work was specified in tables. Throughout the project, “Table A” was used to specify stub/side sewer work and “Table B” was used to specify main line repair work. Houses were visually inspected for basements and split-levels. A house with a basement would mean the sewer connection would be deep. The tables included pertinent information such as approximate depth (excavation) and existing pipe material. Site observations were compared with questionnaires received as the plans were developed.

4.1.2. Specification Preparation. Special attention was given to pipebursting, cured-in-place (CIP) tee and stub lining (T-Liner®), and main line CIP spot repairs. Specifications were also prepared for mechanical sleeves for main line repair, but BUNO chose CIP liners instead. Various combinations of fittings and couplings were researched (e.g. shear resistance, outside diameter compatibility, etc.). District standard details were used and modified, as needed, for anticipated site and construction conditions. Cleanout locations were analyzed and reviewed. The decision was made not to install cleanouts at the property line.

4.1.3. Construction Cost Estimate. Estimated costs were prepared for the final list of bid items based on consultation with local contractors.

4.1.4. King County Review. The County and their consultant reviewed the contract documents at two stages of completion.

4.2. Observations

Writing a universal measurement and payment for pipebursting was difficult due to various site conditions (e.g. depth, length, bend, surface improvements, etc.). Different scenarios were considered but the work ultimately focused on four pipebursting replacement configurations, with separate items for cleanouts, paving, etc. The intent was to capture the core work effort on one property, which is mostly associated with digging holes for pipebursting and is somewhat removed from the length of pipe replaced.

5. Bidding/Contracting

The goal of this element was to advertise for and contract with a contractor per public works bidding requirements.

5.1. Activities

5.1.1. Advertisement. The Board of Commissioners gave authorization to bid. The project was advertised in The Daily Journal of Commerce (two times). CHS distributed the contract documents and the planholders list and answered potential bidders’ questions

5.1.2. Received/reviewed bids. The District received the bids and CHS prepared a bid tabulation (see Appendix) as part of recommendation for award. The low bidder's contracting license, pipebursting license, experience, and references were also reviewed.

5.1.3. Contract Award. Contract documents were prepared for contract execution following award by the District.

5.2. Observations

5.2.1. Four bids were received. The Engineer's Estimate was $1,470,610.00 (w/o tax). The Contractor (Buno Construction, LLC) had the low bid of $1,154,660.00 (w/o tax) and was awarded the contract/project. The average unit prices bid for pipebursting (excluding highest bid price for each item) were:

- $2,400 for 4-inch pipeburst from ROW to house connection (Type A)
- $2,700 for 6-inch pipeburst from ROW excluding house connection (Type B)
- $3,800 for 4-inch pipeburst from sewer main (including tee) to house connection (Type C)
- $4,400 for 6-inch pipeburst from sewer main (including tee) excluding house connection (Type D)

(These construction cost figures do not include mobilization, backfill gravel, crushed rock, asphalt/concrete surfacing restoration)

5.2.2. The District's contract language was too vague regarding pipeburst contractor's required qualifications. It did not differentiate between company experience vs. company personnel experience. Debco, a prior company of the Buno family, had extensive experience with pipebursting, but BUNO Construction (the current company only a few years old) did not have the specific required experience.

6. Construction

6.1. Activities

6.1.1. Preconstruction/Mobilization. A preconstruction meeting was held at the beginning of construction. Guidelines were set at the meeting for progress meetings, shop drawing submittals, required certifications, and progress payments. Progress meetings were held at the beginning of each month (from May until October). Shop drawings of the proposed construction materials were received and reviewed. Contractor certifications (CCTV and pipebursting) were reviewed. Quantities were tallied in a spreadsheet. Progress reports were sent to the County and District along with each progress payment. The District's report summarized the quantities-to-date (pipebursting, "Inspect Only", Main Line Repairs) and detailed any problems. The County's report summarized quantities and detailed problems with installation, system testing, and contractor performance, field changes and change orders.

6.1.2. Side Sewer Inspections. All side sewers were inspected, regardless of any prior inspections, primarily to find location of piping/connections and to document faults. Inspection review and approval prior to replacement was required by the Contract, but was waived because it would be too time-consuming (side sewers were replaced regardless of condition). Illegal connections were found by pouring water into suspect drains and watching for a corresponding flow using the CCTV camera.

6.1.3. Side Sewer Replacement. BUNO's basic methodology for a pipeburst replacement was:

- Dig holes at the upstream end (typically the house connection) and downstream end (typically at the property line or at the tee) to expose the pipe,
- Thread a cable (from the winch) though the pipe from the downstream end and connect the bursting head to the end of the HDPE pipe, then connect the bursting head to the cable,
- Use the winch to pull the pipe (in the downstream direction) then wait for pipe to relax after the bursting head reaches the downstream pit,
- Cut the pipe at both ends and connect HDPE pipe using adapters/couplings.

BUNO was able to complete 3 to 4 pipebursts (properties) per day on average, due mostly to his ability to pipeburst around bends and pipeburst two (2) – 4-inch pipes through one (1) – 6-inch common concrete pipe (thereby giving each house a separate side sewer to the main). BUNO was still paid according to pipeburst work specified (multiple pipebursts, if applicable), but not for any other appurtenances consequently not required (e.g. cleanouts, etc). Short sections of side sewer (bends, etc) were replaced by open cut.

Portions of the contract work were revised as necessary to suit unanticipated conditions different from the plans (e.g. backfall in existing pipe, different alignment, restoration issues, etc.). T-Liner® work was replaced with a combination of pipebursting and Top Hat™ System (a CIP liner product for the stub/tee only) repairs.

Fifteen air tests were performed. (Only the installed portion of HDPE pipe was tested.) The pipe was tested for retention of air pressure for 3 minutes and all tests were successful.

Property owner complaints (e.g. construction, restoration, etc.) were routed to BUNO from the District through the Engineer. Progress on complaint resolution was tracked and recorded by the District .

6.1.4. Main Line Repairs. CIP spot repairs were used to rehabilitate the main line. Gelco Services was subcontracted by BUNO to do the work. Each repair is 3-feet long and was applied using remote control robotics/CCTV camera.

6.1.5. Manhole Repairs. The District crew raised one manhole to grade in the gravel shoulder of Dayton and reset an offset manhole frame on the sewer serving the Highlands golf course.

6.1.6. Restoration/Record Drawings. BUNO was responsible for recording "as-built" conditions of the side sewer. Information, such as length of pipe, type of fitting(s), and distances/offsets, was recorded on CAD sketches of each property provided by the Engineer.

6.2. Observations - General

6.2.1. The progress meetings were beneficial for the County and District to allow them to review BUNO's progress and to refine the Contract document requirements in the context of field conditions.

6.2.2. Due to the Contractor's confusion on the scope of some bid items (i.e. what work was actually encompassed in each bid item in the context of various property situations), CHS took the lead in documenting completed quantities for review by the Contractor. Several meetings were held for the purpose of reconciling fair compensation.

6.2.3. Approximately 107 of the 160 inspected (67%) side sewer stations[2] (regardless of number of services) had at least one fault (e.g. roots, crack, etc.). There are 188 side sewer stations in total (i.e. not all side sewer stations were inspected).

6.3. Observations Pertaining to Public Relations

6.3.1. More property owners signed up for the project as construction progressed. Three properties signed up because they saw that side sewers on neighboring properties were being replaced. Others signed up (after project commencement) because they were reportedly not aware of the project and the inspector informed them of it.

6.3.2. Some property owners were prompt to sign restoration releases, but others did not sign it for fear of something happening after project completion. Approximately 26 releases required additional effort by the District and BUNO to satisfy the homeowner. In some cases, BUNO made up to five (5) attempts to get the restoration release, but the property owner was unreceptive. Of the received restoration releases, some signatures were illegible and/or not signed by the legal owner (e.g. tenant, parents, etc.). In some cases, the owner recently purchased the house and District records had not been updated.

6.3.3. BUNO missed some "additional house connections" (i.e. connections other than at the end of the side sewer) and had to go back to reinstate them. Usually these were found by the property owner requiring immediate response by BUNO.

6.3.4. Several property owners experienced plumbing problems and questioned if it might be due to construction. Only one was discovered to be a result of pipebursting two-4-inch lines together through an existing 6-inch concrete pipe. A belly was created and later removed. Post-installation inspections were valuable in evaluating the property owner's claim for damages. (The other property owner was directed to call a plumber.)

6.3.5. The District provided assistance to 121 N 156th St. in stormwater management. A downspout and yard drain were illegally connected to the side sewer. It was disconnected and a french drain was constructed (under force account) to divert the runoff. With one exception, all other illegal

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[2] Side sewer stations were used for comparison rather than individual side sewers because multiple upstream (4") side sewers share a common 6" stub. If any of the individual 4" side sewers were defective then the 6" pipe would be considered defective.

connections found were disconnected without further remedial work or District financial support.

6.4. Observations Pertaining to Design

6.4.1. The Contract required the pipeburst replacement to reach the house plumbing connection. After completing the first few pipebursts, this requirement was relaxed because it would be unnecessarily more disruptive for the property owner and, in some cases, result in higher restoration costs. (The pre-installation inspections showed that the existing pipe condition upstream was in good condition.) Similarly, side sewers that were under building foundations (house extensions) were not replaced because it was considered private plumbing. Examples where pipebursting did not reach the house connection were: house extensions, awnings, wood decks, concrete patties/sidewalks, stairs, mature vegetation, etc.

6.4.2. A push camera, equipped with a sonde, was inserted from a downstream open pit. By inspecting from the downstream end, the camera was able to reach all branches of any wyes. The camera cable was 200-feet long, but the extent of inspection often depended on how many bends and fittings the camera had to pass through. The further upstream the camera was, the harder it was to push. The furthest upstream the camera reached was approximately 130-feet. Sometimes, BUNO would inspect from the upstream cleanout if it was too difficult to do so from the downstream pit. “Inspect Only” properties were inspected from cleanouts. Twenty-four (24) properties were not inspected because either a cleanout could not be found or it was inaccessible.

6.4.3. Illegal connections were found by pouring water in nearby downspouts, yard drains, etc. and watching for any flow out of the corresponding suspect wye. Other common illegal connections were driveway and foundation drains. Eleven (11) illegal connections were found; ten (10) of them were disconnected:

- Five (5) were simply disconnected from the side sewer, following property owner notification
- One (1) was disconnected and diverted to splash blocks
- One (1) was disconnected and diverted to a french drain (payment under force account)
- Two (2) were disconnected and diverted using permanently installed sump pumps discharging to the street. Costs were shared by BUNO, the District and property owners. These costs are not included in the summary at the end of this report. The estimated cost for each sump pump installation (including discharge pipe and electrical service) is approximately $2000.
- One (1) was disconnected and the property owner was responsible for redirecting the drainage (driveway drain at 15538 Greenwood)
- 15730 2nd Ave (slotted drain behind house) still has an outstanding illegal connection. See Section 6.4.9 below.

Disconnection of illegal connections was challenging due to the variety of field conditions at each property. Solutions varied for each site depending on topography, proximity to or existence of site or roadway storm sewer system, existing private or public improvements. Other than diverting downspouts to splashblocks, each disconnection required a site-specific response

6.4.4. BUNO suggested stiffening inserts (for HDPE mechanical joints) and bead removal (of the HDPE fused joints) should not be required. His claim was researched, verified to be reasonable and accepted.

6.4.5. Excavation plans (required by the Specifications) were waived at the request of BUNO because of the large number of homes. No problems were caused because of waiving this requirement.

6.4.6. DFW (brand name by NDS, Inc.) couplings were used instead of Fernco Strong Back RC Series Couplings after BUNO proposed that the DFW coupling forms a tighter connection than the Strong Back and the crew constantly cut themselves using the Fernco metal ring. Specified Fittings (brand name), a push-on adapter, was specified for the house connection, but was not used because of rigid pipe end conditions (not possible to connect).

6.4.7. Cleanout covers were originally specified as slip-on spigot adapters. BUNO originally installed them without glue. The effectiveness of such an assembly was discussed and a gasketed plug/bell cleanout assembly was chosen instead. BUNO was instructed to go back and glue all previously slip-on cleanout cover/coupling as a result.

6.4.8. Short lengths of side sewer that wrapped around the back of a house (< 4-feet deep) were open-cut (PVC installation) instead of pipeburst.

6.4.9. Site conditions may dictate a rehabilitation type different from what was specified (e.g. the tee may be in good condition, difficulty accessing tee, etc). Nine (9) properties were omitted from pipebursting:

- 15722 and 15730 2nd Ave: The 6” common lies in 15722 and the property owner did not want yard disturbed. The side sewer for 15730 consequently was not replaced. The 6” common and 4” for 15722 were inspected and determined to be in satisfactory condition. An illegal slotted yard drain connection was found at 15722 during inspection. Since the inspection pit was already excavated, only the tee at the main was replaced with PVC.
- 15540 Palatine Ave: Cleanout and house connection is under exposed aggregate concrete (too expensive to restore). The side sewer was inspected and determined to be in satisfactory condition.
- 15710 and 15714 Greenwood: There was an unrecorded shift in property line between the two lots on the District quarter section. The 6” common (which was supposed to be in 15710) is now in 15714 and underneath a driveway. The property owner of 15714 did not want the driveway disturbed. The side sewer for 15710 consequently was not replaced The 6” common was inspected. The tee to 15714 is in poor condition. Since the inspection pit was already excavated, only the tee at the main was replaced with PVC.
- 346 N 149th St: The access pit would have required removing mature hedges that act as a traffic noise (along Westminster Way) barrier. BUNO was not confident in restoring the mature hedge (too expensive to restore). The side sewer was inspected and determined to be in

satisfactory condition (the side sewer on the south side of the house is PVC)

- 14919 Dayton: The house is too close to the main line (approx. 20'). BUNO was not able to inspect it, but review of Pipe Experts' video showed that it was in satisfactory condition (Pipe Experts' video reached the house connection).
- 15030 Dayton: The tee branching from the 6" common is under a mature tree. BUNO was not confident in restoring it.
- 411 N 155th St: There was an unrecorded change in the house footprint. The house connection is most likely underneath the house and the edge of the house is too close to the main line. It was not inspected, but a cleanout was installed for future access.
- 423 N 157th Ct.: The stub was already PVC pipe (good condition). The original proposed work (T-Liner®) was to seal an improper/substandard connection to the main (the PVC pipe was just stubbed-in to the concrete main with rubber gasket). When it was realized that T-Liner® would not be used (see below), a Top Hat™ was used.

6.4.10. BUNO proposed to pipeburst side sewers deeper than 12-feet originally specified for rehabilitation using T-Liner®. His proposal was accepted with conditions. Eight (8) side sewers were still designated to be rehabilitated by T-Liner® because of access difficulties, etc. In the end, T-Liner® was not used because of subcontractor delays and too many requirements from the supplier. Consequently, force account work involving pipebursting and Top Hat™ was proposed and accepted to complete the project.

6.4.11. Restoration of asphalt patches was done in batches (vs. per-property basis) to reduce cost. This resulted in delayed restoration on individual properties.

Driveway restoration was of particular concern at 15706, 15708 and 15710 Greenwood and 15528, 15534, 15536 and 15538 Greenwood. The owners claimed damages to an already damaged driveway (preconstruction photos showed that they were in poor condition already). They complained of such damages as: oil spots, scrapes/gouges, cracks, holes, gate malfunction, murky tap water and disruptions to other utilities. The District agreed to complete seal coating and some additional repair.

6.4.12. Tracking extra excavation depths of the many excavations (one of the bid items) proved to be difficult, especially at the fast pace of construction.

6.4.13. A belly was found in one of the replaced side sewers. The cause has not been confirmed, but this is a reminder that pipebursting is not an exact installation method. The existing pipe slope and/or alignment, soil condition and other constraints ultimately control the final line and grade of the replacement pipe. The belly has since been repaired.

Recommendations

The following recommendations address only how work of similar projects should be address <u>differently</u> than as on this project. If not addressed specifically below, the recommended approach (on a similar project) would be the same as in the "Activities" sections above.

1. **Project Management**
   1.1. We recommend including more detail in the project plan and scope regarding project management reporting and coordination, especially if more than one agency is involved. More discussion in the planning stage could have resulted in a better understanding of the level of coordination appropriate for the project. The earned value-monitoring plan should include separate line items for engineering and construction or other significant tasks to be monitored. The subtasks for the construction phase should be defined in more detail.
2. **Predesign**
   2.1. In order to get the most accurate CCTV information possible, only North American Association of Pipeline Inspectors (NAAPI) or Pipeline Assessment and Certification Program (PACP)-certified CCTV inspectors should be hired (although this requirement is difficult to enforce given the wide range of experienced CCTV inspectors).
   2.2. CCTV stationing measurements should be calibrated by comparing the camera distance counter with predefined distance on a flat surface. The Contract should specify: maximum and minimum camera speeds, camera height, minimum resolution, etc.
   2.3. The appropriate ROW line should be marked ahead of time or information should be given to the inspection crew to correctly identify the ROW. Field locates should be made at the anticipated excavation, regardless of proximity to the ROW (i.e. a locate behind a rockery or at the base of a tree is not useful if excavation will be in the shoulder of the road).
   2.4. The measurements made to reproduce the stub location at ROW were tedious and often not used during construction. Usually, the photos were used to approximate/re-mark the locate. The measurements were used only in cases where identifiable benchmarks (e.g. dense trees, brush, etc.) were around.
3. **Public Relations**
   3.1. The timing of the public meetings (November-January when the District was attempting to receive ROEs prior to advertising for bid) was not good. For a project as large as this, the public meetings should occur outside of the holiday season.
   3.2. The Web page was nice to have with this project and the direct mailings and door hangers resulted in large number of ROEs being returned.
   3.3. Inform property owners about the potential for waterline breaks and the consequent silt and debris that may show up in their water supply.
   3.4. Inform property owners about the potential for minor and superficial marking on the pavement by construction equipment. Property owners should also be notified that pipebursting does not correct bellies.
4. **Design**
   4.1. Dissimilar rehabilitation methods should not be grouped together into the same contract.
   4.2. Consider a budget for seal-coating private driveways.
   4.3. The Contractor should be required to install rubber tracks on excavators.

4.4. The measurement and payment approach used in this project, with some reduction in minor bid items, or a unit-price-per-property approach (includes all replacement work, regardless of length, depth, alignment, etc.) should be used. Describing an appropriate measurement and payment for side sewer replacement by pipebursting was challenging. The properties have a variety of site conditions and the final number of participating properties may not be known at time of bid. In any event, accurately and completely describing the work in the unit price is imperative so contractor claims can be minimized.

4.5. The Contractor should be prepared to pipeburst in any soil condition.

4.6. The extent of pipebursting may not always reach the house connection and is determined by other factors such as cost, owner concerns, and disturbance.

5. Bidding/Contracting

5.1. Include more specific pre-bid qualifications or bid submittal requirements regarding certifications, project-related experience, etc.

6. Construction

6.1. The property owner should preferably be present during construction so he/she can assist the Contractor (e.g. flushing the toilet, operating washing machine, etc) in looking for active/inactive connections.

6.2. Pre-construction side sewer inspection should be required. However, submittal and review of the tape prior to replacement work commencing should not be required (to expedite construction) if all side sewers are to be replaced.

6.3. One of two approaches for securing restoration releases should be used. In this contract, the Contractor was required to complete restoration on each property, then secure a signed restoration release (indicating that the property owner was satisfied with restoration). In the end most releases were signed, but several remained outstanding for various reasons (e.g. owner could not be contacted, uncooperative owners in spite of reasonable restoration efforts, etc.). BUNO recommended an approach used by another agency on a similar project. He recommended that the ROE include contract language that the property owners perform all restoration at their own cost, following backfill of any excavations. The rationale is a "free" side sewer replacement in exchange for one's own restoration work. Either approach (this project's or BUNO'S recommended approach) warrants consideration.

6.4. The restoration release should state that it only be signed by the legal owner and ask for the name to be printed also. The signature should be compared with the District account holder's name and registered owner's name (from KC Assessor's office).

6.5. All new/replaced side sewers should be flushed (with water) prior to CCTV post-installation inspection to document any belly situations.

6.6. Driveways should be documented in detail, especially those with multiple residents and/or are in marginal condition. The Contractor should be extra careful on these private drives.

6.7. Asphalt paving should be more definitively scheduled.

Project Cost Summary

Table 3 is a summary of project costs by project element. Appendix A includes a copy of the bid tabulation and final pay estimate. The District has budgeted a $100,000 reserve fund to address property drainage issues which may come up following construction. This reserve is not reflected in Table 3. Table 4 presents activity unit costs apportioned to the total construction cost.

Table 3: Project Cost Distribution

		District[1]	Engineer	Contractor[2]	Subtotal
Project Management					
	Quarterly Monitoring Reports		$ 5,348		$ 5,348
	Monthly Review		$ 2,481		$ 2,481
	Closeout Report		$ 12,154		$ 12,154
	King Co. Coordination	$ 4,000	$ 8,088		$ 12,088
	Project Management Subtotal	**$ 4,000**	**$ 28,071**	**$ -**	**$ 32,071**
Predesign					
	TV Reports – main line[3]	$ 2,400	$ 7,832		$ 10,232
	Records Research/Base Map	$ 800	$ 16,307		$ 17,107
	TV Side Sewers/Field Review[4]	$ 6,000	$ 45,097		$ 51,097
	Construction Method Review	$ 600	$ 8,404		$ 9,004
	Predesign Subtotal	**$ 9,800**	**$ 77,640**	**$ -**	**$ 87,440**
Public Relations					
	Public Meetings	$ 9,700	$ 24,571		$ 34,271
	Rights of Entry	$ 1,200	$ 8,823		$ 10,023
	Stormwater Mgmt	$ 300	$ 1,209		$ 1,509
	R/W Permit	$ 300	$ 1,086		$ 1,386
	Public Relations Subtotal	**$ 11,500**	**$ 35,689**	**$ -**	**$ 47,189**
Design					
	Plans	$ 800	$ 18,426		$ 19,226
	Specifications		$ 20,017		$ 20,017
	Estimate		$ 3,437		$ 3,437
	Design Subtotal	**$ 800**	**$ 41,879**	**$ -**	**$ 42,679**
Bidding/Contracting					
	Advertise/Open	$ 500	$ 5,212		$ 5,712
	Contract Documents		$ 3,903		$ 3,903
	Bid/Contract Subtotal	**$ 500**	**$ 9,115**	**$ -**	**$ 9,615**
Construction					
	Precon/Mobilization	$ 1,200	$ 8,273	$ 29,974	$ 39,447
	Side Sewer – Inspections		$ 36,315	$ 38,352	$ 74,667
	Side Sewer – Replacement	$ 4,000	$ 78,402	$ 942,553	$1,024,955
	Main Line Repairs		$ 5,349	$ 24,480	$ 29,829
	Manhole Repairs	$ 1,300	$ 973		$ 2,273
	Restoration/Record Drawings	$ 800	$ 21,030	$ 42,643	$ 64,473
	Construction Subtotal	**$ 7,300**	**$150,342**	**$ 1,078,002**	**$1,235,664**

		District[1]	Engineer	Contractor[2]	Total
	Total Project Cost[5,6]	**$ 33,900**	**$342,736**	**$ 1,078,002**	**$1,454,638**

Notes:
1. All District costs estimated by the Engineer.
2. Contractor's figures include applicable Washington State sales tax.
3. Does not include District's prior main line CCTV work or smoke testing.
4. Includes $32,000 for subcontracted CCTV side sewer/stub inspections from main line, for 160 stubs inspected.
5. King County's cost in support of this project are not accounted for above (website, SEPA, environmental review, first mailing, portion of side sewer CCTV work and project signs).
6. Includes actual costs through 8/31/04

The approximate cost for primary project activities is estimated as follows:

Table 4: Activity Unit Costs

Activity	Total	Quantity	Unit Cost
Pipeburst replacement of Side Sewers (per property)	$1,414,423	208	$6,800
"Inspection Only" of Side Sewer (per property)	4,661	20	230
Main Line CIP Spot Repair (per spot repair 3-feet± in length)	34,956	9	3,880

Summary

The goal of this pilot project was to determine the effectiveness of pipebursting all side sewers (regardless of condition). King County is still flow monitoring the region and will present its results (project cost vs. reduction in conveyance and treatment costs) later in 2004. However, other important lessons were learned along the way as discussed in the "Observations" and "Recommendations" above. Conclusions are as follows:

1. In this project, approximately 107 of the 160 (67%) side sewer stations were found to be defective.
2. Two-hundred-sixty-one (261) properties signed up for the project. The work completed is allocated as outlined in Table 5:

Table 5: Summary

Description of Completed Work	
Work on Private Property	
Side Sewer (only) by Pipebursting	151
Side Sewer and Stub by Pipebursting	57
Side Sewer and Stub by T-Liner®	0
Omitted[3]	9
"Inspect Only" Side Sewers	20
Omitted[4]	24
Total signed ROEs	261
Repairs of "Inspect Only" (included in "Side Sewer Only" total)	1
Work in Right-of-Way	
PVC Tee Replacement by Open-Cut[3]	2
Stub Replacement by Pipebursting	3
Stub Replacement by Open-Cut	2
Top Hat™ Repair	1
CIP Main Line Spot Repairs[5]	10

3. The pipebursting portion of the project was finished on schedule and under budget (86% of bid price) mainly due to BUNO's innovations:
   - Deleting T-Liner® repairs and completing such work with pipebursting, in spite of deeper stub connections
   - Pipebursting around bends (cost savings on number of cleanouts)
   - Pipebursting two (2) – 4-inch pipes in place of one (1) – 6-inch pipe

   However, the Contract end date was extended due to difficulties with scheduling T-Liner® and extended work schedule for paving restoration and completion of

[3] See 6.4.9
[4] See 6.4.2
[5] An additional CIP spot repair was made at 15214/20 Dayton and was included in the force account amount. Consequently, only nine (9) CIP spot repairs were paid while ten (10) were actually made.

administrative and contract closeout work. Ultimately, the work scheduled for T-Liner® repair was completed by pipebursting or open-cut pipe replacement.

4. Eleven (11) illegal connections were found, ten of which were disconnected.
5. The project was successfully implemented (scope, budget, schedule) due to the joint effort of the District, County, Engineer and Contractor. Having a contractor experienced with and successful in pipebursting was a critical factor. Determining the effectiveness of I/I removal by complete replacement of side sewers has yet to be made, pending review of flow monitoring data.
6. One significant unresolved issue is the difficulty in gaining voluntary participation by property owners that know or suspect they have an illegal connection, and don't want to bear the cost or burden of disconnection, even in conjunction with a project that will result in side sewer replacement at public cost for public benefit. The sewer service agency must decide how to enforce illegal connection prohibitions. This leads to enforcement questions such as:
    - Should there be a penalty for non-compliance? If so, what?
    - How much time should the property owner be given to comply?
    - Should enforcement be on a District-wide vs. project-specific basis?

    The District or County should consider exploring options to increase participation voluntarily, or consider legal means and ramifications for enforcement of existing policy prohibiting such connections. A statewide or at least regional solution is desired for consistency among local agencies.

APPENDIX
SUPPORTING DOCUMENTS

- FINAL PAY ESTIMATE
- BID-TAB

Progress Payment #9 (Final)

Project: Basin RON002 I/I Removal Pilot Project
Owner: Ronald Wastewater District
Contractor: BUNO Construction LLC
Period: January 1 to April 6, 2004

Bid Item No.	Bid Item Description	Unit	Bid Quantity	Unit Bid Price	Bid Amount	Quantity Complete To Date	TOTAL EARNED TO DATE
1.	Mobilization and Demobilization	LS	1	$27,500.00	$27,500.00	100%	$27,500.00
2.	Side Sewer Inspection	EA	247	$150.00	$37,050.00	235	$35,250.00
3.	Cleanout Installation (with s/s replacement)	EA	344	$50.00	$17,200.00	219	$10,950.00
4.	Cleanout Installation (with CIP Tee & Stub)	EA	4	$700.00	$2,800.00	1	$700.00
5.	Type A Side Sewer Replacement	EA	193	$2,400.00	$463,200.00	181	$434,400.00
6.	Type B Side Sewer Replacement	EA	30	$2,800.00	$84,000.00	31	$86,800.00
7.	Type C Side Sewer Replacement	EA	15	$3,100.00	$46,500.00	27	$83,700.00
8.	Type D Side Sewer Replacement	EA	4	$3,600.00	$14,400.00	26	$93,600.00
9.	Additional Side Sewer Connection	EA	100	$70.00	$7,000.00	78	$5,460.00
10.	Extra Excavation Depth (>4')	VF	210	$15.00	$3,150.00	153	$2,295.00
11.	Extra Excavation Depth (>8')	VF	150	$20.00	$3,000.00	328	$6,560.00
12.	Trenchless Main Line Spot Repair	EA	7	$2,500.00	$17,500.00	9	$22,500.00
13.	Trenchless CIP Tee and Stub Lining	EA	42	$3,400.00	$142,800.00	0	$0.00
14.	Additional CIP Stub Lining	LF	2,120	$33.00	$69,960.00	0	$0.00
15.	Downspout Drainage Diversion	EA	50	$100.00	$5,000.00	8	$800.00
16.	Record Drawing Sketches	EA	208	$50.00	$10,400.00	207	$10,350.00
17.	Asphalt Pavement Restoration	TN	200	$70.00	$14,000.00	228	$15,960.00
18.	Concrete Restoration	SY	1,000	$23.00	$23,000.00	123	$2,829.00
19.	Backfill Gravel	TN	2,700	$9.00	$24,300.00	1436.15	$12,925.35
20.	Asphalt Treated Base	TN	150	$70.00	$10,500.00	0	$0.00
21.	Crushed Rock Surfacing	TN	350	$11.00	$3,850.00	675.41	$7,429.51
22.	Controlled Density Fill	CY	200	$65.00	$13,000.00	0	$0.00
23.	Temp. Erosion & Sedimentation Control	LS	1	$5,500.00	$5,500.00	100%	$5,500.00
24.	Miscellaneous Work by Force Account	LS	1	$75,000.00	$75,000.00	40%	$30,286.57
25.	Shoring	LS	1	$34,000.00	$34,000.00	100%	$34,000.00
26.	Wage Rate Affidavits	EA	2	$25.00	$50.00	2	$50.00
CO1	Increase - Pipebursting in lieu of CIP Tee & Stub Lining (See Note Below)	LS	1	$62,340.00	$62,340.00	97%	$60,290.00
CO1*	Decrease - Deduction of CIP Tee & Stub Lining Work (See Note Below)	LS	1	($56,705.00)	($56,705.00)		
CO2	Reconcile Quantities	LS	1	($170,159.57)	($170,159.57)		
			Total Contract		$990,135.43		

TOTAL AMOUNT EARNED TO DATE	**$990,135.43**
Plus Sales Tax (8.8%)	$87,131.92
Minus Retainage, N/A - Retainage Bond	$0.00
Minus Payments Previously Made:	
Progress Payment #1 5/20/03:	$134,917.77
Progress Payment #2 6/20/03:	$230,343.41
Progress Payment #3 7/20/03:	$127,018.51
Progress Payment #4 8/20/03:	$210,078.68
Progress Payment #5 9/20/03:	$170,166.05
Progress Payment #6 10/20/03:	$58,857.53
Progress Payment #7:11/20/03:	$7,186.24
Progress Payment #8:12/31/03:	$96,788.48
TOTAL AMOUNT DUE THIS PAYMENT	**$41,910.68**
% Complete (as of % of Bid Amount Earned to Date)	**100.0%**

PAYMENT CERTIFICATE #9 (FINAL)
We hereby certify that, in accordance with the accompanying tabulation, the sum of $41910.68 is due and payable to the Contractor, BUNO Construction LLC This payment will cover the period January 1 to April 6, 2004 and is designated as the Progress Payment #9 (Final) and we further certify that 100% of the work has been completed and bond may be released upon:
1. The receipt of the release from the Sales Tax Commission.
2. Upon no liens filed against this Public Works Improvement within 45 days from April 6, 2004
3. The maximum amount of withholding time, or 60 days from April 6, 2004. (per RCW 60.28.011)

CHS Engineers, Inc.

*NOTE: Change Order No. 1 was for a net increase of $5,635.00 to the original contract. The increase was for work completed on certain properties in lieu of work as originally bid. The decrease represents the dollar amount for adjustment of quantities for work not paid nor completed under the original bid items on those same properties. The actual dollar amount of the decrease was determined by decreases in quantities of various bid items.

Project: Basin RON002 I/I Removal Pilot Project
Owner: Ronald Wastewater District
Contractor: BUNO Construction LLC
Period: January 1 to April 6, 2004

CONTRACT SUMMARY

Original Contract Sum	$1,154,660.00
Net Change by Change Order	($164,524.57)
Contract Sum to Date	$ 990,135.43
Total Completed to Date	$ 990,135.43
Total Retainage to Date	Bond
Less Previous Retainage	Bond
Retainage this Payment	Bond
Sales Tax to Date	$ 87,131.92
Less Previous Sales Tax	$ 83,742.08
Sales Tax this Payment	$ 3,389.84
Total Earned Plus Sales Tax	$ 1,077,267.35
Less Previous Payments	$ 1,035,356.67
CURRENT PAYMENT DUE	**$ 41,910.68**

See attached Exhibit A for Force Account Work

Ronald Wastewater District				Page 3 of 3
Basin RON002 I/I Removal Pilot Project				
Period - through 4/6/04				
Cost Adjustment by Force Account				
Address	**Sheet No.**	**Reason/Comment**	**Depth Compensation**	**Subtotal**
119 NW 156th	7	French Drain for downspout/yard drain		$ 450.00
115 NW 159th	8	Deep dig-former CIP Tee & Stub Lining	$ 500.00	$ 500.00
118 NW 159th	8	Deep dig-former CIP Tee & Stub Lining	$ 500.00	$ 500.00
15721 2nd Ave	8	Deep dig-former CIP Tee & Stub Lining	$ 500.00	$ 500.00
15909 1st Ave	8	Deep dig-former CIP Tee & Stub Lining	$ 500.00	$ 500.00
Highland Terrace School	11	Cleanout replacement and pipe inspection		$ 2,241.18
15528 Greenwood	12	Additional work to find/replace exist. side sewer		$ 3,040.77
15208 Dayton	4	Deep dig-former CIP Tee & Stub Lining	$ 500.00	$ 500.00
15551 Greenwood	9	Deep dig-former CIP Tee & Stub Lining	$ 500.00	$ 500.00
15724 Greenwood	13	Deep dig-former CIP Tee & Stub Lining	$ 500.00	$ 500.00
15734 Greenwood	13	Deep dig-former CIP Tee & Stub Lining	$ 500.00	$ 500.00
15001 Dayton	3	Wrong Tee Location On Plan		$ 1,268.90
15031/39 Dayton	4	Wrong Tee Location On Plan (3 attempts)		$ 1,507.41
15539 Greenwood	9	Additional side sewer locate around north side of house		$ 817.80
15715 Greenwood	10	Wrong tee location		$ 2,089.94
15733 Greenwood	10	Reroute side sewer by open cut		$ 2,008.16
15019/25/29 Dayton	4	Wrong Tee Location On Plan (2 attempts)		$ 1,494.88
15236 Greenwood	6	Pipeburst at PVC s/s with Bad Gaskets		$ 6,170.00
15248 Dayton	5	Open cut/Pavement Rest/Backfall		$ 2,497.53
422 N 156th Ct	12	Repair Belly		$ 2,700.00
				$ 30,286.57

Called by: RONALD WASTEWATER DISTRICT For: BASIN RON002 I/I REMOVAL PILOT PROJECT Bid Opening: 10:30 a.m., THU MARCH 6, 2003			Bidders Name and Address	Engineer's Estimate		Buno Construction LLC 20219 99th Ave SE Snohomish, WA 98296		AVERAGE of UNIT PRICES (excluding high)	
Certified Tabulation of Bids Received By: ____________________			Total (w/o tax) Bid Bond		$ 1,470,610.00		$ 1,154,660.00 5%		$ 1,407,755.00
Item No.	Description	Quantity	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
1	Mobilization and Demobilization	1	LS	$ 72,000.00	$ 72,000.00	$ 27,500.00	$ 27,500.00	$ 100,166.67	$ 100,166.67
2	Side Sewer Inspection	247	EA	$ 350.00	$ 86,450.00	$ 150.00	$ 37,050.00	$ 183.33	$ 45,283.33
3	Cleanout Installation (with s/s replacement)	344	EA	$ 400.00	$ 137,600.00	$ 50.00	$ 17,200.00	$ 241.67	$ 83,133.33
4	Cleanout Installation (with CIP Tee & Stub)	4	EA	$ 1,500.00	$ 6,000.00	$ 700.00	$ 2,800.00	$ 900.00	$ 3,600.00
5	Type A Side Sewer Replacement	193	EA	$ 1,900.00	$ 366,700.00	$ 2,400.00	$ 463,200.00	$ 2,366.67	$ 456,766.67
6	Type B Side Sewer Replacement	30	EA	$ 2,300.00	$ 69,000.00	$ 2,800.00	$ 84,000.00	$ 2,733.33	$ 82,000.00
7	Type C Side Sewer Replacement	15	EA	$ 4,200.00	$ 63,000.00	$ 3,100.00	$ 46,500.00	$ 3,766.67	$ 56,500.00
8	Type D Side Sewer Replacement	4	EA	$ 4,200.00	$ 16,800.00	$ 3,600.00	$ 14,400.00	$ 4,433.33	$ 17,733.33
9	Additional Side Sewer Connection	100	EA	$ 500.00	$ 50,000.00	$ 70.00	$ 7,000.00	$ 290.00	$ 29,000.00
10	Extra Excavation Depth (>4')	210	VF	$ 100.00	$ 21,000.00	$ 15.00	$ 3,150.00	$ 65.67	$ 13,790.00
11	Extra Excavation Depth (>8')	150	VF	$ 150.00	$ 22,500.00	$ 20.00	$ 3,000.00	$ 76.67	$ 11,500.00
12	Trenchless Main Line Spot Repair	7	EA	$ 2,500.00	$ 17,500.00	$ 2,500.00	$ 17,500.00	$ 1,933.33	$ 13,533.33
13	Trenchless CIP Tee and Stub Lining	42	EA	$ 3,750.00	$ 157,500.00	$ 3,400.00	$ 142,800.00	$ 2,833.33	$ 119,000.00
14	Additional CIP Stub Lining	2120	LF	$ 38.00	$ 80,560.00	$ 33.00	$ 69,960.00	$ 29.67	$ 62,893.33
15	Downspout Drainage Diversion	50	EA	$ 500.00	$ 25,000.00	$ 100.00	$ 5,000.00	$ 216.67	$ 10,833.33
16	Record Drawing Sketches	208	EA	$ 25.00	$ 5,200.00	$ 50.00	$ 10,400.00	$ 30.00	$ 6,240.00
17	Asphalt Pavement Restoration	200	TN	$ 140.00	$ 28,000.00	$ 70.00	$ 14,000.00	$ 82.67	$ 16,533.33
18	Concrete Restoration	1000	SY	$ 45.00	$ 45,000.00	$ 23.00	$ 23,000.00	$ 24.17	$ 24,166.67
19	Backfill Gravel	2700	TN	$ 15.00	$ 40,500.00	$ 9.00	$ 24,300.00	$ 9.67	$ 26,100.00
20	Asphalt Treated Base	150	TN	$ 65.00	$ 9,750.00	$ 70.00	$ 10,500.00	$ 73.67	$ 11,050.00
21	Crushed Rock Surfacing	350	TN	$ 30.00	$ 10,500.00	$ 11.00	$ 3,850.00	$ 21.00	$ 7,350.00
22	Controlled Density Fill	200	CY	$ 75.00	$ 15,000.00	$ 65.00	$ 13,000.00	$ 61.33	$ 12,266.67
23	Temp. Erosion & Sedimentation Control	1	LS	$ 10,000.00	$ 10,000.00	$ 5,500.00	$ 5,500.00	$ 6,833.33	$ 6,833.33
24	Miscellaneous Work by Force Account	1	LS	$ 75,000.00	$ 75,000.00	$ 75,000.00	$ 75,000.00	$ 75,000.00	$ 75,000.00
25	Shoring	1	LS	$ 40,000.00	$ 40,000.00	$ 34,000.00	$ 34,000.00	$ 32,066.67	$ 32,066.67
26	Wage Rate Affidavits	2	EA	$ 25.00	$ 50.00	$ 25.00	$ 50.00	$ 25.00	$ 50.00
	Subtotal				$ 1,470,610.00		$ 1,154,660.00		$ 1,323,390.00
	TAX calculated at	8.80%	TAX		$ 129,413.68		$ 101,610.08		$ 116,458.32
			TOTAL		**$1,600,023.68**		**$ 1,256,270.08**		**$ 1,439,848.32**
	Comment Code						A		

LEGEND

A. Did not write contract total in words.

B. Did not write unit prices and contract total in words.

Called by: RONALD WASTEWATER DISTRICT For: BASIN RON002 I/I REMOVAL PILOT PROJECT Bid Opening: 10:30 a.m., THU MARCH 6, 2003			Bidders Name and Address	Mocon Corporation 13215-C8 SE Mill Plain Blvd #538 Vancouver, WA 98684		Callen Construction Co., Inc. PO Box 498 Custer, WA 98240		DDJ Construction Co., Inc 11301 186th Ave SE Issaquah, WA 98027	
Certified Tabulation of Bids Received By: ______________________			Total (w/o tax)		$ 1,187,980.00		$ 1,627,530.00		$ 2,110,433.00
			Bid Bond		5%		5%		5%
Item No.	Description	Quantity	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
1	Mobilization and Demobilization	1	LS	$ 118,000.00	$ 118,000.00	$ 155,000.00	$ 155,000.00	$ 95,000.00	$ 95,000.00
2	Side Sewer Inspection	247	EA	$ 150.00	$ 37,050.00	$ 250.00	$ 61,750.00	$ 125.00	$ 30,875.00
3	Cleanout Installation (with s/s replacement)	344	EA	$ 200.00	$ 68,800.00	$ 475.00	$ 163,400.00	$ 157.00	$ 54,008.00
4	Cleanout Installation (with CIP Tee & Stub)	4	EA	$ 500.00	$ 2,000.00	$ 1,500.00	$ 6,000.00	$ 2,000.00	$ 8,000.00
5	Type A Side Sewer Replacement	193	EA	$ 1,400.00	$ 270,200.00	$ 3,300.00	$ 636,900.00	$ 5,400.00	$ 1,042,200.00
6	Type B Side Sewer Replacement	30	EA	$ 1,900.00	$ 57,000.00	$ 3,500.00	$ 105,000.00	$ 6,000.00	$ 180,000.00
7	Type C Side Sewer Replacement	15	EA	$ 2,200.00	$ 33,000.00	$ 6,000.00	$ 90,000.00	$ 6,500.00	$ 97,500.00
8	Type D Side Sewer Replacement	4	EA	$ 2,700.00	$ 10,800.00	$ 7,000.00	$ 28,000.00	$ 6,500.00	$ 26,000.00
9	Additional Side Sewer Connection	100	EA	$ 500.00	$ 50,000.00	$ 300.00	$ 30,000.00	$ 250.00	$ 25,000.00
10	Extra Excavation Depth (>4')	210	VF	$ 175.00	$ 36,750.00	$ 7.00	$ 1,470.00	$ 100.00	$ 21,000.00
11	Extra Excavation Depth (>8')	150	VF	$ 200.00	$ 30,000.00	$ 10.00	$ 1,500.00	$ 150.00	$ 22,500.00
12	Trenchless Main Line Spot Repair	7	EA	$ 2,100.00	$ 14,700.00	$ 1,200.00	$ 8,400.00	$ 2,500.00	$ 17,500.00
13	Trenchless CIP Tee and Stub Lining	42	EA	$ 3,300.00	$ 138,600.00	$ 1,800.00	$ 75,600.00	$ 3,850.00	$ 161,700.00
14	Additional CIP Stub Lining	2120	LF	$ 34.00	$ 72,080.00	$ 22.00	$ 46,640.00	$ 35.00	$ 74,200.00
15	Downspout Drainage Diversion	50	EA	$ 250.00	$ 12,500.00	$ 300.00	$ 15,000.00	$ 250.00	$ 12,500.00
16	Record Drawing Sketches	208	EA	$ 25.00	$ 5,200.00	$ 15.00	$ 3,120.00	$ 25.00	$ 5,200.00
17	Asphalt Pavement Restoration	200	TN	$ 96.00	$ 19,200.00	$ 82.00	$ 16,400.00	$ 85.00	$ 17,000.00
18	Concrete Restoration	1000	SY	$ 17.50	$ 17,500.00	$ 32.00	$ 32,000.00	$ 48.00	$ 48,000.00
19	Backfill Gravel	2700	TN	$ 9.00	$ 24,300.00	$ 11.00	$ 29,700.00	$ 16.00	$ 43,200.00
20	Asphalt Treated Base	150	TN	$ 77.00	$ 11,550.00	$ 74.00	$ 11,100.00	$ 75.00	$ 11,250.00
21	Crushed Rock Surfacing	350	TN	$ 22.00	$ 7,700.00	$ 30.00	$ 10,500.00	$ 75.00	$ 26,250.00
22	Controlled Density Fill	200	CY	$ 55.00	$ 11,000.00	$ 64.00	$ 12,800.00	$ 75.00	$ 15,000.00
23	Temp. Erosion & Sedimentation Control	1	LS	$ 5,000.00	$ 5,000.00	$ 10,000.00	$ 10,000.00	$ 500.00	$ 500.00
24	Miscellaneous Work by Force Account	1	LS	$ 75,000.00	$ 75,000.00	$ 75,000.00	$ 75,000.00	$ 75,000.00	$ 75,000.00
25	Shoring	1	LS	$ 60,000.00	$ 60,000.00	$ 2,200.00	$ 2,200.00	$ 1,000.00	$ 1,000.00
26	Wage Rate Affidavits	2	EA	$ 25.00	$ 50.00	$ 25.00	$ 50.00	$ 25.00	$ 50.00
	Subtotal				$ 1,187,980.00		$ 1,627,530.00		$ 2,110,433.00
	TAX calculated at	8.80%	TAX		$ 104,542.24		$ 143,222.64		$ 185,718.10
			TOTAL		**$ 1,292,522.24**		**$ 1,770,752.64**		**$ 2,296,151.10**
	Comment Code				B				A

LEGEND

A. Did not write contract total in words.

B. Did not write unit prices and contract total in words.

Appendix C

I/I Pilot Project Bid Tabulations

Description:

This appendix contains the bid tabulations for each of the pilot projects.

Reference Chapters:

Chapter 5 – Pilot Project Design
Chapter 6 – Bidding and Administration

Bid Evaluation Summary
Auburn Infiltration Inflow (I/I) Pilot Project- Contract C33042C
Bids Opened: June 12, 2003 @ 1:30 p.m.

Bid Item	Item Description (Abbreviated)	Units	Est.	K.C.Engr.Estimate		BUNO CONSTRUCTION, LLC		KING CONSTRUCTION CO.	
				Unit Price	LumpSum / ExtendedAmt	Unit Price	LumpSum / ExtendedAmt	Unit Price	LumpSum / ExtendedAmt
1	Mobilization/Demobilization @ 5 %	L.S.			$15,270.00		$16,200.00		$19,950.00
2	8-Inch Mainline Replacement by Pipe Bursting	L.F.	2,169	$ 55.00	$119,295.00	$ 75.00	$162,675.00	$ 90.00	$195,210.00
3	Lateral Replacement by Pipe Bursting	L.F.	1,418	$ 44.00	$62,392.00	$ 31.00	$43,958.00	$ 15.00	$21,270.00
4	Lateral Replacement by Dig and Replace	L.F.	382	$ 44.00	$16,808.00	$ 31.00	$11,842.00	$ 69.00	$26,358.00
5	Mainline Spot Repair by Dig and Replace	L.S.			$12,000.00		$3,750.00		$13,500.00
6	Cleanout	Each	24	$ 170.00	$4,080.00	$ 100.00	$2,400.00	$ 1,080.00	$25,920.00
7	Manhole Pan	Each	9	$ 275.00	$2,475.00	$ 200.00	$1,800.00	$ 310.00	$2,790.00
8	Traffic Control Measures	L.S.			$1,000.00		$10,000.00		$25,150.00
9	Import Backfill	C.Y.	700	$ 24.00	$16,800.00	$ 14.00	$9,800.00	$ 10.00	$7,000.00
10	Asphalt Pavement Patch	Ton	90	$ 250.00	$22,500.00	$ 100.00	$9,000.00	$ 50.00	$4,500.00
11	Manhole	Each	9	$ 4,500.00	$40,500.00	$ 2,500.00	$22,500.00	$ 5,000.00	$45,000.00
12	Trench Excavation Safety Systems	L.S.			$5,000.00		$30,000.00		$23,350.00
13	Excavation and Replacement of Unsuitable Materials	C.Y.	50	$ 50.00	$2,500.00	$ 15.00	$750.00	$ 12.00	$600.00
	Total Bid Price				**$ 320,620.00**		**$ 324,675.00**		**$ 410,598.00**

Brier Infiltration Inflow (I/I) Pilot Project- Contract C33043C
Bids Opened: May 27, 2003 @ 1:30 p.m.

Bid Item	Item Description (Abbreviated)	Units	Est. Qty.	K.C.Engr.Estimate		Gelco Services, Inc		Pilchuck Diversified Serv. (Div. Of Pilchuck Cont. Inc.)	
Bid Item	Item Description	Unit	Est. Qty.	Unit Price	LumpSum / ExtendedAmt	Unit Price	LumpSum / ExtendedAmt	Unit Price	LumpSum / ExtendedAmt
1	Mobilization/Demobilization	LS			$ 20,580.00		$ 21,000.00		$ 24,570.00
2	Service Connection and Lateral Rehabilitation Liner, Lateral Connection Liner	LF	339	$ 165.00	$ 55,935.00	$ 255.00	$ 86,445.00	$ 263.17	$ 89,214.63
3	Manhole Rehabilitation Liner, Poly-Triplex Lining System	VF	176	$ 385.00	$ 67,760.00	$ 445.00	$ 78,320.00	$ 463.50	$ 81,576.00
4	8-Inch Mainline Rehabilitation	LF	1,305	$ 50.00	$ 65,250.00	$ 38.00	$ 49,590.00	$ 56.93	$ 74,293.65
5	12-Inch Mainline Rehabilitation	LF	1,603	$ 55.00	$ 88,165.00	$ 55.00	$ 88,165.00	$ 69.77	$ 111,841.31
6	Initial Vacuum Testing	EA	35	$ 385.00	$ 13,475.00	$ 275.00	$ 9,625.00	$ 457.71	$ 16,019.85
7	Chemical Grouting	EA	21	$ 2,200.00	$ 46,200.00	$ 1,000.00	$ 21,000.00	$ 836.86	$ 17,574.06
8	Cleanout, 0 to 4-Foot Depth	EA	5	$ 240.00	$ 1,200.00	$ 1,300.00	$ 6,500.00	$ 1,268.40	$ 6,342.00
9	Cleanout, 4 to 8-Foot Depth	EA	7	$ 330.00	$ 2,310.00	$ 2,200.00	$ 15,400.00	$ 1,542.00	$ 10,794.00
10	Cleanout, 8 to 14-Foot Depth	EA	9	$ 510.00	$ 4,590.00	$ 3,400.00	$ 30,600.00	$ 2,790.00	$ 25,110.00
11	Cleanout Casting	EA	6	$ 200.00	$ 1,200.00	$ 315.00	$ 1,890.00	$ 344.00	$ 2,064.00
12	Asphalt Pavement Restoration	TN	1	$ 800.00	$ 800.00	$ 850.00	$ 850.00	$ 619.20	$ 619.20
13	Concrete Sidewalk Replacement	SY	22	$ 100.00	$ 2,200.00	$ 110.00	$ 2,420.00	$ 96.00	$ 2,112.00
14	Concrete Curb and Gutter Replacement	LF	60	$ 30.00	$ 1,800.00	$ 42.00	$ 2,520.00	$ 35.00	$ 2,100.00
15	Top Soil	TN	14	$ 50.00	$ 700.00	$ 51.00	$ 714.00	$ 51.09	$ 715.26
16	Trench Excavation Safety System	LS			$ 5,500.00		$ 3,200.00		$ 2,760.00
17	Manhole Pans	EA	3	$ 275.00	$ 825.00	$ 240.00	$ 720.00	$ 304.00	$ 912.00
18	8-Inch Mainline Spot Repair	EA	2	$ 2,750.00	$ 5,500.00	$ 1,600.00	$ 3,200.00	$ 8,220.00	$ 16,440.00
19	Traffic Control Measures	LS			$ 6,000.00		$ 2,500.00		$ 24,480.00
20	Roof Drain Disconnection at 3612 233rd Place SW	LS			$ 2,750.00		$ 700.00		$ 2,478.00
	Total Bid Price				**$ 392,740.00**		**$ 425,359.00**		**$ 512,015.96**

Kent Infiltration Inflow (I/I) Pilot Project- Contract C33044C
Bids Opened: June 10, 2003 @ 1:30 p.m.

			Est.	K.C. Engr. Estimate		Michels	
	Item Description (Abbreviated)	Units	Qty.	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt
Bid Item	Item Description	Unit	Est. Qty.				
1	Mobilization / Demobilization (not to Exceed 5% of the Total Bid Price)	LS			$ 35,809.00		$ 50,000.00
2	Service Connection and Lateral Rehabilitation Liner, T-Liner™:	LF	3,362	$ 75.00	$ 252,150.00	$ 118.00	$ 396,716.00
3	Cure in Place Pipe, 4-Inch	LF	5,200	$ 42.00	$ 218,400.00	$ 35.00	$ 182,000.00
4	Cure in Place Pipe, 6-Inch	LF	1,484	$ 45.00	$ 66,780.00	$ 42.00	$ 62,328.00
5	Excavate and Replace 6 Inch and Smaller Sewer Line	LF	1,200	$ 45.00	$ 54,000.00	$ 30.00	$ 36,000.00
6	Cleanout, 0- to 4-Foot Depth	EA	160	$ 150.00	$ 24,000.00	$ 900.00	$ 144,000.00
7	Cleanout, 4- to 8-Foot Depth	EA	70	$ 180.00	$ 12,600.00	$ 1,000.00	$ 70,000.00
8	Cleanout, 8- to 14-Foot Depth	EA	70	$ 225.00	$ 15,750.00	$ 1,100.00	$ 77,000.00
9	Cleanout Casting	EA	70	$ 100.00	$ 7,000.00	$ 150.00	$ 10,500.00
10	Spot Repair, 0- to 4-Foot Depth	EA	20	$ 400.00	$ 8,000.00	$ 300.00	$ 6,000.00
11	Spot Repair, 4- to 8-Foot Depth	EA	10	$ 800.00	$ 8,000.00	$ 400.00	$ 4,000.00
12	Spot Repair, 8- to 14-Foot Depth	EA	10	$ 1,500.00	$ 15,000.00	$ 500.00	$ 5,000.00
13	Asphalt Pavement Patch	TN	50	$ 120.00	$ 6,000.00	$ 100.00	$ 5,000.00
14	Cast-in-Place Concrete	CY	30	$ 350.00	$ 10,500.00	$ 250.00	$ 7,500.00
15	Beauty Bark	CY	50	$ 35.00	$ 1,750.00	$ 100.00	$ 5,000.00
16	Top Soil	TN	50	$ 45.00	$ 2,250.00	$ 70.00	$ 3,500.00
17	Trench Excavation Safety Systems	LS			$ 5,000.00		$ 20,000.00
18	Traffic Control Measures	LS			$ 5,000.00		$ 5,000.00
19	Record Drawings	LS			$ 7,000.00		$ 10,000.00
	Total Bid Price				**$ 754,989.00**		**$ 1,099,544.00**

Kirkland Infiltration Inflow (I/I) Pilot Project- Contract C33045C
Bids Opened: June 5, 2003 @ 3:00 p.m.

Bid Item	Item Description (Abbreviated)	Units	Est. Qty.	K.C.Engr.Estimate		BUNO CONSTRUCTION, LLC		PILCHUCK DIVERSIFIED SERVICES		SHORELINE CONSTRUCTION CO.		B&L UTILITY INC	
Bid Item	Item Description	Unit	Est. Qty.	Unit Price	LumpSum / ExtendedAmt	Unit Price	LumpSum / ExtendedAmt	Unit Price	LumpSum / ExtendedAmt	Unit Price	LumpSum / ExtendedAmt	Unit Price	LumpSum / ExtendedAmt
1	Mobilization/Demobilization (enter amount not to exceed 5% of the Total Bid Price)	LS			$ 38,900.00		$ 38,500.00		$ 47,800.00		$ 42,200.00		$ 100,000.00
2	8-Inch Sewer Main Replacement by Pipe Bursting	LF	3921	$70	$ 274,470.00	$95.00	$ 372,495.00	$69.35	$ 271,921.35	$87.00	$ 341,127.00	$ 96.00	$ 376,416.00
3	6-Inch Lateral Replacement by Pipe Bursting	LF	523	$60	$ 31,380.00	$41.00	$ 21,443.00	$79.40	$ 41,526.20	$62.00	$ 32,426.00	$ 81.00	$ 42,363.00
4	6-Inch Lateral Replacement by Open Excavation	LF	2092	$50	$ 104,600.00	$41.00	$ 85,772.00	$100.00	$ 209,200.00	$55.00	$ 115,060.00	$ 80.00	$ 167,360.00
5	Imported Backfill	CY	2531	$27	$ 68,337.00	$15.00	$ 37,965.00	$22.00	$ 55,682.00	$30.00	$ 75,930.00	$ 35.00	$ 88,585.00
6	Cleanout, 4'-8' Depth	EA	75	$1,100	$ 82,500.00	$150.00	$ 11,250.00	$1,550.00	$ 116,250.00	$700.00	$ 52,500.00	$ 400.00	$ 30,000.00
7	Traffic Control Measures	LS			$ 20,000.00		$ 20,000.00		$ 1,581.00		$ 5,000.00		$ 10,000.00
8	Traffic Control Labor	HR	1000	$39	$ 39,000.00	$34.00	$ 34,000.00	$47.00	$ 47,000.00	$40.00	$ 40,000.00	$ 38.00	$ 38,000.00
9	Asphalt Pavement Patch	TN	325	$75	$ 24,375.00	$80.00	$ 26,000.00	$183.00	$ 59,475.00	$125.00	$ 40,625.00	$ 150.00	$ 48,750.00
10	Trench Excavation Safety Systems as needed to meet the requirements of Chapter 49.17 RCW	LS			$ 25,300.00		$ 60,000.00		$ 3,000.00		$ 1,000.00		$ 10,000.00
11	New Manhole	EA	3	$3,300	$ 9,900.00	$2,500.00	$ 7,500.00	$3,443.00	$ 10,329.00	$10,000.00	$ 30,000.00	$ 5,500.00	$ 16,500.00
12	Replacement Manhole	EA	16	$3,700	$ 59,200.00	$2,500.00	$ 40,000.00	$3,376.00	$ 54,016.00	$10,000.00	$ 160,000.00	$ 5,500.00	$ 88,000.00
13	Remove Ex. Manhole & Connect Ex. Laterals to Sewer Main	EA	2	$2,200	$ 4,400.00	$2,500.00	$ 5,000.00	$2,907.00	$ 5,814.00	$5,000.00	$ 10,000.00	$ 3,000.00	$ 6,000.00
14	Concrete Sidewalk/ Driveway Replacement	CY	22	$28	$ 611.60	$225.00	$ 4,950.00	$395.00	$ 8,690.00	$450.00	$ 9,900.00	$ 500.00	$ 11,000.00
15	Concrete Curb and Gutter Replacement	LF	360	$28	$ 10,080.00	$15.00	$ 5,400.00	$26.00	$ 9,360.00	$25.00	$ 9,000.00	$ 50.00	$ 18,000.00
16	Additional Lateral and Side Sewer CCTV Inspection	LF	5000	$2.75	$ 13,750.00	$1.50	$ 7,500.00	$3.00	$ 15,000.00	$2.00	$ 10,000.00	$ 2.00	$ 10,000.00
17	Excavation and Replacement of Unsuitable Materials	CY	200	$22	$ 4,400.00	$15.00	$ 3,000.00	$23.00	$ 4,600.00	$40.00	$ 8,000.00	$ 25.00	$ 5,000.00
18	Surveying and Resetting of Monuments and Property Corners	LS			$ 10,000.00		$ 1,000.00		$ 8,455.00		$ 5,000.00		$ 50,000.00
	Total Bid Price				**$ 821,203.60**		**$ 781,775.00**		**$ 969,699.55**		**$ 987,768.00**		**$ 1,115,974.00**
	Percentage Change (from the Engineers Estimate)						**95%**		**118%**		**120%**		**136%**

Mercer Island Infiltration Inflow (I/I) Pilot Project- Contract C33047C
Bids Opened: June 10, 2003 @ 1:00 p.m.

				K.C. Engr. Estimate		Gelco		Insituform		Planned Engineered		Michels Pipeline	
	Item Description (Abbreviated)	Units	Est. Qty.	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt
Bid Item	Item Description	Unit	Est. Qty.										
1	Mobilization/Demobilization (enter amount not to exceed 10% of the Total Bid Price)	LS			$ 42,584.00		$ 13,500.00		$ 9,000.00		$ 10,500.00		$ 35,000.00
2	8 inch Mainline Rehabilitation	LF	15,512	$ 38.00	$ 589,456.00	$ 23.25	$ 360,654.00	$ 24.75	$ 383,922.00	$ 26.75	$ 414,946.00	$ 27.00	$ 418,824.00
3	Service Connection Rehabilitation Liner	EA	225	$ 1,000.00	$ 225,000.00	$ 1,600.00	$ 360,000.00	$ 1,650.00	$ 371,250.00	$1,675.00	$ 376,875.00	$1,800.00	$ 405,000.00
4	Traffic Control Measures	LS			$ 10,000.00		$ 2,500.00		$ 12,000.00		$ 3,500.00		$ 12,000.00
	Total Bid Price				**$ 867,040.00**		**$ 736,654.00**		**$ 776,172.00**		**$ 805,821.00**		**$ 870,824.00**
	Form of Bid Complete			10% contingency	$ 953,744.00								

Redmond Infiltration Inflow (I/I) Pilot Project- Contract C33048C
Bids Opened: June 5, 2003 @ 2:30 p.m.

	Item Description (Abbreviated)	Units	Est. Qty.	K.C. Engr. Estimate		Pilchuck		Gelco Services, Inc.	
Bid Item	Item Description	Unit	Est. Qty.	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt
1	Mobilization/Demobilization (enter amount not to exceed 10% of the Total Bid Price)	LS			$ 39,900.00		$ 88,000.00		
2	12-Inch Mainline Rehabilitation Using Multiliner	LF	1,311	$ 77.00	$ 100,947.00	$ 72.00	$ 94,392.00		
3	10-Inch Mainline Rehabilitation Using Multiliner	LF	1,691	$ 66.00	$ 111,606.00	$ 60.00	$ 101,460.00		
4	8-Inch Mainline Rehabilitation Using Multiliner	LF	3,055	$ 55.00	$ 168,025.00	$ 45.00	$ 137,475.00		
5	Service Connection and Lateral Rehabilitation Liner Using T-Liner	LF	620	$ 220.00	$ 136,400.00	$ 312.00	$ 193,440.00		
6	Service Connection Rehabilitation Liner Using “Top Hat” Lateral Sealing Systems	EA	20	$ 1,600.00	$ 32,000.00	$ 2,800.00	$ 56,000.00		
7	Cleanout, 0-8 Foot Depth	EA	62	$ 1,100.00	$ 68,200.00	$ 800.00	$ 49,600.00		
8	Grout Pipe Penetration in Manhole	EA	6	$ 330.00	$ 1,980.00	$ 900.00	$ 5,400.00		
9	Manhole Chimney Interior Coating	EA	22	$ 360.00	$ 7,920.00	$ 400.00	$ 8,800.00		
10	Chemical Grouting	EA	13	$ 2,200.00	$ 28,600.00	$ 1,000.00	$ 13,000.00		
11	Manhole Pan	EA	7	$ 275.00	$ 1,925.00	$ 600.00	$ 4,200.00		
12	Traffic Control Measures	LS			$ 18,000.00		$ 25,000.00		
13	Traffic Control Labor	HR	1,000	$ 39.00	$ 39,000.00	$ 35.00	$ 35,000.00		
14	Controlled Density Fill (CDF)	CY	150	$ 110.00	$ 16,500.00	$ 70.00	$ 10,500.00		
15	Asphalt Pavement Patch	TN	25	$ 275.00	$ 6,875.00	$ 350.00	$ 8,750.00		
16	Concrete Sidewalk Panel Replacement	SY	70	$ 110.00	$ 7,700.00	$ 125.00	$ 8,750.00		
17	Trench Excavation Safety Systems	LS			$ 6,000.00		$ 8,000.00		
18	Mainline Replacement by Pipe Bursting	LF	265	$ 75.00	$ 19,875.00	$ 90.00	$ 23,850.00		
19	Mainline Spot Repair Using Multiliner	EA	5	$ 3,100.00	$ 15,500.00	$ 3,500.00	$ 17,500.00		
20	Record Drawings	LS			$ 11,000.00		$ 10,000.00		
	Total Bid Price				**$ 837,953.00**		**$ 899,117.00**		**NO BID**

King County Regional I&I Program
Ronald
Construction Cost Summary

Bid Item No.	Bid Item Description	Est. Qty.	Units	Engineer's Estimate Unit Price	Extended Amount	Low Bid Unit Price	Low Bid Extended Amount
1	Mobilization and Demobilization	1	LS	$ 72,000.00	$ 72,000.00	$ 27,500	$ 27,500.00
2	Side Sewer Inspection	247	EA	$ 350.00	$ 86,450.00	$ 150	$ 37,050.00
3	Cleanout Installation (with s/s replacement)	344	EA	$ 400.00	$ 137,600.00	$ 50	$ 17,200.00
4	Cleanout Installation (with CIP Tee & Stub)	4	EA	$ 1,500.00	$ 6,000.00	$ 700	$ 2,800.00
5	Type A Side Sewer Replacement	193	EA	$ 1,900.00	$ 366,700.00	$ 2,400	$ 463,200.00
6	Type B Side Sewer Replacement	30	EA	$ 2,300.00	$ 69,000.00	$ 2,800	$ 84,000.00
7	Type C Side Sewer Replacement	15	EA	$ 4,200.00	$ 63,000.00	$ 3,100	$ 46,500.00
8	Type D Side Sewer Replacement	4	EA	$ 4,200.00	$ 16,800.00	$ 3,600	$ 14,400.00
9	Additional Side Sewer Connection	100	EA	$ 500.00	$ 50,000.00	$ 70	$ 7,000.00
10	Extra Excavation Depth (>4')	210	VF	$ 100.00	$ 21,000.00	$ 15	$ 3,150.00
11	Extra Excavation Depth (>8')	150	VF	$ 150.00	$ 22,500.00	$ 20	$ 3,000.00
12	Trenchless Main Line Spot Repair	7	EA	$ 2,500.00	$ 17,500.00	$ 2,500	$ 17,500.00
13	Trenchless CIP Tee and Stub Lining	42	EA	$ 3,750.00	$ 157,500.00	$ 3,400	$ 142,800.00
14	Additional CIP Stub Lining	2120	LF	$ 38.00	$ 80,560.00	$ 33	$ 69,960.00
15	Downspout Drainage Diversion	50	EA	$ 500.00	$ 25,000.00	$ 100	$ 5,000.00
16	Record Drawing Sketches	208	EA	$ 25.00	$ 5,200.00	$ 50	$ 10,400.00
17	Asphalt Pavement Restoration	200	TN	$ 140.00	$ 28,000.00	$ 70	$ 14,000.00
18	Concrete Restoration	1000	SY	$ 45.00	$ 45,000.00	$ 23	$ 23,000.00
19	Backfill Gravel	2700	TN	$ 15.00	$ 40,500.00	$ 9	$ 24,300.00
20	Asphalt Treated Base	150	TN	$ 65.00	$ 9,750.00	$ 70	$ 10,500.00
21	Crushed Rock Surfacing	350	TN	$ 30.00	$ 10,500.00	$ 11	$ 3,850.00
22	Controlled Density Fill	200	CY	$ 75.00	$ 15,000.00	$ 65	$ 13,000.00
23	Temp. Erosion & Sedimentation Control	1	LS	$ 10,000.00	$ 10,000.00	$ 5,500	$ 5,500.00
24	Miscellaneous Work by Force Account	1	LS	$ 75,000.00	$ 75,000.00	$ 75,000	$ 75,000.00
25	Shoring	1	LS	$ 40,000.00	$ 40,000.00	$ 34,000	$ 34,000.00
26	Wage Rate Affidavits	2	EA	$ 25.00	$ 50.00	$ 25	$ 50.00
				TOTAL	$ 1,470,610.00	Subtotal	$ 1,154,660.00
				WSST AT 8.8%	$ 129,413.68	WSST @8.8%	$ 101,610.08
				TOTAL	$ 1,600,023.68	Contract Total	$ 1,256,270.08

Lake Forest Park Infiltration Inflow (I/I) Pilot Project- Contract C33046C
Bids Opened: May 20, 2003 @ 1:30 p.m.

Bid Item	Item Description (Abbreviated)	Units	Est. Qty.	K.C.Engr.Estimate		Gelco Services, Inc.		Michels Pipeline Construction		Planned and Engineered Construction Inc.	
Bid Item	Item Description	Unit	Est. Qty.	Unit Price	LumpSum / ExtendedAmt	Unit Price	LumpSum / ExtendedAmt	Unit Price	LumpSum / ExtendedAmt	Unit Price	LumpSum / ExtendedAmt
1	Mobilization / Demobilization (amount not to exceed 5% of the Total Bid Price)	LS			$ 32,720.00		$ 18,000.00		$ 41,500.00		$ 25,000.00
2	Adjust Existing Frame and Lid	EA	13	$ 750.00	$ 9,750.00	$ 1,725.00	$ 22,425.00	$ 700.00	$ 9,100.00	$ 750.00	$ 9,750.00
3	Replace Existing Frame and Lid	EA	2	$ 1,000.00	$ 2,000.00	$ 1,560.00	$ 3,120.00	$ 1,200.00	$ 2,400.00	$ 1,500.00	$ 3,000.00
4	Chemical Grouting	EA	21	$ 2,500.00	$ 52,500.00	$ 950.00	$ 19,950.00	$ 900.00	$ 18,900.00	$ 1,350.00	$ 28,350.00
5	Interior Coating for Manhole	EA	21	$ 2,000.00	$ 42,000.00	$ 3,000.00	$ 63,000.00	$ 1,750.00	$ 36,750.00	$ 2,300.00	$ 48,300.00
6	8 Inch Mainline Rehabilitation	LF	8866	$ 45.00	$ 398,970.00	$ 44.00	$ 390,104.00	$ 52.00	$ 461,032.00	$ 70.00	$ 620,620.00
7	12 Inch Mainline Rehabilitation	LF	157	$ 50.00	$ 7,850.00	$ 92.00	$ 14,444.00	$ 85.00	$ 13,345.00	$ 75.00	$ 11,775.00
8	8 Inch Service Connection Rehabilitation Liner	EA	126	$ 1,000.00	$ 126,000.00	$ 1,950.00	$ 245,700.00	$ 1,750.00	$ 220,500.00	$ 1,650.00	$ 207,900.00
9	12 Inch Service Connection Rehabilitation Liner	EA	2	$ 1,200.00	$ 2,400.00	$ 2,200.00	$ 4,400.00	$ 1,800.00	$ 3,600.00	$ 1,700.00	$ 3,400.00
10	8 Inch Service Connection Dig and Replace	EA	1	$ 4,000.00	$ 4,000.00	$ 4,300.00	$ 4,300.00	$ 3,650.00	$ 3,650.00	$ 4,500.00	$ 4,500.00
11	Traffic Control Measures	LS			$ 5,000.00		$ 7,700.00		$ 12,000.00		$ 9,500.00
12	Asphalt Pavement Patch	TN	5	$ 200.00	$ 1,000.00	$ 650.00	$ 3,250.00	$ 250.00	$ 1,250.00	$ 175.00	$ 875.00
13	Concrete Pavement Patch 12-Inch thick	SY	2	$ 1,000.00	$ 2,000.00	$ 1,700.00	$ 3,400.00	$ 600.00	$ 1,200.00	$ 150.00	$ 300.00
14	Trench Excavation Safety System (as stated above)	LS			$ 2,000.00		$ 2,100.00		$ 500.00		$ 2,500.00
	Total Bid Price				**$ 688,190.00**		**$ 801,893.00**		**$ 825,727.00**		**$ 975,770.00**

Coal Creek Utility District Infiltration Inflow (I/I) Pilot Project- Contract C33108C
Bids Opened: June 17, 2003 @ 1:00 p.m.

	Item Description (Abbreviated)	Units	Est. Qty.	K.C. Engr. Estimate		Pilchuck		S.L. Larsen	
Bid Item	Item Description	Unit	Est. Qty.	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt
1	Re-Align/Reset Frame on Chimney and Seal, Raise to Grade	EA	15	$ 2,200.00	$ 33,000.00	$ 1,480.00	$ 22,200.00	$ 1,100.00	$ 16,500.00
2	Manhole Pans	EA	20	$ 275.00	$ 5,500.00	$ 350.00	$ 7,000.00	$ 500.00	$ 10,000.00
3	Paving Ring Replacement	EA	8	$ 2,200.00	$ 17,600.00	$ 1,975.00	$ 15,800.00	$ 1,800.00	$ 14,400.00
4	Interior Chimney Coating, Product G, Flex Seal Utility Sealant	EA	12	$ 500.00	$ 6,000.00	$ 1,000.00	$ 12,000.00	$ 1,200.00	$ 14,400.00
5	Interior Coating for Manhole, Including Chimney, Product D Sauereisen 210S	EA	29	$ 2,750.00	$ 79,750.00	$ 3,850.00	$ 111,650.00	$ 10,000.00	$ 290,000.00
6	Chemical Grouting	EA	13	$ 2,420.00	$ 31,460.00	$ 1,670.00	$ 21,710.00	$ 3,000.00	$ 39,000.00
7	Manhole Spot Repairs With Grout	EA	6	$ 330.00	$ 1,980.00	$ 835.00	$ 5,010.00	$ 1,000.00	$ 6,000.00
8	Grout Pipe Penetrations in Manholes	EA	25	$ 330.00	$ 8,250.00	$ 760.00	$ 19,000.00	$ 2,800.00	$ 70,000.00
9	Mobilization / Demobilization (amount not to exceed 5% of the Total Bid Price)	LS		$ 10,000.00	$ 10,000.00	$ 13,500.00	$ 13,500.00	$ 23,000.00	$ 23,000.00
10	Traffic Control Measures	LS		$ 8,800.00	$ 8,800.00	$ 53,400.00	$ 53,400.00	$ 7,500.00	$ 7,500.00
11	Traffic Control Labor	HR	200	$ 39.00	$ 7,800.00	$ 38.00	$ 7,600.00		$ 9,000.00
	Total Bid Price				**$ 210,140.00**		**$ 288,870.00**		**$ 499,800.00**

Northshore Utility District Infiltration Inflow (I/I) Pilot Project- Contract C33109C
Bids Opened: June 17, 2003 @ 1:00 p.m.

	Item Description (Abbreviated)	Units	Est. Qty.	K.C. Engr. Estimate		Pilchuck		S.L. Larsen	
Bid Item	Item Description	Unit	Est. Qty.	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt
1	Re-Align/Reset Frame on Chimney and Seal, Raise to Grade	EA	8	$ 2,420.00	$ 19,360.00	$ 1,480.00	$ 11,840.00	$ 1,100.00	$ 8,800.00
2	Manhole Pans	EA	21	$ 275.00	$ 5,775.00	$ 350.00	$ 7,350.00	$ 500.00	$ 10,500.00
3	Paving Ring Replacement	EA	3	$ 2,200.00	$ 6,600.00	$ 1,975.00	$ 5,925.00	$ 1,000.00	$ 3,000.00
4	Chimney Barrier	EA	8	$ 1,540.00	$ 12,320.00	$ 2,750.00	$ 22,000.00	$ 1,000.00	$ 8,000.00
5	Chimney Replacement – HDPE Leveling Rings	EA	17	$ 1,980.00	$ 33,660.00	$ 2,800.00	$ 47,600.00	$ 3,000.00	$ 51,000.00
6	Interior Chimney Coating, Product H - Permaflex	EA	13	$ 440.00	$ 5,720.00	$ 1,000.00	$ 13,000.00	$ 1,200.00	$ 15,600.00
7	Interior Chimney Boot	EA	8	$ 330.00	$ 2,640.00	$ 875.00	$ 7,000.00	$ 1,000.00	$ 8,000.00
8	Interior Coating for Manhole, including Chimney, Product E - Spraywall	EA	35	$ 2,860.00	$ 100,100.00	$ 3,850.00	$ 134,750.00	$ 10,000.00	$ 350,000.00
9	Chemical Grouting	EA	35	$ 2,530.00	$ 88,550.00	$ 1,670.00	$ 58,450.00	$ 3,000.00	$ 105,000.00
10	Manhole Spot Repairs with Grout	EA	9	$ 440.00	$ 3,960.00	$ 835.00	$ 7,515.00	$ 2,500.00	$ 22,500.00
11	Grout Pipe Penetrations in Manholes	EA	59	$ 330.00	$ 19,470.00	$ 760.00	$ 44,840.00	$ 1,500.00	$ 88,500.00
12	Mobilization / Demobilization (amount not to exceed 5% of the Total Bid Price)	LS		$ 15,000.00	$ 15,000.00	$ 20,000.00	$ 20,000.00	$ 30,000.00	$ 30,000.00
13	Traffic Control Measures	LS		$ 13,200.00	$ 13,200.00	$ 53,000.00	$ 53,000.00	$ 15,000.00	$ 15,000.00
14	Traffic Control Labor	HR	320	$ 39.00	$ 12,480.00	$ 38.00	$ 12,160.00	$45.00	$ 14,400.00
	Total Bid Price				**$ 338,835.00**		**$ 445,430.00**		**$ 730,300.00**

Val Vue Sewer District Infiltration Inflow (I/I) Pilot Project- Contract C33110C
Bids Opened: June 17, 2003 @ 1:00 p.m.

Bid Item	Item Description (Abbreviated) / Item Description	Units / Unit	Est. Qty.	K.C. Engr. Estimate		GARY HARPER		PILCHUCK		S.L. LARSEN	
				Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt	Unit Price	LumpSum / Extended Amt
1.	Re-Align/Reset Frame on Chimney and Seal, Raise to Grade	EA	2	$ 2,200.00	$ 4,400.00	$ 2,900.00	$ 5,800.00	$ 2,000.00	$ 4,000.00	$ 1,100.00	$ 2,200.00
2.	Manhole Pans	EA	6	$ 275.00	$ 1,650.00	$ 700.00	$ 4,200.00	$ 350.00	$ 2,100.00	$ 500.00	$ 3,000.00
3.	Interior Chimney Coating, Product G, Flex Seal Utility Sealant	EA	5	$ 275.00	$ 1,375.00	$ 2,000.00	$ 10,000.00	$ 1,200.00	$ 6,000.00	$ 1,000.00	$ 5,000.00
4.	Interior Coating for Manhole, including Chimneys, Product A, Raven 405 Ultra High Build Epoxy	EA	20	$ 2,200.00	$ 44,000.00	$ 3,000.00	$ 60,000.00	$ 3,850.00	$ 77,000.00	$ 9,900.00	$ 198,000.00
5.	Manhole Spot Repairs with Grout	EA	1	$ 330.00	$ 330.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 1,000.00	$ 2,400.00	$ 2,400.00
6.	Grout Pipe Penetrations in Manholes	EA	14	$ 330.00	$ 4,620.00	$ 1,050.00	$ 14,700.00	$ 760.00	$ 10,640.00	$ 2,800.00	$ 39,200.00
7.	Mobilization / Demobilization (amount not to exceed 5% of the Total Bid Price)	LS		$ 3,400.00	$ 3,400.00	$ 5,000.00	$ 5,000.00	$ 6,000.00	$ 6,000.00	$ 13,000.00	$ 13,000.00
8.	Traffic Control Measures	LS		$ 6,600.00	$ 6,600.00	$ 800.00	$ 800.00	$ 15,000.00	$ 15,000.00	$ 5,000.00	$ 5,000.00
9.	Traffic Control Labor	HR	120	$ 39.00	$ 4,680.00	$ 40.00	$ 4,800.00	$ 38.00	$ 4,560.00	$ 45.00	$ 5,400.00
	Total Bid Price				**$ 71,055.00**		**$ 106,300.00**		**$ 126,300.00**		**$ 273,200.00**

Manhole Infiltration Inflow (I/I) Pilot Project- Contract C33120C
Bids Opened: July 22, 2003 @ 1:00 p.m.

Bid Item	Item Description (Abbreviated) / Item Description	Units / Unit	Est. Qty.	K.C. Engr. Estimate Unit Price	K.C. Engr. Estimate LumpSum / Extended Amt	PIPE EXPERTS Unit Price	PIPE EXPERTS LumpSum / Extended Amt	GELCO Unit Price	GELCO LumpSum / Extended Amt	ROAD CONSTRUCTION NW Unit Price	ROAD CONSTRUCTION NW LumpSum / Extended Amt
	Val Vue Sewer District										
1	Re-Align / Reset Frame on Chimney & Seal, Raise to Grade	Each	2	$ 2,200.00	$ 4,400.00	$ 750.00	$ 1,500.00	$ 2,609.00	$ 5,218.00	$ 3,000.00	$ 6,000.00
2	Manhole Pan	Each	6	$ 600.00	$ 3,600.00	$ 400.00	$ 2,400.00	$ 465.00	$ 2,790.00	$ 1,000.00	$ 6,000.00
3	Interior Chimney Coating	Each	5	$ 800.00	$ 4,000.00	$ 800.00	$ 4,000.00	$ 880.00	$ 4,400.00	$ 1,500.00	$ 7,500.00
4	Chemical Grouting	Each	24	$ 2,500.00	$ 60,000.00	$ 635.00	$ 15,240.00	$ 750.00	$ 18,000.00	$ 7,000.00	$ 168,000.00
5	Mobilization/Demobilization (amount not to exceed 5% of the Val Vue Subtotal)	L.S.	1	$ 3,600.00	$ 3,600.00	$ 1,100.00	$ 1,100.00	$ 1,465.00	$ 1,465.00	$ 9,000.00	$ 9,000.00
	Val Vue Subtotal				$ 75,600.00		$ 24,240.00		$ 31,873.00		$ 196,500.00
	Coal Creek Utility District										
6	Re-Align / Reset Frame on Chimney & Seal, Raise to Grade	Each	15	$ 2,200.00	$ 33,000.00	$ 900.00	$ 13,500.00	$ 2,026.50	$ 30,397.50	$ 3,000.00	$ 45,000.00
7	Manhole Pan	Each	20	$ 600.00	$ 12,000.00	$ 400.00	$ 8,000.00	$ 465.00	$ 9,300.00	$ 1,500.00	$ 30,000.00
8	Paving Ring Replacement	Each	8	$ 2,400.00	$ 19,200.00	$ 1,900.00	$ 15,200.00	$ 3,549.00	$ 28,392.00	$ 2,500.00	$ 20,000.00
9	Interior Chimney Coating	Each	12	$ 800.00	$ 9,600.00	$ 800.00	$ 9,600.00	$ 880.00	$ 10,560.00	$ 1,500.00	$ 18,000.00
10	Chemical Grouting	Each	50	$ 2,500.00	$ 125,000.00	$ 635.00	$ 31,750.00	$ 750.00	$ 37,500.00	$ 5,000.00	$ 250,000.00
11	Mobilization/Demobilization (amount not to exceed 5% of the Coal Creek Subtotal)	L.S.	1	$ 9,940.00	$ 9,940.00	$ 3,900.00	$ 3,900.00	$ 5,326.50	$ 5,326.50	$ 17,000.00	$ 17,000.00
	Coal Creek Subtotal				$ 208,740.00		$ 81,950.00		$ 121,476.00		$ 380,000.00
	Northshore Utility District										
12	Re-Align / Reset Frame on Chimney & Seal, Raise to Grade	Each	8	$ 2,200.00	$ 17,600.00	$ 700.00	$ 5,600.00	$ 2,079.00	$ 16,632.00	$ 3,000.00	$ 24,000.00
13	Manhole Pan	Each	21	$ 600.00	$ 12,600.00	$ 400.00	$ 8,400.00	$ 465.00	$ 9,765.00	$ 1,000.00	$ 21,000.00
14	Paving Ring Replacement	Each	3	$ 2,400.00	$ 7,200.00	$ 1,900.00	$ 5,700.00	$ 3,832.50	$ 11,497.50	$ 2,500.00	$ 7,500.00
15	Chimney Barrier	Each	8	$ 1,800.00	$ 14,400.00	$ 450.00	$ 3,600.00	$ 2,415.00	$ 19,320.00	$ 2,000.00	$ 16,000.00
16	Chimney Replacement - HDPE Leveling Rings	Each	17	$ 2,200.00	$ 37,400.00	$ 1,200.00	$ 20,400.00	$ 2,289.00	$ 38,913.00	$ 4,000.00	$ 68,000.00
17	Interior Chimney Coating	Each	13	$ 800.00	$ 10,400.00	$ 800.00	$ 10,400.00	$ 880.00	$ 11,440.00	$ 1,500.00	$ 19,500.00
18	Interior Chimney Boot	Each	8	$ 1,000.00	$ 8,000.00	$ 900.00	$ 7,200.00	$ 585.00	$ 4,680.00	$ 1,500.00	$ 12,000.00
19	Chemical Grouting	Each	76	$ 2,500.00	$ 190,000.00	$ 635.00	$ 48,260.00	$ 750.00	$ 57,000.00	$ 4,500.00	$ 342,000.00
20	Mobilization/Demobilization (amount not to exceed 5% of the Northshore Subtotal)	L.S.	1	$ 14,880.00	$ 14,880.00	$ 5,240.00	$ 5,240.00	$ 6,639.00	$ 6,639.00	$ 26,000.00	$ 26,000.00
	Northshore Subtotal				$ 312,480.00		$ 114,800.00		$ 175,886.50		$ 536,000.00
	Total Bid Price				**$ 596,820.00**		**$ 220,990.00**		**$ 329,235.50**		**$ 1,112,500.00**

King County Regional I&I Prog
Skyway Sewer Rehabilitation
Construction Cost Summary

Bid Item No.	Bid Item Description	Est. Qty.	Units	Engineer's Estimate Unit Price	Extended Amount	Contract Unit Price	Contract Amount
1	Mobilization	1	LS	$76,650.00	$ 76,650.00	$ 120,000.00	$ 120,000.00
2	Trench Safety System	1	LS	$15,750.00	$ 15,750.00	$ 20,000.00	$ 20,000.00
3	Mainline Replacement by Pipe Burst	6,700	LF	$ 63.00	$ 422,100.00	$ 38.00	$ 254,600.00
4	Mainline Replacement by Open Trench Method	2,900	LF	$ 78.75	$ 228,375.00	$ 38.00	$ 110,200.00
5	Side Sewer Replacement by Pipe Burst	11,000	LF	$ 46.20	$ 508,200.00	$ 34.00	$ 374,000.00
6	Side Sewer Replacement by Open Trench Method	4,000	LF	$ 52.50	$ 210,000.00	$ 34.00	$ 136,000.00
7	Ductile Iron Side Sewer Replacement by Open Trench Method	300	LF	$ 77.70	$ 23,310.00	$ 36.00	$ 10,800.00
8	Cleanout, 0' - 4' Depth	160	EA	$ 157.50	$ 25,200.00	$ 60.00	$ 9,600.00
9	Cleanout, 4' - 8' Depth	100	EA	$ 420.00	$ 42,000.00	$ 70.00	$ 7,000.00
10	Cleanout, 8' - 12' Depth	10	EA	$ 735.00	$ 7,350.00	$ 100.00	$ 1,000.00
11	Replace Manhole	38	EA	$ 3,675.00	$ 139,650.00	$ 2,000.00	$ 76,000.00
12	Traffic Control	1	LS	$12,600.00	$ 12,600.00	$ 60,000.00	$ 60,000.00
13	Permanent Pavement Patch	550	TN	$ 73.50	$ 40,425.00	$ 80.00	$ 44,000.00
14	Excavation and Replacement of Unsuitable Materials	50	CY	$ 31.50	$ 1,575.00	$ 15.00	$ 750.00
15	Import Backfill in Right-of-Way	2,600	CY	$ 27.30	$ 70,980.00	$ 12.00	$ 31,200.00
16	Native Backfill in Right-of-Way	2,600	CY	$ 6.30	$ 16,380.00	$ 1.00	$ 2,600.00
17	Crushed Surfacing Top Course Installed in Driveways, Shoulders, and Alleys	400	TN	$ 16.80	$ 6,720.00	$ 20.00	$ 8,000.00
18	Top Soil	100	TN	$ 26.25	$ 2,625.00	$ 40.00	$ 4,000.00
19	Beauty Bark	100	CY	$ 42.00	$ 4,200.00	$ 30.00	$ 3,000.00
20	Cast -in-Place Concrete	30	CY	$ 84.00	$ 2,520.00	$ 200.00	$ 6,000.00
21	Pothole, 0- to 6 ft deep	30	EA	$ 262.50	$ 7,875.00	$ 150.00	$ 4,500.00
				TOTAL	$1,864,485.00	Subtotal	$1,283,250.00
				WSST AT 8.8%	$164,074.68	WSST @8.8%	$112,926.00
				TOTAL	$2,028,559.68	Contract Total	$1,396,176.00

Appendix D

I/I Pilot Project Flow Monitoring

Tables follow text.

Description:

This appendix documents: (a) the pre-rehabilitation flow monitoring conducted during the winter of 2002/2003, and (b) the post-rehabilitation flow monitoring conducted during the winter of 2003/2004 for the I/I pilot project basins.

Reference Chapter:

Chapter 8 – Rehabilitation Effectiveness

Author:

Abraham Araya, King County

See also:

- *2000/2001 Wet Weather Flow Monitoring, May 2001*
- *2001/2002 Wet Weather Flow Monitoring, June 2002*

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Section 1 - Equipment Summary

Three types of open-channel flow meters from Marsh-McBirney, Inc. and ADS Environmental Services (ADS) were installed and used during the 2002/2003 (pre-rehabilitation) and 2003/2004 (post-rehabilitation) monitoring periods. The flow meter technology of each type of meter used during the pre- and post-rehabilitation periods is summarized below based on information gathered from the manufacturer (or vendor) of the respective meter type. Detailed information on meter specifications and/or accuracy is tabulated in Table D-1.

1.1 ADS Environmental Services Model 3600/01 Flow Meter

The ADS 3600/01 flow monitoring system uses a combination of depth and velocity sensors and a data logger (monitor) to measure flow.

Depth is measured using an ultrasonic sensor and a pressure sensor. The ultrasonic sensor is mounted at the crown of the pipe and consists of four separate transceiver crystals, with each crystal capable of transmitting and receiving ultrasonic signal. It calculates the depth of flow by transmitting and receiving sound waves from the top of the pipe to the water surface (the range) and measuring the time elapsed between transmission and reception of the signal. This sensor only measures depth of flow (DOF) up to full pipe capacity.

The pressure sensor is often mounted at the bottom of the pipe and can measure depths of flow greater than full pipe. This sensor contains a differential pressure transducer that transmits an output voltage corresponding to the difference between the water pressure and the air pressure in the sewer pipe. The depth board in the monitor calculates the depth of flow based on the difference in pressures.

The Doppler velocity sensor has two ultrasonic crystals and is mounted at the bottom of the pipe. The transmitting crystal sends ultrasonic sound waves at a specific frequency upward into the flow. The receiving crystal then receives sound waves that have been reflected by particles in the flow. The change in the sound waves' frequency from transmission to reception is used to determine the velocity of the flow based on the Doppler effect principle. The Doppler velocity sensor measures the peak velocity that must converted to an average velocity for flow calculation. Average velocity is calculated from the peak velocity using average-to-peak ratios (Av/Pk) and gain values calculated from velocity profiles performed during monitoring.

FieldScan and Profile, ADS proprietary software packages, are used to configure and activate meters, collect data, perform diagnostic procedures, and for data review/analysis.

1.2 Marsh-McBirney Flo-Tote Models 260 and 3000

The Marsh-McBirney Flo-Tote models are electromagnetic area/velocity flow meters that measure both velocity and level using a single probe. Both velocity and level sensors are housed in one probe, which is installed at the bottom of the pipe. The Model 3000 (FT3) meter has a sensor that can be disconnected and a logger, which is interchangeable with the Model 460 Flo-Dar sensors. The Model 260 (FT2) meter has a system where the sensor and logger are one unit.

The open channel sensor utilizes Faraday's Law of Electromagnetic Induction to measure velocity of the water in the pipe. The sensor generates an electromagnetic field, creating a voltage in the water. The magnitude of the voltage is directly proportional to the velocity of the water. The velocity electrodes on the top of the sensor measure this voltage, which is then translated into velocity of the water. Average velocity is calculated from the sensed velocity using site calibration coefficients calculated from velocity profiles performed during monitoring.

The level or depth of water is measured using a piezo resistive differential pressure transducer located in the sensor. The transducer is an electronic device that uses a thin diaphragm to convert pressure to an electronic signal. The level is calculated using the difference between the water and air pressure (also read by the transducer) readings.

1.3 Marsh-McBirney Flo-Dar Models 460

The Flo-Dar unit combines digital Doppler radar velocity sensing technology with ultrasonic pulse echo and a pressure transducer to measure open channel flow. The data from the sensors are stored in a data logger connected to the sensor. The sensor is mounted slightly above the top of the pipe being measured and can withstand being submerged during surcharged conditions.

The water velocity is determined much the same way that radar guns measure the velocity of an automobile or a baseball. The radar beam is transmitted from the sensor at a defined angle to the flow surface. The sensor measures the surface velocity of the water by determining the shift in frequencies between the transmitted and received signals (reflected from the surface). The sensed surface velocity is converted to average velocity using empirical equations or algorithms embedded in the sensor. The radar velocity sensor does not work once the sensor is submerged in the water.

A pulse echo, look-down, ultrasonic transducer in the sensor unit is used to measure the depth of flow (or level of fluid). When the fluid level rises higher than 4 inches below the ultrasonic transducer, the depth of flow is determined using the pressure transducer. Flo-Ware, a proprietary software package, is used to configure and activate meters, collect data, and to perform diagnostics and data review/analysis.

Section 2 - Uptime Percent Summary

There were data losses during the 2002/2003 (pre-rehabilitation) and 2003/2004 (post-rehabilitation) monitoring periods. The data losses (and data gaps) ranged in duration from less than 1 day to a little over 3 weeks during the pre-rehabilitation monitoring period and from about 1 day to about 1 week during the post-rehabilitation period.

The probable reasons for the data loss are discussed in Chapter 8 and include: (a) mismatches in computer software versions between the flow meter and the computer used for data downloading, (b) low battery voltages, and (c) meter "lock up" during field verifications.

Firmware and software incompatibility can cause corrupt files that eventually lock up the meter and cause communication errors when downloading data. To "unlock" the meter, a new site set up must be sent. This process clears or deletes any data in a unit's memory. Battery-related problems include low voltages or loss of power due to loosening of the main battery contacts when the unit is pulled and laid on its side during data download. If the battery is not secured inside the compartment, the connection between the data logger and sensor is lost, resulting in no data recorded.

Some of the observed data gaps in the flow data are the result of editing out (or flagging) poor quality data from the final flow calculation.

Tables D-2.1 and D-2.2 contain tabulated information on data gap periods at specific monitoring sites and the main reasons for the observed data losses and gaps in the final flow calculation.

Section 3 - Field Verification Procedures

As briefly discussed in Chapter 8, field verifications were performed to finalize the data and calculate flow quantity.

Field verification included manually measuring depth, velocity, and flow quantity at the monitoring site and comparing these readings with real-time readings from the meter. Field verifications were used to independently verify the accuracy of the flow meters and to generate depth-velocity relationships and variables that could be used in flow calculations (example: site coefficients for Marsh McBirney Flo-Tote meters, velocity multipliers for Flo-Dar meters, and average-to-peak ratios [Av/Pk] for ADS meters). Field crews descended into the manhole to take the manual measurements.

The type of field verification performed depended on the monitoring site conditions. A complete velocity profile was performed at sites where depth of flow was greater than 5 inches and remained relatively constant, and flow was stable. For sites with depths of flow between 2 and 5 inches, a peak velocity and depth (PVD) verification was performed. Weir verifications were performed at sites where the depth of flow was less than 2 inches. Flow quantities were verified using a volumetric weir.

A velocity profile was performed at sites where the depth of flow was greater than 5 inches. Velocity profile information allowed average velocity to be determined in order to calculate Av/Pk ratios (ADS meters), site coefficients (Flo-Tote 2 and 3), and velocity multipliers (Flo-Dar) for use in flow calculations. When performing a velocity profile, velocity readings were taken with a portable velocity meter at set depths of flow. PVD readings were performed before and after a velocity profile.

PVD verification involved taking manual field measurements and then comparing these values with meter readings taken within a few minutes of the manual readings. Once a field crew member entered the manhole, meter readings were taken by "firing" the sensors. The field measurements were then taken immediately (or within a few minutes) following the meter measurements. Once the field crew member positioned himself/herself where the flow was unobstructed, depth was measured (where the flow was deepest) to the nearest 1/8 inch. The depth could be measured in two ways. The first involved placing the measuring stick or ruler directly in the flow at the appropriate location in relation to the pipe and the sensor, and taking the readings (DOF). The second method involved placing the measuring stick (or ruler) at the face of the ultrasonic sensor (for ADS meters and Flo-Dars) or at the crown of the pipe and measuring the air gap from these locations down to the water surface (air DOF). For sites with sediment/silt accumulation, the depth of silt was measured and recorded. Once the depth measurement was taken, peak velocity was measured by scanning through the flow with a portable velocity meter. The manually measured depth and velocity results from the portable velocity meter were recorded on a site calibration form along with the sensor/meter real-time measurement.

Weir verification was performed at flows where manual velocity readings were difficult or impossible due to the shallow DOF. The THEL-MAR Volumetric weir was used to verify flow quantity at shallow depths. The THEL-MAR Volumetric weir is a compounded weir that incorporates the advantage of a 90^{o} V-notch for measuring flow. The V-notch section measures from 57 to 3,700 gallons per day (gpd). The rectangular portion of the weir is capable of measuring (in gpd) up to 35 percent of pipe capacity. Flow rates are indexed on each side of the weir and the calibration lines are in 2-millimeter (mm) (0.0787- inch) increments.

Once the weir was installed, it was leveled using the bubble level mounted at the top of the weir plate. Flow rates were read after letting the water back up behind the weir and flow was uniform and stabilized. Instantaneous flow rates were read where the flow surface intersected the calibration lines. Manual readings of the depth of flow (DOF) and peak velocity were taken before installing the weir and after the last weir measurement was taken and the flow stabilized and returned to "normal." A set of three manual and real-time measurements were taken per site (verification) visit.

Once the field verifications were performed, the results were recorded on a site calibration/verification form. Information entered in the site calibration forms included date and time of site visit, site name and meter/sensor serial number, real-time depth and velocity readings, manual depth and velocity readings, silt level, battery level, and site conditions and observed problems.

The error margin for the manual depth measurements was set at +/- 0.13 inches. Some site conditions that could have affected field verification results include velocities greater than 7 feet per second (ft/sec), especially in shallow flow conditions; presence of a pump station upstream of a monitoring site; wavy and surging flow conditions in the monitoring location; and limited bench room and work space in the monitoring location.

Summaries of the field verifications performed during the pre- and post-rehabilitation monitoring periods are shown in Tables D-3.1, D-3.2 and D-3.3.

Section 4 - Data Editing and Finalization Process

As briefly discussed in Chapter 8, raw data collected from the flow meters were reviewed and edited as necessary. Field verifications and site finalization procedures were performed to finalize the data and calculate flow quantity.

Field verifications were used to independently verify the accuracy of the flow meters and to generate depth-velocity relationships and variables that could be used in flow calculations.

The process of site finalization included re-measuring the pipe dimensions, measuring any silt accumulation in the pipe, reviewing any unusual hydraulic conditions at a monitoring site, and reviewing and evaluating velocity parameters including gain, average-to-peak ratios, site coefficients, and velocity multipliers. Measuring the silt level was very important because any sediment in the pipe would displace the flow (artificially raising the DOF) and skew the flow calculations.

The quality and reliability of depth and velocity readings from flow meters determined the accuracy and reliability of the resulting calculated flow quantity. Depth and velocity sensors can be affected by local hydraulic conditions at the monitoring site and can give erroneous or invalid readings. Some of the factors contributing to poor quality depth and/or velocity data can include:

- Slow and sluggish flows (2 ft/sec velocity) contributing to sensor fouling
- Downstream blockage, and possibly related upstream surcharges contributing to sensor fouling
- Shallow and fast flows where a slight increase in depth may cause the flow to spray off the sensor/ring assembly and splash onto the ultrasonic sensor (mounted at the crown of the pipe), yielding erroneous depth data
- Non-uniform and poor velocity profiles (in the pipe), resulting in erroneous calculation of average-to-peak ratios, gain values, or velocity multipliers
- Malfunctioning depth and/or velocity sensors
- Very shallow flow conditions where the sensors are unable to sense velocity during such low flow conditions (velocity is forced to zero)
- Incorrect site setups during meter installation or reactivation

Erroneous data included depth and/or velocity "pops" and "drop outs", depth and velocity not showing matching diurnal patterns during normal open channel flow, and shifts in depth indicating a backwater condition unaccompanied by a drop in velocity. Erroneous or invalid data were identified using a scattergraph (x-y plot of depth versus velocity) and hydrograph (time series plot of depth and velocity).

Editing data involved removing and/or correcting unreliable or invalid depth and velocity data. Based on review and analysis of field confirmations, field crew observations during site visits, and historical trend and data consistency with site hydraulics, some of the invalid data was reconstituted or flagged. Flagging is a term applied to removing the invalid data from flow calculations. The terms "data reconstitution," "reconstruction," or "snapping" refer to the process of generating depth-velocity relationships using good quality and valid data to reconstruct poor/erroneous velocity (and in some cases depth) data. These terms are used interchangeably in this report. Reconstituted or snapped data are used in flow quantity calculations.

4.1 Using Scattergraphs and Hydrographs to Review and Edit Data

An x-y plot was used to graph depth and velocity data from meter readings and results from field verifications. This scattergraph technique of data evaluation and reconstitution is based on a definable depth-velocity relationship and the theoretical Manning pipe curve, which predicts that in open channel gravity flows, there is a predictable velocity for every depth of flow. For a properly functioning meter, the depth and velocity readings should fall on or around the pipe curve. Depth and velocity field confirmations were plotted on the depth-velocity scattergraph and were compared to meter readings to verify that the meter was functioning properly.

Hydrographs are time series plots showing depth and velocity (and flow quantity if desired). Hydrograph plots can be used to identify and edit erroneous/invalid depth and/or velocity data.

Scattergraph and hydrograph plots can show repeatability of the measured data, provide information on the steadiness of the flow, and show significant hydraulic changes such as backwater conditions and flow increase due to rain events. Scattergraphs and hydrographs can also be used to reconstruct or snap erroneous/invalid data when supported by field confirmations and well-established depth-velocity relationships, or to flag erroneous/invalid data when there is not enough justification to reconstruct or snap the data.

The following examples show how invalid data were identified, flagged, and in some cases snapped (to curve) using hydrograph and scattergraph plots. The example below shows how changes in hydraulic conditions were identified using a combination of hydrograph and scattergraph plots.

4.1.1 Invalid Depth Data

Figure 4.1 illustrates how invalid depth was identified and flagged on a hydrograph. Depth and velocity showed repeated diurnal patterns with velocity increasing with an increase in depth. Around 11/25/03, depth values spiked without any significant and matching increase in velocity. There were no rain events on 11/26 and 11/27, but the depth of flow spiked to depths of flow close to that observed during the significant rain events on 11/18 and 11/19/03. Although there was a rain event on 11/28, the effect was masked by the invalid depth data before and after this rain event. The invalid data were flagged and were not used for flow quantity calculation.

Figure 4.1- Hydrograph of Invalid Depth Data Due to Sensor Fouling

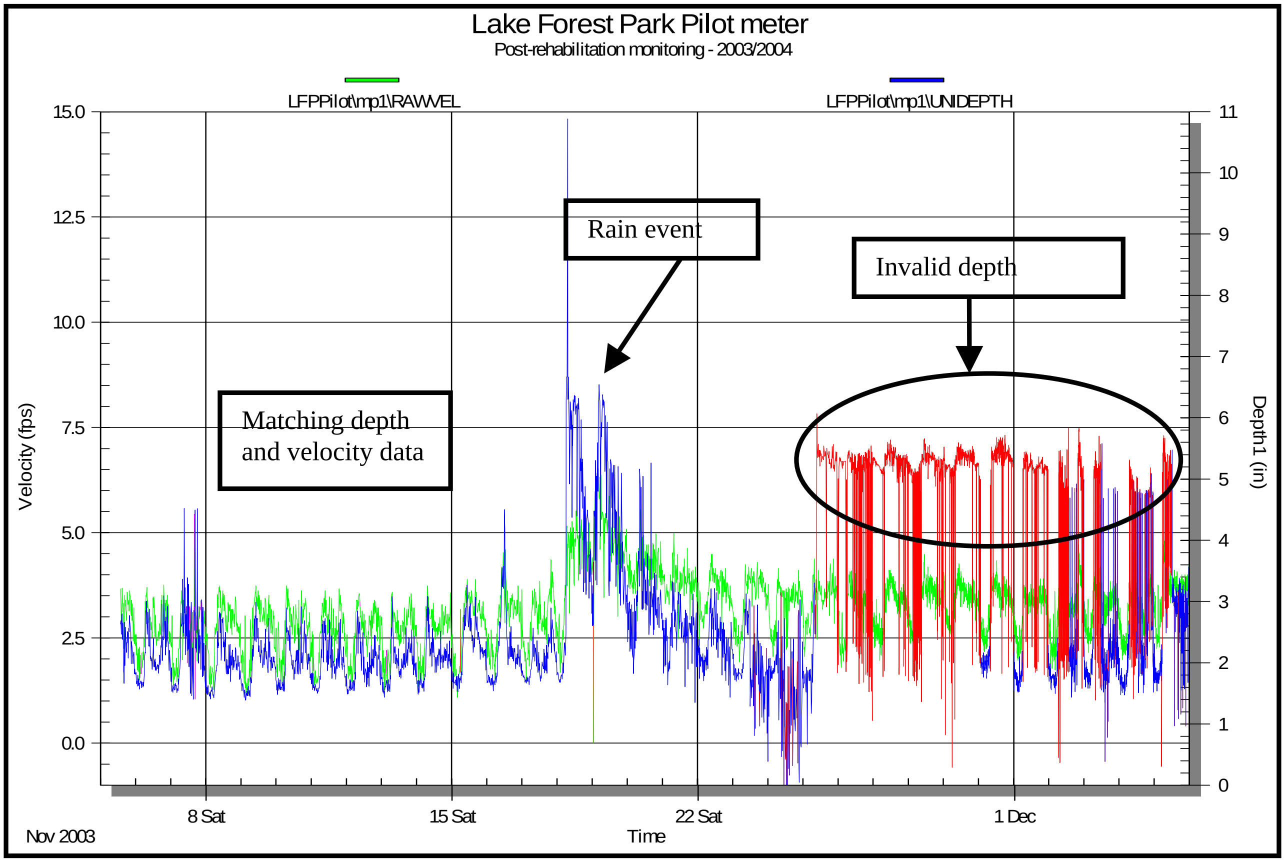


Figure 4.2 is a scattergraph showing invalid and flagged velocity data. In this graph there are some depth data that show ultrasonic depth values at full or near full pipe heights. During such periods where the ultrasonic depth sensor indicated surcharge conditions, depth data from the pressure sensor was used to calculate flow quantity. Figure 4.3 is a scattergraph plot with velocity on the x-axis and depth on the y-axis, showing the flagged depth data illustrated in Figure 4.1. Field verification data are also plotted on this scattergraph.

Figure 4.2 - Scattergraph of Invalid Velocity Showing Open Channel Flow and Backwater and Surcharged Conditions

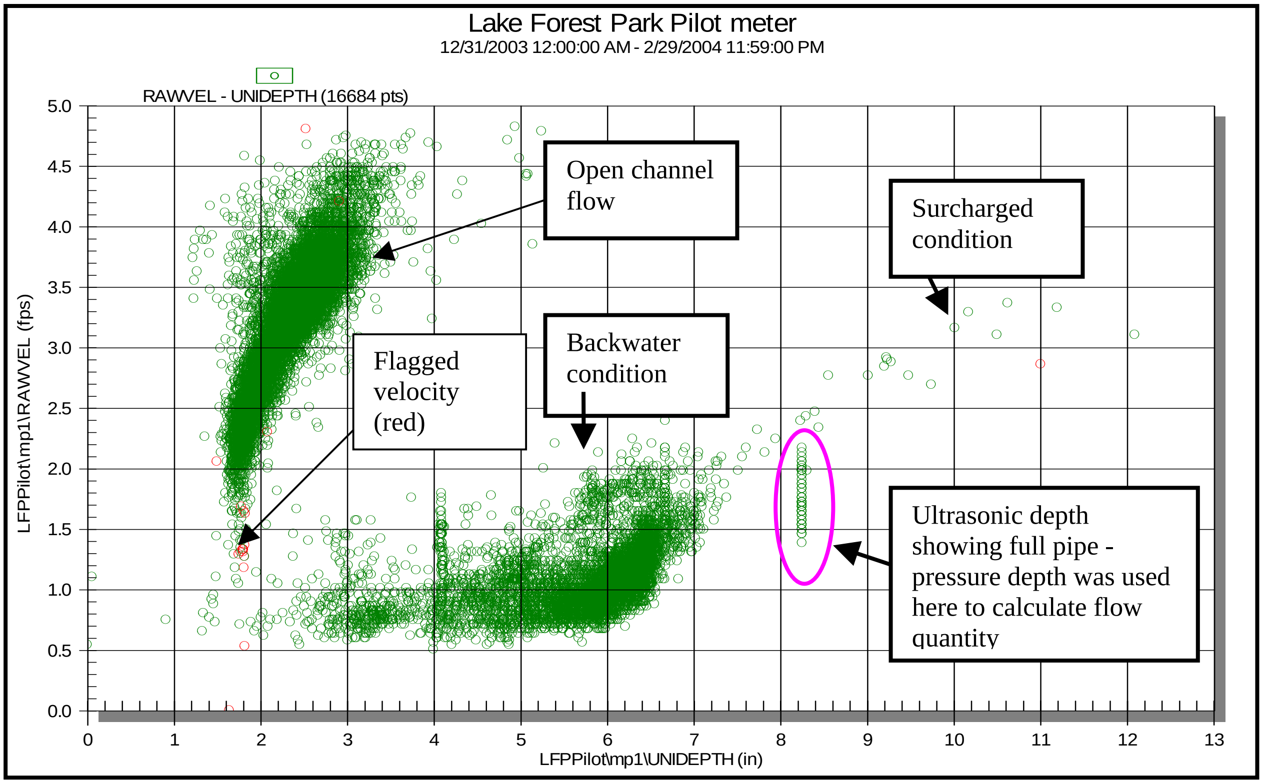
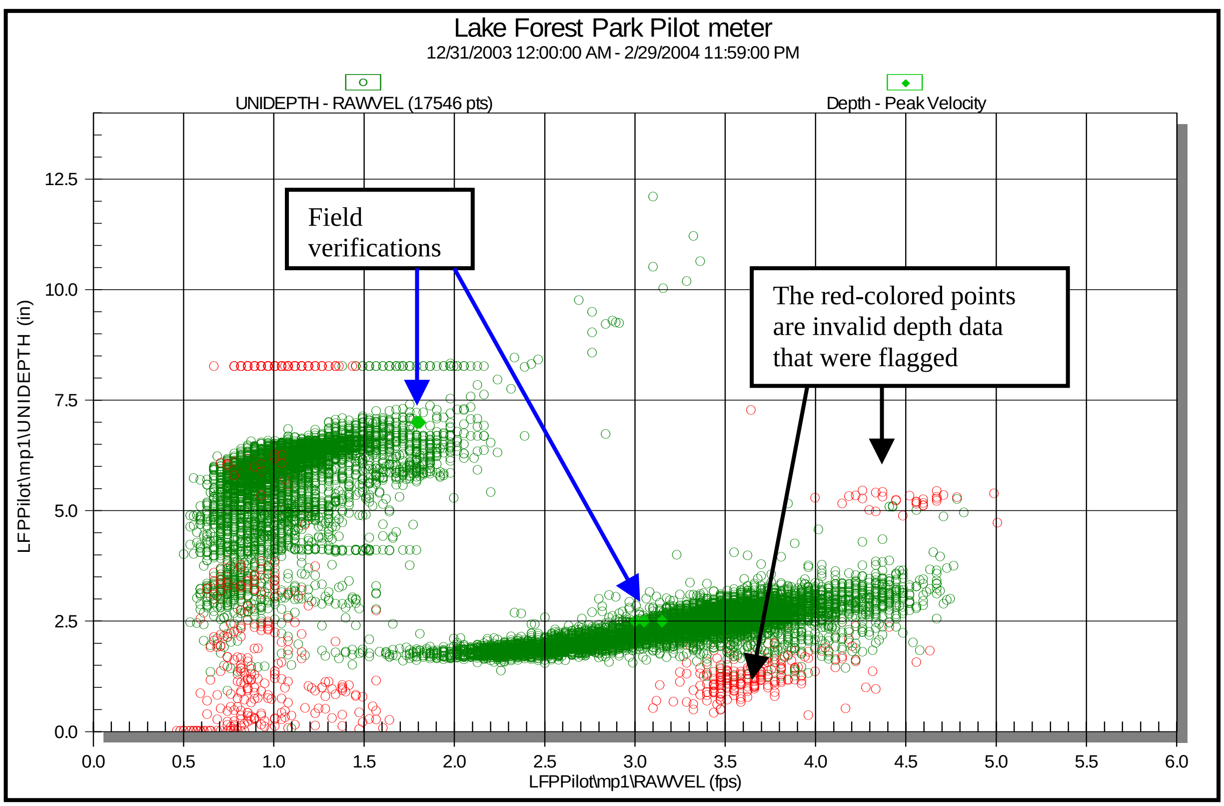


Figure 4.3 - Scattergraph of Invalid Depth Data

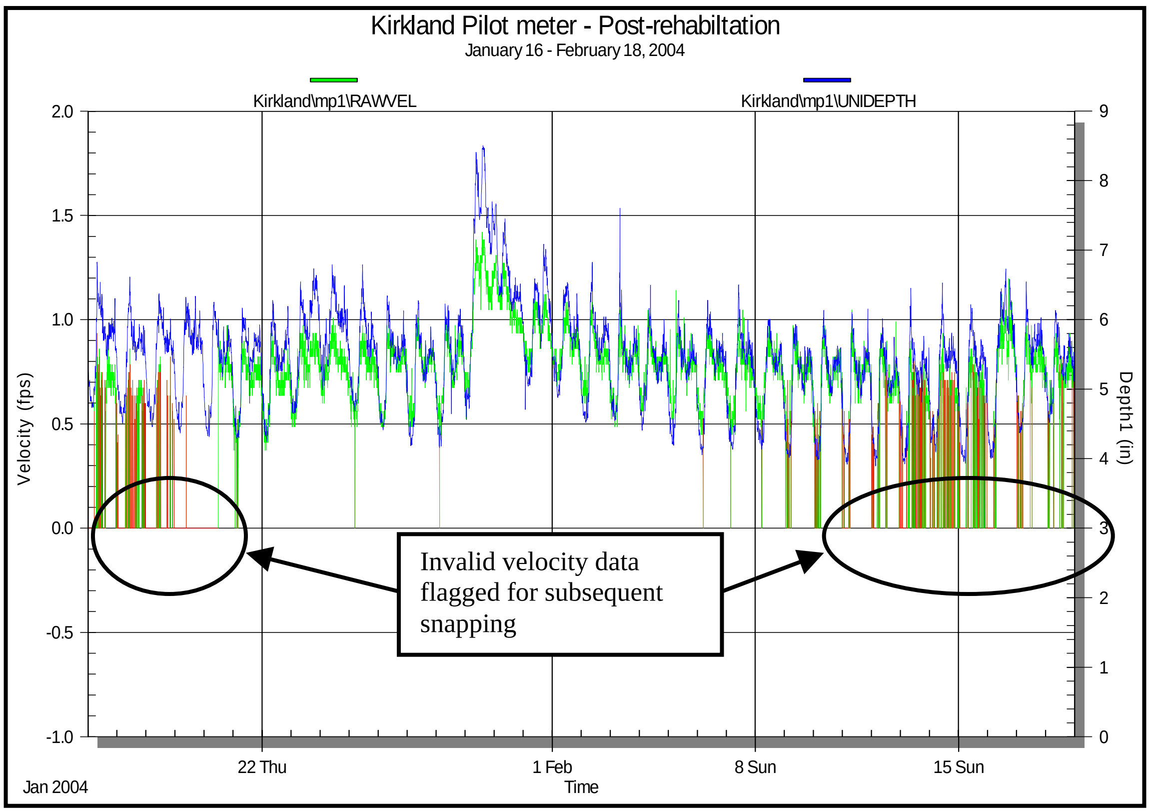


4.1.2 Invalid Velocity Data and Data Reconstitution

Figures 4.4 to 4.7 illustrate how invalid velocity data were identified, selected, flagged, and reconstituted. Figure 4.4 shows good depth and velocity data, with some velocity data occasionally dropping to zero. This is a relatively deep (4 to 6 inches DOF) and slow (less than 1 ft/sec for the most part) site. There were no depth dropouts corresponding to the observed velocity dropouts. The velocity dropouts could be the result of debris covering the sensor.

Once the invalid velocity data was identified, these data points could either be flagged (i.e., removed from further flow quantity calculation) or reconstituted based on a well-developed depth-velocity relationship at the monitoring site. The hydrograph in Figure 4.4 and scattergraph in Figure 4.5 indicate that the depth-velocity data at this site were repeatable and regular (open channel flow), satisfying the main requirement of the data reconstitution (or reconstruction) process. As shown in Figure 4.5, a best-fit curve was drawn through the depth-velocity data and tolerance limits were set.

Figure 4.4 - Hydrograph of Invalid Velocity Data



Invalid velocity data were selected (blue box in Figure 4.5) and reconstituted based on the tolerance limit and location of the invalid data (above and/or below, or within the tolerance limit). In the example shown in Figure 4.5, invalid data only below the tolerance limit were reconstituted (or snapped to curve). Figures 4.6 and 4.7 show the reconstituted velocity data in hydrograph and scattergraph plots, respectively. Reconstituted velocity data are presented as magenta colored data points on these graphs.

Figure 4.5 - Scattergraph of Invalid Velocity Data, Best-Fit Curve, and Tolerance Limits Set for Data Reconstitution

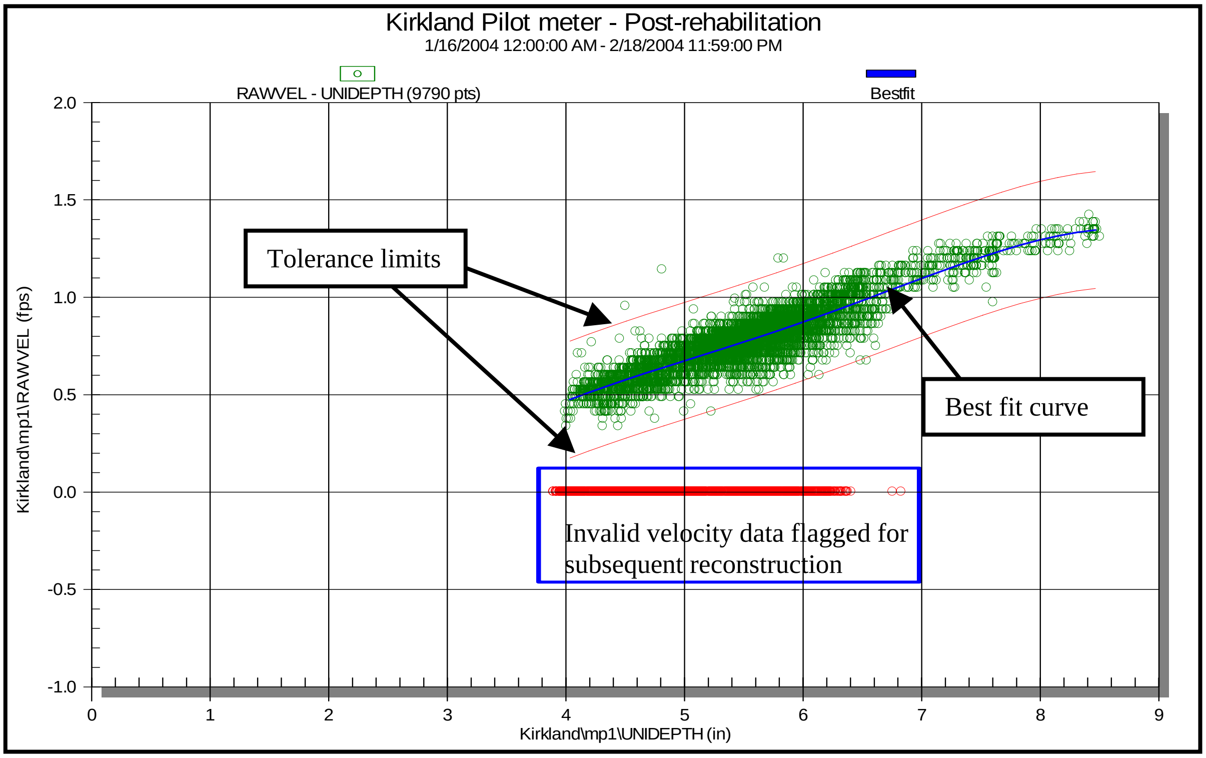


Figure 4.6 - Hydrograph of Reconstituted Velocity Data

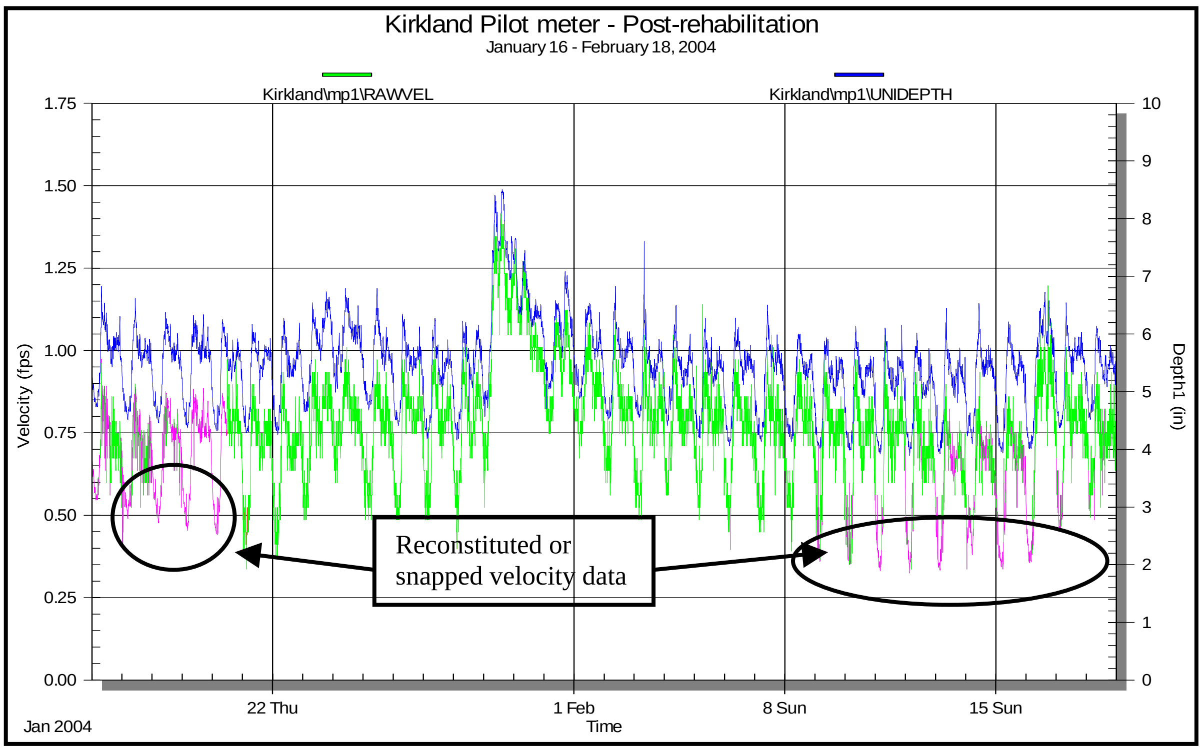
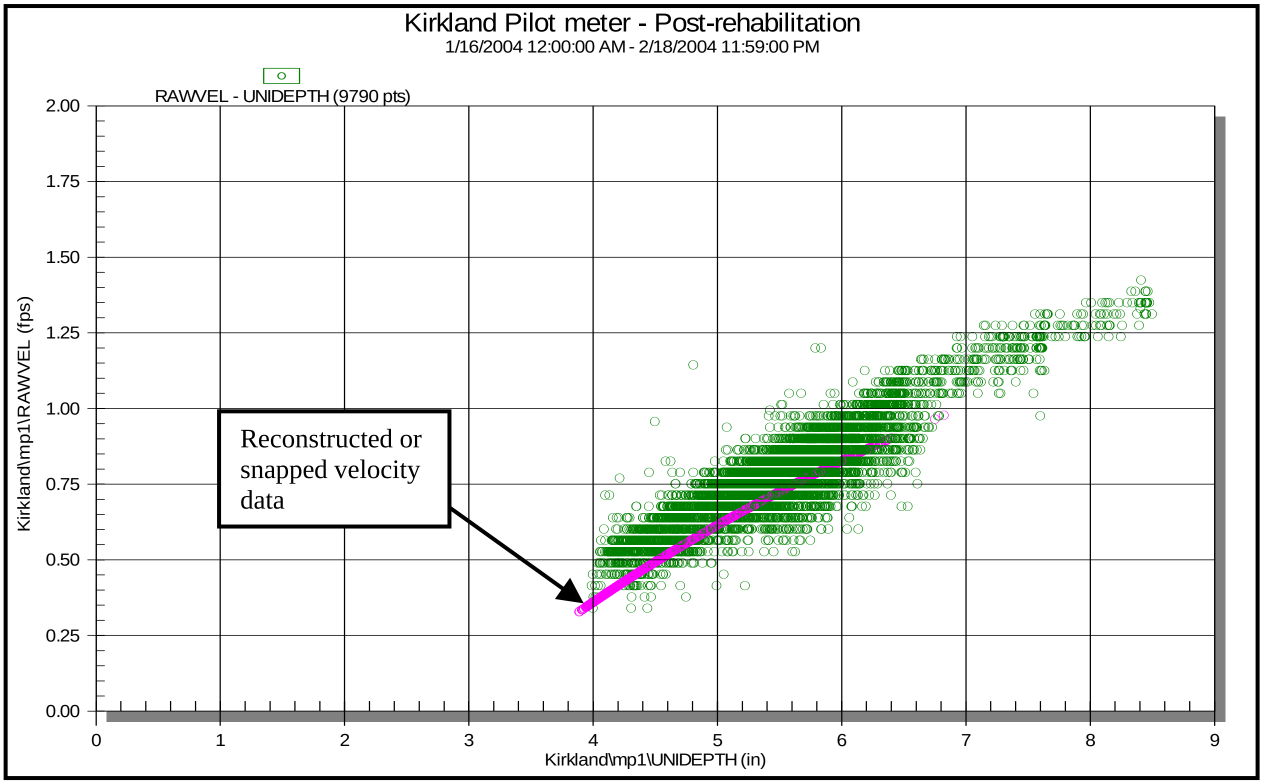


Figure 4.7 - Scattergraph of Reconstituted Velocity Data

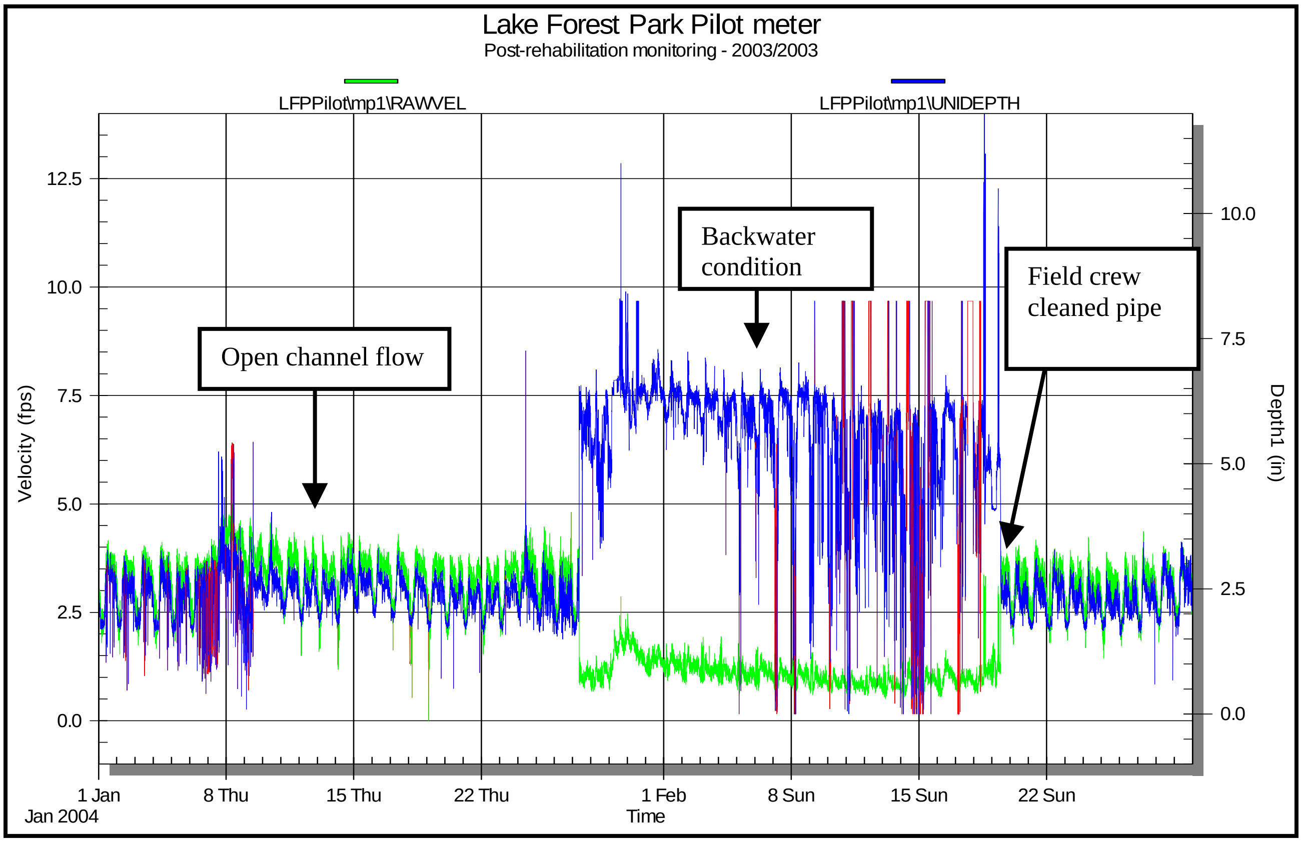


4.1.3 Identifying Unusual Hydraulic (Non-Open Channel Flow) Conditions

In addition to identifying and editing invalid depth and velocity data, hydrograph and scattergraph plots can be used to identify unusual hydraulics or changes in hydraulic at a monitoring site.

When the raw flow data from the Lake Forest Park Pilot Project site were reviewed, it was noted that the flow changed significantly around 1/27/04. Prior to 1/27/04, depth and velocity patterns showed a regular and repeatable pattern where increase or decrease in depth was accompanied by increase or decrease in velocity. Depth values ranged from 1.5 to 2 inches and velocity varied from about 2 to 4 ft/sec during the dry day periods. After 1/27/04, the site became deeper (4 to 7.5 inches) and slower (velocity less than 2 ft/sec). Depth and velocity varied inversely. The field crew performed a manhole investigation on 2/19/04 and found that there was a huge accumulation of trash and rags blocking the flow in the downstream side of the pipe. This temporary blockage backed up the flow, increasing the depth and decreasing the velocity. Field verification was performed during the high flow condition, then the crew removed the blocking debris. Flow returned to normal open channel flow. Figures 4.8 and 4.9 illustrate how changes in hydraulic conditions were identified using a combination of hydrograph and scattergraph plots.

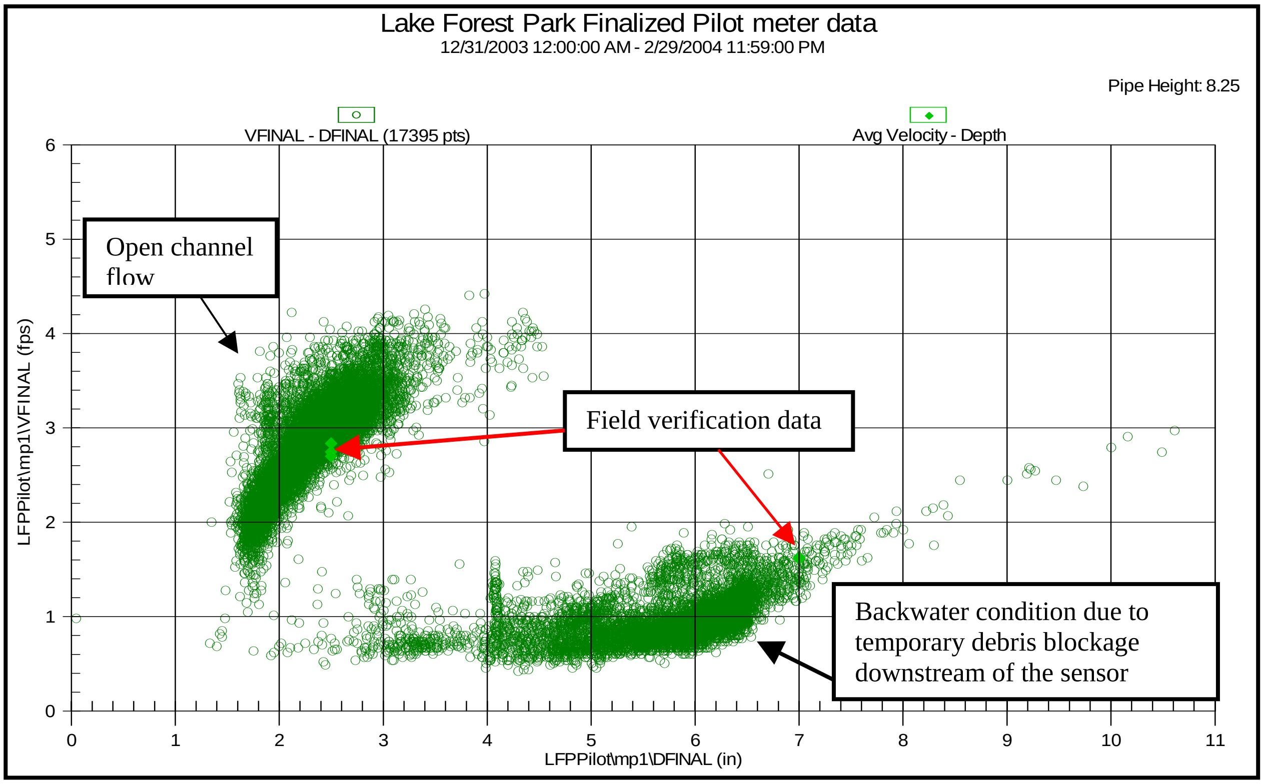
Figure 4.8 - Hydrograph Illustrating Backwater Conditions due to Temporary Debris Blockage and Invalid Depth Data (In Red)



4.2 Using Scaling and Scrubbing Factors to Edit Data

Review of flow data collected during the 2000/2001 and 2001/2002 flow monitoring periods indicated that the flow data from the Mercer mini-basin meter might not have been reliable during peak flow times. This was verified by performing a flow test on 3/19/03. During the test, a relatively constant flow of hydrant water was added to the system. Although the flow was maintained at a relatively constant rate, the pipe surcharged and the measured flow increased from about 0.4 to 0.9 mgd. The site exhibited backwater conditions at depths greater than approximately 3 to 3.5 inches (0.4 to 0.5 mgd) caused by flow restrictions associated with the downstream manhole and/or the Lake line. The test data indicated that during such surcharge events the flow meter was calculating flow in excess of what was actually being conveyed by the system, and that flow data collected during storm events when the system surcharged were unreliable.

Figure 4.9 - Scattergraph Illustrating Backwater Conditions due to Temporary Debris

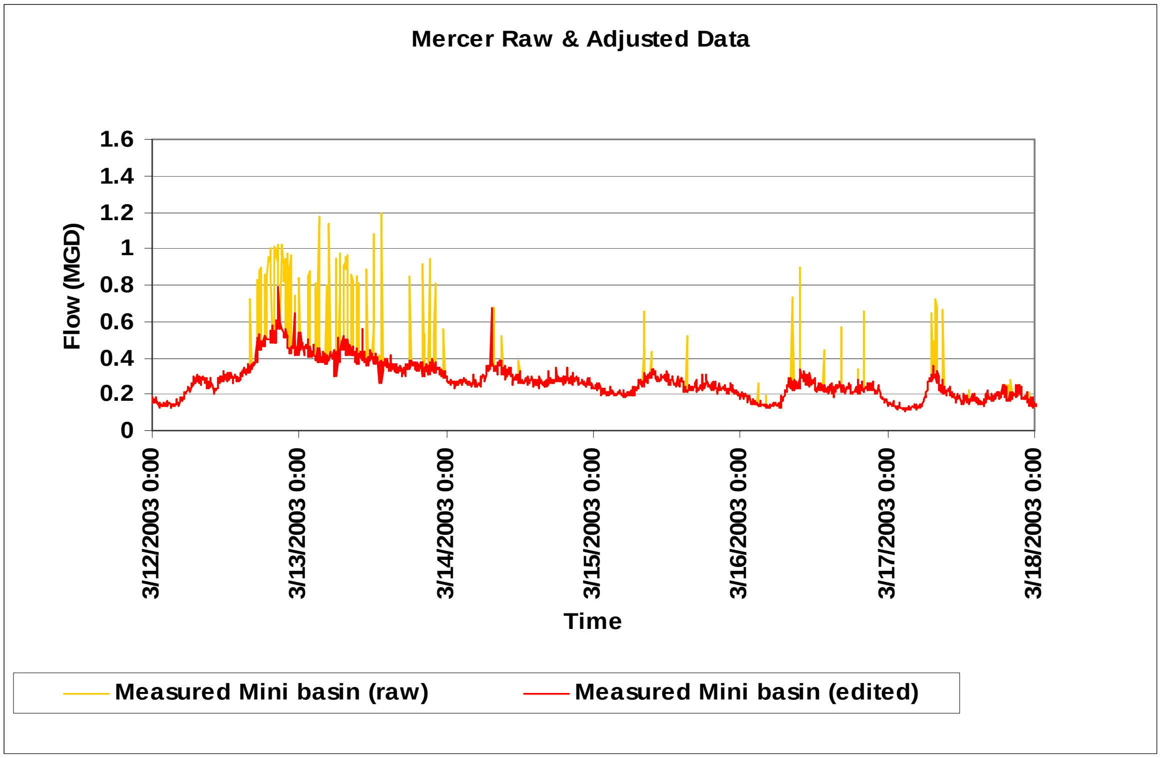


Two approaches were used to estimate the peak flows at the Mercer mini-basin meter during the 2002/2003 and 2003/2004 flow monitoring periods

4.2.1 Scrubbing Factor Approach

A scrubbing routine was established based on the results of the flow test conducted on 3/19/03 and the peak-to-minimum-value ratios in a 50- to 60-minute span during rain events when the system surcharged. This routine established an empirical limit of 150 percent to make the peak flow data consistent with what was observed/measured during the calculation window. If the measured peak was greater than the minimum value (in the 1-hour span) by more than 150 percent, it was rejected and substituted with the minimum value. Otherwise, the recorded value was kept as valid data. Figure 4.10 illustrates the results of this procedure. This approach was used to edit spikes of shorter duration (less than 1 hour) during the 2002/2003 and 2003/2004 flow monitoring periods.

Figure 4.10 - An Example of Data Scrubbing



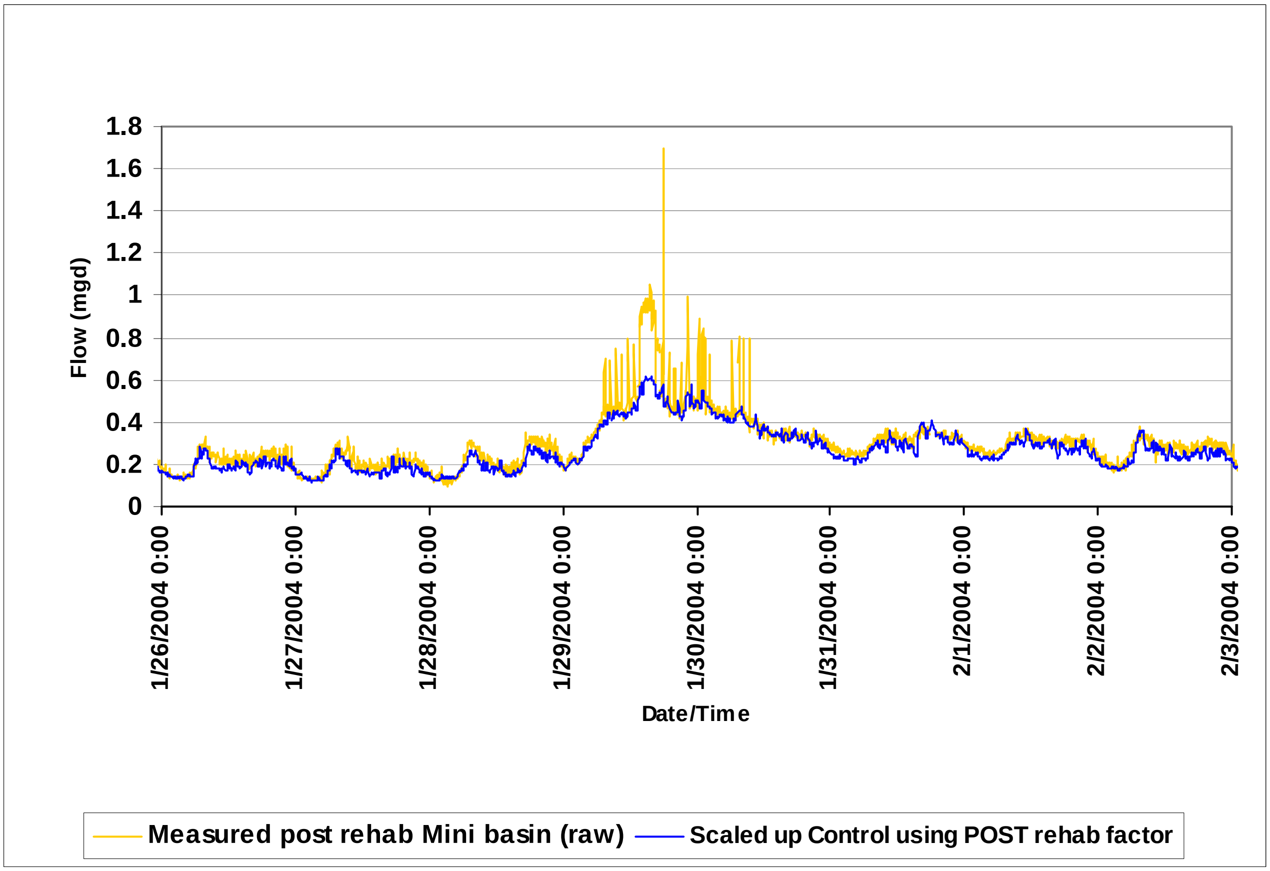
4.2.2 Scaling Factor Approach

The scaling factor approach was used to estimate the peak flows (during surcharged conditions) at the Mercer Island mini-basin meter (MRC012 2001/2002) using measured flow from the Mercer Island control basin. The flow from the control basin made up about 26 percent of the total flow measured at the mini-basin (for the 3/5 to 4/11/03 time period used to generate the scaling factor). Using this relationship, the measured control basin flow was scaled up to simulate the mini-basin flow and was then compared with the measured mini-basin flow. The measured mini-basin flow was edited to remove erroneous/invalid data prior to comparison. An average scaling factor of 4.28 was calculated using this approach. This scaling factor was a better fit for wet weather than dry weather flow data.

The percent relative difference between the average "scaled up" control basin flow rate and the average measured mini-basin flow rate for the 3/5/03 to 4/11/03 time period was 5.33 percent. That is, for the time period used, the average "scaled up" control basin flow rate was 5.33 percent higher than the average measured mini-basin flow rate. When individual rain events were considered, the relative difference dropped almost by half (-2.58 percent for the period 3/12/03 to 3/13/03 and 2.41 percent for the period 3/20/03 to 3/23/03). The percent relative difference was calculated as *% relative difference = [(Scaled up flow - Measured mini-basin flow)/Measured mini-basin flow] X 100*. The low percent relative difference between the scaled up and the measured flows demonstrates that it was possible and reasonable to accurately estimate the peak flows (during surcharged pipe conditions) at the mini-basin monitoring site using this approach. For comparison purposes, it is important to note that various submerged area/velocity flow meters, non-contact area/velocity meters, and flumes and volumetric weirs have an overall flow measurement accuracy of +/- 5% (of the reading). Depending on the monitoring site hydraulics and/or existing flow conditions, the actual accuracy values may be lower or higher than the manufacturer's stated accuracy values.

Due to rehabilitation work done in the Mercer mini-basin during the 2003/2004 post-rehabilitation monitoring period, the scaling factor was recalculated (3.069) using post-rehabilitation flow data. The scaled-up control site data were used to replace mini-basin peak flow data only during rain events when the pipe was in a surcharged condition and the peaks were of longer duration (more than 1 hour). For smaller duration peaks, the scrubbing approach was used. Figure 4.11 shows a comparison of the raw mini-basin data and the mini-basin flow data generated by using the scaling approach.

Figure 4.11 - Mercer Mini-Basin Data Scaled Up Using the Post-Rehabilitation Control Site Data and Post-Rehabilitation Scaling Factor



Section 5 - Data Quality Summary

Subjective or qualitative quality rating criteria were established and used to classify data quality into three classes: Poor, Fair, and Good. A data loss rating was also established based on the amount of data loss/gap or uptime percentage. Tables D-5.1a and D-5.1b list the criteria used for these classifications.

Tables D-5.2 and D-5.3 summarize the data quality during the pre- and post-rehabilitation flow monitoring periods. In these tables, a general summary of the data review is provided. Where applicable, data adjustments done at a particular site are also included in the data review summary. Qualitative description of the data quality is provided in order to put a level of confidence on the collected data.

As discussed in Section 4, quality and reliability of depth and velocity readings from the flow meters determine the accuracy and reliability of the resulting calculated flow quantity. Plotting depth and velocity data from the meters along with field verification results can show the reliability of the measured data.

It may be difficult to assign a certain level of confidence to flow data based only on the quality of the data collected. Other factors, including how well the flow balances between upstream and downstream sites, may also need to be taken into consideration. For example, the Kirkland control and pilot monitoring sites produced fair to good quality flow data. Minimal editing was performed and some adjustments to the raw flow data were done based on field observations and verifications. When flow from the upstream (control meter) and the downstream (pilot meter) sites were compared, the net flow at the downstream site was found to be very small. This may indicate that either the flow contribution from the downstream basin was very little or the flow data at either one of the sites may be suspect. This sort of analysis requires investigating the flow schematics in detail and performing a complete velocity profile. Unfortunately, performing a complete profile requires higher flows than those observed at these sites during most of the monitoring period.

List of Tables

Table D-1 - Summary of meter specifications

Manufacturer/Vendor	**ADS Environmental Services (ADS)**	**Marsh-McBirney, Inc**	**Marsh-McBirney, Inc**	**Marsh-McBirney, Inc**	**Marsh-McBirney, Inc**
Flow meter model	3601	Flo-Dar 460	Flo-Tote 3	Flo-Tote2 (Model 260)	Flo-Mate 2000 Velocity meter
Velocity Sensor					
Type	Peak velocity, Doppler	Radar	Electromagnetic (Faraday's Law)	Electromagnetic (Faraday's Law)	Electromagnetic (Faraday's Law)
Range (feet/sec)	- 5 to + 20	0.75 to 20	-5 to + 20	-20 to + 20	-0.05 to + 20
Resolution (feet/sec)	0.04	N/A	0.01	0.01	
Accuracy	0 to 5 feet/sec, accuracy = 1.0% of full scale (20 feet/sec) 5 to 10 feet/sec, accuracy = 1.5% full scale (20 feet/sec) 10 to 15 feet/sec, accuracy = 3.5% full scale (20 feet/sec)	± 0.5% of reading ± 0.1 feet/sec	± 2% of reading, ± 0.05 zero stability at 0 to + 10 ft/sec	± 2% of reading ± zero stability	± 2% of reading plus zero stability
Repeatability	N/A	N/A	N/A		
Zero Stability	N/A	N/A	± 0.05% feet/sec	± 0.05% feet/sec	± 0.05% feet/sec
Depth Sensor					
Type	Quad redundant ultrasonic	Ultrasonic	Submerged pressure sensor	Submerged pressure sensor	
Range	0 to 96 inches and a dead zone of 0.5 inches	0.25 to 60 inches	0.4 to 138 inches	0 to 138 inches	
Resolution	0.125?	N/A	0.1 inch	± 0.1 inch	
Accuracy	0.125 inches or 0.5% of reading (whichever is greater)	±1% of reading ± 0.25 inches	± 1% of reading		
Repeatability	zero drift	N/A	N/A		
Flow Measurement	N/A	± 5% of reading	± 5% of reading	N/A	
User software (for data retrieval and/or reporting)	Quadrascan; FieldScan; Profile	Flo-Ware	Flo-Ware	Flo-Ware	

N/A = Not available

The information in this table is compiled from "features and specification" materials published by the respective vendor. Any divergence from the published information is not intentional.

Table D-2.1. 2002/2003 Pre-rehabilitation Uptime summary report

METER ID	Start Time	End Time	Total number of days monitored	Uptime (QFINAL)[a]	Significant data gaps	Reason for data loss
Auburn Control	11/4/02 3:20 PM	4/23/03 10:20 AM	169.79	95.77%	data gap 3/17 to 3/23	battery-related problems; monitor malfunction
Auburn Pilot	11/4/02 12:45 PM	4/24/03 10:40 AM	170.91	98.80%		
Auburn Subtraction	11/4/02 1:50 PM	5/1/03 10:25 AM	177.86	92.06%	data gap 12/27/02 to 1/10/03	computer/software/firmware version mismatches and low batteries
Brier Control	11/5/02 11:40 AM	6/21/03 12:05 AM	227.52	80.51%	12/5 -12/6/02*;data gap 2/11 - 2/15/03 & 3/1 - 4/9/03	* = poor depth data flagged; computer/software/firmware version mismatches and low batteries
Brier Pilot	11/5/02 10:05 AM	5/30/03 11:45 PM	206.57	99.50%		
Kent Control	10/31/02 10:00 AM	5/27/03 9:45 AM	207.99	95.41%	data gap 12/31/02 - 1/9/03	battery-related problems
Kent Pilot A	10/30/02 2:30 PM	6/19/03 1:15 PM	231.95	97.72%	3/28 - 4/2/03	battery-related problems
Kent Pilot B	10/31/02 11:30 AM	5/27/03 8:50 AM	207.89	90.74%	data gap 11/13 - 11/18/02; 3/28 - 4/9/03; 5/1 - 5/4/03	computer/software/firmware version mismatches and low batteries
Kirkland Control	11/5/02 1:10 PM	6/17/03 8:50 AM	223.82	98.28%	data gap 1/4 - 1/7/03	battery-related problems
Kirkland Pilot	11/6/02 3:05 PM	7/3/03 12:45 PM	238.91	100.00%		
Mercer Control	11/1/02 9:50 AM	7/21/03 12:40 PM	262.12	97.64%	data gap - 11/18/02 partial; 4/27 - 4/30/03; 5/25 - 5/28/03	battery-related problems
Mercer Mini	3/5/03 10:50 AM	4/20/03 6:55 AM	45.84	95.16%		
Mercer Pilot	10/31/02 1:30 PM	7/21/03 11:35 AM	262.92	87.64%	11/18/02 partial day; 1/1 -1/3/03*; 2/8 - 2/11; 3/12 - 3/26; 4/16-4/29/03**	* = poor depth data flagged;** = computer/software/firmware version mismatches and low batteries
Redmond Control	11/1/02 11:05 AM	7/22/03 8:10 AM	262.88	99.62%	11/18 - 11/19/02 partial day	
Redmond Mini	12/12/02 12:50 PM	6/1/03 7:20 PM	171.27	99.85%		
Redmond Pilot	11/1/02 12:05 PM	7/22/03 9:40 AM	262.90	69.71%	data gaps 12/12/02 - 1/2/03; 1/22 - 1/31/03; 3/11 - 4/2/03; 4/29 - 5/27/03	computer/software/firmware version mismatches and low batteries
Skyway Control	10/29/02 2:30 PM	5/2/03 8:45 AM	184.76	94.60%	data gap 12/23/02 - 1/2/03	battery-related problems
Skyway Pilot	10/29/02 12:45 PM	5/2/03 9:30 AM	184.86	99.98%		
		Average	**205.60**	**94.05%**		

No Uptime	Complete data loss - % good data is <0
Limited Uptime	Partial loss - % good data is > 0 and <80
Perfect Uptime	% good data is > 80

a = Uptime is the percentage of data points that were recorded by a flow meter and considered valid. The Report is based on QFINAL and a 5 minute data interval unless noted

Table D-2.2. 2003/2004 Post-rehabilitation Uptime summary report

METER ID	Start Time	End Time	Total number of days monitored	Uptime (QFINAL)[a]	Significant data gaps	Reason for data loss
Auburn Control	10/8/2003 13:45	2/4/2004 10:10	118.85	98.35%	Data loss : Partial day - 12/29/03; Whole day: 12/30 and 12/31/03	battery-related problems
AuburnPilot	10/27/2003 12:45	2/4/2004 10:25	99.90	98.93%	Data loss : Partial day - 11/16 and 11/17/03	battery-related problems
Auburn Subtraction	10/27/2003 13:30	2/4/2004 11:00	99.90	93.57%	Data loss : Partial day - 11/25*, 11/26*, 12/24, and 12/29/03; Whole day: 12/25 - 12/28/03.	* = meter pulled for MH construction to seal leak; battery-related problems
Brier Control	12/1/2003 14:30	2/6/2004 12:15	66.91	99.92%		
Brier Pilot	12/16/2003 9:25	2/6/2004 12:10	52.11	99.93%		
Coal Creek Control	10/31/2003 10:40	2/4/2004 11:25	96.03	99.97%		
Coal Creek Pilot	12/15/2003 10:50	2/4/2004 11:40	51.03	99.67%		
Kent Control	10/9/2003 9:00	3/8/2004 9:10	151.01	99.93%		
Kent Pilot A	1/16/2004 11:35	3/8/2004 8:45	51.88	82.90%	Data loss : Partial day - 2/2 and 2/11/04; Whole day: 2/3 - 2/10/04	battery-related problems; logger/sensor malfunction
Kent Pilot B	1/16/2004 12:35	3/8/2004 9:45	51.88	82.51%	Data loss : Partial day - 2/17 and 2/16/04; Whole day: 2/18 - 2/25/04	battery-related problems; logger/sensor malfunction
Kirkland Control	10/7/2003 12:35	2/4/2004 14:05	120.06	99.97%		
Kirkland Pilot	10/9/2003 14:15	2/4/2004 13:35	117.97	99.94%		
Lake Forest Park Control	11/3/2003 14:20	2/6/2004 9:20	94.79	98.26%		
Lake Forest Park Pilot	11/5/2003 13:45	2/6/2004 10:15	92.85	91.96%	Data loss : Partial day - 11/25, 11/30-12/12, and 12/4-12/5/03; Whole day: 11/26 - 11/29/03. The LFP Pilot meter was collected using a 15 minute data collect interval 11/5/03 to 12/05/03. The interval is 5 minutes after 12/05/03. The uptime report is generated using the 15 minute average.	Poor quality depth data flagged
Mercer Control	10/7/2003 11:40	2/4/2004 13:15	120.07	99.95%		
Mercer Mini	10/21/2003 11:00	2/4/2004 12:55	106.08	99.91%	The Mercer Mini meter was collected using a 15 minute data collect interval 10/21/03 to 11/25/03. The interval is 5 minutes after 11/25/03. The uptime report is generated using the 15 minute average.	
Mercer Pilot	10/20/2003 10:25	2/4/2004 12:50	107.10	94.37%	Data loss : Partial day - 11/18 and 11/24/03; Whole day:11/19 - 11/23/03.	Contractor removed meter for line cleaning (with out notifying KC crew).
Northshore Control	10/31/2003 12:45	2/6/2004 11:20	97.94	99.39%		
Northshore Pilot	12/15/2003 13:10	2/6/2004 10:30	52.89	99.98%		
Redmond Control	11/21/2003 10:45	3/2/2004 13:20	102.11	99.96%		
Redmond Mini	10/21/2003 12:40	3/2/2004 12:55	133.01	99.80%		
Redmond Pilot	12/1/2003 12:45	3/8/2004 11:50	97.96	99.94%		
Ronald Control	10/31/2003 14:50	2/26/2004 14:55	118.00	99.99%		
Ronald Pilot	10/22/2003 13:40	2/26/2004 14:30	127.03	81.47%	Data loss : Partial day - 11/03, 11/13-11/14, 11/18-11/19, 11/25, 12/5, 12/22, and 12/30/03, 1/7 and 1/9/04 ; Whole day: 11/26 - 12/04, 12/23 - 12/29/03 and 1/8/04. **Flo-Dar after 1/9/04 (ADS meter before 1/9/04)**	Poor quality depth data flagged
Skyway Control	10/6/2003 11:25	2/2/2004 10:00	118.94	99.95%		
Skyway Pilot	10/9/2003 10:30	2/2/2004 9:45	115.97	99.95%		
Val Vue Control (017)	10/31/2003 9:30	2/17/2004 13:15	109.16	97.65%	Data loss : Partial day - 12/29/03; Whole day: 12/30 - 12/31/03	battery-related problem
Val Vue Pilot (019)	10/22/2003 11:05	2/17/2004 13:30	118.10	97.89%	Data loss : Partial day - 12/29 and 12/31/03; Whole day: 12/30	battery-related problem
		Average	**99.63**	**97.00%**		

No Uptime	Complete data loss - % good data is <0
Limited Uptime	Partial loss - % good data is > 0 and <80
Perfect Uptime	% good data is > 80

a = Uptime is the percentage of data points that were recorded by a flow meter and considered valid. The Report is based on QFINAL and a 5 minute data interval unless noted

Table D - 3.1. Pre- and Post-rehabilitation field verification summary

Site Name	Pre-rehabilitation monitoring period		Post-rehabilitation monitoring period	
	number of site visits*	number of field verifications**	number of site visits*	number of field verifications**
Auburn Control	6	11	8	24
Auburn Pilot	7	11	8	24
Auburn Subtraction	6	12	9	25
Brier Control	9	16	6	18
Brier Pilot	6	8	5	15
Coal Creek Control	N/A	N/A	8	26
Coal Creek Pilot	N/A	N/A	4	12
Kent Control	7	22	11	57
Kent Pilot A	9	13	5	17
Kent Pilot B	9	25	5	24
Kirkland Control	5	5	8	25
Kirkland Pilot	7	11	9	25
Lake Forest Park Control	N/A	N/A	6	21
Lake Forest Park Pilot	N/A	N/A	9	29
Mercer Control	10	15	9	30
Mercer Mini	2	9	8	24
Mercer Pilot	9	17	9	27
North Shore Control	N/A	N/A	8	24
North Shore Pilot	N/A	N/A	4	12
Redmond Control	8	12	6	19
Redmond Mini	3	5	8	24
Redmond Pilot	8	11	7	21
Ronald Control	N/A	N/A	10	30
Ronald Pilot	N/A	N/A	12	36
Skyway Control	6	7	8	24
Skyway Pilot	6	7	8	24
Val Vue Control	N/A	N/A	6	18
Val Vue Pilot	N/A	N/A	8	24

* = site visits during which field verifications were performed
** = individual depth and/or velocity and/or flow quantity (weir) readings taken for field verification of meter functionality/accuracy
N/A = site not monitored during the pre-rehab flow monitoring period of 2002/2003

Table D - 3.2. Meter accuracy specifications and pre-rehabilitation depth, velocity, and flow quantity field verifications

Manufacturer/Vendor	**ADS**	**Marsh-McBirney**	**Marsh-McBirney**
Flow meter model	3601	Flo-Dar 460	Flo-Mate 2000 Velocity meter
Velocity Sensor			
Type	Peak velocity, Doppler	Radar	Electromagnetic
Range (feet/sec)	- 5 to + 20	0.75 to 20	-0.05 to + 20
Resolution (feet/sec)	0.04	N/A	
Accuracy	0 to 5 feet/sec, accuracy = 1.0% of full scale (20 feet/sec) 5 to 10 feet/sec, accuracy = 1.5% full scale (20 feet/sec) 10 to 15 feet/sec, accuracy = 3.5% full scale (20 feet/sec)	± 0.5% of reading ± 0.1 feet/sec	± 2% of reading plus zero stability
Repeatability	N/A	N/A	
Zero Stability	N/A	N/A	± 0.05% feet/sec
Depth Sensor			
Type	Quad redundant ultrasonic	Ultrasonic	
Range	0 to 96 inches and a dead zone of 0.5 inches	0.25 to 60 inches	
Resolution	0.125?	N/A	
Accuracy	0.125 inches or 0.5% of reading (whichever is greater)	±1% of reading ± 0.25 inches	
Repeatability	zero drift	N/A	
Flow Measurement	N/A	± 5% of reading	
User software (for data retrieval and/or reporting)	Quadrascan; FieldScan; Profile	Flo-Ware	N/A (velocity values read from meter display)

N/A = Not available

NOTES to consider when evaluating the field verifications

1)The Marsh-McBirney Flo-Mate Model 2000 velocity meter is used to verify velocity at monitoring sites (ADS uses this meter for similar purposes)
2) During the 2000/01 and 2001/02 I/I flow monitoring periods, ADS Environmental Services (ADS) used the approach that depth confirmations were valid if the meter and field readings were within ± 0.25 inches
3) Accuracy of the Thel-Mar volumetric weir used for field verification of flow is ± 5% of reading
4) The accuracy (plus/minus) for the manually measured depth is set at 0.13 inches
5) The information in this table is compiled from "features and specification" materials published by the respective vendor. Any divergence from the published information is not intentional.

Table D-3.2 (continued)

AUBURN CONTROL (old Auburn Mini)

Real Time (meter measurements)				Field Measurements (manual verification)			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
11/4/02 2:35 PM	4.11	2.58		11/4/02 2:35 PM	4.13	2.68	
11/4/02 2:36 PM	4.09	2.39		11/4/02 2:36 PM	4.00	2.67	
11/4/02 2:37 PM	4.17	2.54		11/4/02 2:38 PM	4.00	2.68	
11/14/02 10:57 AM	4.05	1.65		11/14/02 10:57 AM	4.00	1.66	
12/10/02 11:11 AM	4.63	1.98		12/10/02 11:11 AM	4.63	1.92	
12/15/02 10:37 AM	6.40	2.66		12/15/02 10:37 AM	6.38	2.60	
12/20/02 11:37 AM	5.27	N/A		12/20/02 11:37 AM	5.25	2.75	
1/14/03 12:40 PM	5.55			1/14/03 12:40 PM	5.50		
1/14/03 12:42 PM	5.30			1/14/03 12:42 PM	5.30		
1/14/03 12:46 PM		2.88		1/14/03 12:46 PM		2.77	
1/14/03 12:48 PM		2.88		1/14/03 12:48 PM		2.82	

Kirk Harris' time (ETT QA/QC) used to avoid confusion

Table D-3.2 (continued)

AUBURN PILOT (old Auburn Control)

Real Time (meter measurements)				Field Measurements (manual verification)			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
11/4/02 12:11 PM	2.70	2.58		11/4/02 12:11 PM	2.63	2.49	
11/4/02 12:11 PM	2.72	2.62		11/4/02 12:11 PM	2.75	2.41	
11/4/02 12:12 PM	2.72	2.54		11/4/02 12:12 PM	2.63	2.41	
11/14/02 11:33 AM	2.02	2.32		11/14/02 11:33 AM	2.00	2.42	
12/10/02 10:40 AM	2.99	2.74		12/10/02 10:40 AM	3.00	2.97	
12/15/02 11:05 AM	4.89	3.70		12/15/02 11:05 AM	4.84	3.95	
12/20/02 12:02 PM	3.52	3.14		12/20/02 12:02 PM	3.50	3.00	
1/6/03 11:44 AM	4.64	3.52		1/6/03 11:45 AM	4.50	3.48	
1/14/03 12:07 PM	3.46			1/14/03 12:05 PM	3.63		
1/14/03 12:07 PM	3.46			1/14/03 12:07 PM	3.50		
1/14/03 12:08 PM	3.45			1/14/03 12:07 PM	3.50		
1/14/03 12:11 PM		2.80		1/14/03 12:11 PM		2.50	
1/14/03 12:13 PM		2.92		1/14/03 12:13 PM		2.80	

Kirk Harris' time (ETT QA/QC) used to avoid confusion

Table D-3.2 (continued)

AUBURN SUBTRACTION (old Auburn Pilot)

Real Time (meter measurements)				**Field Measurements (manual verification)**					
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (gpd)***	**Flow (gpd)***	**Average of weir readings****
11/4/02 1:36 PM	0.75	0.82	0.01	11/4/02 1:30 PM	0.50				
11/4/02 1:39 PM	0.77	0.72	0.01	11/4/02 1:39 PM	0.25				
11/4/02 1:41 PM	0.65	0.93	0.01	11/4/02 1:40 PM	0.38				
11/4/02 1:43 PM	0.58	1.26	0.01	11/4/02 1:42 PM	0.25				
11/14/02 11:10 AM	0.54			11/14/02 11:10 AM	0.50				
11/14/02 11:12 AM	0.50			11/14/02 11:12 AM	0.52				
12/10/02 10:39 AM	0.71	1.87	0.02	12/10/02 10:39 AM	0.63				
12/16/02 10:41 AM	0.86	2.02	0.03	12/16/02 10:41 AM	0.88	1.98			
12/20/02 11:49 AM	0.70	1.17		12/20/02 11:49 AM	0.63				
1/14/03 10:55 AM	0.85	1.22	0.02	1/14/03 10:55 AM	0.90				
1/14/03 11:06 AM	0.94	0.77	0.01	1/14/03 11:06 AM	0.89				
1/14/03 11:31 AM			17095.00	1/14/03 11:29 AM			11180	13780	12480
1/14/03 11:32 AM			12445.00	1/14/03 11:29 AM			11180	13780	12480

Kirk Harris' time (ETT QA/QC) used to avoid confusion

Weir reading after flow has stabilized in to normal flow condition

initial set up

flow in GPD

* = weir measurements (low and high flow rate readings on the Weir's face plate)

** = Average of the "high" and "low" readings from the Weir

Table D-3.2 (continued)

BRIER CONTROL

Real Time (meter measurements)				**Field Measurements (manual verification)**				
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	
11/5/02 11:38 AM	2.58	1.26	0.10					
11/5/02 11:43 AM	2.37	1.37	0.10					
11/5/02 11:46 AM	2.23	1.10	0.07	11/5/02 11:46 AM	2.50	1.21		
11/5/02 11:48 AM	2.38	1.52	0.11	11/5/02 11:47 AM	2.50	1.26		
11/21/02 12:57 PM	2.02	1.25	0.07					
11/21/02 12:58 PM	1.96	1.54	0.08	11/21/02 12:59 PM	2.00	1.20		
12/2/02 11:16 AM	2.61	0.83	0.07	12/2/02 11:15 AM	2.50	0.78		
12/6/02 11:56 AM	2.71	1.67	0.14					
12/6/02 11:57 AM	2.57	1.35	0.11					
12/6/02 11:58 AM	2.51	1.46	0.11	12/6/02 11:58 AM	2.50	1.38		
12/17/02 11:27 AM	2.41	1.12	0.08	12/17/02 11:27 AM	2.38	1.07		
1/3/03 12:15 PM	3.06	1.35		1/3/03 12:15 PM	3.10	1.28		
1/15/03 1:34 PM	2.21	1.25	0.08					
1/15/03 1:40 PM	2.13	1.45	0.09	1/15/03 1:40 PM	2.38			
1/15/03 1:40 PM	2.13	1.25	0.08	1/15/03 1:41 PM	2.08			
1/15/03 1:43 PM	2.40	1.40		1/15/03 1:42 PM		1.52		
6/19/03 11:13 AM	4.92	1.44	0.28	6/19/03 11:13 AM	4.00	0.54		clogged pipe- debris under pipe; very dirty site
6/19/03 11:18 AM	4.62	1.41	0.25					
6/19/03 11:25 AM	4.10	1.59	0.224	6/19/03 11:24 AM	3.75	0.75		
6/19/03 11:34 AM	3.85	1.33	0.19	6/19/03 11:31 AM	3.75	0.94		
7/3/2003 10:21	2.33	1.9	0.13	7/3/2003 10:22	2.20	1.55		
7/3/2003 10:28	2.30	1.16	0.08	7/3/2003 10:30	2.40	1.21		
7/3/2003 10:32	3.13	1.67	0.18					
7/3/2003 10:38	3.27	2.06	0.23	7/3/2003 10:40	2.70	1.96		

Kirk Harris' time (ETT QA/QC) used to avoid confusion

Table D-3.2 (continued)

BRIER PILOT

Real Time (meter measurements)				**Field Measurements (manual verification)**			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
11/5/02 10:18 AM	2.49	1.72		11/5/02 10:12 AM	2.38	1.72	
11/5/02 10:19 AM	2.47	1.61		11/5/02 10:14 AM	2.38	1.83	
11/5/02 10:20 AM	2.48	1.57		11/5/02 10:15 AM	2.50	1.82	
11/5/02 10:21 AM	2.57	1.98					
11/5/02 10:22 AM	2.64	1.50					
11/13/02 1:20 PM	2.58	1.56		11/13/02 1:20 PM	2.50	1.48	
11/26/02 10:20 AM	2.38	1.50		11/26/02 10:20 AM	2.25	1.50	
12/2/02 11:00 AM	2.80	1.48		12/2/02 11:00 AM	2.63	1.37	
1/15/03 2:10 PM	3.08			1/15/03 2:11 PM	3.00		
1/15/03 2:12 PM	2.87			1/15/03 2:11 PM	3.00		
1/15/03 2:13 PM		1.68		1/15/03 2:12 PM		2.27	
1/15/03 2:14 PM		1.61		1/15/03 2:14 PM		1.5	
7/3/2003 11:41	5:08			7/3/2003 11:48	0.9		
7/3/2003 11:48	5:09			7/3/2003 11:50	1	3.21	
7/3/2003 11:05	5:16			7/3/2003 11:54	1.8	3.5	

Kirk Harris' time (ETT QA/QC) used to avoid confusion

MONITOR NOT FUNCTIONING PROPERLY at time of cal

Table D-3.2 (continued)

KENT CONTROL

Real Time (meter measurements)				**Field Measurements (manual verification)**					
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow ***	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow****	**Flow****	**Average of Weir readings**
10/31/02 10:18 AM	0.68	2.05	0.02 MGD	10/31/02 10:19 AM	0.63				
10/31/02 10:20 AM	0.62	2.00	0.02 MGD	10/31/02 10:21 AM	0.50				
10/31/02 10:21 AM	0.61	1.98	0.02 MGD	10/31/02 10:22 AM	0.63				
10/31/02 10:23 AM	0.64	1.94	0.02 MGD	10/31/02 10:23 AM	0.63				
11/12/02 11:40 AM	0.73	2.02	0.02 MGD						
11/12/02 11:58 AM	0.69	1.99	0.02 MGD						
11/12/02 12:04 PM	0.85	2.09	26801	11/12/02 12:04 PM	0.75		25860	23170	24515
11/18/02 9:48 AM	0.75	1.90	20221						
11/18/02 9:54 AM	0.66	2.01	17761	11/18/02 9:55 AM	0.75		20590	23170	21880
11/21/02 11:27 AM	0.72	1.56	18831	11/21/02 11:29 AM	0.75		18110	15730	16920
11/21/02 11:31 AM	0.78	1.99	22744						
12/16/02 11:32 AM	1.10	2.30	0.04 MGD	12/16/02 11:32 AM	1.00	2.50			
1/14/03 2:43 PM	1.01	2.32	0.04 MGD	1/14/03 2:43 PM	1.25				
1/14/03 2:46 PM	0.98	2.25	0.04 MGD	1/14/03 2:48 PM		1.58			
1/14/03 2:50 PM	0.88	2.25	30218	1/14/03 2:50 PM	1.00				
1/14/03 2:50 PM	0.88	2.25	30218	1/14/03 2:51 PM		1.55			
1/14/03 2:57 PM	0.91	1.93	27374	1/14/03 2:55 PM			23170	20590	21880
1/14/03 2:59 PM	1.00	2.22	35905						
1/14/03 3:00 PM	0.95	2.08	31283						
1/14/03 3:07 PM	0.84	2.12	26784	1/14/03 3:05 PM			28640	31520	30080
2/20/03 11:43 AM	0.81	2.04	24317						
2/20/03 11:45 AM	0.86	1.85	24112	2/20/03 11:45 AM	0.75				
2/20/03 11:57 AM	0.87	2.42	32320	2/20/03 12:00 PM			20590	18110	19350
2/20/03 12:05 PM	0.72	1.94	19352	2/20/03 12:02 PM			20590	18110	19350
2/20/03 12:05 PM	0.72	1.94	19352	2/20/03 12:04 PM			20590	18110	19350
2/20/03 12:07 PM	0.71	1.97	19600	2/20/03 12:07 PM	0.70				
				6/19/03 2:59 PM	0.50		5473	7301	
Monitor internal battery dead - unable to fire sensors				6/19/03 3:01 PM	0.75		5473	7301	
values will be compared with collected data @ corresponding time				6/19/03 3:04 PM	0.75		9243	11290	

Kirk Harris' time (ETT QA/QC) used to avoid confusion

* flow in gallons per day (GPD) unless specified

** = weir measurements.

Table D-3.2 (continued)

KENT PILOT A

Real Time (meter measurements)				**Field Measurements (manual verification)**					
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow***	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow ****	**Flow ****	**Average weir readings**
10/30/02 2:20 PM	0.66	3.44	0.03 MGD	10/30/02 2:13 PM	0.38				
10/30/02 2:24 PM	0.67	3.51	0.03 MGD	10/30/02 2:24 PM	0.63				
11/12/02 12:25 PM	0.69	4.17	0.04 MGD						
11/12/02 12:34 PM	0.80	4.30	0.05 MGD	11/12/02 12:34 PM	0.75				
11/12/02 12:35 PM	0.76	4.58	0.05 MGD						
11/18/02 10:02 AM	0.67	3.86	0.04 MGD	11/18/02 10:00 AM	0.75				
11/21/02 10:40 AM	0.59	3.56	26982.00						
11/21/02 10:47 AM	0.59	3.41	25648.00	11/21/02 10:45 AM			23170	20590	21880
12/16/02 11:40 AM	0.80	5.78	0.07 MGD	12/16/02 11:46 AM	0.88	5.63			
12/20/02 10:45 AM	0.46	2.68	13930.00	12/20/02 10:45 AM	0.50		13460	11290	12375
1/14/03 3:30 PM	0.61	3.42	27073.00	1/14/03 3:29 PM	0.45				
1/14/03 3:32 PM	0.59	3.28	24553.00	1/14/03 3:31 PM	0.49				
2/20/03 1:18 PM	0.68	4.11	38173.00	2/20/03 1:18 PM	0.63				
6/19/03 2:17PM	0.58	3.44	0.03 MGD						
6/19/03 2:24PM	0.60	4.06	0.03 MGD	6/19/03 2:24PM	0.5				
				6/19/03 2:26PM	0.5				
6/19/03 2:30PM	0.58	3.65	0.03 MGD	6/19/03 2:31PM	0.5				

INSTALL Date; sensor offset adjusted
Kirk Harris' time (ETT QA/QC) used to avoid confusion

* flow in GPD unless specified
** = weir measurements in GPD. Values used are highlighted in yellow

Table D-3.2 (continued)

Real Time (meter measurements) | **Field Measurements (manual verification)**

Date/Time	Depth (in)	Velocity (fps)	Flow *	Date/Time	Depth (in)	Velocity (fps)	Flow (gpd)*	Flow (gpd)*	Average weir readings**
10/31/02 11:24 AM	0.72	2.00	0.02 MGD	10/31/02 11:25 AM	0.69				
10/31/02 11:26 AM	0.70	1.93	0.02 MGD	10/31/02 11:27 AM	0.63				
10/31/02 11:27 AM	0.70	1.98	0.02 MGD	10/31/02 11:28 AM	0.69				
11/18/02 9:21 AM	1.04	1.34	0.02 MGD						
11/18/02 9:25 AM	0.99	1.10	0.02 MGD						
11/18/02 9:38 AM	0.94	1.89	27975	11/18/02 9:40 AM	1.00	n/a	31520	28640	30080
11/21/02 11:09 AM	1.14	2.08	40684.00	11/21/02 11:10 AM	1.00	2.00			
11/21/02 11:15 AM	0.91	2.08	29618.00	11/21/02 11:12 AM	1.00	n/a	25860	28640	27250
11/26/02 11:40 AM	1.26	1.82	0.04 MGD	11/26/02 11:40 AM	1.25	1.73			
12/9/02 10:08 AM	1.19	1.46	0.03 MGD	12/9/02 10:08 AM	1.13	1.33			
12/20/02 10:35 AM	1.05	2.13	0.04 MGD	12/20/02 10:35 AM	1.00	2.10			
1/14/03 2:00 PM	1.36	1.78	0.05 MGD						
1/14/03 2:01 AM	1.07	2.16	38722.00	1/14/03 2:01 PM	0.80	n/a			
1/14/03 2:04 PM	1.05	2.07	35943.00	1/14/03 2:04 PM	1.00	n/a			
1/14/03 2:10 PM	1.07	2.10	37749.00	1/14/03 2:08 PM			25860	28640	27250
1/14/03 2:21 PM	0.90	1.97	27431.00	1/14/03 2:20 PM			23170	25866	24518
1/14/03 2:22 PM	0.90	1.84	25635.00	1/14/03 2:20 PM			23170	25866	24518
2/20/03 12:37 PM	0.98	1.92	30206.00						
2/20/03 12:39 PM	1.09	1.86	34172.00	2/20/03 12:40 PM	1.00				
				2/20/03 12:52 PM			20590	18110	19350
				2/20/03 12:53 PM			15730	1346	8538
				2/20/03 12:54 PM			15730	1346	8538
2/20/03 12:56 PM	0.87	1.71	27822	2/20/03 12:55 PM			20590	18110	19350
2/20/03 12:56 PM	0.87	1.71	27822	2/20/03 12:56 PM	0.88				
5/27/03 10:09 AM	0.93	2.04	29865						
5/27/03 10:15 AM	1.03	2.15	36491	5/27/03 10:15 AM	1.15				
5/27/03 10:15 AM	1.03	2.15	36491	5/27/03 10:20 AM			31520	28640	30080
				5/27/03 10:22 AM			31520	28640	30080
				5/27/03 10:24 AM			25860	23170	24515
5/27/03 10:29 AM	1.07	2.16	39031	5/27/03 10:29 AM	1.13				
5/27/03 10:32 AM	1.01	2.13	35331	5/27/03 10:33 AM	1.00				

Kirk Harris' time (ETT QA/QC) used to avoid confusion

* flow in GPD unless specified
** = weir measurements in GPD. Values used are highlighted in yellow

Table D-3.2 (continued)

KIRKLAND CONTROL (old Kirkland Pilot)

Real Time (meter measurements)				Field Measurements (manual verification)			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
11/5/02 1:10 PM	3.38	1.75	0.23				
11/5/02 1:11 PM	3.32	1.76	0.22				
11/5/02 1:13 PM	3.34	1.74	0.22				
11/19/02 11:20 AM	3.82	2.09	0.32	11/19/02 11:21 AM	3.50	1.45	
11/19/02 11:23 AM	3.58	1.76	0.24	11/19/02 11:21 AM	3.63	1.52	
11/25/02 12:50 PM	3.22	1.53	0.19	11/25/02 12:50 PM	3.25	1.50	
12/3/02 11:00 AM	5.12	0.82		12/3/02 11:00 AM	5.25	0.75	
01/15/03	No field verification was done due to traffic related problems						
01/16/03	No field verification was done due to traffic related problems						
6/17/02 9:40 AM	3.57	2.01	0.28	6/17/02 9:45 AM	3	2.4	
6/17/02 9:49 AM	3.63	1.6	0.24	6/17/02 9:50 AM	2	1.13	1.13
6/17/02 10:00 AM	3.77	1.64	0.25				

please see Kirk Harris' 1/17/03 memo for details

Table D-3.2 (continued)

KIRKLAND PILOT (old Kirkland Control)

Real Time (meter measurements)				Field Measurements (manual verification)			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
11/6/02 12:45 PM	4.37	1.46		11/6/02 12:45 PM	4.38	1.43	
11/6/02 12:50 PM	4.41	1.46		11/6/02 12:50 PM	4.38	1.40	
11/6/02 12:53 PM	4.40	1.46		11/6/02 12:53 PM	4.38	1.46	
11/19/02 11:02 AM	4.07	1.23		11/19/02 11:02 AM	4.00	1.20	
11/25/02 11:54 AM	3.79	1.27		11/25/02 11:54 AM	3.63	1.24	
12/3/02 11:00 AM	5.12	0.82		12/3/02 11:00 AM	5.25	0.75	
12/12/02 11:43 AM	5.12						
1/15/03 12:30 PM	3.88			1/15/03 12:31 PM	3.88		
1/15/03 12:32 PM	3.91			1/15/03 12:31 PM	3.88		
1/15/03 12:33 PM		1.31		1/15/03 12:33 PM		1.27	
7/3/2003 13:46	3.75	1.23					
7/3/2003 13:54	3.95	1.23		7/3/2003 13:54	4.00	1.37	
7/3/2003 13:57	3.90	1.27		7/3/2003 13:56	4.00	1.30	
7/3/2003 13:57	3.90	1.27		7/3/2003 13:57	4.00	1.15	

Kirk Harris' times (ETT QA/QC) in the 1/17/03 memo are incorrect (1 hour difference)

Table D-3.2 (continued)

MERCER CONTROL

Real Time (meter measurements)				Field Measurements (manual verification)					
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (gpd)***	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (gpd)****	**Flow (gpd)****	**Average of weir readings*****
11/1/02 9:45 AM	0.64	4.39	0.04 MGD	11/1/02 9:45 AM	0.56				
11/12/02 9:01 AM	0.62	5.38	0.04 MGD	11/12/02 9:01 AM	0.69				
11/12/02 9:03 AM	0.63	5.08	0.04 MGD						
11/12/02 9:05 AM	0.63	1.73	0.01 MGD						
11/18/02 11:46 AM	0.39	3.63	14914	11/18/02 11:46 AM	0.38		11290	13460	12375
11/27/02 11:21 AM	0.38	4.06	0.02 MGD	11/27/02 11:21 AM	0.38				
12/2/02 9:55 AM	0.38	3.04	11779	12/2/02 9:50 AM	0.38		11290	13460	12375
12/18/02 11:15 AM	0.50	4.34	0.03 MGD	12/18/02 11:10 AM	0.50	4.32			
1/2/03 9:40 AM	1.10	6.32		1/2/03 9:41 AM	1.13	6.24			
1/16/03 11:52 AM	0.54	4.42		1/16/03 11:52 AM	0.75				
1/16/03 11:54 AM	0.65	4.48		1/16/03 11:55 AM		4.41			
7/2/2003 2:31	0.41	3.66		7/2/2003 2:28	0.8	3.6			
7/2/2003 2:31	0.41	3.66		7/2/2003 2:33	0.5	3.19			
7/2/2003 2:35	0.41	3.26		7/2/2003 2:33	0.5	3.19			
7/2/2003 2:38	0.39	3.26		7/2/2003 2:40	0.6	3.48			
7/21/03 1:39 PM	0.61	5.37		7/21/03 1:40 PM	0.5				
7/21/03 1:42 PM	0.44	5.25		7/21/03 1:42 PM	0.6				
7/21/03 1:44 PM	0.42	4.15		7/21/03 1:44 PM	0.55				

Kirk Harris' time (ETT QA/QC) used to avoid confusion

* flow in GPD unless specified
*** = weir measurements in GPD. Values used are highlighted in yellow

Table D-3.2 (continued)

MERCER MINI

Real Time (meter measurements)				Field Measurements (manual verification)			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
3/5/2003 10:36:00 AM*	1.75			3/5/03 10:36 AM	2.25		
3/5/03 10:37 AM	1.65			3/5/03 10:37 AM	1.88		
3/5/03 10:41 AM	1.67			3/5/03 10:41 AM	1.63		
3/5/03 10:47 AM		5.09		3/5/03 10:47 AM		4.50	
3/5/03 10:50 AM		4.41		3/5/03 10:50 AM		4.14	
3/5/03 10:53 AM		4.45		3/5/03 10:53 AM		4.7	
3/20/2003 10:49	1.92			3/20/2003 10:49	2		
3/20/2003 10:54		4.97		3/20/2003 10:54		4.21	
3/20/2003 10:56		4.64		3/20/2003 10:56		4.39	

* = install date ; selected upairs changed

Table D-3.2 (continued)

MERCER PILOT

Real Time (meter measurements)				**Field Measurements (manual verification)**			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
10/31/02 1:22 PM	0.91	0.93	0.01	10/31/02 1:23 PM	0.94		
10/31/02 1:24 PM	0.89	0.99	0.01	10/31/02 1:24 PM	0.94		
10/31/02 1:25 PM	0.91	0.91	0.01	10/31/02 1:26 PM	1.00		
11/12/02 8:32 AM	1.95	1.73	0.07	11/12/02 8:34 AM	1.96	1.71	
11/12/02 8:42 AM	2.00	1.72	0.08				
11/12/02 8:44 AM	2.09	1.23	0.06				
11/27/02 11:14 AM	0.96	1.09	0.02	11/27/02 11:14 AM	0.96	0.97	
12/2/02 9:47 AM	1.24	1.06	0.02	12/2/02 9:47 AM	1.13	0.99	
12/18/02 10:53 AM	1.84	1.34	0.05	12/18/02 10:55 AM	1.38	1.50	
12/18/02 10:58 AM	1.44	1.47	0.04				
12/18/02 11:01 AM	1.26	1.35	0.03				
1/2/03 9:30 AM	2.57	2.13		1/2/03 9:30 AM	2.50	2.10	
1/16/03 11:28 AM	1.27	1.24	0.03	1/16/03 11:30 AM	1.30		
1/16/03 11:33 AM	1.41	1.35		1/16/03 11:33 AM		1.25	
1/16/03 11:33 AM	1.41	1.35		1/16/03 11:34 AM		1.41	
7/2/2003 1:05	1.05	1.14		7/2/2003 1:06	1.00	1.35	
				7/2/2003 1:09	1.25	1.57	
7/2/2003 1:13	1.05	1.09		7/2/2003 1:15	1.25	1.20	
7/2/2003 1:17	1.98	1.04		7/2/2003 1:15	1.25	1.20	
7/21/03 12:29 PM	1.28	0.79					
				7/21/03 12:40 PM	1	0.87	
7/21/03 12:50 PM	1.23	0.91		7/21/03 12:51 PM	1	0.95	
7/21/03 12:52 PM	1.2	1		7/21/03 12:53 PM	1.9	0.9	

Kirk Harris' time (ETT QA/QC) used to avoid confusion

Table D-3.2 (continued)

REDMOND CONTROL

Real Time (meter measurements)				**Field Measurements (manual verification)**			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
11/1/02 11:08 AM	2.32	1.33	0.07	11/1/02 11:08 AM	2.25	1.24	
11/1/02 11:10 AM	2.29	0.90	0.05	11/1/02 11:10 AM	2.25	1.12	
11/1/02 11:13 AM	2.44	1.20	0.07				
11/19/02 10:16 AM	2.75	1.23	0.08				
11/19/02 10:19 AM	2.81	1.74	0.12	11/19/02 10:19 AM	2.75	1.32	
11/25/02 11:05 AM	2.98	1.84	0.14	11/25/02 10:59 AM	2.00	1.62	
12/12/02 12:40 PM	2.97	2.07	0.16				
1/2/03 10:26 AM	3.00	1.48		1/2/2003 10:27AM	3.00	1.50	
1/15/03 11:01 AM	3.04	1.59		1/15/03 11:01 AM	3.00		
1/15/03 11:03 AM	2.88	1.61		1/15/03 11:04 AM		1.53	
1/15/03 11:06 AM	2.85	1.81		1/15/03 11:07 AM		1.62	
2/21/03 10:42 AM	2.86	1.86		2/21/03 10:40 AM	2.88	1.80	
7/22/03 9:07 AM	2.01	0.96					
7/22/03 9:13 AM	2.11	1.03	0.05	7/22/03 9:12 AM	1.9	0.95	
				7/22/03 9:14 AM	2	1.01	
7/22/03 9:16 AM	2.21	0.99		7/22/03 9:17 AM	2	1.09	

Kirk Harris' time (ETT QA/QC) used to avoid confusion

Table D-3.2 (continued)

REDMOND MINI

Real Time (meter measurements)				Field Measurements (manual verification)			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
12/12/02 12:20 PM	4.51	1.70		12/12/02 12:20 PM	4.50	1.63	
1/15/03 10:17 AM	5.09			1/15/2003 10:17:00 AM*	4.88		
1/15/03 10:20 AM	5.12			1/15/2003 10:21:00 AM*	5.13		
1/15/03 10:25 AM		1.89		1/15/03 10:25 AM		1.89	
2/21/03 10:25 AM	7.65	0.93		2/21/03 10:28 AM	7.63	0.90	

Kirk Harris' time (ETT QA/QC) used to avoid confusion

* = The offset in the LIF (in the laptop used for data collection/verification) was set at 1.50. The field measurements are adjusted by 0.25 inches to match the correct offset value (1.75) used to record the depth data. This was applied only to the 1/15/03 field verification and doesn't affect the data collected by the meter (which records data using the correct offset value of 1.75 inches)

Table D-3.2 (continued)

REDMOND PILOT

Real Time (meter measurements)				Field Measurements (manual verification)				
Date/Time	**Depth (in)**	**Velocity (fps)***	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	
11/1/02 12:01 PM	2.50	1.54	0.12					
11/1/02 12:04 PM	2.62	1.78	0.15	11/1/02 12:03 PM	2.50	1.00		Install date
11/19/02 10:29 AM	2.74	1.56	0.14	11/19/02 10:29 AM	2.76	1.32		
11/25/02 11:30 AM	2.89	1.65	0.15	11/25/02 11:30 AM	2.88	1.62		
12/12/02 12:48 PM	2.69	1.78	0.15					
1/2/03 10:42 AM	3.00	1.41		1/2/03 10:42 AM	3.00	1.38		
1/15/03 11:38 AM	2.75	1.86	0.16	1/15/03 11:38 AM	2.75			
1/15/03 11:40 AM		1.54		1/15/03 11:40 AM		1.30		
1/15/03 11:41 AM		1.44		1/15/03 11:42 AM		1.24		
2/21/03 10:48 AM	2.83	1.24		2/21/03 10:49 AM	2.88	1.2		
7/22/03 9:40 AM	2.81	1.89						
7/22/03 9:48 AM	2.86	1.22		7/22/03 9:47 AM	2.75	0.99		
7/22/03 9:50 AM	2.94	1.24		7/22/03 9:49 AM	2	1.1		
				7/22/03 9:51 AM	2.75	1.1		

Kirk Harris' time (ETT QA/QC) used to avoid confusion

* = velocity pattern changed on February 5, 2003 after the sensor and monitor were swapped(changed) at this site. The velocity pattern changed after this date, but the depth pattern remained the same. Depth and velocity tracking very well after the swap on 2/5/03. The pattern change is due to the re positioning of the sensor producing a better velocity profile.

Table D-3.2 (continued)

SKYWAY CONTROL

Real Time (meter measurements)				Field Measurements (manual verification)			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
10/29/02 2:34 PM	0.78	1.97	0.02				
10/29/02 2:35 PM	0.76	2.01	0.02				
11/12/02 10:06 AM	2.28	3.02	0.16	11/12/02 10:06 AM	2.25	3.05	
11/18/02 10:45 AM	0.93	2.29	0.03	11/18/02 10:47 AM	1.00	2.32	
12/18/02 11:55 AM	1.98	2.89	0.12	12/18/02 11:55 AM	2.80	2.00	
1/2/03 11:52 AM	3.05	3.13		1/2/03 11:52 AM	3.00	3.48	
1/16/03 1:04 PM	1.30	2.48	0.06	1/16/03 1:05 PM	1.25		
1/16/03 1:06 PM	1.25	1.44	0.03	1/16/03 1:05 PM	1.25		
1/16/03 1:06 PM	1.25	1.44	0.03	1/16/03 1:06 PM		2.23	
1/16/03 1:08 PM	1.25	2.52	0.06	1/16/03 1:09 PM		2.47	

Kirk Harris' time (ETT QA/QC) used to avoid confusion

Table D-3.2 (continued)

SKYWAY PILOT

Real Time (meter measurements)				Field Measurements (manual verification)			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
10/29/02 12:47 PM	0.84	4.46	0.06	10/29/02 12:47 PM	0.63		INSTALL DATE measurement;Sensor offset adjusted
11/12/02 9:45 AM	1.49	7.01	0.06	11/12/02 9:45 AM	1.50	6.96	
11/18/02 10:39 AM	0.96	5.27	0.08	11/18/02 10:40 AM	1.00		
12/18/02 11:40 AM	1.50	7.22	0.22	12/18/02 11:45 AM	1.50	7.13	
1/2/03 11:25 AM	2.31	8.71		1/2/03 11:25 AM	2.30	8.20	
1/16/03 12:39 PM	1.33	6.32	0.16	1/16/03 12:39 PM	1.25		
1/16/03 12:40 PM	1.36	6.34	0.16	1/16/03 12:40 PM		5.99	

Kirk Harris' time (ETT QA/QC) used to avoid confusion

Table D-3.3. Meter accuracy specifications and post-rehabilitation depth, velocity, and flow quantity field verifications

Manufacturer/Vendor	**ADS**	**Marsh-McBirney**	**Marsh-McBirney**	**Marsh-McBirney**	**Marsh-McBirney**
Flow meter model	3601	Flo-Dar 460	Flo-Tote 3	Flo-Tote2 (Model 260)	Flo-Mate 2000 Velocity meter
Velocity Sensor					
Type	Peak velocity, Doppler	Radar	Electromagnetic (Faraday's Law)	Electromagnetic (Faraday's Law)	Electromagnetic (Faraday's Law)
Range (feet/sec)	- 5 to + 20	0.75 to 20	-5 to + 20	-20 to + 20	-0.05 to + 20
Resolution (feet/sec)	0.04	N/A	0.01	0.01	
Accuracy	0 to 5 feet/sec, accuracy = 1.0% of full scale (20 feet/sec) 5 to 10 feet/sec, accuracy = 1.5% full scale (20 feet/sec) 10 to 15 feet/sec, accuracy = 3.5% full scale (20 feet/sec)	± 0.5% of reading ± 0.1 feet/sec	± 2% of reading, ± 0.05 zero stability at 0 to + 10 ft/sec	± 2% of reading ± zero stability	± 2% of reading plus zero stability
Repeatability	N/A	N/A	N/A		
Zero Stability	N/A	N/A	± 0.05% feet/sec	± 0.05% feet/sec	± 0.05% feet/sec
Depth Sensor					
Type	Quad redundant ultrasonic	Ultrasonic	Submerged pressure sensor	Submerged pressure sensor	
Range	0 to 96 inches and a dead zone of 0.5 inches	0.25 to 60 inches	0.4 to 138 inches	0 to 138 inches	
Resolution	0.125?	N/A	0.1 inch	± 0.1 inch	
Accuracy	0.125 inches or 0.5% of reading (whichever is greater)	±1% of reading ± 0.25 inches	± 1% of reading		
Repeatability	zero drift	N/A	N/A		
Flow Measurement	N/A	± 5% of reading	± 5% of reading	N/A	
User software (for data retrieval and/or reporting)	Quadrascan; FieldScan; Profile	Flo-Ware	Flo-Ware	Flo-Ware	

N/A = Not available

NOTES to consider when evaluating the field verifications

1)The Marsh-McBirney Flo-Mate Model 2000 velocity meter is used to verify velocity at monitoring sites (ADS uses this meter for similar purposes)
2) During the 2000/01 and 2001/02 I/I flow monitoring periods, ADS Environmental Services (ADS) used the approach that depth confirmations were valid if the meter and field readings were within ± 0.25 inches
3) Accuracy of the Thel-Mar volumetric weir used for field verification of flow is ± 5% of reading
4) The accuracy (plus/minus) for the manually measured depth is set at 0.13 inches
5) The information in this table is compiled from "features and specification" materials published by the respective vendor. Any divergence from the published information is not intentional.

Table D-3.3 (continued)

AUBURN CONTROL

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
				10/8/03 1:45 PM	3.38	2.20	
				10/8/03 1:46 PM	3.38	2.32	
10/8/03 1:48 PM	3.52	2.17		10/8/03 1:47 PM	3.50	2.41	
10/8/03 1:49 PM	3.44	2.24		10/8/03 1:47 PM	3.50	2.41	
10/8/03 1:50 PM	3.57	2.92					
11/4/03 10:08 AM	4.60	1.68		11/4/03 10:09 AM	4.50	1.70	
11/4/03 10:10 AM		1.94		11/4/03 10:09 AM	4.50	1.70	
11/4/03 10:10 AM		1.94		11/4/03 10:10 AM	5.00	2.00	
11/4/03 10:12 AM		1.87		11/4/03 10:12 AM	4.50	1.68	
11/17/03 11:34 AM	5.16	2.69		11/17/03 11:35 AM	5.00	2.79	
11/17/03 11:35 AM	5.13	3.03		11/17/03 11:35 AM	5.00	2.79	
11/17/03 11:35 AM	5.13	3.03		11/17/03 11:36 AM	4.88	3.00	
11/17/03 11:37 AM	5.00	2.73		11/17/03 11:37 AM	4.88	2.90	
12/2/03 12:30 PM	5.29	2.99		12/2/03 12:30 PM	5.50	3.04	
12/2/03 12:32 PM	4.96	2.88		12/2/03 12:32 PM	5.00	2.92	
12/2/03 12:34 PM	4.82	2.95		12/2/03 12:34 PM	5.00	2.99	
12/18/03 8:00 AM	6.06	3.33		12/18/03 8:00 AM	6.00	3.26	
12/18/03 8:02 AM	5.98	3.22		12/18/03 8:02 AM	6.00	3.23	
12/18/03 8:05 AM	5.89	3.07		12/18/03 8:05 AM	6.00	3.06	
12/29/03 1:45 PM	4.99	2.51		12/29/03 1:45 PM	5.10	2.45	
12/29/03 1:47 PM	4.85	2.58		12/29/03 1:47 PM	5.00	2.50	
12/29/03 1:49 PM	4.74	2.66		12/29/03 1:49 PM	4.75	2.59	
1/15/04 12:50 PM	6.01	3.20		1/15/04 12:50 PM	5.75	3.20	
1/15/04 12:52 PM	5.85	3.25		1/15/04 12:52 PM	5.25	3.30	
1/15/04 12:55 PM	5.17	3.20		1/15/04 12:55 PM	5.25	3.20	
1/27/04 12:21 PM	4.68	2.79		1/27/04 12:25 PM	4.50	2.50	
1/27/04 12:28 PM	4.43	2.93		1/27/04 12:29 PM	5.00	2.65	
1/27/04 12:32 PM	5.58	2.96		1/27/04 12:33 PM	5.50	3.00	

Table D-3.3 (continued)

AUBURN PILOT

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
10/27/03 1:00 PM	2.54	2.24		10/27/03 1:00 PM	2.50	2.20	
10/27/03 1:03 PM	2.49	2.36		10/27/03 1:03 PM	2.50	2.28	
10/27/03 1:05 PM	2.58	2.88		10/27/03 1:05 PM	2.50	2.83	
11/4/03 10:57 AM	2.35	2.47		11/4/03 10:57 AM	2.50	2.47	
11/4/03 11:00 AM	2.29	2.17		11/4/03 11:00 AM	2.25	2.07	
11/4/03 11:03 AM	2.25	2.36		11/4/03 11:03 AM	2.25	2.30	
11/17/03 12:10 PM	2.75	2.84		11/17/03 12:12 PM	2.50	3.03	
11/17/03 12:13 PM	2.43	2.73		11/17/03 12:12 PM	2.50	3.03	
11/17/03 12:13 PM	2.43	2.73		11/17/03 12:14 PM	2.50	3.02	
11/17/03 12:15 PM	2.48	2.73		11/17/03 12:14 PM	2.50	3.02	
11/17/03 12:15 PM	2.48	2.73		11/17/03 12:16 PM	2.50	3.00	
12/2/03 12:53 PM	3.31	2.88		12/2/03 12:53 PM	3.38	3.00	
12/2/03 12:55 PM	3.31	3.10		12/2/03 12:55 PM	3.25	3.06	
12/2/03 12:57 PM	3.55	3.67		12/2/03 12:57 PM	3.50	3.65	
12/18/03 9:23 AM	3.26	2.79		12/18/03 9:23 AM	3.25	2.80	
12/18/03 9:25 AM	3.12	2.76		12/18/03 9:25 AM	3.13	2.69	
12/18/03 9:27 AM	3.13	2.66		12/18/03 9:27 AM	3.13	2.64	
12/29/03 2:18 PM	3.21	3.03		12/29/03 2:19 PM	3.13	3.10	
12/29/03 2:21 PM	4.15	3.18		12/29/03 2:21 PM	4.20	3.20	
12/29/03 2:23 PM	4.28	3.25		12/29/03 2:23 PM	4.20	3.20	
1/15/04 1:15 PM	4.76	3.23		1/15/04 1:15 PM	4.66	3.50	
1/15/04 1:16 PM	4.50	3.48		1/15/04 1:16 PM	4.50	3.50	
1/15/04 1:19 PM	4.46	3.44		1/15/04 1:19 PM	4.25	3.40	
1/27/04 12:59 PM	4.23	2.89		1/27/04 1:00 PM	4.25	2.85	
1/27/04 1:04 PM	4.02	2.86		1/27/04 1:05 PM	4.20	3.00	
1/27/04 1:06 PM	3.94	2.83		1/27/04 1:07 PM	3.80	2.65	

Table D-3.3 (continued)

AUBURN SUBTRACTION

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
10/27/03 1:31 PM	2.51	5.54		10/27/03 1:31 PM	2.50	4.95	
10/27/03 1:34 PM	2.48	5.39		10/27/03 1:34 PM	2.63	5.08	
10/27/03 1:37 PM	2.52	5.37		10/27/03 1:37 PM	2.50	5.10	
11/4/03 10:32 AM	1.16	3.92		11/4/03 10:32 AM	1.00	2.25	
11/4/03 10:36 AM	0.85	1.56		11/4/03 10:36 AM	0.75	1.91	
11/4/03 10:39 AM	0.65	0.93		11/4/03 10:39 AM	0.75	1.00	
11/17/03 12:38 PM	0.7	1.22		11/17/03 12:41 PM	0.75		
11/26/03 3:38 PM	2.78	6.01					
				11/26/03 3:46 PM	2.5		
12/2/03 1:13 PM	3.73	6.11		12/2/03 1:13 PM	3.75	6.00	
12/2/03 1:17 PM	3.70	6.01		12/2/03 1:17 PM	3.75	5.89	
12/2/03 1:20 PM	3.68	6.00		12/2/03 1:20 PM	3.75	5.85	
12/18/03 8:46 AM	0.22	1.32		12/18/03 8:46 AM	0.25		
12/18/03 9:05 AM	2.64	5.94		12/18/03 9:05 AM	2.50	5.74	
12/18/03 9:08 AM	2.58	5.83		12/18/03 9:08 AM	2.50	5.74	
12/18/03 9:10 AM	2.48	5.77		12/18/03 9:10 AM	2.55	5.70	
12/29/03 2:37 PM	0.61	2.07		12/29/03 2:37 PM	0.50	2.00	
12/29/03 2:39 PM	0.43	1.05		12/29/03 2:39 PM	0.50	1.05	
12/29/03 2:43 PM	0.20	0.93		12/29/03 2:43 PM	0.25	0.85	
1/15/04 1:45 PM	0.20	1.26	2086.9	1/15/04 1:46 PM	0.20		
1/15/04 1:47 PM	2.86	5.57		1/15/04 1:47 PM	3.00	5.50	Pumps on
1/15/04 1:49 PM	2.80	5.64		1/15/04 1:49 PM	3.00	5.50	
1/15/04 1:53 PM	2.71	5.55		1/15/04 1:53 PM	2.90	5.50	
1/27/04 1:27 PM	2.89	4.97	0.42	1/27/04 1:29 PM	3.00	5.00	
1/27/04 1:33 PM	0.90	3.39	0.05	1/27/04 1:35 PM	0.85	3.00	
1/27/04 1:37 PM	0.57	0.87	0.01	1/27/04 1:39 PM	0.63	0.75	

Table D-3.3 (continued)

BRIER CONTROL

Real Time				Field Measurements			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
12/1/03 2:16 PM	4.49	1.17		12/1/03 2:18 PM	4.50	0.87	
12/1/03 2:20 PM	4.46	1.13		12/1/03 2:21 PM	4.60	0.99	
12/1/03 2:23 PM	4.51	1.14		12/1/03 2:24 PM	4.50	0.87	
12/16/03 10:03 AM	4.66	1.16					
12/16/03 10:10 AM	4.46	1.13		12/16/03 10:08 AM	4.50	0.95	
12/16/03 10:10 AM	4.46	1.13		12/16/03 10:11 AM	4.38	0.95	
12/16/03 10:15 AM	4.66	1.17		12/16/03 10:16 AM	4.50	1.00	
12/30/03 10:24 AM	4.11	1.15		12/30/03 10:24 AM	4.00	1.10	
12/30/03 10:29 AM	4.27	1.21		12/30/03 10:29 AM	4.25	1.15	
12/30/03 10:32 AM	4.10	1.10		12/30/03 10:32 AM	4.00	0.98	
1/14/04 1:13 PM	4.65	1.80		1/14/04 1:14 PM	4.50	1.51	
1/14/04 1:18 PM	4.89	1.72		1/14/04 1:18 PM	4.88	1.09	
1/14/04 1:25 PM	4.47	1.18		1/14/04 1:25 PM	4.50	0.94	
1/29/04 11:55 AM	5.23	1.58		1/29/04 11:55 AM	5.25	1.45	
1/29/04 11:58 AM	5.11	1.58		1/29/04 11:59 AM	5.25	1.50	
1/29/04 12:00 PM	5.20	1.56		1/29/04 12:01 PM	5.38	1.56	
2/20/04 11:55 AM	4.81	1.22		2/20/04 11:56 AM	4.75	0.88	
2/20/04 11:58 AM	4.45	1.08		2/20/04 11:56 AM	4.75	0.88	
2/20/04 12:04 PM	4.40	1.07		2/20/04 12:05 PM	4.50	0.85	
2/20/04 12:04 PM	4.40	1.07		2/20/04 12:07 PM	4.50	0.85	

Table D-3.3 (continued)

BRIER PILOT

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
12/16/03 9:28 AM	2.12	3.63		12/16/03 9:30 AM	2.13	3.5	
12/16/03 9:31 AM	2.12	4.08		12/16/03 9:30 AM	2.13	3.5	
12/16/03 9:31 AM	2.12	4.08		12/16/03 9:32 AM	2.13	4.09	
12/16/03 9:33 AM	2.14	3.63		12/16/03 9:32 AM	2.13	4.09	
12/16/03 9:33 AM	2.14	3.63		12/16/03 9:34 AM	2.25	3.7	
12/30/03 11:03 AM	2.20	2.69		12/30/03 11:03 AM	2.00	2.70	
12/30/03 11:05 AM	2.16	2.77		12/30/03 11:05 AM	2.25	2.67	
12/30/03 11:07 AM	2.13	2.80		12/30/03 11:07 AM	2.00	2.77	
1/14/04 1:45 PM	2.06	3.74		1/14/04 1:45 PM	2.00	3.75	
1/14/04 1:47 PM	2.11	3.93		1/14/04 1:47 PM	2.13	4.00	
1/14/04 1:49 PM	2.31	3.97		1/14/04 1:47 PM	2.25	4.02	
1/29/04 11:22 AM	2.96	4.38		1/29/04 11:23 AM	3.00	4.36	
1/29/04 11:26 AM	2.96	4.38		1/29/04 11:27 AM	3.00	4.31	
1/29/04 11:28 AM	3.02	4.30		1/29/04 11:29 AM	3.00	4.12	
2/20/04 11:34 AM	2.62	2.99		2/20/04 11:34 AM	2.56	3.1	
2/20/04 11:35 AM	2.61	3.01		2/20/04 11:35 AM	2.56	3	
2/20/04 11:36 AM	2.58	2.89		2/20/04 11:36 AM	2.56	3	

Table D-3.3 (continued)

COAL CREEK CONTROL

Real Time				**Field Measurements**			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
10/31/03 10:37 AM	2.51	1.42		10/31/03 10:36 AM	2.50	1.31	
10/31/03 10:43 AM	2.83	2.00		10/31/03 10:41 AM	2.75	1.26	
10/31/03 10:43 AM	2.83	2.00		10/31/03 10:43 AM	3.00	1.35	
10/31/03 10:45 AM	3.00	1.27		10/31/03 10:43 AM	3.00	1.35	
				11/4/03 1:36 PM	2.25		
				11/4/03 1:40 PM	2.38	1.1	
11/4/03 1:43 PM	2.44	1.35		11/4/03 1:45 PM	2.38	1.14	
11/4/03 1:46 PM	2.25	1.38		11/4/03 1:45 PM	2.38	1.14	
11/4/03 1:48 PM	2.28	1.08		11/4/03 1:48 PM	2.38	1.1	
11/18/03 10:08 AM	3.33	1.68		11/18/03 10:08 AM	3.00	2.00	
11/18/03 10:10 AM	3.41	1.76		11/18/03 10:10 AM	3.25	1.71	
11/18/03 10:12 AM	3.26	1.68		11/18/03 10:12 AM	3.50	1.67	
12/3/03 10:23 AM	3.41	2.73		12/3/03 10:23 AM		1.70	
12/3/03 10:25 AM	3.31	1.80		12/3/03 10:25 AM	3.25	1.82	
12/3/03 10:26 AM	3.28	1.91		12/3/03 10:26 AM	3.25	1.83	
12/3/03 10:29 AM	3.23	1.83		12/3/03 10:30 AM	3.25	1.79	
12/17/03 10:39 AM	3.24	1.68		12/17/03 10:39 AM	3.16	1.68	
12/17/03 10:40 AM	3.36	1.85		12/17/03 10:40 AM	3.33	1.75	
12/17/03 10:42 AM	3.43	1.99		12/17/03 10:42 AM	3.50	1.90	
12/30/03 9:54 AM	2.93	2.09		12/30/03 9:54 AM	2.95	1.89	
12/30/03 9:55 AM	3.15	2.17		12/30/03 9:56 AM	3.25	1.89	
12/30/03 9:58 AM	3.21	2.17		12/30/03 9:58 AM	3.33	1.99	
1/13/04 11:02 AM	3.58	1.48		1/13/04 11:02 AM	3.56	1.44	
1/13/04 11:03 AM	3.60	1.45		1/13/04 11:03 AM	3.63	1.43	
1/13/04 11:04 AM	3.62	1.53		1/13/04 11:04 AM	3.63	1.44	
1/30/04 12:07 PM	5.47	2.09		1/30/04 12:07 PM	5.50	2.23	
1/30/04 12:14 PM	5.32	2.02		1/30/04 12:14 PM	5.30	2.20	
1/30/04 12:16 PM	5.45	1.98		1/30/04 12:17 PM	5.50	2.20	

Table D-3.3 (continued)

Coal Creek Pilot

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
12/15/03 11:03 AM	3.95	2.17		12/15/03 11:03 AM	4.00	2.10	
12/15/03 11:06 AM	3.82	2.09		12/15/03 11:06 AM	3.88	2.06	
12/15/03 11:09 AM	3.77	2.02		12/15/03 11:09 AM	3.88	2.00	
12/30/03 9:18 AM	3.43	1.83		12/30/03 9:19 AM	3.33	1.69	
12/30/03 9:23 AM	3.41	1.98		12/30/03 9:24 AM	3.25	1.50	
12/30/03 9:30 AM	3.49	1.87		12/30/03 9:30 AM	3.50	1.50	
1/13/04 11:20 AM	3.64	1.78		1/13/04 11:20 AM	3.50	1.78	
1/13/04 11:21 AM	3.57	1.75		1/13/04 11:21 AM	3.50	1.78	
1/13/04 11:22 AM	3.60	1.78		1/13/04 11:22 AM	3.50	1.80	
1/30/04 12:26 PM	6.06	2.15		1/30/04 12:26 PM	5.88	2.02	
1/30/04 12:28 PM	6.08	2.39		1/30/04 12:28 PM	5.88	2.33	
1/30/04 12:30 PM	6.06	2.43		1/30/04 12:30 PM	5.88	2.41	

Table D-3.3 (continued)

KENT CONTROL

Real Time				**Field Measurements**					
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Weir Flow (gpd)**	**Weir Flow (gpd)**	**Average of weir readings***
10/9/03 9:46 AM	0.83	2.2	27043	10/9/03 9:45 AM	0.88				
				10/9/03 9:55 AM			28640	31520	30080
				10/9/03 9:57 AM			28640	31520	30080
10/9/03 10:04 AM	0.79	2.21	25507	10/9/03 9:59 AM			25860	28640	27250
10/9/03 10:04 AM	0.79	2.21	25507	10/9/03 10:02 AM	0.88				
11/4/03 8:55 AM	0.61	1.87			0.68				
11/4/03 8:57 AM	0.67	2.16							
11/4/03 8:59 AM	0.59	2.15							
				11/4/03 9:07 AM	0.75		18110	20590	19350
				11/4/03 9:09 AM	0.68		18110	20590	19350
11/17/03 10:00 AM	0.6	1.95	14942	11/17/03 10:00 AM	0.63				
11/17/03 10:04 AM	0.6	1.89	14640	11/17/03 10:04 AM	0.63				
				11/17/03 10:12 AM			23170	25860	24515
				11/17/03 10:14 AM			23170	25860	24515
				11/17/03 10:15 AM			18110	20590	19350
				11/17/03 10:16 AM			18110	20590	19350
11/17/03 10:22 AM	0.8	2.04	23779	11/17/03 10:17 AM			18110	20590	19350
11/17/03 10:25 AM	0.67	1.82	16540						
12/3/03 9:28 AM	0.64	1.97	20605.1	12/3/03 9:30 AM	0.63		Weir in @ 9:30		
				12/3/03 9:38 AM			20590	23170	21880
				12/3/03 9:40 AM			20590	23170	21880
				12/3/03 9:42 AM			20590	23170	21880
				12/3/03 9:43 AM			20590	23170	21880
12/3/03 9:45 AM	0.74	1.99	20756.87	12/3/03 9:45 AM	0.63		Weir out @ 9:42		
12/3/03 9:46 AM	0.73	2.07	20120.74	12/3/03 9:45 AM	0.63				
12/18/03 10:20 AM	0.64	2.06	17390.5	12/18/03 10:20 AM	0.63		Weir in @10:20		
				12/18/03 10:30 AM			15730	18110	16920
				12/18/03 10:32 AM			15730	18110	16920
				12/18/03 10:34 AM			15730	18110	16920
12/18/03 10:40 AM	0.65	2.06	17927.32	12/18/03 10:40 AM	0.63		Weir out @ 10:34		
12/30/03 12:46 PM	0.83	2.2	27329.07	12/30/03 12:51 PM	0.9		Weir in @ 12:52		
				12/30/03 1:07 PM			25860	28640	
				12/30/03 1:09 PM			25860	28640	

Table D-3.3 (continued)

KENT CONTROL

Real Time				Field Measurements				
				12/30/03 1:09 PM			25860	28640
12/30/03 1:17 PM	0.78	2.22	25242	12/30/03 1:17 PM	0.75	Weir in @ 1:15		
12/30/03 1:18 PM	0.75	2.12	22492	12/30/03 1:18 PM	0.75			
1/15/04 11:33 AM	0.92	2.1	30383.23	1/15/04 11:33 AM	1	Weir in @ 11:33		
				1/15/04 11:43 AM			31520	28640
				1/15/04 11:45 AM			31520	28640
				1/15/04 11:47 AM		Weir out @ 11:4	31520	28640
				1/15/04 11:47 AM			25860	28640
1/15/04 11:53 AM	0.87	2.13	28191.76	1/15/04 11:53 AM	0.9			
1/28/04 10:50 AM	0.9	2.14	29826.75	1/28/04 10:50 AM	0.9	Weir in		
				1/28/04 11:00 AM			31520	28640
				1/28/04 11:02 AM			31520	28640
				1/28/04 11:03 AM			31520	28640
1/28/04 11:05 AM	0.75	2.14	22911.76	1/28/04 11:05 AM	0.75	Weir out		
2/11/04 9:52 AM	0.63	1.98	16236	2/11/04 9:52 AM	0.63	Weir in		
				2/11/04 10:03 AM			18110	15730
				2/11/04 10:05 AM			18110	15730
				2/11/04 10:07 AM		Weir out	18110	15730
2/11/04 10:17 AM	0.73	2.14	21967					
2/26/04 12:35 PM	0.86	2.01	26229.71	2/26/04 12:35 PM	0.85			
				2/26/04 12:36 PM		Weir in	25860	28640
				2/26/04 12:46 PM			25860	28640
				2/26/04 12:47 PM			25860	28640
				2/26/04 12:49 PM		Weir out		
2/26/04 12:51 PM	0.66	2.04		2/26/04 12:51 PM	0.75			
3/8/04 9:11 AM	0.77	2.22	24439.74	3/8/04 9:11 AM	0.75	Weir in		
				3/8/04 9:21 AM			31520	34490
				3/8/04 9:22 AM			31520	34490
				3/8/04 9:24 AM		Weir out	31520	34490
3/8/04 9:35 AM	1.09	2.31	42477.83	3/8/04 9:37 AM	1.25			
3/8/04 9:37 AM	1.1	2.49	46380.72	3/8/04 9:37 AM	1.25			

* flow in GPD unless specified

Table D-3.3 (continued)

KENT PILOT A

Real Time				Field Measurements					
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (gpd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Weir Flow (gpd) Right**	**Weir Flow (gpd) Left**	**Average of weir readings***
1/16/04 11:28 AM	0.62	2.63		1/16/04 11:29 AM	0.50				
1/16/04 11:33 AM	0.57	4.47		1/16/04 11:33 AM	0.50				
1/28/04 10:27 AM	0.44	3.16	15348	1/28/04 10:27 AM	0.50		weir in		
				1/28/04 10:30 AM			15730	18110	16920
				1/28/04 10:31 AM			15730	13490	14610
				1/28/04 10:33 AM			15730	13490	14610
				1/28/04 10:34 AM			15730	13490	14610
1/28/04 10:35 AM	0.39	3.76	15554	1/28/04 10:35 AM	0.50		weir out		
2/11/04 8:36 AM	0.86	3.89	51652	2/11/04 8:37 AM	0.86	3.73			
2/11/04 8:43 AM	0.91	4.76		2/11/04 8:45 AM	1.00	4.70			
2/11/04 8:49 AM	0.93	4.13		2/11/04 8:51 AM	1.00	4.10			
2/26/04 12:11 PM	0.86	3.96		2/26/04 12:12 PM	0.75				
2/26/04 12:18 PM	0.87	3.78		2/26/04 12:19 PM	0.50				
2/26/04 12:21 PM	0.86	3.54		2/26/04 12:21 PM	0.55				
3/8/04 8:49 AM	0.83	4.03		3/8/04 8:50 AM	0.75				
3/8/04 8:52 AM	0.85	3.71		3/8/04 8:52 AM	0.63				
3/8/04 8:58 AM	0.88	3.75		3/8/04 8:58 AM	0.5				

* flow in GPD unless specified

Table D-3.3 (continued)

KENT PILOT B

Real Time				Field Measurements						
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Flow (gpd) Right**	**Flow (gpd) Left**	**Average of weir readings***
1/16/04 12:34 PM	0.61	2.24	17695.57	1/16/04 12:35 PM	0.63					
1/16/04 12:37 PM	0.64	1.51	12664.75	1/16/04 12:38 PM	0.63	Weir in				
				1/16/04 12:48 PM				25860	23170	24515
				1/16/04 12:50 PM				25860	23170	24515
				1/16/04 12:52 PM				20590	18110	19350
				1/16/04 12:54 PM				20590	18110	19350
1/16/04 12:56 PM	0.66	2.14	19049.88	1/16/04 12:56 PM	0.63	Removed weir		20590	18110	19350
1/28/04 11:18 AM	0.74	1.96	20551.2	1/28/04 11:18 AM	0.75	weir in				
				1/28/04 11:28 AM				25860	23170	24515
				1/28/04 11:29 AM				25860	23170	24515
				1/28/04 11:30 AM				25860	23170	24515
1/28/04 11:42 AM	0.60	1.99	15407.47	1/28/04 11:42 AM	0.63	weir out				
2/11/04 9:17 AM	0.70	2.06	19886	2/11/04 9:20 AM	0.75	weir in				
				2/11/04 9:31 AM				25090	18110	21600
				2/11/04 9:33 AM				25090	18110	21600
				2/11/04 9:35 AM		weir out		25090	18110	21600
2/11/04 9:38 AM	0.71	2.27	22513							
2/26/04 1:00 PM	1.07	1.58	28378.32	2/26/04 1:01 PM	1.13	weir in				
				2/26/04 1:12 PM				25090	18110	21600
				2/26/04 1:13 PM				25090	28640	26865
				2/26/04 1:15 PM		weir out		25090	18110	21600
2/26/04 1:20 PM	1.04	1.80	31076.75	2/26/04 1:20 PM	1.00					
3/8/04 9:46 AM	1.28	1.17		3/8/04 9:46 AM	1.25	1.01				
3/8/04 9:49 AM	1.55	2.19		3/8/04 9:51 AM	1.50	1.25				
3/8/04 9:50 AM	1.61	1.19		3/8/04 9:51 AM	1.50	1.25				
3/8/04 9:54 AM	1.54	1.19		3/8/04 9:55 AM	1.70	1.08				

* flow in GPD unless specified

Table D-3.3 (continued)

KIRKLAND CONTROL

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in) +/- .13	Velocity (fps)	Flow (mgd)
10/7/03 1:35 PM	2.64	1.55	0.14	10/7/03 1:35 PM	2.5	1.44	
10/7/03 1:38 PM	2.84	1.71	0.17	10/7/03 1:38 PM	2.63	1.56	
10/7/03 1:45 PM	2.98	1.83	0.20	10/7/03 1:38 PM	2.75	1.63	
10/7/03 1:50 PM	2.85	1.59		10/7/03 1:40 PM	2.75	1.45	
11/5/03 12:42 PM	2.65	1.63		11/5/03 12:43 PM	2.68	1.37	
11/5/03 12:46 PM	2.92	1.50		11/5/03 12:47 PM	2.75	1.27	
11/5/03 12:50 PM	2.76	1.41		11/5/03 12:51 PM	2.75	1.27	
11/19/03 10:05 AM	4.29	2.13		11/19/03 10:06 AM	4.25	2.11	
11/19/03 10:09 AM	3.86	2.41		11/19/03 10:09 AM	4.00	1.95	
11/19/03 10:15 AM	3.82	1.92		11/19/03 10:16 AM	4.00	1.92	
12/4/03 12:23 PM	2.86	1.51		12/4/03 12:23 PM	2.88	1.42	
12/4/03 12:26 PM	2.9	1.68		12/4/03 12:27 PM	2.88	1.51	
12/4/03 12:30 PM	2.85	1.81		12/4/03 12:31 PM	2.88	1.83	
12/19/03 10:11 AM	3.14	1.89		12/19/03 10:11 AM	3.00	1.61	
12/19/03 10:15 AM	3.05	1.41		12/19/03 10:15 AM	3.00	1.41	
12/19/03 10:17 AM	3.01	1.45		12/19/03 10:17 AM	3.00	1.41	
12/29/03 12:02 PM	3.27	1.93		12/29/03 12:02 PM	3.25	1.86	
12/29/03 12:08 PM	2.99	1.84		12/29/03 12:08 PM	3.00	1.75	
12/29/03 12:12 PM	2.98	1.55		12/29/03 12:12 PM	3.00	1.54	
1/15/04 11:43 AM	3.28	1.87		1/15/04 11:43 AM	3.38	1.78	
1/15/04 11:45 AM	3.43	1.84		1/15/04 11:45 AM	3.38	1.69	
1/15/04 11:46 AM	3.57	1.54		1/15/04 11:46 AM	3.50	1.59	
1/26/04 11:05 AM	3.09	1.57		1/26/04 11:05 AM	3.00	1.47	
1/26/04 11:09 AM	3.24	1.48		1/26/04 11:09 AM	3.25	1.46	
1/26/04 11:12 AM	3.32	1.49		1/26/04 11:12 AM	3.25	1.45	

Table D-3.3 (continued)

KIRKLAND PILOT

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
10/9/03 2:15 PM	3.33	1.01		10/9/03 2:15 PM	3.38	1.09	
10/9/03 2:17 PM	3.40	1.12		10/9/03 2:17 PM	3.50	1.08	
10/9/03 2:20 PM	3.37	1.08		10/9/03 2:19 PM	3.50	1.12	
11/5/03 12:23 PM	5.35	0.86		11/5/03 12:23 PM	5.00	0.83	
11/5/03 12:25 PM	5.34	0.79		11/5/03 12:25 PM	5.00	0.79	
11/5/03 12:30 PM	5.28	0.90		11/5/03 12:28 PM	5.00	0.90	
11/19/03 9:45 AM	8.00	1.27		11/19/03 9:45 AM	8.50	1.34	
11/19/03 9:47 AM	7.93	1.27		11/19/03 9:47 AM	8.00	1.28	
11/19/03 9:49 AM	7.92	1.23		11/19/03 9:49 AM	8.00	1.30	
12/4/03 12:01 PM	5.36	0.82		12/4/03 12:02 PM	5.38	0.83	
12/4/03 12:02 PM	5.36	0.86		12/4/03 12:02 PM	5.38	0.83	
12/4/03 12:03 PM	5.38	0.79		12/4/03 12:03 PM	5.38	0.83	
12/4/03 12:03 PM	5.38	0.79		12/4/03 12:04 PM	5.38	0.80	
12/19/03 9:52 AM	6.31	0.97		12/19/03 9:52 AM	6.25	1.00	
12/19/03 9:54 AM	6.36	1.01		12/19/03 9:54 AM	6.25	1.00	
12/19/03 9:56 AM	6.29	1.01		12/19/03 9:56 AM	6.25	1.00	
12/29/03 11:38 AM	5.72	0.79		12/29/03 11:38 AM	5.75	0.91	
12/29/03 11:39 AM	5.68	0.79		12/29/03 11:39 AM	5.63	0.72	
12/29/03 11:40 AM	5.69	0.82		12/29/03 11:41 AM	5.50	0.84	
1/2/04 8:49 AM	6.01			1/2/04 8:49 AM	6.00		
1/15/04 11:25 AM	6.30	0.79		1/15/04 11:25 AM	6.25	0.86	
1/15/04 11:26 AM	6.31	0.82		1/15/04 11:26 AM	6.25	0.95	
1/15/04 11:27 AM	6.36	0.86		1/15/04 11:27 AM	6.25	0.97	
1/26/04 10:30 AM	5.70	0.82		1/26/04 10:30 AM	5.70	0.87	
1/26/04 10:36 AM	5.73	0.86		1/26/04 10:36 AM	5.68	0.91	
1/26/04 10:37 AM	5.72	0.86		1/26/04 10:37 AM	5.68	0.85	

Table D-3.3 (continued)

Lake Forest Park Control

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
11/3/03 2:10 PM	3.06			11/3/03 2:10 PM	3.00		
11/3/03 2:13 PM	2.88			11/3/03 2:13 PM	3.00		
11/3/03 2:14 PM	2.94			11/3/03 2:14 PM	3.00		
11/3/03 2:15 PM		2.77		11/3/03 2:15 PM	2.00	2.66	
11/3/03 2:16 PM		3.70		11/3/03 2:16 PM		3.35	
11/3/03 2:17 PM		3.89		11/3/03 2:17 PM		3.51	
11/19/03 12:10 PM	6.20	3.29		11/19/03 12:11 PM	6.25	3.31	
11/19/03 12:12 PM	6.21	3.55		11/19/03 12:11 PM	6.25	3.31	
11/19/03 12:12 PM	6.21	3.55		11/19/03 12:13 PM	6.25	3.57	
11/19/03 12:14 PM	6.20	4.56		11/19/03 12:13 PM	6.25	3.57	
11/19/03 12:14 PM	6.20	4.56		11/19/03 12:15 PM	6.33	4.60	
12/16/03 11:54 AM	3.35	4.04		12/16/03 11:55 AM	3.25	3.93	
12/16/03 11:55 AM	3.35	4.23		12/16/03 11:55 AM	3.25	3.93	
12/16/03 11:57 AM	3.34	4.53		12/16/03 11:57 AM	3.38	4.17	
12/16/03 11:57 AM	3.34	4.53		12/16/03 11:59 AM	3.38	4.51	
12/29/03 1:52 PM	3.58	4.41		12/29/03 1:52 PM	3.50	4.39	
12/29/03 1:55 PM	3.55	3.93		12/29/03 1:55 PM	3.50	3.89	
12/29/03 1:57 PM	3.72	4.30		12/29/03 1:57 PM	3.50	4.20	
1/14/04 11:42 AM	3.92	4.49		1/14/04 11:42 AM	4.00	4.47	
1/14/04 11:45 AM	3.84	4.53		1/14/04 11:45 AM	3.88	4.32	
1/14/04 11:48 AM	3.88	4.67		1/14/04 11:48 AM	3.88	4.60	
1/29/04 1:02 PM	6.31	3.74		1/29/04 1:02 PM	6.25	3.88	
1/29/04 1:03 PM	6.31	4.53		1/29/04 1:03 PM	6.25	4.67	
1/29/04 1:04 PM	6.20	4.56		1/29/04 1:04 PM	6.25	4.63	

Table D-3.3 (continued)

Lake Forest Park Pilot

Real Time				Field Measurements			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
11/5/03 1:59 PM	2.66	3.74		11/5/03 1:57 PM	2.00		
11/5/03 1:59 PM	2.66	3.74		11/5/03 1:59 PM	2.50	3.80	
11/5/03 2:00 PM	2.65	3.44		11/5/03 2:00 PM	2.68	3.38	
11/5/03 2:04 PM	2.47	3.48		11/5/03 2:05 PM	2.38	3.71	
11/19/03 11:35 AM	5.06	4.83		11/19/03 11:35 AM	5.00	4.87	
11/19/03 11:37 AM	4.86	5.31		11/19/03 11:37 AM	5.00	5.15	
11/19/03 11:39 AM	5.15	5.42		11/19/03 11:39 AM	5.00	5.32	
12/5/03 11:00 AM	4.27	3.93		12/5/03 11:00 AM	4.25	4.01	
12/5/03 11:01 AM	3.73	3.67		12/5/03 11:01 AM	4.00	3.57	
12/5/03 11:02 AM	3.30	4.11		12/5/03 11:02 AM	3.25	4.09	
12/16/03 11:32 AM	3.01	3.03		12/16/03 11:32 AM	3.13	2.94	
12/16/03 11:33 AM	2.73	3.06		12/16/03 11:33 AM	2.75	3.02	
12/16/03 11:34 AM	2.77	3.10		12/16/03 11:34 AM	2.88	3.09	
12/29/03 1:28 PM	2.41	3.37		12/29/03 1:28 PM	2.50	3.38	
12/29/03 1:29 PM	2.34	3.70		12/29/03 1:29 PM	2.25	3.68	
12/29/03 1:30 PM	2.32	3.18		12/29/03 1:30 PM	2.25	3.10	
1/9/04 11:55 AM	2.66			1/9/04 11:55 AM	3.00		
1/9/04 11:56 AM	2.75			1/9/04 11:56 AM	3.00		
1/9/04 11:58 AM	2.62			1/9/04 11:58 AM	3.00		
1/9/04 12:00 PM	2.91			1/9/04 12:00 PM	3.00		
1/14/04 12:18 PM	2.64	3.30		1/14/04 12:18 PM	2.50	3.15	
1/14/04 12:19 PM	2.53	3.00		1/14/04 12:19 PM	2.50	3.05	
1/14/04 12:20 PM	2.57	2.96		1/14/04 12:20 PM	2.50	3.00	

Table D-3.3 (continued)

Lake Forest Park Pilot

Real Time				Field Measurements			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
1/29/04 12:43 PM	6.97	1.83		1/29/04 12:43 PM	7.00	1.79	
1/29/04 12:44 PM	6.92	1.84		1/29/04 12:44 PM	7.00	1.81	
1/29/04 12:45 PM	6.93	1.91		1/29/04 12:45 PM	7.00	1.80	
2/19/04 11:33 AM	2.57	3.15		2/19/04 11:34 AM	2.50	3.20	
2/19/04 11:35 AM	2.51	3.3		2/19/04 11:34 AM	2.50	3.20	
2/19/04 11:35 AM	2.51	3.3		2/19/04 12:00 AM	2.5	3.25	

Table D-3.3 (continued)

MERCER CONTROL

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in) +/- 0.13	Velocity (fps)	Flow (mgd)	Flow (gpd)	Flow (gpd)	Average of weir readings*
10/7/03 12:13 PM	0.57	4.46	31732	10/7/03 12:13 PM	0.5					
10/7/03 12:16 PM	weir install			10/7/03 12:13 PM	0.5					
				10/7/03 12:25 PM	surge of water			28640	31540	30090
				10/7/03 12:26 PM				13460	15730	14595
10/7/03 12:30 PM	removed weir			10/7/03 12:27 PM				23170	25190	24180
10/7/03 12:32 PM	0.43	2.89	13718	10/7/03 12:29 PM				11290	13640	12465
10/7/03 12:32 PM	0.43	2.89	13718	10/7/03 12:32 PM	0.5					
10/20/03 11:56 AM	1.42	7.05		10/20/03 11:57 AM	1.5	6.7				
10/20/03 12:00 PM	1.34	6.72		10/20/03 12:02 PM	1.5	6.43				
10/20/03 12:03 PM	1.47	7.14		10/20/03 12:02 PM	1.5	6.43				
10/20/03 12:03 PM	1.47	7.14		10/20/03 12:05 PM	1.5	6.94				
11/6/03 10:44 AM	0.47	3.32	18219							
11/6/03 10:51 AM	0.56	3.8	26428	11/6/03 10:51 AM	0.5	3.66				
11/6/03 10:54 AM	0.56	3.68	25898	11/6/03 10:54 AM	0.5	3.52				
11/6/03 10:57 AM	0.6	4.76	33139	11/6/03 10:57 AM	0.63	4.02				
11/18/03 12:11 PM	1.32	6.93		11/18/03 12:13 PM	1.38	5.90				
11/18/03 12:16 PM	1.30	6.27		11/18/03 12:16 PM	1.25	6.40				
11/18/03 12:18 PM	1.34	6.78		11/18/03 12:18 PM	1.25	6.75				
12/3/03 12:21 PM	0.75	4.84		12/3/03 12:21 PM	0.63	4.56				
12/3/03 12:23 PM	0.73	4.43		12/3/03 12:24 PM	0.68	4.32				
12/3/03 12:27 PM	0.84	5.39		12/3/03 12:28 PM	0.80	4.97				
12/17/03 9:39 AM	0.70	4.68		12/17/03 9:39 AM	0.75	4.70				
12/17/03 9:42 AM	0.74	4.76		12/17/03 9:42 AM	0.75	4.40				
12/17/03 9:44 AM	0.71	3.76		12/17/03 9:44 AM	0.75	3.86				
12/30/03 11:58 AM	0.76	5.19		12/30/03 11:58 AM	0.85	5.00				
12/30/03 12:00 PM	0.74	4.71		12/30/03 12:00 PM	0.75	4.75				
12/30/03 12:10 PM	0.77	4.77		12/30/03 12:10 PM	0.85	4.75				
1/13/04 9:55 AM	0.80	4.70		1/13/04 9:56 AM	0.88	4.34				
1/13/04 10:00 AM	0.93	5.26		1/13/04 10:00 AM	0.90	4.15				
1/13/04 10:04 AM	0.90	5.39		1/13/04 10:05 AM	0.90	4.53				

Table D-3.3 (continued)

MERCER CONTROL

Real Time				Field Measurements						
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in) +/- 0.13**	**Velocity (fps)**	**Flow (mgd)**	**Flow (gpd)**	**Flow (gpd)**	**Average of weir readings***
1/29/04 8:38 AM	1.21	6.56		1/29/04 8:39 AM	1.20	6.45				
1/29/04 8:45 AM	1.23	6.19		1/29/04 8:45 AM	1.25	6.00				
1/29/04 8:48 AM	1.23	6.74		1/29/04 8:48 AM	1.25	6.50				

* flow in GPD unless specified

Table D-3.3 (continued)

MERCER Mini

Real Time				Field Measurements			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
10/21/03 11:09 AM	2.48	4.95		10/21/03 11:11 AM	2.50	5.10	
10/21/03 11:12 AM	2.57	5.54		10/21/03 11:11 AM	2.50	5.10	
10/21/03 11:12 AM	2.57	5.54		10/21/03 11:12 AM	2.63	5.20	
10/21/03 11:13 AM	2.96	5.50		10/21/03 11:12 AM	2.63	5.20	
10/21/03 11:13 AM	2.96	5.50		10/21/03 11:15 AM	2.75	5.10	
11/6/03 10:26 AM	1.58	3.14		11/6/03 10:27 AM	1.25	3.23	
11/6/03 10:28 AM	1.60	3.53		11/6/03 10:30 AM	1.50	3.41	
11/6/03 10:32 AM	1.70	3.84	avg.	11/6/03 10:33 AM	1.63	4.29	
		4.29	peak				
11/18/03 12:00 PM	17.62			11/18/03 12:00 PM	17.50		
11/18/03 12:01 PM	17.61			11/18/03 12:01 PM	17.50		
11/18/03 12:05 PM	17.82			11/18/03 12:04 PM	17.50		
12/3/03 12:04 PM	1.90	3.97		12/3/03 12:05 PM	2.00	3.83	
12/3/03 12:07 PM	1.97	4.11		12/3/03 12:08 PM	1.88	4.12	
12/3/03 12:09 PM	1.97	3.87		12/3/03 12:10 PM	1.88	3.94	
12/17/03 9:23 AM	2.17	4.30		12/17/03 9:23 AM	2.30	4.10	
12/17/03 9:24 AM	2.11	4.71		12/17/03 9:24 AM	2.25	4.84	
12/17/03 9:28 AM	2.13	4.81		12/17/03 9:28 AM	2.25	4.70	
12/30/03 11:39 AM	2.13	5.05		12/30/03 11:39 AM	2.10	4.85	
12/30/03 11:41 AM	1.81	4.90		12/30/03 11:41 AM	1.80	4.50	
12/30/03 11:43 AM	1.78	4.79		12/30/03 11:43 AM	1.80	4.50	
1/13/04 9:32 AM	2.27	4.91		1/13/04 9:32 AM	2.25	4.87	
1/13/04 9:36 AM	2.12	4.91		1/13/04 9:36 AM	2.00	4.89	
1/13/04 9:38 AM	2.20	4.88		1/13/04 9:38 AM	2.25	4.92	
1/29/04 9:28 AM	2.44	6.66		1/29/04 9:28 AM	2.50	6.50	
1/29/04 9:32 AM	2.40	6.51		1/29/04 9:32 AM	2.50	6.50	
1/29/04 9:34 AM	5.56	6.50		1/29/04 9:34 AM	5.60	6.50	

Table D-3.3 (continued)

MERCER PILOT

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
10/20/03 11:14 AM	2.75						
10/20/03 11:22 AM	2.62	2.25		10/20/03 11:23 AM	2.75	2.23	
10/20/03 11:25 AM	2.62	2.31		10/20/03 11:26 AM	2.75	2.17	
10/20/03 11:28 AM	2.83	1.54		10/20/03 11:30 AM	2.75	1.67	
11/6/03 11:18 AM	0.96	0.69		11/6/03 11:18 AM	1.00	0.65	
11/6/03 11:22 AM	0.92	0.60		11/6/03 11:22 AM	1.88	0.62	
11/6/03 11:26 AM	0.96	0.74		11/6/03 11:26 AM	1.00	0.72	
11/18/03 11:43 AM	2.88	2.45		11/18/03 11:40 AM	2.50	3.00	
11/18/03 11:43 AM	2.88	2.45		11/18/03 11:44 AM	2.50	3.10	
11/18/03 11:46 AM	2.94	2.49		11/18/03 11:44 AM	2.50	3.10	
11/18/03 11:50 AM	2.82	2.46		11/18/03 11:48 AM	2.60	2.67	
11/25/03 10:08 AM	1.52	1.38		11/25/03 10:10 AM	1.50	1.36	
11/25/03 10:13 AM	1.47	1.46		11/25/03 10:15 AM	1.40	1.47	
11/25/03 10:17 AM	1.76	1.43		11/25/03 10:15 AM	1.40	1.47	
11/25/03 10:17 AM	1.76	1.43		11/25/03 10:20 AM	1.50	1.39	
12/3/03 11:34 AM	1.82	1.50		12/3/03 11:35 AM	1.75	1.54	
12/3/03 11:40 AM	1.76	1.29		12/3/03 11:42 AM	1.75	1.31	
12/3/03 11:44 AM	1.63	1.19		12/3/03 11:45 AM	1.63	1.22	
12/17/03 8:53 AM	1.58	1.44		12/17/03 8:57 AM	1.40	1.51	
12/17/03 9:01 AM	1.56	1.39		12/17/03 9:01 AM	1.50	1.40	
12/17/03 9:04 AM	1.52	1.33		12/17/03 9:05 AM	1.50	1.27	
12/30/03 11:05 AM	1.36	1.19		12/30/03 11:06 AM	1.25	1.19	
12/30/03 11:11 AM	1.39	1.21		12/30/03 11:11 AM	1.33	1.19	
12/30/03 11:15 AM	1.45	1.27		12/30/03 11:16 AM	1.25	1.30	
1/13/04 8:52 AM	2.01	1.49	0.06				
1/13/04 8:57 AM	1.89	1.33		1/13/04 8:57 AM	1.90	1.23	
1/13/04 9:00 AM	1.97	1.41		1/13/04 9:01 AM	2.00	1.36	
1/13/04 9:04 AM	1.89	1.47		1/13/04 9:05 AM	1.85	1.45	
1/29/04 9:54 AM	2.77	2.23		1/29/04 9:54 AM	2.75	2.20	
1/29/04 9:59 AM	2.68	2.11		1/29/04 9:59 AM	2.60	2.10	
1/29/04 10:04 AM	2.60	2.08		1/29/04 10:05 AM	2.60	2.05	

Table D-3.3 (continued)

Northshore Control

Real Time Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Field Measurements Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
10/31/03 12:49 PM	2.3	2.22		10/31/03 12:49 PM	2	1.88	
10/31/03 12:52 PM	2.25	1.53		10/31/03 12:52 PM	2.25	2.09	
10/31/03 12:55 PM	1.85	1.53		10/31/03 12:54 PM	2	1.48	
11/6/03 1:05 PM	1.64	1.57		11/6/03 1:05 PM	1.75	1.41	
11/6/03 1:08 PM	1.79	1.66		11/6/03 1:09 PM	1.75	1.42	
11/6/03 1:10 PM	2.01	1.5		11/6/03 1:11 PM	2	1.52	
11/19/03 11:01 AM	5.15	2.32		11/19/03 11:01 AM	5	2.39	
11/19/03 11:03 AM	5.26	2.39		11/19/03 11:03 AM	5	2.35	
11/19/03 11:05 AM	5.04	2.39		11/19/03 11:05 AM	5		
12/4/03 1:00 PM	3.49	1.72		12/4/03 1:01 PM	3.5	1.83	
12/4/03 1:02 PM	3.44	1.68		12/4/03 1:01 PM	3.5	1.83	
12/4/03 1:02 PM	3.44	1.68		12/4/03 1:03 PM	3.5	1.59	
12/4/03 1:04 PM	3.39	1.72		12/4/03 1:03 PM	3.5	1.59	
12/4/03 1:04 PM	3.39	1.72		12/4/03 1:05 PM	3.5	1.65	
12/19/03 9:12 AM	3.02	2.21		12/19/03 9:13 AM	2.88	2.18	
12/19/03 9:14 AM	3.05	2.06		12/19/03 9:13 AM	2.88	2.18	
12/19/03 9:14 AM	3.05	2.06		12/19/03 9:15 AM	2.9	2.06	
12/19/03 9:16 AM	3.32	2.24		12/19/03 9:15 AM	2.9	2.06	
12/19/03 9:16 AM	3.32	2.24		12/19/03 9:17 AM	3.25	2.14	
12/30/03 9:20 AM	3.4	1.91		12/30/03 9:20 AM	3.5	1.89	
12/30/03 9:23 AM	3.93	1.98		12/30/03 9:23 AM	4	2.01	
12/30/03 9:25 AM	3.91	1.94		12/30/03 9:25 AM	4	1.87	
1/15/04 1:15 PM	3.82	1.94		1/15/04 1:15 PM	3.75	2	
1/15/04 1:16 PM	3.85	1.87		1/15/04 1:16 PM	3.75	1.9	
1/15/04 1:17 PM	3.77	1.91		1/15/04 1:17 PM	3.75	2	
1/27/04 11:20 AM	3.27	1.72		1/27/04 11:20 AM	3.13	1.71	
1/27/04 11:21 AM	3.14	1.68		1/27/04 11:21 AM	3	1.65	
1/27/04 11:22 AM	3.14	1.75		1/27/04 11:22 AM	3	1.7	

Table D-3.3 (continued)

Northshore Pilot

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
12/15/03 1:14 PM	2.03	1.38		12/15/03 1:14 PM	2.00	1.35	
12/15/03 1:16 PM	2.04	1.46		12/15/03 1:16 PM	2.00	1.52	
12/15/03 1:17 PM	2.06	1.46		12/15/03 1:17 PM	2.00	1.54	
12/30/03 9:48 AM	2.01	1.35		12/30/03 9:48 AM	2.00	1.32	
12/30/03 9:51 AM	2.06	1.38		12/30/03 9:51 AM	2.00	1.30	
12/30/03 9:53 AM	2.06	1.35		12/30/03 9:53 AM	2.00	1.00	
1/15/04 12:40 PM	2.22	1.57		1/15/04 12:40 PM	2.25	1.51	
1/15/04 12:41 PM	2.25	1.57		1/15/04 12:41 PM	2.25	1.52	
1/15/04 12:42 PM	2.24	1.64		1/15/04 12:42 PM	2.25	1.68	
1/27/04 11:45 AM	2.06	1.57		1/27/04 11:45 AM	2.00	1.55	
1/27/04 11:46 AM	2.10	1.42		1/27/04 11:46 AM	2.13	1.38	
1/27/04 11:47 AM	2.19	1.65		1/27/04 11:47 AM	2.20	1.63	

Table D-3.3 (continued)

REDMOND CONTROL

Real Time				Field Measurements			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**
11/21/03 10:43 AM	2.40	1.68		11/21/03 10:42 AM	2.50	1.43	
11/21/03 10:49 AM	2.54	1.77		11/21/03 10:50 AM	2.50	1.63	
11/21/03 10:51 AM	2.00	2.01		11/21/03 10:51 AM	2.50	1.65	
11/21/03 10:51 AM	2.00	2.01		11/21/03 10:52 AM	2.70	1.80	
12/4/03 11:07 AM	1.41	1.09		12/4/03 11:08 AM	1.50	0.89	
12/4/03 11:12 AM	2.31	1.31	Blockage in Pipe		Blockage in Pipe		
12/4/03 11:15 AM	1.24	1.10		12/4/03 11:17 AM	1.25	0.87	
12/4/03 11:20 AM	7.41	2.62		12/4/03 11:22 AM	7.50	2.40	
12/4/03 11:23 AM	7.50	2.53		12/4/03 11:22 AM	7.50	2.40	
12/4/03 11:23 AM	7.50	2.53		12/4/03 11:25 AM	7.50	2.40	
12/19/03 11:05 AM	2.39	1.60		12/19/03 11:06 AM	2.25	1.40	
12/19/03 11:11 AM	2.53	1.70		12/19/03 11:12 AM	2.50	1.48	
12/19/03 11:15 AM	2.44	1.79		12/19/03 11:15 AM	2.50	1.48	
12/29/03 9:18 AM	1.38	0.82		12/29/03 9:18 AM	1.50	0.89	
12/29/03 9:24 AM	1.53	0.94		12/29/03 9:24 AM	1.50	0.98	
12/29/03 9:27 AM	1.59	0.88		12/29/03 9:27 AM	1.50	0.99	
1/15/04 10:26 AM	1.91	1.74		1/15/04 10:28 AM	1.88	1.38	
1/15/04 10:31 AM	2.05	1.53		1/15/04 10:33 AM	2.15	1.32	
1/15/04 10:34 AM	2.09	1.30		1/15/04 10:33 AM	2.15	1.32	
1/15/04 10:34 AM	2.09	1.30		1/15/04 10:36 AM	2.00	1.24	
1/27/04 10:15 AM	2.30	1.41		1/27/04 10:15 AM	2.25	1.34	
1/27/04 10:18 AM	2.27	1.86		1/27/04 10:18 AM	2.25	1.76	
1/27/04 10:21 AM	2.27	1.40					

Table D-3.3 (continued)

REDMOND MINI

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
10/21/03 12:35 PM	5.08	2.02		10/21/03 12:35 PM	4.88	1.81	
10/21/03 12:36 PM	5.15	2.06		10/21/03 12:37 PM	5.00	1.88	
10/21/03 12:38 PM	5.11	2.02		10/21/03 12:41 PM	5.00	1.81	
11/6/03 12:21 PM	5.01	2.13		11/6/03 12:21 PM	5.00	2.12	
11/6/03 12:24 PM	4.99	2.06		11/6/03 12:24 PM	5.00	2.05	
11/6/03 12:27 PM	5.03	2.06		11/6/03 12:27 PM	5.00	2.03	
11/18/03 1:00 PM	5.40	1.94		11/18/03 1:00 PM	5.50	2.30	
11/18/03 1:05 PM	5.60	2.13		11/18/03 1:05 PM	5.50	2.11	
11/18/03 1:07 PM	5.65	2.06		11/18/03 1:08 PM	5.25	2.11	
12/4/03 10:53 AM	5.27	1.98		12/4/03 10:53 AM	5.25	2.06	
12/4/03 10:56 AM	5.20	1.87		12/4/03 10:56 AM	5.25	1.89	
12/4/03 10:58 AM	5.14	2.09		12/4/03 10:58 AM	5.25	2.06	
12/19/03 10:44 AM	4.77	1.78		12/19/03 10:44 AM	4.75	1.87	
12/19/03 10:48 AM	4.89	1.94		12/19/03 10:48 AM	5.00	1.90	
12/19/03 10:50 AM	4.88	1.94		12/19/03 10:50 AM	5.00	1.85	
12/29/03 9:02 AM	4.59	1.83		12/29/03 9:02 AM	4.50	1.82	
12/29/03 9:03 AM	4.59	1.72		12/29/03 9:03 AM	4.50	1.74	
12/29/03 9:05 AM	4.53	1.65		12/29/03 9:05 AM	4.50	1.66	
1/15/04 10:55 AM	4.98	2.13		1/15/04 10:55 AM	5.00	2.03	
1/15/04 10:57 AM	4.95	1.91		1/15/04 10:57 AM	4.80	2.00	
1/15/04 10:59 AM	4.96	1.87		1/15/04 10:59 AM	4.80	1.90	
1/27/04 10:45 AM	5.02	2.09		1/27/04 10:45 AM	5.00	1.91	
1/27/04 10:46 AM	5.04	2.28		1/27/04 10:46 AM	5.00	2.12	
1/27/04 10:47 AM	4.98	2.24		1/27/04 10:47 AM	5.00	2.15	

Table D-3.3 (continued)

REDMOND PILOT

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
10/21/03 1:20 PM	3.15	1.28		10/21/03 1:15 PM	3.00	1.11	
10/21/03 1:25 PM	3.30	1.37		10/21/03 1:27 PM	3.13	1.09	
10/21/03 1:28 PM	3.37	1.03		10/21/03 1:27 PM	3.13	1.09	
10/21/03 1:28 PM	3.37	1.03		10/21/03 1:30 PM	3.00	1.10	
Meter Pulled							
12/1/03 12:43 PM	3.18	0.54		12/1/03 12:45 PM	3.13	1.19	
12/1/03 12:48 PM	3.18	1.04		12/1/03 12:49 PM	3.13	1.19	
12/1/03 12:50 PM	3.20	1.48		12/1/03 12:52 PM	3.13	1.11	
12/1/03 12:54 PM	3.22	0.60		12/1/03 12:52 PM	3.13	1.11	
12/19/03 11:38 AM	2.89	1.43		12/19/03 11:39 AM	2.88	1.14	
12/19/03 11:42 AM	2.87	1.44		12/19/03 11:43 AM	2.88	1.31	
12/19/03 11:44 AM	3.03	1.46		12/19/03 11:43 AM	2.88	1.31	
12/19/03 11:44 AM	3.03	1.46		12/19/03 11:44 AM	3.00	1.41	
12/29/03 9:46 AM	2.98	0.72		12/29/03 9:46 AM	3.00	0.80	
12/29/03 9:52 AM	2.99	0.99		12/29/03 9:52 AM	5.00	1.00	
12/29/03 9:56 AM	3.10	1.48		12/29/03 9:56 AM	3.25	1.18	
1/15/04 10:03 AM	3.61	0.99		1/15/04 10:03 AM	3.75	1.05	
1/15/04 10:07 AM	3.47	0.94		1/15/04 10:08 AM	3.38	1.13	
1/15/04 10:10 AM	3.27	0.90		1/15/04 10:11 AM	3.25	1.02	
1/27/04 9:53 AM	3.31	0.98		1/27/04 9:53 AM	3.25	0.91	
1/27/04 9:57 AM	3.45	0.79		1/27/04 9:58 AM	3.50	0.85	
1/27/04 10:01 AM	3.44	0.75		1/27/04 10:02 AM	3.50	0.80	
3/8/04 11:54 AM	3.05	0.98		3/8/04 11:54 AM	3.00	1.00	
3/8/04 11:58 AM	3.05	0.89		3/8/04 11:58 AM	3.12	1.00	
3/8/04 12:02 PM	3.20	0.65		3/8/04 12:03 PM	3.25	0.80	
3/8/04 12:07 PM	2.99	0.88					

Table D-3.3 (continued)

RONALD Control

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
10/31/03 2:23 PM	1.09	1.50					
10/31/03 2:28 PM	1.06	1.23		10/31/03 2:28 PM	1.13	1.31	
10/31/03 2:30 PM	0.97	1.23		10/31/03 2:30 PM	1.00	1.20	
10/31/03 2:30 PM	0.97	1.23		10/31/03 2:32 PM	1.00	1.20	
11/6/03 2:31 PM	0.94	1.38		11/6/03 2:31 PM	1.00	1.15	
11/6/03 2:33 PM	1.12	1.76		11/6/03 2:33 PM	1.00	1.62	
11/6/03 2:35 PM	0.99	1.05		11/6/03 2:35 PM	1.00	1.00	
11/19/03 12:56 PM	2.75	4.82		11/19/03 12:56 PM	2.90	4.80	
11/19/03 12:58 PM	2.79	4.56		11/19/03 12:58 PM	2.90	4.69	
11/19/03 1:00 PM	2.78	4.82		11/19/03 1:00 PM	2.90	4.75	
12/5/03 10:31 AM	2.11	2.62		12/5/03 10:31 AM	2.00	2.52	
12/5/03 10:32 AM	2.17	2.62		12/5/03 10:32 AM	2.13	2.57	
12/5/03 10:33 AM	2.15	2.69		12/5/03 10:33 AM	2.13	2.60	
12/16/03 12:26 PM	1.70	1.62		12/16/03 12:29 PM	1.75	1.68	
12/16/03 12:29 PM	1.90	2.02		12/16/03 12:29 PM	1.75	1.68	
12/16/03 12:31 PM	1.82	2.09		12/16/03 12:30 PM	1.88	2.04	
12/16/03 12:31 PM	1.82	2.09		12/16/03 12:31 PM	1.88	2.05	
12/30/03 1:37 PM	1.75	1.87		12/30/03 1:37 PM	1.75	1.68	
12/30/03 1:40 PM	1.75	1.61		12/30/03 1:40 PM	1.75	1.50	
12/30/03 1:42 PM	1.70	1.72		12/30/03 1:42 PM	1.63	1.58	
1/14/04 10:24 AM	2.54	2.63		1/14/04 10:24 AM	2.50	2.47	
1/14/04 10:25 AM	2.48	2.19		1/14/04 10:25 AM	2.50	2.20	
1/14/04 10:26 AM	2.53	2.21		1/14/04 10:26 AM	2.50	2.22	
1/29/04 9:19 AM	3.28	3.33		1/29/04 9:20 AM	3.25	3.20	
1/29/04 9:20 AM	3.13	3.33		1/29/04 9:20 AM	3.25	3.20	
1/29/04 9:21 AM	2.97	3.23		1/29/04 9:21 AM	3.25	3.19	
1/29/04 9:21 AM	2.97	3.23		1/29/04 9:22 AM	3.00	3.15	
2/19/04 12:43 PM	2.65	2.19		2/19/04 12:43 PM	2.60	2.10	
2/19/04 12:46 PM	2.65	2.02		2/19/04 12:46 PM	2.60	2.00	
2/19/04 12:50 PM	2.65	2.00		2/19/04 12:50 PM	2.60	2.00	
2/26/04 2:52 PM	2.29	1.65		2/26/04 2:52 PM	2.00	1.65	
2/26/04 2:58 PM	2.20	1.55		2/26/04 2:58 PM	1.75	1.65	
2/26/04 3:00 PM	2.20	1.50		2/26/04 3:02 PM	2.00	1.55	

Table D-3.3 (continued)

RONALD PILOT

Real Time				Field Measurements			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in) +/- .13**	**Velocity (fps)**	**Flow (mgd)**
10/22/03 1:44 PM	1.71	4.64		10/22/03 1:44 PM	1.75	4.47	
10/22/03 1:49 PM	1.76	4.30		10/22/03 1:49 PM	1.75	4.34	
10/22/03 1:51 PM	1.88	4.60		10/22/03 1:51 PM	1.75	4.46	
11/6/03 2:04 PM	1.70	2.26		11/6/03 2:04 PM	1.63	2.15	
11/6/03 2:07 PM	1.69	3.01		11/6/03 2:07 PM	1.63	3.03	
11/6/03 2:09 PM	1.75	3.03		11/6/03 2:09 PM	1.63	3.02	
11/19/03 1:30 PM	2.78	7.55		11/19/03 1:30 PM	2.75	7.23	
11/19/03 1:33 PM	3.14	7.63		11/19/03 1:33 PM	3.00	7.78	
11/19/03 1:35 PM	3.14	7.89		11/19/03 1:35 PM	3.00	7.75	
12/5/03 10:12 AM	1.85	5.72		12/5/03 10:12 AM	2.00	5.68	
12/5/03 10:13 AM	1.70	5.09		12/5/03 10:13 AM	1.88	4.88	
12/5/03 10:14 AM	1.79	5.39		12/5/03 10:14 AM	2.00	5.25	
12/12/03 9:24 AM	1.95	4.81		12/12/03 9:24 AM	2.00	4.69	
12/12/03 9:26 AM	1.76	4.85		12/12/03 9:26 AM	1.88	4.59	
12/12/03 9:28 AM	1.82	5.56		12/12/03 9:28 AM	2.00	5.32	
12/16/03 12:55 PM	1.87	4.44		12/16/03 12:57 PM	1.88	4.54	
12/16/03 12:57 PM	1.69	4.48		12/16/03 12:57 PM	1.88	4.54	
12/16/03 1:00 PM	1.75	4.17		12/16/03 1:00 PM	1.75	4.29	
12/16/03 1:00 PM	1.75	4.17		12/16/03 1:02 PM	1.88	4.09	
12/30/03 1:07 PM	1.80	4.31		12/30/03 1:07 PM	1.75	4.25	
12/30/03 1:11 PM	1.89	3.80		12/30/03 1:11 PM	1.75	3.75	
12/30/03 1:13 PM	1.82	3.10		12/30/03 1:13 PM	1.75	3.14	
1/9/04 1:31 PM	1.40	4.90		1/9/04 1:32 PM	1.38	4.87	
1/9/04 1:35 PM	1.35	4.96		1/9/04 1:36 PM	1.38	4.89	
1/9/04 1:39 PM	1.39	5.55		1/9/04 1:40 PM	1.38	5.45	
1/14/04 11:06 AM	1.14	3.83		1/14/04 11:06 AM	1.13	3.94	
1/14/04 11:11 AM	1.16	4.78		1/14/04 11:11 AM	1.13	4.79	
1/14/04 11:14 AM	1.16	5.36		1/14/04 11:15 AM	1.13	4.84	
1/29/04 9:42 AM	1.24	4.88		1/29/04 9:43 AM	1.25	4.23	

Table D-3.3 (continued)

RONALD PILOT

Real Time				Field Measurements			
Date/Time	**Depth (in)**	**Velocity (fps)**	**Flow (mgd)**	**Date/Time**	**Depth (in) +/- .13**	**Velocity (fps)**	**Flow (mgd)**
1/29/04 9:47 AM	1.30	4.63		1/29/04 9:48 AM	1.25	4.50	
1/29/04 9:51 AM	1.29	5.46		1/29/04 9:52 AM	1.25	4.36	
2/19/04 1:13 PM	0.97	4.18		2/19/04 1:13 PM	1.00	4.05	
2/19/04 1:17 PM	0.99	4.13		2/19/04 1:17 PM	1.00	4.10	
2/19/04 1:20 PM	1.00	4.11		2/19/04 1:20 PM	1.00	4.05	
2/26/04 2:26 PM	0.88	2.88		2/26/04 2:27 PM	1	2.78	
2/26/04 2:36 PM	0.98	4.38		2/26/04 2:36 PM	1	4.15	
2/26/04 2:38 PM	0.97	3.82		2/26/04 2:38 PM	1	3.5	

Table D-3.3 (continued)

SKYWAY CONTROL

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
10/6/03 11:52 AM	0.75	2.21		10/6/03 11:52 AM	0.75		
10/6/03 11:58 AM	0.79	2.33					
				10/6/03 12:10 PM	0.75		
				10/6/03 12:12 PM			
				10/6/03 12:14 PM			
10/6/03 12:20 AM	0.93	2.44		10/6/03 12:20 PM	1.00		
10/6/03 12:24 AM	0.90	2.38					
11/4/03 12:59 PM	1.10	2.42		11/4/03 12:58 PM	0.75	2.10	
11/4/03 12:59 PM	1.10	2.42		11/4/03 12:59 PM	0.78	2.02	
11/4/03 1:03 PM	1.02	2.38		11/4/03 1:03 PM	1.00	2.36	
11/4/03 1:05 PM	0.95	2.27		11/4/03 1:03 PM	1.00	2.36	
11/18/03 9:22 AM	5.48	4.97		11/18/03 9:23 AM	5.33	5.60	
11/18/03 9:25 AM	5.57	5.07		11/18/03 9:26 AM	5.40	5.60	
11/18/03 9:29 AM	5.53	4.71		11/18/03 9:31 AM	5.40	5.66	
12/2/03 10:19 AM	1.29	2.79		12/2/03 10:20 AM	1.38	2.78	
12/2/03 10:23 AM	1.33	2.66		12/2/03 10:24 AM	1.38	2.75	
12/2/03 10:26 AM	1.45	2.55		12/2/03 10:27 AM	1.38	2.48	
12/17/03 11:47 AM	1.27	2.73		12/17/03 11:47 AM	1.25	2.64	
12/17/03 11:51 AM	1.26	2.59		12/17/03 11:51 AM	1.25	2.45	
12/17/03 11:53 AM	1.26	2.51		12/17/03 11:53 AM	1.25	2.60	
12/29/03 10:07 AM	1.63	2.73		12/29/03 10:07 AM	1.60	2.60	
12/29/03 10:12 AM	1.26	2.79		12/29/03 10:12 AM	1.25	2.60	
12/29/03 10:15 AM	1.37	2.85		12/29/03 10:15 AM	1.40	2.80	
1/13/04 1:43 PM	1.54	2.92		1/13/04 1:43 PM	1.50	3.07	
1/13/04 1:48 PM	1.45	2.76		1/13/04 1:48 PM	1.50	2.66	
1/13/04 1:50 PM	1.42	3.05		1/13/04 1:50 PM	1.38	3.02	
1/27/04 9:56 AM	1.33	2.82	0.07	1/27/04 9:59 AM	1.25	2.90	
1/27/04 10:01 AM	1.33	2.70	0.07	1/27/04 10:03 AM	1.30	2.80	
1/27/04 10:05 AM	1.30	2.64	0.06	1/27/04 10:07 AM	1.33	2.75	

Table D-3.3 (continued)

SKYWAY PILOT

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
10/9/03 11:31 AM	0.33	5.37	16475.5	10/9/03 11:31 AM	0.38		
				10/9/03 11:44 AM			
10/9/03 11:45 AM	0.23	4.93		10/9/03 11:45 AM	0.25		
10/9/03 11:47 AM	0.23	4.53		10/9/03 11:45 AM	0.25		
10/9/03 11:47 AM	0.23	4.53		10/9/03 11:48 AM	0.38		
11/4/03 12:27 PM	0.18	5.72					
11/4/03 12:31 PM	0.28	5.61		11/4/03 12:33 PM	0.38	5.31	
11/4/03 12:36 PM	0.15	4.96		11/4/03 12:36 PM	0.30	4.82	
11/4/03 12:38 PM	0.23	5.05		11/4/03 12:39 PM	0.25	4.75	
11/18/03 8:49 AM	0.65	8.10		11/18/03 8:50 AM	0.69	8.20	
11/18/03 8:53 AM	0.74	8.49		11/18/03 8:54 AM	0.50	8.44	
11/18/03 8:59 AM	0.79	8.52		11/18/03 8:59 AM	0.90	8.00	
12/2/03 9:45 AM	0.47	6.28		12/2/03 9:46 AM	0.60	6.45	
12/2/03 9:51 AM	0.99	6.93		12/2/03 9:52 AM	1.00	6.88	
12/2/03 9:55 AM	0.67	6.39		12/2/03 9:56 AM	0.75	5.86	
12/17/03 11:27 AM	0.47	6.15		12/17/03 11:27 AM	0.50	5.94	
12/17/03 11:31 AM	0.53	6.09		12/17/03 11:31 AM	0.75	5.71	
12/17/03 11:34 AM	0.54	6.21		12/17/03 11:34 AM	0.50	5.80	
12/29/03 9:41 AM	0.38	5.2		12/29/03 9:42 AM	0.40	5.75	
12/29/03 9:46 AM	0.52	6.88		12/29/03 9:47 AM	0.60	6.75	
12/29/03 9:50 AM	0.44	6.56		12/29/03 9:50 AM	0.50	6.50	
1/13/04 1:12 PM	0.61	6.59		1/13/04 1:12 PM	0.68	5.76	
1/13/04 1:18 PM	Level cal			1/13/04 1:17 PM	Level cal		
1/13/04 1:23 PM	0.77	6.75		1/13/04 1:23 PM	0.68	5.01	
1/13/04 1:28 PM	0.82	6.41		1/13/04 1:28 PM	0.90	5.99	
1/27/04 9:11 AM	0.61	5.83	0.04	1/27/04 9:18 AM	0.63	5.70	
1/27/04 9:20 AM	0.57	6.00	0.04	1/27/04 9:25 AM	0.60	6.10	
1/27/04 9:27 AM	0.57	6.26	0.04	1/27/04 9:30 AM	0.60	5.80	

Table D-3.3 (continued)

VALVUE Control

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
10/31/03 9:20 AM	0.88	10.66		10/31/03 9:20 AM	1.00	9.00	
10/31/03 9:35 AM	0.76	10.10		10/31/03 9:35 AM	1.00	10.00	
10/31/03 9:36 AM	0.87	10.17		10/31/03 9:36 AM	1.00	9.90	
11/6/03 9:37 AM	0.73	7.93		11/6/03 9:37 AM	0.75	8.15	
11/6/03 9:39 AM	0.79	8.08		11/6/03 9:39 AM	0.75	8.01	
11/6/03 9:41 AM	0.83	8.68		11/6/03 9:41 AM	0.88	7.47	
11/17/03 9:28 AM	0.85	9.54		11/17/03 9:28 AM	0.88	10.10	
11/17/03 9:29 AM	0.75	8.90		11/17/03 9:29 AM	0.88	7.86	
11/17/03 9:31 AM	0.77	10.32		11/17/03 9:31 AM	0.88	10.01	
12/17/03 12:43 PM	0.92	9.91		12/17/03 12:43 PM	1.00	9.89	
12/17/03 12:47 PM	0.83	9.32		12/17/03 12:47 PM	1.00	9.25	
12/17/03 12:48 PM	0.83	9.22		12/17/03 12:48 PM	1.00	9.25	
12/29/03 10:50 AM	1.00	11.00		12/29/03 10:50 AM	1.00	10.90	
12/29/03 10:52 AM	0.99	10.97		12/29/03 10:52 AM	1.00	10.90	
12/29/03 10:54 AM	0.99	10.75		12/29/03 10:54 AM	1.00	10.90	
1/15/04 10:50 AM		11.58		1/15/04 10:50 AM		11.30	
1/15/04 10:51 AM		11.57		1/15/04 10:51 AM		11.38	
1/15/04 10:53 AM		11.58		1/15/04 10:53 AM		11.50	

Table D-3.3 (continued)

VALVUE PILOT

Real Time Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)	Field Measurements Date/Time	Depth (in)	Velocity (fps)	Flow (mgd)
10/22/03 10:50 AM	1.45	1.27		10/22/03 10:50 AM	1.38	1.29	
10/22/03 10:53 AM	1.52	1.76		10/22/03 10:53 AM	1.30	1.74	
10/22/03 10:59 AM	1.48	1.46		10/22/03 10:59 AM	1.50	1.33	
11/6/03 9:00 AM	0.92	0.75		11/6/03 9:00 AM	0.88		
11/6/03 9:02 AM	1.12	0.71		11/6/03 9:02 AM	1.00		
11/6/03 9:05 AM	1.23	0.86		11/6/03 9:05 AM	1.25		
11/17/03 9:13 AM	1.06	0.52		11/17/03 9:14 AM	1.00	0.54	
11/17/03 9:16 AM	0.95	0.67		11/17/03 9:16 AM	1.00	0.58	
11/17/03 9:17 AM	0.99	0.90		11/17/03 9:18 AM	1.00	0.81	
12/2/03 11:05 AM	1.46	1.38		12/2/03 11:05 AM	1.40	1.33	
12/2/03 11:15 AM	1.36	1.87		12/2/03 11:15 AM	1.38	1.74	
12/2/03 11:17 AM	1.41	1.68		12/2/03 11:17 AM	1.40	1.83	
12/17/03 12:30 PM	1.11	0.40		12/17/03 12:30 PM	1.00	0.40	
12/17/03 12:33 PM	1.12	0.41		12/17/03 12:33 PM	1.00	0.33	
12/17/03 12:35 PM	1.10	0.40		12/17/03 12:35 PM	1.00	0.35	
12/29/03 12:58 PM	4.38	4.38		12/29/03 12:58 PM	3.75	3.66	
12/29/03 1:00 PM	3.66	3.63		12/29/03 1:00 PM	3.53	3.66	
12/29/03 1:02 PM	2.28	3.33		12/29/03 1:02 PM	2.15	3.20	
1/15/04 10:12 AM	6.10	3.50		1/15/04 10:12 AM	5.90	3.40	
1/15/04 10:15 AM	5.00	2.87		1/15/04 10:15 AM	5.25	2.50	
1/15/04 10:20 AM	1.87	1.42		1/15/04 10:20 AM	2.00	1.50	
1/27/04 11:15 AM	1.48	0.34		1/27/04 11:19 AM	1.00	0.35	
1/27/04 11:21 AM	1.47	0.37		1/27/04 11:23 AM	1.13	0.45	
1/27/04 11:24 AM	1.55	0.47		1/27/04 11:23 AM	1.13	0.45	
1/27/04 11:24 AM	1.55	0.47		1/27/04 11:25 AM	1.00	0.45	

Table D - 4.1 Data adjustment summary for the Pre-rehabilitation monitoring period (2002/2003)

Site Name	Comments*
Auburn Control	No significant data adjustment
Auburn Pilot	No significant data adjustment
Auburn Subtraction	No significant data adjustment
Brier Control	Velocity multiplier was modified and flow was recalculated using the modified multiplier. Based on upstream and downstream flow imbalance, the flow data at the Brier Control site was reviewed. The raw FFT (velocity spectrum) and data files were sent to Marsh McBirney technical staff for further analysis. Velocity multipliers (used by the meter algorithm to convert surface velocity to average velocity) were extracted giving an average value of 1.13. This high value and the high % relative deviation of velocity field verifications indicated that the FFT algorithm may be wrong. Further review showed that, due to poor hydraulics, the FFT was consistently picking up the higher values of the double hump velocity spectrums (representing both the surface velocity and the velocity of the waves moving across the surface). Based on the observation that the meter was reading high and that it was picking on the "high" side, surface to average velocity ratios were extracted from the lower humps and a velocity multiplier of 0.84 was estimated for this site. Even though this is not the preferred method of adjusting the velocity multiplier ("GAIN" in ADS meters), it is the best estimate in the absence of a complete profile. Due to the low flow condition, no velocity profile was done at this site.
Brier Pilot	No significant data adjustment
Kent Control	No significant data adjustment
Kent Pilot A	data gap - inconsistent data deleted
Kent Pilot B	No significant data adjustment
Kirkland Control	Velocity multiplier (used to convert surface to average velocity) was modified based on field verifications and flow was recalculated using the modified multiplier. The method and approach used are similar to the one used for Brier Control (see above)
Kirkland Pilot	No significant data adjustment
Mercer Control	No significant data adjustment
Mercer Mini	Velocity snapped - Velocity sensor not functioning properly after 3/26; velocity reconstituted 3/27 through 4/20/03 based on previous good depth-velocity relationships
Mercer Pilot	Some poor depth data flagged; Velocity drops to zero during early morning hours reconstituted (snapped to curve)
Redmond Control	No significant data adjustment
Redmond Mini	No significant data adjustment
Redmond Pilot	Due to the data loss experienced at this site, the sensor was replaced on 2/5/03. The velocity pattern prior to 2/25/03 was spiky and the diurnal pattern was not well defined. After the sensor swap, velocity pattern matched that of depth and the diurnal pattern was well defined. Depth pattern remained the same before and after the sensor swap. Velocity data prior to 2/5/03 is snapped to curve based on depth-velocity relationship after 2/5/03. Velocity drops to zero during early morning hours are snapped to curve
Skyway Control	No significant data adjustment
Skyway Pilot	No significant data adjustment

* = No significant data adjustment indicates differences between the RAW and EDITED data were less than 10%. Where the difference is > 10%, summary of the reason for the difference is provided. The difference between the two data sets include depth and/or velocity adjustments based on field verification, and data gaps where depth and/or velocity data have been edited/flagged.

Table D - 4.2 Data adjustment summary for the Post-rehabilitation monitoring period (2003/2004)

Site Name	Comments*
Auburn Control	No significant data adjustment
Auburn Pilot	No significant data adjustment
Auburn Subtraction	No significant data adjustment
Brier Control	Velocity drops to zero snapped to curve; Velocity multiplier changed from 1 to 0.84 based on velocity profiling. Level Cal changed - The level calibration allows one to adjust the calibration in the level measurement system. Calibrating the level helps obtain maximum accuracy from the flow meter.
Brier Pilot	Based on field verifications, depth was adjusted by 0.13 inches from 1/8 to 1/23/04.
Coal Creek Control	No significant data adjustment
Coal Creek Pilot	No significant data adjustment
Kent Control	No significant data adjustment
Kent Pilot A	Depth sensor malfunctioned and was replaced on 2/2/04; depth data from 1/30/04 6:20 PM to 2/2/04 12:10 PM reconstructed using depth-velocity relationship before 1/30/04; data after 2/11/04 was collected using a level cal of 0.35 inches. These depth data have been adjusted by -0.35 inches to reflect the final level cal of 0.0 inches. In addition, depth data from 2/11 to 2/17/04 have been adjusted by -0.13 inches (margin of error for the field measurements) to match the data after 2/17/04
Kent Pilot B	The 2/17/04 field log indicates that the sensor cable was in the flow (at the time of visit) causing a slight back up. Sensor cables in the flow may also interfere with the ultrasonic level sensor signal and affect the depth measurement. The depth data from 2/11/04 9:50 AM to 2/17/04 12 PM appears to be off by 0.5 to 1 inch compared to the historical data (before 2/11/04 and after 2/17/04).
Kirkland Control	Velocity multiplier changed based on field verification/observation; some velocity reconstituted (snapped)
Kirkland Pilot	Velocity drops snapped
Lake Forest Park Control	No significant data adjustment
Lake Forest Park Pilot	Erroneous depth data flagged
Mercer Control	No significant data adjustment
Mercer Mini	No significant data adjustment
Mercer Pilot	No significant data adjustment
North Shore Control	No significant data adjustment
North Shore Pilot	Velocity drops snapped
Redmond Control	Velocity drops snapped
Redmond Mini	No significant data adjustment
Redmond Pilot	No significant data adjustment
Ronald Control	Ultrasonic sensor was swapped on 1/14/04; The electronic offset was not adjusted properly when swapping the sensor and the depth is adjusted by 1/2 inch (after 1/14/04) to reflect the change due to the improper electronic offset adjustment; field verifications on 1/14/04 indicate that the meter was off by about 0.5 inches

Table D - 4.2 Data adjustment summary for the Post-rehabilitation monitoring period (2003/2004)

Site Name	**Comments***
Ronald Pilot	The original meter produced poor depth and spiky velocity - slight increase in depth was causing the flow to spray off of the sensor/ring assembly and splash on to the ultrasonic sensor (mounted at the crown of the pipe) giving erroneous depth data; Due to unreliable depth data during slightly elevated depths of flow, the meter was replaced with a Flo-Dar unit. The Flo-Dar unit produced good depth and velocity data; Based on field verifications and consistency with the Flo-Dar unit, data from the ADS meter was adjusted by -0.13 inches. Depth ranges from about 1 to 3 inches; velocity ranges 1 to 6 fps; some erroneous velocity and significant amount of depth data flagged
Skyway Control	Velocity multiplier changed based on field verification/observation
Skyway Pilot	Based on field verifications, the depth data was adjusted by 0.17 inches (level cal =0.17 on 1/13/04 verification). During install (10/9/03) it was noted that the incoming pipe (to the manhole) was offset. The field crew realigned the sensor on 11/4 to compensate for the pipe offset (Earth Tech visited the site on 11/7 to check the meter placement and the pipe offset). The depth data from 10/9 to 11/5/03 was reconstructed based on the data after realignment. erroneous velocity and depth data edited;
Val Vue Control	No significant data adjustment
Val Vue Pilot	No significant data adjustment

* = No significant data adjustment indicates differences between the RAW and EDITED data were less than 10%. Where the difference is > 10%, summary of the reason for the difference is provided. The difference between the two data sets include depth and/or velocity adjustments based on field verification, and data gaps where depth and/or velocity data have been edited/flagged.

Table D-5.1a - Data Quality Rating

Data Quality Rating	
Rating	**Criteria**
Good	Minimal to moderate data loss; depth and velocity diurnal patterns matching and consistent with site hydraulics; routine editing performed to flag pops and drops in the data not consistent with the site hydraulics
Fair	Moderate to significant data loss; depth and velocity diurnal patterns matching and consistent with site hydraulics; depth and/or velocity problems identified, and editing performed to flag erroneous data; some data reconstitution performed
Poor	Significant to extensive data loss; depth and velocity diurnal patterns may or may not be matching and in some instances may not be consistent with site hydraulics; Significant amount of data editing and/or reconstitution performed.

Table D-5.1b - Data Loss Rating

Data Loss Rating	
Rating	**Criteria**
Minimal	> 95% Uptime
Moderate	90 - 95% Uptime
Significant	80 - < 90% Uptime
Extensive	< 80% Uptime

Table D - 5.2 Pre-rehabilitation monitoring period final data review summary and comments on data quality and data gaps

Site Name	Data Quality*	Data loss**	Data Review
Auburn Control	Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 2 inches to full pipe and velocity from less than 1 fps to about 3-1/2 fps; velocity occasionally drops to zero; zero velocities not edited; depth on few occasions flatlined at about 8 inches indicating a surcharged condition. As the pressure sensor wasn't functional the depth of flow above full pipe (height) is not determined but assumed to be at least 10 inches (full pipe). Depth and velocity patterns indicate pump station influenced flow; site responds to rain events (increased depth and velocity)
Auburn Pilot	Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 1-1/2 inches to full pipe and velocity from less than 1 fps to about 4 fps; velocity occasionally drops to zero; zero velocities not edited; depth on few occasions flatlined at about 8 inches indicating a surcharged condition. As the pressure sensor wasn't functional the depth of flow above full pipe (height) is not determined but assumed to be at least 10 inches (full pipe). Depth and velocity patterns indicate pump station influenced flow; probable surcharge conditions observed; site responds to rain events (increased depth and velocity); slight back water conditions (above 6.5 inches of depth of flow) observed
Auburn Subtraction	Good	Moderate	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 1-1/2 inches to about 3 inches and velocity from less than 1 fps to about 6 fps; velocity occasionally drops to zero; zero velocities not edited; Shallow and fast flow; Depth and velocity patterns indicate pump station influenced flow; site responds to rain events
Brier Control	Poor to fair	Significant	Good depth data; velocity data poor to fair; some velocity data reconstructed and depth data flagged; Depth ranges from about 1.5 to 5.5 inches and velocity from < 1 fps to about 3 fps; Poor hydraulics - very dirty line- debris accumulate and block flow temporarily creating back water conditions at shallow depths (2 to 3 inches) and distorting the velocity profile (where the radar beam hits the flow and senses the velocity); site responds to rain events (increased depth and velocity); Velocity multiplier (to convert surface to average velocity) was modified based on field verifications
Brier Pilot	Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 1.5 inches to 7 inches and velocity from < 1 fps to about 3 1/2 fps; some poor depth data flagged; depth and velocity patterns changed (increased) 3/22 - 4/16/03; good hydraulics - open channel flow; site responds to rain events (increased depth and velocity); Velocity Gain (to convert Peak to average velocity) was modified based on field verifications.
Coal Creek Control	N/A	N/A	N/A
Coal Creek Pilot	N/A	N/A	N/A
Kent Control	Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 0.5 inches to 1.5 inches and velocity from 1 fps to about 3 fps; some poor velocity data reconstructed; good hydraulics - open channel flow; site responds to rain events (increased depth and velocity)
Kent Pilot A	Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; shallow and fast flow - Depth ranges from about 1 to 2 inches and velocity from 2 to about 8 fps; few erroneous depth data flagged; good hydraulics - open channel flow; site responds to rain events (increased depth and velocity)
Kent Pilot B	Fair	Moderate	Good depth and fair velocity data; patterns match with velocity increasing as depth increased during open channel flow conditions and velocity dropping while depth increased during back water conditions ; Depth ranges from about 1.5 to 3 inches and velocity from < 1 fps to about 3 fps; some poor velocity data edited; poor to good hydraulics - mostly open channel flow but site goes in to back water conditions occasionally; very dirty line- debris accumulate and block flow temporarily creating back water conditions at shallow depths (2 to 3 inches) and distorting the velocity profile (where the radar beam hits the flow and senses the velocity); site responds to rain events (increased depth and velocity)
Kirkland Control	Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 2.5 to 5 inches and velocity from < 1 fps to about 3 fps; good hydraulics - open channel flow; site responds to rain events (increased depth and velocity); Velocity multiplier (to convert surface to average velocity) was modified based on field verifications

Table D - 5.2 Pre-rehabilitation monitoring period final data review summary and comments on data quality and data gaps

Site Name	Data Quality*	Data loss**	Data Review
Kirkland Pilot	Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 2 inches to 6.5 inches and velocity from < 1 fps to about 1-1/2 fps; Flow is relatively deep and slow; Site exhibited two-three patterns during this monitoring period. 11/17 to 11/19 and 11/29 to 12/12, the site hydraulics shifted to a deeper and slower pattern; the hydraulic shift may have been caused by a temporary blockage downstream of the monitoring site; significant response to rain events
Lake Forest Park Control	N/A	N/A	N/A
Lake Forest Park Pilot	N/A	N/A	N/A
Mercer Control	Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Shallow and fast flow - depth ranges from about 0.5 to 2 inches and velocity from 2 to about 8 fps; good hydraulics - open channel flow; site responds to rain events (increased depth and velocity)
Mercer Mini	Fair	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 1 to 3.5 inches and velocity from about 1 to 6 fps; erroneous depth and velocity spikes are flagged; velocity sensor not functioning properly after 3/26; velocity reconstituted 3/27 through 4/20/03 based on previous good depth-velocity relationships; Good hydraulics - open channel flow up to about 3 1/2 inches of flow; site surcharges at shallow depths (above 3.5 inches) due to blockage downstream (the D/S MH (30090)has a plate baffle mounted on it's discharge side to prevent clogging of the Lake Line)- a flow test on 3/19/03 has confirmed this; site responds to rain events (increased depth and velocity)
Mercer Pilot	Fair	Significant	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 0.5 to 3 inches and velocity from 0.5 to about 2.5 fps; some poor depth data flagged; velocity drops to zero during early morning hours; velocity drops reconstituted (snapped to curve);good hydraulics - relatively shallow and slow open channel flow; site responds to rain events (increased depth and velocity)
North Shore Control	N/A	N/A	N/A
North Shore Pilot	N/A	N/A	N/A
Redmond Control	Fair to Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 1 to 4 inches and velocity from < 1 to about 2 fps; erroneous depth and velocity data edited; velocity drops during early morning hours snapped to curve (reconstituted); good hydraulics - open channel flow; site responds to rain events (increased depth and velocity)
Redmond Mini	Good	Minimal	Good depth and velocity data; diurnal patterns with mostly velocity increasing as depth increased; Depth ranges from about 5 inches to 9 inches and velocity mostly < 2 fps ; some poor velocity data flagged; Slow and moderately deep flow; site slightly responds to rain events and exhibits three patterns - (1) open channel flow - example 12/17 - 12/23/02 (2) back water conditions above approximately 5 inches of flow - example 1/4 to 1/6/03 and (3) hydraulic shift to a deeper and slower pattern - example 2/18 - 2/24/03. The hydraulic shift is believed to have been caused by temporary blockage from debris accumulating downstream of the monitoring point. Cobble to boulder sized debris have been observed in the pipe one manhole downstream of this monitoring manhole. There has been a sink hole repair construction in a line that enters the system downstream of the Redmond Mini monitoring site. It appears that pieces of debris from the construction activity may have been dislodged and deposited in to the line downstream creating temporary blockage (click
Redmond Pilot	Poor to fair	Extensive	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 1 to 6.5 inches and velocity from < 1 to about 3 fps; Due to the data loss, the sensor was replaced on 2/5/03. The velocity pattern prior to 2/25/03 was spiky and the diurnal pattern was not well defined. After the sensor swap, velocity pattern matched that of depth and the diurnal pattern was well defined. Depth pattern remained the same before and after the sensor swap. Velocity data prior to 2/5/03 is snapped to curve based on depth-velocity relationship after 2/5/03. Velocity drops to zero during early morning hours. These velocity data are snapped to curve. good hydraulics - open channel flow; even though most of the data loss occurred during rain events, this site appears to respond to rain events (increased depth and velocity)
Ronald Control	N/A	N/A	N/A
Ronald Pilot	N/A	N/A	N/A

Table D - 5.2 Pre-rehabilitation monitoring period final data review summary and comments on data quality and data gaps

Site Name	Data Quality*	Data loss**	Data Review
Skyway Control	Fair to Good	Moderate	Good depth and velocity data; patterns match with velocity increasing as depth increased; Fast and shallow flow (mostly < 2 inches except during rain events); Depth ranges from < 1 to about 6 inches and velocity from about 1 to about 5 fps; velocity quality dropped slightly after 1/2/03 especially during and after rain events; some velocity data is reconstituted; good hydraulics - open channel flow; site exhibits two patterns - during rain events and at other times (no rain); site responds to rain events (increased depth and velocity)
Skyway Pilot	Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Fast and shallow flow (< 2 inches except during rain events) - depth ranges from about 0.5 to 3.5 inches and velocity from 3 to about 10 fps; good hydraulics - open channel flow; site responds to rain events (increased depth and velocity)
Val Vue Control	N/A	N/A	N/A
Val Vue Pilot	N/A	N/A	N/A

N/A = Not monitored during the 2002/2003 pre-rehabilitation monitoring period

*, ** = qualitative ratings set by King County- click on links for details; ** = Data gap periods are listed in Appendix D Table D-2.1

Table D - 5.3 Post-rehabilitation monitoring period final data review summary and comments on data quality and data gaps

Site Name	Data Quality*	Data loss**	Data review
Auburn Control	Fair to Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 2 inches to full pipe and velocity from less than 1 fps to about 4-1/2 fps; some velocity drops snapped to curve and erroneous velocity and depth data flagged; depth on few occasions flatlined at about full pipe indicating a surcharged condition. Pressure sensor depth used instead of ultrasonic depth during surcharge periods. Velocity sensor replaced 12/18/03. Depth and velocity patterns indicate pump station influenced flow; surcharge conditions observed (10/20/03 to 11.5 inches); site responds to rain events (increased depth and velocity).
Auburn Pilot	Fair to Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 2 inches to 30 inches (during surcharge on 11/18 - 11/19/03) and velocity from about 1 fps to about 3.5 fps; some velocity drops snapped to curve and erroneous velocity and depth data flagged; surcharged conditions observed 11/18/03, 11/19/03, and 1/29/04 (to about 18 inches). Depth on few occasions flatlined at about full pipe indicating surcharged conditions. Pressure sensor depth used instead of ultrasonic depth during surcharge periods. Depth and velocity patterns indicate pump station influenced flow; site responds to rain events (increased depth and velocity).
Auburn Subtraction	Fair to Good	Moderate	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 1/4 inches to 3 inches and velocity from about 1/2 fps to about 6 fps; some velocity drops snapped to curve and erroneous velocity and depth data edited; Depth and velocity patterns indicate pump station influenced flow; site responds to rain events (increased depth and velocity), but no surcharge observed.
Brier Control	Fair to Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 3 inches to 6 inches and velocity from about 1/2 fps to about 1-1/2 fps; some velocity drops snapped to curve and erroneous velocity and depth data edited; fair to good hydraulics - moderately deep and slow flow; site responds to rain events (increased depth and velocity), but did not surcharge; Velocity multiplier changed to from 1 to 0.84 based on velocity profiling. Level Cal changed
Brier Pilot	Fair to Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 1.5 inches to 3.5 inches and velocity from about 1 fps to about 4-1/2 fps; good hydraulics - shallow and moderately fast open channel flow; site responds to rain events (increased depth and velocity) some velocity drops snapped to curve and erroneous velocity and depth data flagged; Based on field verifications, depth was adjusted by 0.13 inches from 1/8 to 1/23/04.
Coal Creek Control	Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from 1 to 6 inches and velocity from about 1/2 fps to about 2-1/2 fps; good hydraulics - shallow and slow open channel flow; site responds to rain events (increased depth and velocity) minimal data editing done.
Coal Creek Pilot	Fair to Good	Minimal	Good velocity data; Poor depth data; patterns match with velocity increasing as depth increased; Depth ranges from about 2.5 to 4 inches (mostly) and velocity from about 1 fps to about 2-1/2 fps; erroneous velocity and depth data flagged; fair hydraulics - moderately deep and slow open channel flow; site responds to rain events (increased depth and velocity) minimal data editing done. Pressure depth used 1/29 - 1/30/04. No surcharge was observed.
Kent Control	Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 1/2 inches to 2-1/2 inches and velocity from about 1-1/2 fps to about 3-1/2 fps; erroneous velocity and depth data edited (minimal data editing done); fair to good hydraulics - shallow and slow flow; site responds to rain events (increased depth and velocity), but did not surcharge

Table D - 5.3 Post-rehabilitation monitoring period final data review summary and comments on data quality and data gaps

Site Name	Data Quality*	Data loss**	Data review
Kent Pilot A	Fair to Good	Significant	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth is less than 1 inches and velocity ranges from about 1-1/2 fps to about 5-1/2 fps; erroneous velocity and depth data edited ; fair to good hydraulics - shallow and fast flow; slight response to the 1/29 - 1/30/04 rain event (increased depth and velocity), but did not surcharge. Depth sensor malfunctioned and was replaced on 2/2/04; depth data from 1/30/04 6:20 PM to 2/2/04 12:10 PM reconstructed using depth-velocity relationship before 1/30/04; data after 2/11/04 was collected using a level cal of 0.35 inches. These depth data have been adjusted by -0.35 inches to reflect the final level cal of 0.0 inches. In addition, depth data from 2/11 to 2/17/04 has been adjusted by -0.13 inches (margin of error for the field measurements) to match the data after 2/17/04 - use this portion of the data with caution.
Kent Pilot B	Poor to Fair	Significant	Poor to fair depth and velocity data; Depth ranges from 1/2 to 2 inches and velocity from about 1/2 fps to about 2-1/2 fps; erroneous velocity and depth data edited ; poor to fair hydraulics - shallow and slow; site exhibits alternating open channel flow and back water conditions ; dirty line - debris accumulate and block flow temporarily creating back water conditions even at shallow depths (< 2 inches) distorting the depth-velocity profile; slight response to the 1/29 - 1/30/04 rain event; the 2/17/04 field log indicates that the sensor cable was in the flow (at the time of visit) causing a slight back up. Sensor cables in the flow may also interfere with the ultrasonic level sensor signal and affect the depth measurement. The depth data from 2/11/04 9:50 AM to 2/17/04 12 PM appears to be off by 0.5 to 1 inch compared to the historical data (before 2/11/04 and after 2/17/04). These portion of the data have been adjusted, but should be used cautiously.
Kirkland Control	Fair to Good	Minimal	Good depth and velocity data; Depth ranges from 2 to 6 inches and velocity from about 1 fps to about 2-1/2 fps; erroneous velocity and depth data edited; some velocity data reconstructed ; Velocity multiplier changed; good hydraulics - moderately deep and slow; site responds to rain events, but didn't surcharge
Kirkland Pilot	Fair to Good	Minimal	Good depth data; Poor velocity data during early morning hours (drops to zero); patterns match with velocity increasing as depth increased; Depth ranges from about 3 to 10 inches (during rain storms) and velocity from about 1/2 fps to about 1-1/2 fps; erroneous velocity and depth data flagged; velocity drops snapped to curve; fair to good hydraulics - moderately deep and slow open channel flow; site responds to rain events (increased depth and velocity). Two patterns observed - flow became deeper and slower after 10/17/03. No surcharge was observed.
Lake Forest Park Control	Fair to Good	Minimal	Good depth and velocity data; velocity spiky; patterns match with velocity increasing as depth increased; Depth ranges from about 2 to 10 inches (during rain storms - 11/18/03) and velocity from about 2-1/2 fps to about 5 fps; erroneous velocity and depth data flagged; some velocity drops snapped to curve; fair to good hydraulics - relatively fast open channel flow; site responds to rain events (increased depth and velocity). Site surcharged for a short time on 11/18/03.
Lake Forest Park Pilot	Fair	Moderate	Poor depth data; velocity spiky; Depth ranges from about 1 to 7 inches (during surcharge and backwater conditions) and velocity from about 1 fps to about 5 fps; erroneous velocity and depth data flagged; pressure sensor depth used during surcharge and occasionally to replace poor ultrasonic depth data; poor to fair hydraulics - shallow and relatively fast open channel flow; site responds to rain events (increased depth and velocity);Site surcharged on 11/18/03 and 1/29/04; Backwater conditions observed 1/27/03 to 2/19/04 - field observation indicated that debris in the pipe could have created the observed backwater condition in the pipe by partially blocking the pipe and increasing the depth and reducing the velocity of the flow.
Mercer Control	Good	Minimal	Good depth and velocity data; Depth ranges from 1/2 to about 2-1/2 inches and velocity from about 2 fps to about 7 fps; erroneous velocity and depth data edited (minimal data editing); good hydraulics - shallow and fast flow; site responds to rain events, but didn't surcharge.

Table D - 5.3 Post-rehabilitation monitoring period final data review summary and comments on data quality and data gaps

Site Name	Data Quality*	Data loss**	Data review
Mercer Mini	Good	Minimal	Good depth and velocity data; Depth ranges from about 1 to 2-1/2 inches, but spikes to full pipe during rain storms; This site exhibits backwater conditions even at lower depths of flow (3.5 to 4 inches) and overflows to the overflow pipe (@ 17.5 inches); such depth spikes have been edited; erroneous velocity and depth data flagged; pressure sensor depth used during surcharge; fair to good hydraulics - shallow and relatively fast (velocity 1 to 6 fps) open channel flow; site responds to rain events (increased depth and velocity);Site surcharged on 11/18/03, 11/19/03, 1/7/04, and1/29/04.
Mercer Pilot	Fair to Good	Moderate	Good depth and velocity data; Depth ranges from about 1 to about 3-1/2 inches and velocity from about 1/2 fps to about 3 fps; erroneous velocity and depth data edited; velocity values that drop to zero during early morning hours are snapped to curve(minimal data editing); good hydraulics - relatively shallow and slow flow; site responds to rain events, but didn't surcharge.
North Shore Control	Fair to Good	Minimal	Good depth and velocity data; Depth ranges from about 1 to 6-1/2 inches; velocity ranges 1/2 to 2-1/2 fps; erroneous velocity and depth data flagged; some velocity data snapped to curve; fair to good hydraulics - moderately deep and relatively slow open channel flow; site responds to rain events (increased depth and velocity) , but no surcharge observed.
North Shore Pilot	Fair	Minimal	Good depth and poor velocity data; Depth ranges from about 1 to 3-1/2 inches; velocity ranges 1/2 to 2 fps; erroneous velocity and depth data flagged; some velocity data snapped to curve; poor to fair hydraulics - shallow and slow open channel flow; site responds to rain events (increased depth and velocity) , but no surcharge observed.
Redmond Control	Fair	Minimal	Good depth and spiky velocity data; Depth ranges from about 1 to 3 inches and goes to full pipe and surcharged during some spiky events; velocity ranges from less than 1 fps to about 2-1/2 fps; spiky velocity and some zero values snapped to curve and erroneous velocity and depth data edited; fair to good hydraulics - relatively shallow and slow flow slight response to rain events (increased depth and velocity).
Redmond Mini	Fair to Good	Minimal	Good depth and velocity data; Depth ranges from about 2 1/2 to 7 1/2 inches; velocity ranges 1/2 to 3 fps; early morning spikes(up to 25 inches max on 11/22/03) observed on 11/16, 11/18, 11/20, 11/22, 11/24, 11/26, 12/3, 12/12, 12/16, 12/17, 12/18, 12/19, and 12/23/03 and 1/21/04; erroneous velocity and depth data flagged; fair to good hydraulics moderately deep and slow open channel flow; site responds to rain events (increased depth and velocity) , but no surcharge due to rain observed; slight pattern shifts observed - site became deeper and faster starting 11/18/03 and returned to relatively shallower and slower around 12/20/03.
Redmond Pilot	Fair to Good	Minimal	Good depth and velocity data; Depth ranges from about 2 to 4 inches mostly and goes to full pipe and surcharged during some spiky events; velocity ranges from less than 1 fps to about 1-1/2 fps; spiky velocity and some zero values snapped to curve and erroneous velocity and depth data edited; fair to good hydraulics - relatively shallow and slow flow slight response to rain events (increased depth and velocity). Two patterns are apparent - site became deeper and slower after 2/20/04.
Ronald Control	Fair to Good	Minimal	Good depth and velocity data; Depth ranges from about 1/2 to 3-1/2 inches; velocity ranges 1/2 to 6 fps; erroneous velocity and depth data flagged; fair to good hydraulics - shallow and fast open channel flow; site responds to rain events (increased depth and velocity) , but no surcharge due to rain observed; Ultrasonic sensor was swapped on 1/14/04; The electronic offset was not adjust properly when swapping the sensor and the depth is adjusted by 1/2 inch (after 1/14/04) to reflect the change due to the improper electronic offset adjustment; field verifications on 1/14/04 indicate that the meter was off by about 0.5 inches

Table D - 5.3 Post-rehabilitation monitoring period final data review summary and comments on data quality and data gaps

Site Name	Data Quality*	Data loss**	Data review
Ronald Pilot	Poor to Fair	Significant	The ADS meter produced poor depth and spiky velocity - slight increase in depth was causing the flow to spray off of the sensor/ring assembly and splash on to the ultrasonic sensor (mounted at the crown of the pipe) giving erroneous depth data; Due to unreliable depth data during slightly elevated depths of flow, the ADS meter was replaced with a Flo-Dar unit. The Flo-Dar unit produced good depth and velocity data; Based on field verifications and consistency with the Flo-Dar unit, data from the ADS meter was adjusted by -0.13 inches. Depth ranges from about 1 to 3 inches; velocity ranges 1 to 6 fps; erroneous velocity and depth data flagged; poor to fair hydraulics - shallow and fast open channel flow; site responds to rain events (increased depth and velocity) , but no surcharge due to rain observed; two patterns observed - site got deeper and faster after the 11/18 - 11/19/03 storm
Skyway Control	Good	Minimal	Good depth and velocity data; Depth ranges from 1/2 to about 6 inches and velocity from about 1-1/2 fps to about 5 fps (during rain events); few erroneous velocity data edited (minimal data editing); good hydraulics - shallow (mostly < 2 inches) and slow (except during rain events) flow; site responds to rain events, but didn't surcharge. Velocity multiplier changed.
Skyway Pilot	Fair to Good	Minimal	Good depth and velocity data; Depth less than 2 inches and velocity ranges from about 3 to about 6 fps (and increased to about 10 fps during rain events); Based on field verifications, the depth data was adjusted by 0.17 inches (level cal =0.17 on 1/13/04 verification). During install (10/9/03) it was noted that the incoming pipe (to the manhole) was offset. The field crew realigned the sensor on 11/4 to compensate for the pipe offset (Earth Tech visited the site on 11/7 to check the meter placement and the pipe offset). The depth data from 10/9 to 11/5/03 was reconstructed based on the data after realignment. erroneous velocity and depth data edited; good hydraulics - shallow (< 2 inches) and fast flow; site responds to rain events, but didn't surcharge.
Val Vue Control	Fair to Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 1/2 inches to 2 inches and velocity from 3 fps to about 14 fps; some velocity drops snapped to curve and erroneous velocity and depth data flagged; fair to good hydraulics - shallow and fast open channel flow; site responds to rain events (increased depth and velocity) , but no surcharge due to rain observed; Very difficult site to confirm velocity (flow too fast)
Val Vue Pilot	Fair to Good	Minimal	Good depth and velocity data; patterns match with velocity increasing as depth increased; Depth ranges from about 1/2 inches to 4.5 inches and velocity from 1/2 fps to about 4.5 fps; some velocity drops snapped to curve and erroneous velocity and depth data flagged; fair to good hydraulics - shallow and moderately fast pump station influenced flow; site responds to rain events (increased depth and velocity) , but no surcharge due to rain observed; There is a Dosing Station upstream of this site. The Dosing Station consists of a rock catcher structure and a wet well dry well area. The Station feeds a double siphon dosing it to as a means to keep the siphons clean. The wet well is 8' in diameter and flushes 4' every time it flushes. The station has a 50.3 cubic feet or 377 gallons per/flush capacity.

*, ** = qualitative ratings set by King County- click on links for details; ** = Data gap periods are listed in Appendix D Table D-2.2

Appendix E

I/I Pilot Project Rainfall Monitoring

Description:

This appendix documents the rainfall monitoring and data development conducted for the subsequent modeling and analysis.

Reference Chapter:

Chapter 8 – Rehabilitation Effectiveness

Author:

Mike Morgan, P.E., Earth Tech Team

RAINFALL MONITORING

BACKGROUND

Rainfall time series were developed for the pilot project modeling basins as a composite of CALAMAR events and rain gauge data. Time series of rain gauge readings were first developed by combining the three nearest correctly working rainfall gauges that triangulated the modeling area into one data set. Note that four gauges were used if the three nearest were missing a large amount of data. The gauges were combined using a simple inverse distance weighted interpolation approach, with a weighting power of two, and the distance represented by the distance from the gauge to the centroid of the modeling basin. After the rain gauge time series were developed, the CALAMAR event time series were substituted into the rain gauge time series to become a composite time series.

RAINFALL TIME SERIES

The King County Wastewater Treatment Division (WTD) and Water and Land Resources Division (WLRD) each operate a network of rain gauges throughout King County. For each pilot project modeling basin, nearby WLRD and WTD rain gauges were combined into one representative rainfall time series. The three closest gauges that triangulated the modeling area of concern were combined at a 5-minute time interval. When the three closest gauges were missing a large amount of data, the next closest gauge was also added to the combination. Gauges that were not working properly during any given period were excluded from the analysis. See Table 1 for a list of the gauges used to develop the rainfall time series for each modeling basin.

Table 1
Rain Gauges Used to Develop Rainfall Time Series

Agency	Pilot/Mini Basin	Sub-Basin	Rain Gauge	Rain Gauge	Rain Gauge	Rain Gauge
Auburn	ABN002	Pilot Control	LOWG LOWG	COVG COVG	LHPS LHPS	
Kent	KNT014	Pilot Control	MOIN MOIN	KENT KENT	STAR STAR	SEQU SEQU
ValVue	VAL019	Pilot	REBA	TUKW	MOIN	
ValVue	VAL017	Control	REBA	TUKW	MOIN	
Skyway	BLS002	Pilot Control	HAMM HAMM	MAPL MAPL	TUKW TUKW	
Coal Creek	CCR002	Pilot	MERC	FACT	HEAT	LOWM
Coal Creek	CCR009	Control	MERC	FACT	HEAT	LOWM
Mercer Island	MRC012	Pilot Control	PINE PINE	MEDI MEDI	MERC MERC	RAIN RAIN
Kirkland	KRK011	Pilot Control	JBAY JBAY	KIRK KIRK	YARR YARR	
Northshore	NUD038	Pilot	KENM	NORW	NCKR	BOTH
Northshore	BOT012	Control	KENM	NORW	NCKR	BOTH

Agency	Pilot/Mini Basin	Sub-Basin	Rain Gauge	Rain Gauge	Rain Gauge	Rain Gauge
Brier	BRR004	Pilot Control	LYON LYON	KENM KENM	BOTH BOTH	
Lake Forest Park	RON041	Pilot	LYON	KENM	City of Seattle RG1	
Lake Forest Park	RON039	Control	LYON	KENM	City of Seattle RG1	
Ronald	RON002	Pilot	BOEN	LYON	City of Seattle RG1	
Ronald	RON045	Control	BOEN	LYON	City of Seattle RG1	
Redmond	RDM009	Pilot Control	HOLL HOLL	NOVH NOVH	KIRK KIRK	XRDS XRDS

The gauges were combined with a simple inverse distance weighted interpolation method. The centroid of the basin was chosen as the point of reference for the distance estimate to the surrounding gauges. The weighting power was set to the square. Other weighting powers were considered; however, the square qualitatively best represented the data and is assumed to be an optimal standard among the scientific community.

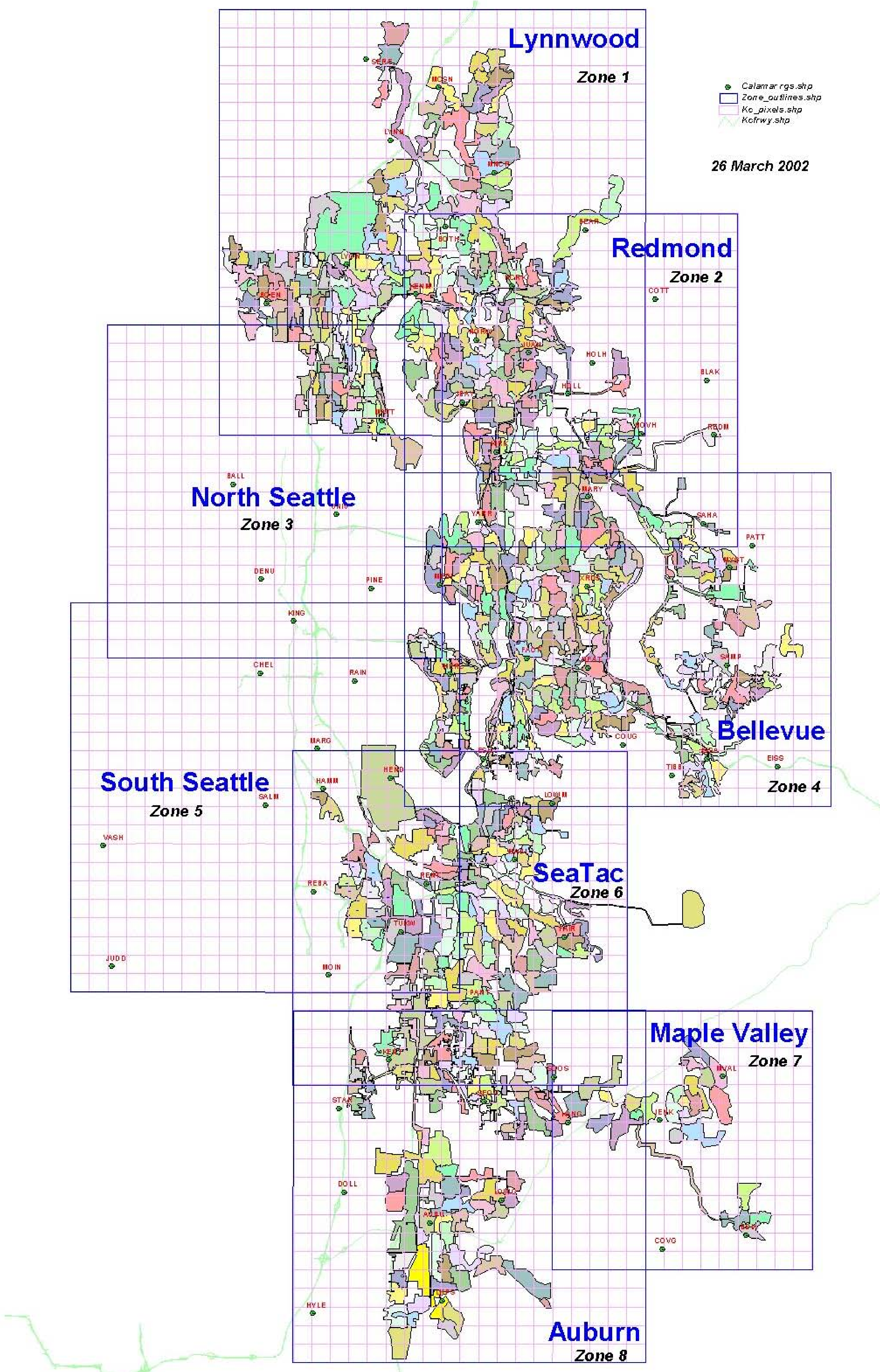
CALAMAR EVENT TIME SERIES

Principles of Radar Technology and CALAMAR

CALAMAR (CAlcul de LAMes d'eau a l'Aide du Radar--translates to "Calculating Rain with the Aid of Radar") was used to calculate rainfall during storm events. CALAMAR operates by acquiring raw reflectivity images from the NEXRAD radar and processing the data with a geographic resolution of 1 km^2 pixels and a 5-minute temporal resolution. Rain gauges provide "ground truth" such that, when calibrated, a pixel containing a rain gauge will show approximately the same rainfall value as a rain gauge within that pixel. This works well on a storm-by-storm basis since each type of storm cell produces a characteristically similar radar image. However, using the technology over a large service area provides the opportunity for multiple storms of different characteristics to occur simultaneously within the service area. In order to assure that only the rainfall in each region is used to calibrate the radar image for that region, the King County service area was separated into eight calibration zones of 200 to 500 km^2 each (see Figure 1).

The CALAMAR calibration process was adjusted in 2004 in the Lynnwood and Redmond zones to take into account the frequent occurrence of the bright band filling the radar beam south of the Lynnwood zone and in most of the Redmond zone. The bright band affects the translation of the raw NEXRAD reflectivity image to rainfall. The rain gauges used to calibrate these zones were adjusted; however, the zone definitions were not affected.

Figure 1
CALAMAR Calibration Zones



Network of Calibrating Rain Gauges

The King County WTD and WLRD network of rain gauges was used for calibration by CALAMAR. An additional 25 gauges were installed to create sufficient density for calibration. Rain gauge BOTH was relocated approximately 1/4 mile east during the summer of 2001. Table 2 is an inventory of all King County rain gauges.

Table 2
Rain Gauge Inventory

WLRD GAUGE_#	GAUGE_NAME	CALAMAR NAME	DESCRIPTION
02V	Blakely Ridge	BLAK	Blakely Ridge Precipitation, near Redmond.
04U	Boeing Creek	BOEN	Shoreline Community College near Seattle.
02W	Cottage Lake	COTT	At King County Fire Station near Cottage Lake
63Y	Cougar Mountain	COUG	Cougar Mountain Park
09U	Covington Creek	COVG	Near Horseshoe Lake, near Black Diamond.
11U	Des Moines Creek	MOIN	In Tyee Golf Course, in SeaTac.
14U	East Fork Issaquah	EISS	East Fork Issaquah Precipitation, west of High Point.
31Y	Fairwood	FAIR	None
HCU	Hamm Creek	HAMM	None
51W	Hollywood Hill	HOLH	In Hollywood, north of Redmond.
26U	Jenkins Creek	JENK	Near Shadow Lake.
27U	Juanita Creek	JUAN	K.C. Fire Station in Kingsgate.
28U	Judd Creek	JUDD	Vashon Cemetery
41V	Lake Dolloff	DOLL	South of Lake Dollof, near Federal Way.
42U	Lake Reba	REBA	Near Lake Reba detention facility.
32U	Lower Green River	LOWG	At K.C. Fire Station, near Auburn.
37U	Lower May Creek	LOWM	Near Renton.
35U	Lyons Creek	LYON	At Brugers Bog KCPW Shop in Lake Forest Park.
31U	Maplewood	MAPL	Near Renton.
MLU	Mystic Lake	MYST	At Fire station
24V	East Fork Hylebos	HYLE	East Fork Hylebos
43U	North Vashon	VASH	Heights Water District
51U	Norway	NORW	South Bothell.
03Y	Panther Creek	PANT	Panther Regional Detention Pond, near Kent.
48U	Patterson Creek	PATT	SR 202 near Redmond.
18V	Redmond UPD	REDM	In Northridge UPD
50U	Salmon Creek	SALM	15th Ave SW north of SW 106th ST.
54V	Soos Creek	SOOS	In Soos Creek Park.
41U	Star Lake	STAR	South of Star Lake, near Federal Way.
67U	Tibbetts Creek	TIBB	On SR 900, near Issaquah.
WTD GAUGE_#	**GAUGE_NAME**	**CALAMAR NAME**	**DESCRIPTION**
XXXXXX0770	25 West Main St., Auburn	AUBU	City Hall, 25 West Main St., Auburn
XXXXXX4992	5000-6000 block James, Kent	KENT	5000-6000 block James, Kent
XXXXXX3145	525 1st Ave., Issaquah	ISSA	525 1st Ave., Issaquah
LQF815078VL	Ballard RS	BALL	Ballard RS
LQF806078VL	Chelan RS	CHEL	Chelan RS
LQF602078VL	RG at Dexter and Republican	DENN	RG at Dexter and Republican
LQF813178VL	Denny Way RS	DENU	Denny Way RS
LQF773078VL	East Marginal Way PS	MARG	East Marginal Way PS
LQF783078VL	East Pine PS	PINE	East Pine PS
LQF335214VL	ESI Sect. 4, MH R02-25, Renton	ESI4	ESI Sect. 4, Manhole R02-25, Renton
	Heathfield PS	HEAT	Heathfield PS
LQF774078VL	Henderson PS	HEND	Henderson PS
LQF308078VL	Hollywood PS	HOLL	Hollywood PS
LQF788078VL	Kenmore PS	KENM	Kenmore PS
LQF801078VL	King Street RS	KING	King Street RS
LQF786078VL	Matthews Park PS	MATT	Matthews Park PS

LQF770078VL	Rainier Ave PS	RAIN	Rainier Ave PS
LQF819078VL	University RS	UNIV	University RS
New WTD Gauges	**New RG_NUMBER**	**CALAMAR NAME**	**DESCRIPTION**
N/A	1	SEQU	Sequoia Jr. HS
N/A	2	LHPS	Lakeland Hills PS
N/A	3	KANG	Fire Station, 15635 Kent Kangley
N/A	4	MVAL	Maple Valley Retention Pond D92151
N/A	5	BDIA	Black Diamond PS, Jones Lake rd.
N/A	6	MERC	School Admin. Mercer Island
N/A	7	FACT	Factoria Transfer Station
N/A	8	MEDI	Medina PS
N/A	10	XRDS	Fire Station 3, 16100 NE 8th St
N/A	11	SAMP	Retention Pond, 235th Pl. N & 32nd St
N/A	12	SAHA	Retention Pond, 22124 Redmond Fall City Rd
N/A	13	NOVH	Retention Pond, 18808 103rd St. D90930
N/A	14	MARY	Marymoor Park
N/A	15	KIRK	Kirkland Maint. Center, 915 8th St
N/A	16	YARR	Yarrow Bay PS
N/A	17	NCRK	North Creek PS
N/A	18	BEAR	Retention Pond, 229th St SE & 75 Av SE
N/A	19	MNCR	Retention Pond, 19812 26th Dr. SE
N/A	20	BOTH	Intermountain Glass, 23905 Meridian Av. S
N/A	21	LYNN	Lynnwood HS
N/A	22	MCSN	Alderwood PS 17, Mill Creek
N/A	23	SERE	Fire Station 3, 4323 Serene Way
N/A	24	TUKW	Tukwila PS
N/A	25	RENT	Renton WWTP
N/A	26	JBAY	KC Service Center, Juanita Dr and 93rd Av.
Note: New WTD Gauge Number 9 not placed for the study			

In addition to the rain gauges listed above, 2 Snohomish County gauges and 17 City of Seattle gauges were also used for calibration by CALAMAR. Thus, the total number of calibration gauges was 92.

CALAMAR Events

The CALAMAR event time series were developed for all rainfall events corresponding to the flow monitoring periods. Seven rainfall events were selected during both the pre- and post-rehabilitation monitoring periods as events that created a measurable I/I response in the project basins. Rainfall events that were affected by snowfall were not included. Table 3 lists the selected events.

Table 3
CALAMAR Events

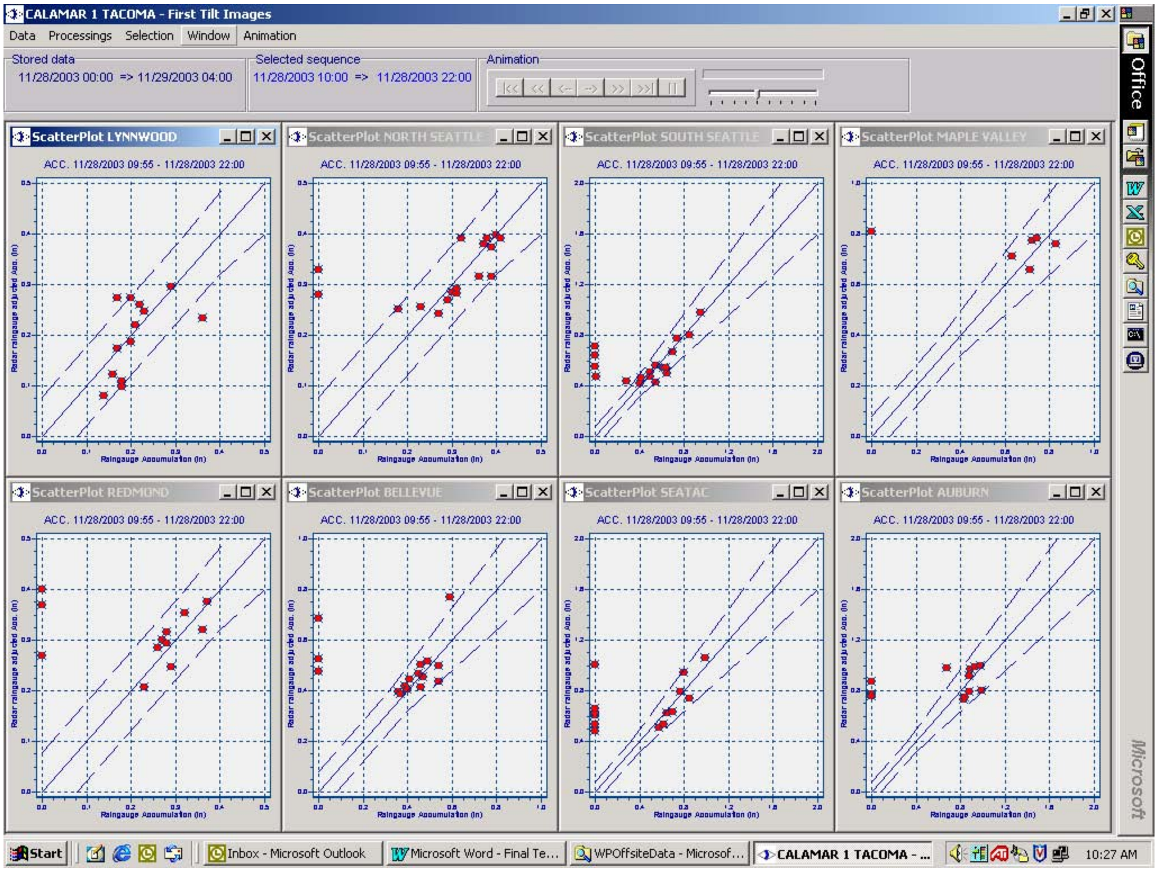
Storm	Event Start Time	Event Stop Time
2002/03 Pre-Rehab Monitoring Season		
1	12/13/2002 12:20 12/14/2002 2:15	12/13/2002 21:45 12/15/2002 3:10
2	12/15/2002 4:00 12/15/2002 21:00 12/17/2002 0:00	12/15/2002 6:00 12/16/2002 9:35 12/17/2002 10:25
3	1/1/2003 8:30 1/1/2003 23:30 1/2/2003 3:00 1/2/2003 6:00 1/2/2003 16:30	1/1/2003 22:30 1/2/2003 3:00 1/2/2003 6:00 1/2/2003 12:15 1/3/2002 0:00
4	1/4/2003 4:30	1/4/2003 12:30
5	1/21/2003 0:00 1/21/2003 9:30 1/22/2003 6:00 1/23/2003 2:20	1/21/2003 5:00 1/21/2003 13:30 1/22/2003 16:55 1/23/2003 4:30
6	3/12/2003 1:15 3/12/2003 9:15	3/12/2003 6:20 3/13/2003 3:15
7	3/21/2003 0:00 3/21/2003 13:00 3/21/2003 21:00 3/22/2003 3:00 3/23/2003 8:30	3/21/2003 7:00 3/21/2003 21:00 3/22/2003 3:00 3/22/2003 9:00 3/24/2003 0:00
2003/04 Post Rehab Monitoring Season		
1	10/19/2003 22:30	10/21/2003 5:00
2	11/17/2003 18:00	11/19/2003 3:30
3	11/28/2003 10:00	11/28/2003 22:00
4	12/4/2003 15:30 12/4/2003 19:55 12/5/2003 3:00 12/5/2003 7:00	12/4/2003 18:15 12/5/2003 0:00 12/5/2003 7:00 12/5/2003 12:00
5	1/14/2004 2:10	1/14/2004 23:55
6	1/23/2004 13:30	1/23/2004 22:20
7	1/29/2004 3:00 1/30/2004 0:00	1/29/2004 16:00 1/30/2004 2:30

Events were initially chosen based on the I/I response in the project basins. For CALAMAR purposes, events were further broken down into smaller time periods that had similar radar behavior, and dry weather episodes embedded in the initial event were disregarded.

Calibration Scatterplots

The basic tool for evaluating the calibration of each zone is a scatterplot displaying the rain gauge accumulation versus the radar rainfall accumulation for each rainfall event. These scatterplots allow dysfunctional rain gauges to be identified so that they can be disregarded during the calibration of the zone in which they reside. Figure 2 shows an example of the scatterplots for all of the calibration zones for Post-Rehabilitation Storm 3 that occurred on 11/28/2003.

Figure 2
CALAMAR Scatterplots for 11/28/03



As shown on the scatterplots, the rain gauges that fell along the y-axis were measuring zero and not functioning properly. These gauges were disregarded from the calibration.

CALAMAR can also identify inaccurate rain gauges. Inaccuracies can have several causes including plugged funnels, corroded tipping buckets, or being in the "rain shadow" of trees or buildings. Rain shadows exist when a rain gauge is partially obstructed by structures and trees or if nearby buildings significantly alter wind patterns above the rain gauge.

Table 4 lists, for each calibration zone, the percentage of pixels with an accumulation within 20 percent of the accumulation of the associated rain gauge. Because of the change to the CALAMAR calibration process for the Lynnwood and Redmond zones, the storms from the 2001/02 monitoring process were re-evaluated. The results of the re-evaluation are also included in Table 4.

Table 4
CALAMAR Calibration Summary

2001-2002 Monitoring Season

Storm	Storm Start Time	Storm End Time	Lynnwood	Redmond	N. Seattle	Bellevue	S. Seattle	Seatac	M. Valley	Auburn	Storm Average	No. of Gauges in Calibration
			King County Calibration Zones									
1	11/4/2001 16:40	11/5/2001 2:00	91%	88%	100%	82%	65%	80%	100%	89%	87%	77
2	11/13/2001 15:05	11/14/2001 19:00	91%	100%	100%	100%	94%	100%	100%	100%	98%	
	11/15/2001 6:00	11/15/2001 15:10	82%	75%	86%	100%	59%	100%	100%	78%	85%	
	11/15/2001 18:00	11/16/2001 7:00	100%	100%	100%	91%	100%	100%	100%	100%	99%	77
3	11/19/2001 1:00	11/19/2001 20:25	100%	100%	100%	83%	100%	100%	80%	78%	93%	
	11/19/2001 23:30	11/20/2001 4:35	100%	100%	93%	92%	65%	80%	100%	100%	91%	
	11/20/2001 14:50	11/20/2001 18:50	100%	100%	100%	100%	82%	100%	100%	100%	98%	
	11/20/2001 19:50	11/20/2001 23:55	100%	100%	93%	100%	76%	90%	100%	89%	94%	77
4	11/21/2001 21:30	11/22/2001 5:30	80%	88%	100%	67%	100%	78%	100%	100%	89%	
	11/22/2001 5:30	11/22/2001 13:00	100%	100%	87%	75%	88%	89%	80%	100%	90%	
	11/22/2001 14:00	11/23/2001 4:30	70%	88%	80%	75%	69%	78%	80%	78%	77%	77
5	11/28/2001 3:45	11/28/2001 15:55	78%	75%	79%	50%	56%	78%	60%	100%	72%	
	11/28/2001 18:30	11/18/2001 21:00	100%	100%	100%	100%	100%	100%	100%	100%	100%	
	11/28/2001 21:00	11/29/2001 0:05	89%	88%	93%	92%	94%	78%	100%	100%	92%	
	11/29/2001 5:35	11/29/2001 14:25	89%	100%	100%	58%	94%	78%	80%	100%	87%	
	11/30/2001 4:00	11/30/2001 7:00	100%	88%	86%	67%	88%	100%	100%	100%	91%	
	11/30/2001 17:00	11/30/2001 22:00	100%	100%	79%	42%	88%	89%	100%	100%	87%	75
6	12/12/2001 9:30	12/12/2001 14:30	100%	100%	100%	33%	93%	100%	100%	100%	91%	
	12/13/2001 3:30	12/13/2001 21:00	60%	100%	91%	92%	93%	100%	100%	89%	91%	72
7	12/15/2001 9:30	12/15/2001 14:30	100%	88%	87%	33%	69%	100%	80%	67%	78%	
	12/16/2001 0:00	12/16/2001 5:30	100%	100%	93%	75%	93%	60%	100%	78%	87%	
	12/16/2001 5:30	12/17/2001 1:00	80%	88%	93%	67%	69%	90%	100%	56%	80%	77
8	12/31/2001 1:00	12/31/2001 8:00	100%	78%	100%	92%	100%	100%	100%	100%	96%	
	1/1/2002 13:30	1/1/2002 18:00	73%	100%	93%	75%	94%	100%	80%	78%	87%	
	1/1/2002 18:05	1/2/2002 1:00	82%	88%	100%	92%	94%	90%	100%	100%	93%	78
9	1/6/2002 9:25	1/8/2002 1:15	90%	100%	100%	92%	100%	90%	80%	89%	93%	
	1/8/2002 3:30	1/8/2002 5:30	82%	100%	100%	100%	100%	100%	100%	100%	98%	78
10	1/12/2002 1:00	1/12/2002 9:00	91%	100%	60%	92%	80%	100%	100%	100%	90%	78
		Average % within 20%	90%	94%	93%	79%	86%	91%	94%	92%	90%	

2002-2003 Pre-Rehab Monitoring Season

Storm r	Storm Start Time	Storm End Time	Lynnwood	Redmond	N. Seattle	Bellevue	S. Seattle	Seatac	M. Valley	Auburn	Storm Average	No. of Gauges in Calibration
			King County Calibration Zones									
1	12/13/2002 12:20	12/13/2002 21:45	82%	86%	100%	55%	63%	80%	100%	90%	82%	
	12/14/2002 2:15	12/15/2002 3:10	55%	71%	100%	82%	75%	100%	40%	70%	74%	75
2	12/15/2002 4:00	12/15/2002 6:00	100%	100%	100%	100%	100%	100%	100%	100%	100%	
	12/15/2002 21:00	12/16/2002 9:35	55%	100%	100%	55%	81%	70%	100%	90%	81%	
	12/17/2002 0:00	12/17/2002 10:25	91%	100%	100%	73%	94%	100%	100%	100%	95%	75
3	1/1/2003 8:30	1/1/2003 22:30	80%	86%	100%	60%	94%	100%	100%	100%	90%	
	1/1/2003 23:30	1/2/2003 3:00	100%	100%	100%	100%	83%	100%	100%	56%	92%	
	1/2/2003 3:00	1/2/2003 6:00	100%	100%	100%	90%	72%	100%	100%	100%	95%	
	1/2/2003 6:00	1/2/2003 12:15	100%	100%	100%	100%	94%	100%	100%	100%	99%	
	1/2/2003 16:30	1/3/2003 0:00	80%	86%	100%	90%	83%	90%	60%	56%	81%	76
4	1/4/2003 4:30	1/4/2003 12:30	80%	100%	100%	90%	94%	100%	100%	78%	93%	76
5	1/21/2003 0:00	1/21/2003 5:00	100%	100%	100%	100%	100%	100%	100%	100%	100%	
	1/21/2003 9:30	1/21/2003 13:30	100%	100%	100%	100%	100%	89%	100%	78%	96%	
	1/22/2003 6:00	1/22/2003 16:55	82%	100%	100%	91%	76%	100%	100%	89%	92%	
	1/23/2003 2:20	1/23/2003 4:30	91%	100%	93%	100%	53%	78%	100%	100%	89%	76
6	3/12/2003 1:15	3/12/2003 6:20	100%	100%	100%	100%	94%	89%	100%	80%	95%	
	3/12/2003 9:15	3/13/2003 3:15	91%	100%	87%	80%	65%	89%	80%	60%	82%	77
7	3/21/2003 0:00	3/21/2003 7:00	100%	100%	100%	100%	100%	100%	100%	100%	100%	
	3/21/2003 13:00	3/21/2003 21:00	91%	63%	85%	60%	67%	89%	80%	70%	76%	
	3/21/2003 21:00	3/22/2003 3:00	91%	88%	92%	100%	100%	100%	100%	60%	91%	
	3/22/2003 3:00	3/22/2003 9:00	100%	100%	85%	100%	73%	56%	80%	60%	82%	
	3/23/2003 8:30	3/24/2003 0:00	91%	100%	85%	90%	100%	56%	100%	90%	89%	74
		Average % within 20%	89%	95%	97%	87%	85%	90%	93%	83%	90%	

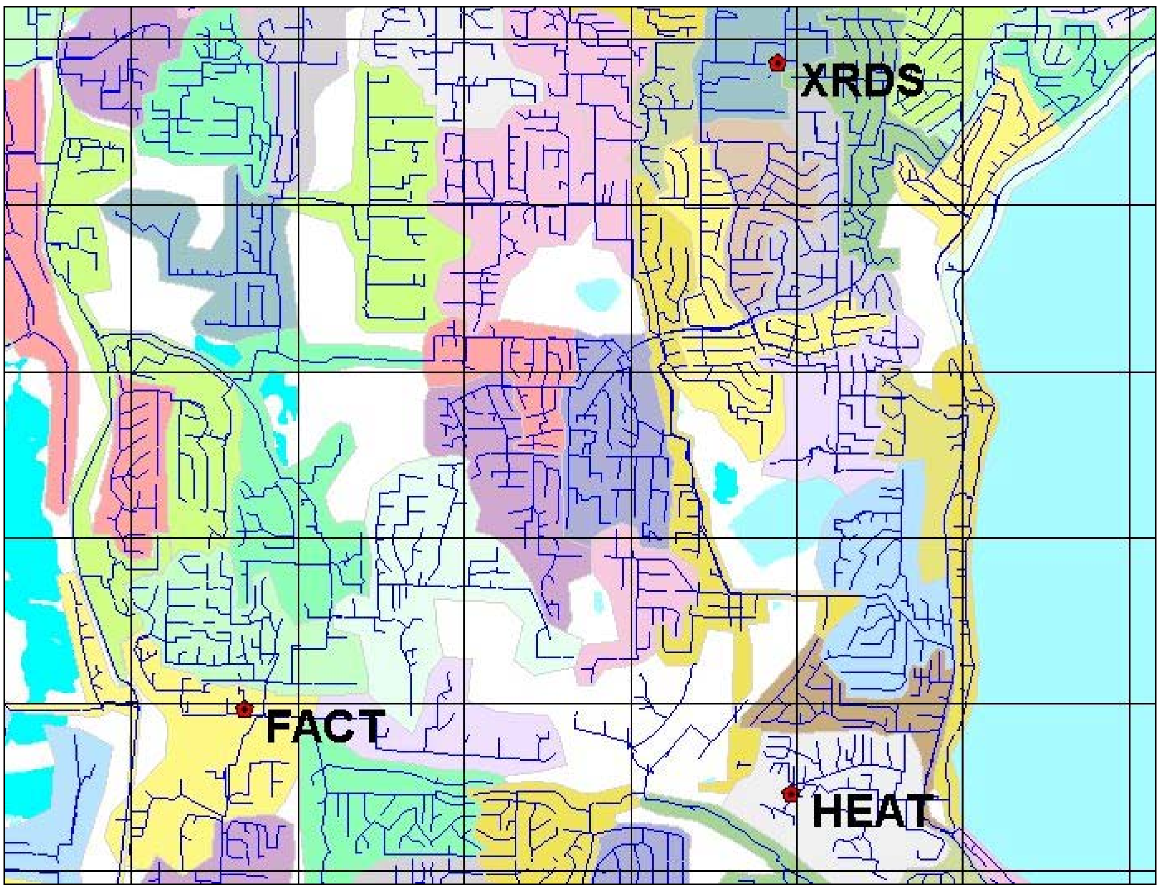
2003-2004 Post-Rehab Monitoring Season

Storm Number	Storm Start Time	Storm End Time	Lynnwood	Redmond	N. Seattle	Bellevue	S. Seattle	Seatac	M. Valley	Auburn	Storm Average	No. of Gauges in Calibration
			King County Calibration Zones									
1	10/19/2003 22:30	10/21/2003 5:00	89%	100%	100%	91%	79%	100%	100%	100%	95%	69
2	11/17/2003 18:00	11/19/2003 3:30	86%	71%	100%	82%	87%	75%	100%	78%	85%	70
3	11/28/2003 10:00	11/28/2003 22:00	82%	100%	100%	91%	81%	100%	100%	89%	93%	74
4	12/4/2003 15:30	12/4/2003 18:15	73%	100%	100%	90%	100%	100%	100%	100%	95%	
	12/4/2003 19:55	12/5/2003 0:00	100%	86%	100%	50%	87%	100%	100%	100%	90%	
	12/5/2003 3:00	12/5/2003 7:00	91%	100%	79%	91%	100%	100%	100%	100%	95%	
	12/5/2003 7:00	12/5/2003 12:00	64%	100%	64%	73%	93%	100%	100%	78%	84%	73
5	1/14/2004 2:10	1/14/2004 23:55	82%	86%	100%	82%	88%	100%	80%	75%	87%	71
6	1/23/2004 13:30	1/23/2004 22:20	100%	100%	100%	82%	87%	100%	100%	100%	96%	71
7	1/29/2004 3:00	1/29/2004 16:00	80%	100%	100%	78%	80%	88%	100%	100%	91%	
	1/30/2004 0:00	1/30/2004 2:30	100%	71%	100%	78%	80%	100%	100%	100%	91%	65
		Average % within 20%	86%	92%	95%	81%	87%	97%	98%	93%	91%	

Pixel Rain Data

In its most basic form, the output from CALAMAR is a series of rainfall measurements for every 1 km^2 pixel in the service area. To provide perspective of 1 km^2 pixels and 20,000 linear foot mini-basins, a collection of mini-basins in the City of Bellevue with 1 km^2 pixels superimposed is shown in Figure 3. Also shown are three of several rain gauges that will calibrate this zone. Sanitary sewer lines are shown in each colored mini-basin. CALAMAR produces a digital hyetograph for each pixel.

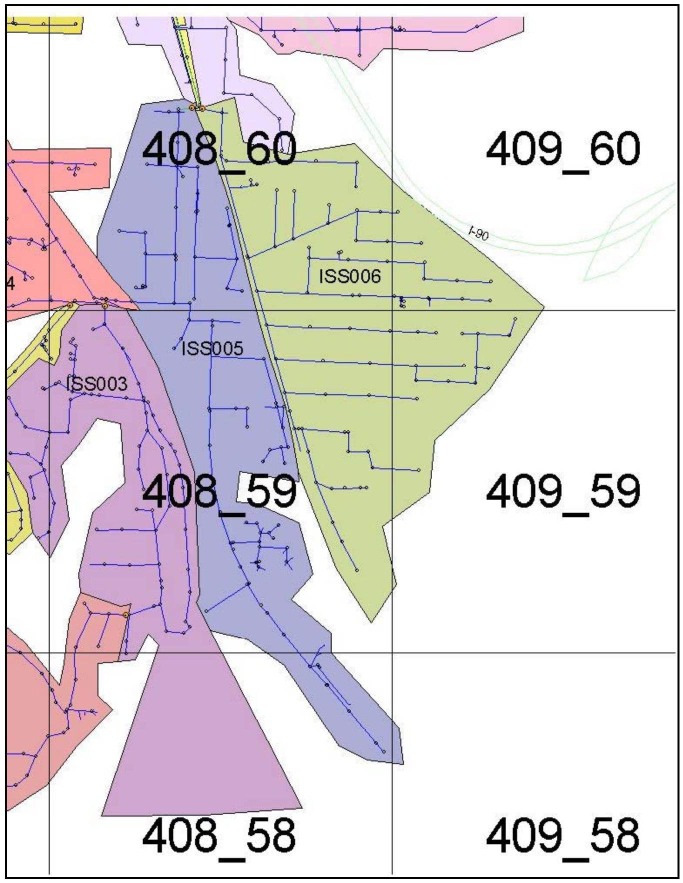
Figure 3
Bellevue Mini-basins, Three Rain Gauges and 1 km^2 Pixels



Conversion from Pixel Data to Mini-basin Rain Data

A CALAMAR rainfall data file was created for each of the pilot project mini-basins. Many of the mini-basins are positioned in multiple pixels, and Geographic Information System (GIS) was used to determine the percent of the area of each mini-basin in each pixel. Figure 4 shows several mini-basins located in Issaquah and the CALAMAR pixels overlaid on the mini-basins. The pixel numbers were derived from the approximate location in kilometers of the northwest corner of each pixel. The numbering system is similar to the Washington State Plane Coordinate system. For example the pixel 408_59 is located 408 km east and 59 km north of the coordinate starting point.

Figure 4
Issaquah Mini-basins and CALAMAR Pixels



As shown in the above figure, Mini-Basin ISS005 falls into multiple pixels. Table 5 illustrates how GIS was used to determine the percent of the area of each mini-basin in each pixel. The yellow highlighting is on the 5 pixels that contribute rainfall to Mini-Basin ISS005, and the column "Percent" lists the percentage of each pixel. For example, nearly 54 percent of the rain on Mini-Basin ISS005 comes from pixel 408_59. This process produces both time series and accumulated rainfall data for each mini-basin.

Table 5
Determination of Percent of Rainfall on a Mini-basin

BASIN	PERCENT	EAST	NORTH	PIXEL
ISS004	0.0002	406	60	406_60
ISS004	0.0311	407	59	407_59
ISS004	0.1228	407	59	407_59
ISS004	0.0000	408	59	408_59
ISS004	0.0000	408	59	408_59
ISS004	0.7432	407	60	407_60
ISS004	0.0357	408	60	408_60
ISS004	0.0670	408	60	408_60
ISS005	0.0052	409	58	409_58
ISS005	0.1000	408	58	408_58
ISS005	0.5397	408	59	408_59
ISS005	0.3549	408	60	408_60
ISS005	0.0001	408	60	408_60
ISS006	0.2003	409	59	409_59
ISS006	0.0006	409	59	409_59
ISS006	0.1273	409	60	409_60
ISS006	0.3393	408	59	408_59
ISS006	0.3326	408	60	408_60
ISS007	0.1790	409	60	409_60
ISS007	0.3648	409	61	409_61
ISS007	0.0389	408	61	408_61
ISS007	0.2614	408	60	408_60
ISS007	0.1560	410	61	410_61

Once the CALAMAR rainfall time series were generated, these data were substituted into the rain gauge time series to become a composite rainfall time series.

Appendix F

I/I Pilot Project Model Calibration

Description:

This appendix includes a memorandum describing the confidence in modeling reduction results, hydrographs of modeling results of the pilot and control basins, and linear regressions used for establishing peak 20-year flows.

Reference Chapter:

Chapter 8 – Rehabilitation Effectiveness

Author:

Paul Glenn, P.E., King County

MEMORANDUM

To: Earth Tech Team
From: Bob Swarner and Paul Glenn

Date: August 25, 2004

Reason: Confidence in Reduction Results

Hydrologic modeling in general has uncertainties associated with it. The propagation of uncertainties in rainfall and flow data is not addressed in this memorandum; however, a qualitative confidence in the final reduction results is provided. Confidence in the reduction results is provided as a guideline for using the results to determine the effectiveness of different types of rehabilitation work.

The Modeling Confidence Table 1-1 provides a qualitative assessment of the rehabilitation effectiveness.

Final model calibrations were rated as excellent, good, fair, and poor. An excellent rating was for a model that fit all flow data. A good rating was for a model that fit most of the rainfall events and the inter-event flow data. A fair rating was for a model that generally fit the flow data, but did not fit some of the events. A poor rating was for a model that did not fit the flow data.

The confidence in 20-year peak results for pre- and post-rehabilitation was determined: (a) using the largest measured event return period used in model calibration, (b) the total number of CALAMAR events used for calibration that were equal to or larger than an accumulation of 0.5 inches, and (c) the quality of the final calibration with the following criteria:

- Excellent - the model had an excellent fit to the flow data, at least 5 events were used for calibration, and the largest event was a 20-year event.
- Good - the model had a good or excellent fit to the flow data, at least 5 events were used for calibration, and the largest event was near a 1-year event.
- Fair - the model was calibrated to less than 5 events, had a fair calibration, or the largest event was much less than a 1-year event.
- Poor - the model had a poor calibration or was calibrated to only one event.

The final rating for confidence in 20-year peak reduction results was based on the pre- and post-rehabilitation 20-year peak result confidence and comparison of the modeled reduction with the reduction estimated from measured flows. Final confidences were determined with this criteria: if the modeled 20-year I/I reduction was similar to the I/I reduction estimated from measured flows, the rating was determined to be the highest of the pre- or post-rehabilitation confidence in 20-year results ratings. Otherwise, the rating was taken as the lowest rating between the pre- and post-rehabilitation confidence in 20-year results ratings.

MODELING CONFIDENCE TABLE 1-1

				PRE-REHABILITATION				POST-REHABILITATION						FINAL
Name	Pilot/Mini Basin	Major Basin	Sub-basins	Largest Measured Event Return Period (yr)	Number of CALAMAR Events Used for Calibration (1)	Quality of Calibration (2)	Confidence in 20-Year Peak Results (3)	Largest Measured Event Return Period (yr)	Number of CALAMAR Events Used for Calibration (1)	Quality of Calibration (2)	Confidence in 20-Year Peak Results (3)	20-year Modeling I/I Reduction Results	I/I Reduction Estimated from Measured Flow	Confidence in 20-Year Peak Reduction Results (4)
Auburn	ABN002	M_ABN018	Pilot A	0.9	5	Excellent	Good					NAR	NA	Good
			Pilot B	0.5	5	Fair	Fair					NAR	NA	Fair
Kent	KNT014	M_KNT031	Pilot	1.5	7	Excellent	Good	0.06 -0.48	1	Fair	Poor	71-81	60	Good
Val Vue	VAL019	M_VAL020	Pilot	15.5	10	Good	Good					NAR	NA	Good
Skyway	BLS002	M_BLS009	Pilot	0.7 -0.9	7	Good	Good	5.9 - 8.6	7	Fair	Fair	86	77	Good
Coal Creek	CCR002	M_COAL007	Pilot	2.1	10	Good	Good					NAR	39	Good
Mercer	MRC012	M_ENATA01A	Pilot	0.9	2	Excellent	Fair	1.9	5	Good	Good	37	44	Good
Kirkland	KRK011	M_KRK008	Pilot	1.0	6	Fair	Fair	2.3	5	Fair	Fair	28	28	Fair
North Shore	NUD038	M_KENMR054	Pilot	1.5	10	Good	Good	0.9	1	Excellent	Fair	23	82	Fair
Brier	BRR004	M_LYON021	Pilot	0.4	5	Excellent	Good	1.2	2	Good	Fair	50	36	Good
Lake Forest Park	RON041	M_KENMR000	Pilot	1.2	10	Fair	Fair	0.9	2	Excellent	Fair	69	65	Fair
Ronald	RON002	M_BOECR043	Pilot	1.8	6	Good	Good	0.4	2	Excellent	Fair	74	57	Good
Redmond	RDM009	M_NWLKS001	Pilot A	16	2	Excellent	Fair					NAR	NA	Fair
			Pilot B	0.3	2	Poor	Poor					NAR	NA	Poor

Notes:

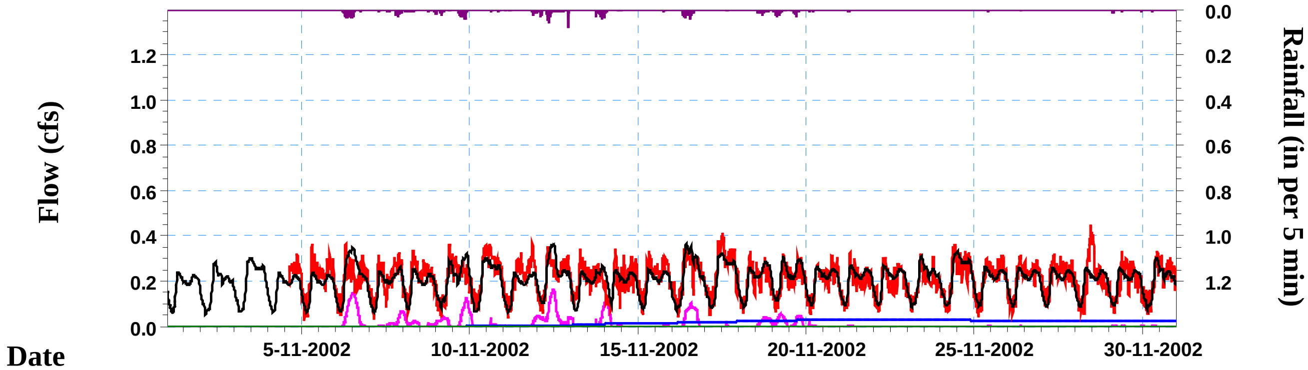
(1) - An event is defined as the duration of the CALAMAR rainfall time series. A CALAMAR time series may span multiple days and there may be multiple points to calibrate to for the series. Note also that only accumulations greater than or equal to 0.5 inches are reported.

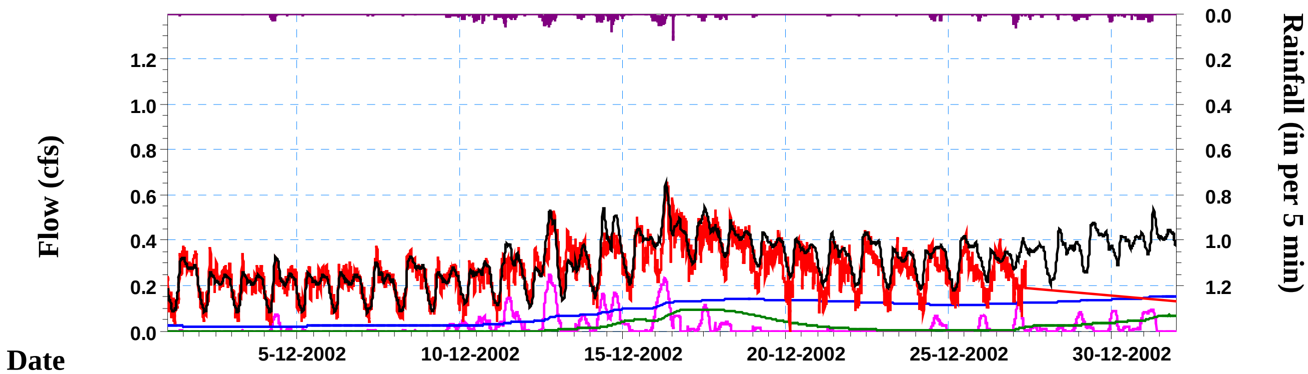
(2) - Rated as poor, fair, good, and excellent.
Excellent = the model fits all flow data.
Good = the model fits most of the rainfall events and the inter-event flow data.
Fair = the model generally fits the flow data, but does not fit some of the events.
Poor = the model does not fit the flow data.

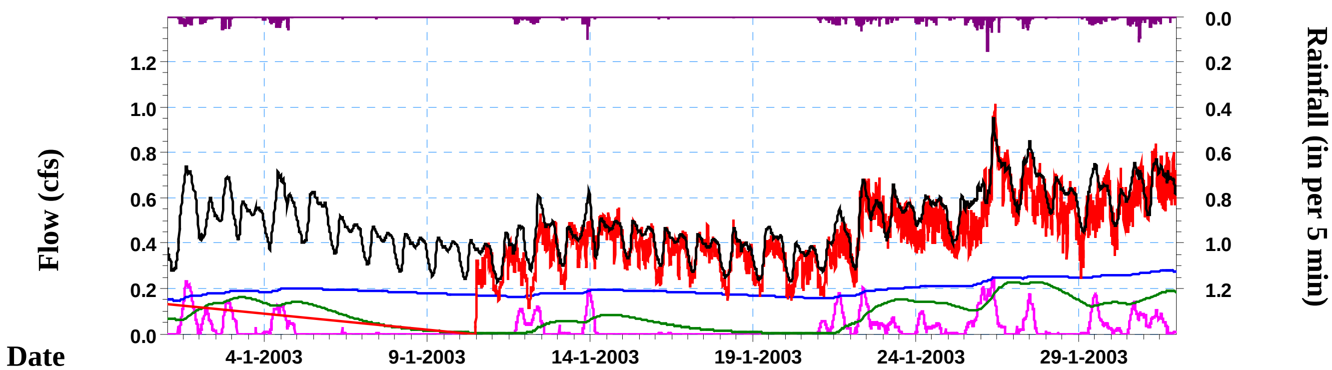
(3) - Rated as poor, fair, good, and excellent.
Excellent = the model has an excellent fit to the flow data, at least 5 events were used for calibration, and the largest event was a 20-year event.
Good =the model has a good or excellent fit to the flow data, at least 5 events were used for calibration, and the largest event was near a 1-year event.
Fair = the model was calibrated to less that 5 events, has a fair calibration, or the largest event was much less than a 1-year event.
Poor = the model has a poor calibration or was calibrated to only one event.

(4) Note that if the modeled 20-year I/I reduction was similar to the I/I reduction estimated from measured flows, the rating was determined to be the highest of the pre or post-rehabilitation confidence in 20-year results ratings. Otherwise, the rating was taken as the lowest rating between the pre and post-rehabilitation confidence in 20-year results ratings.

Auburn Pilot A Basin (2002-2003 Monitoring Period)

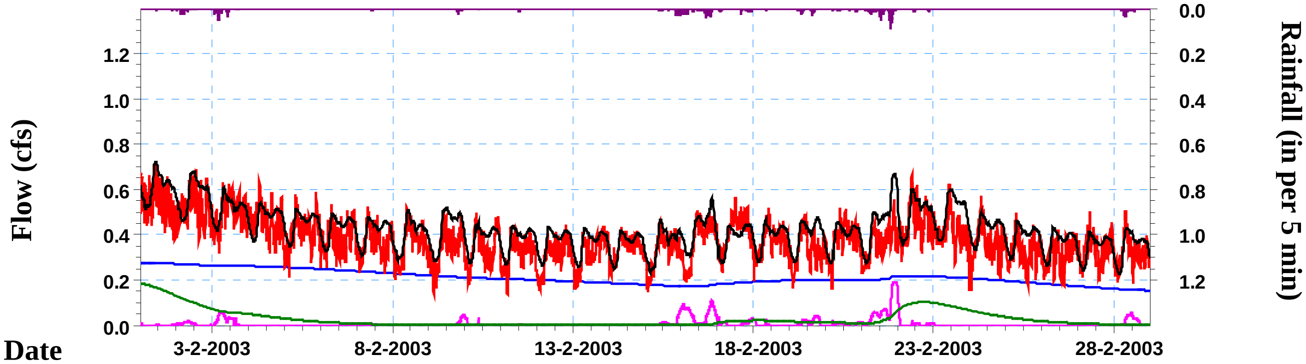


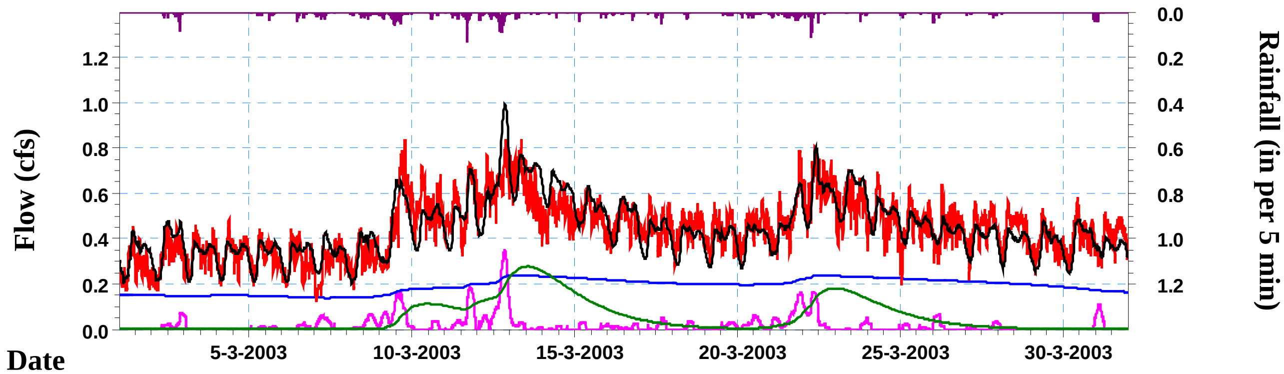


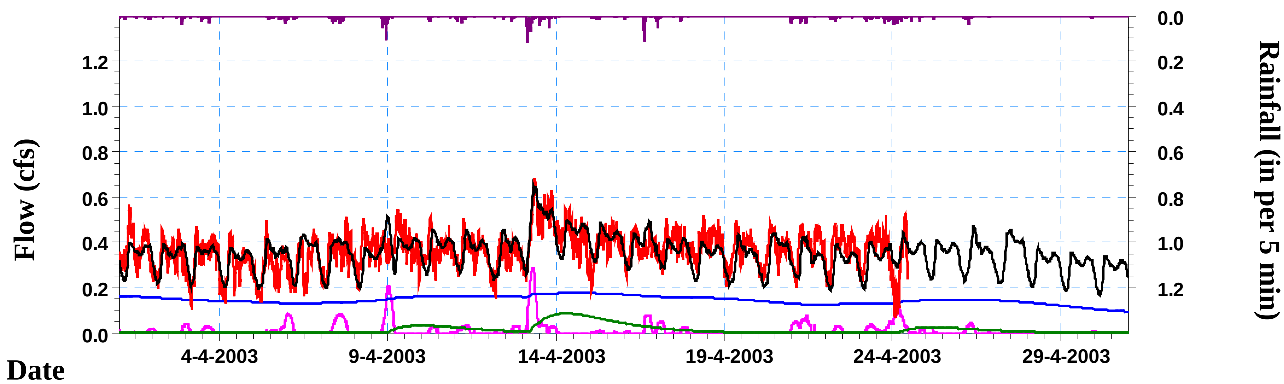


Legend: Measured Flow; Measured Rainfall; Total Simulated Flow; Fast Response Component; Slow Infiltration; Rapid Infiltration

Date Format (dd-mm-yyyy)





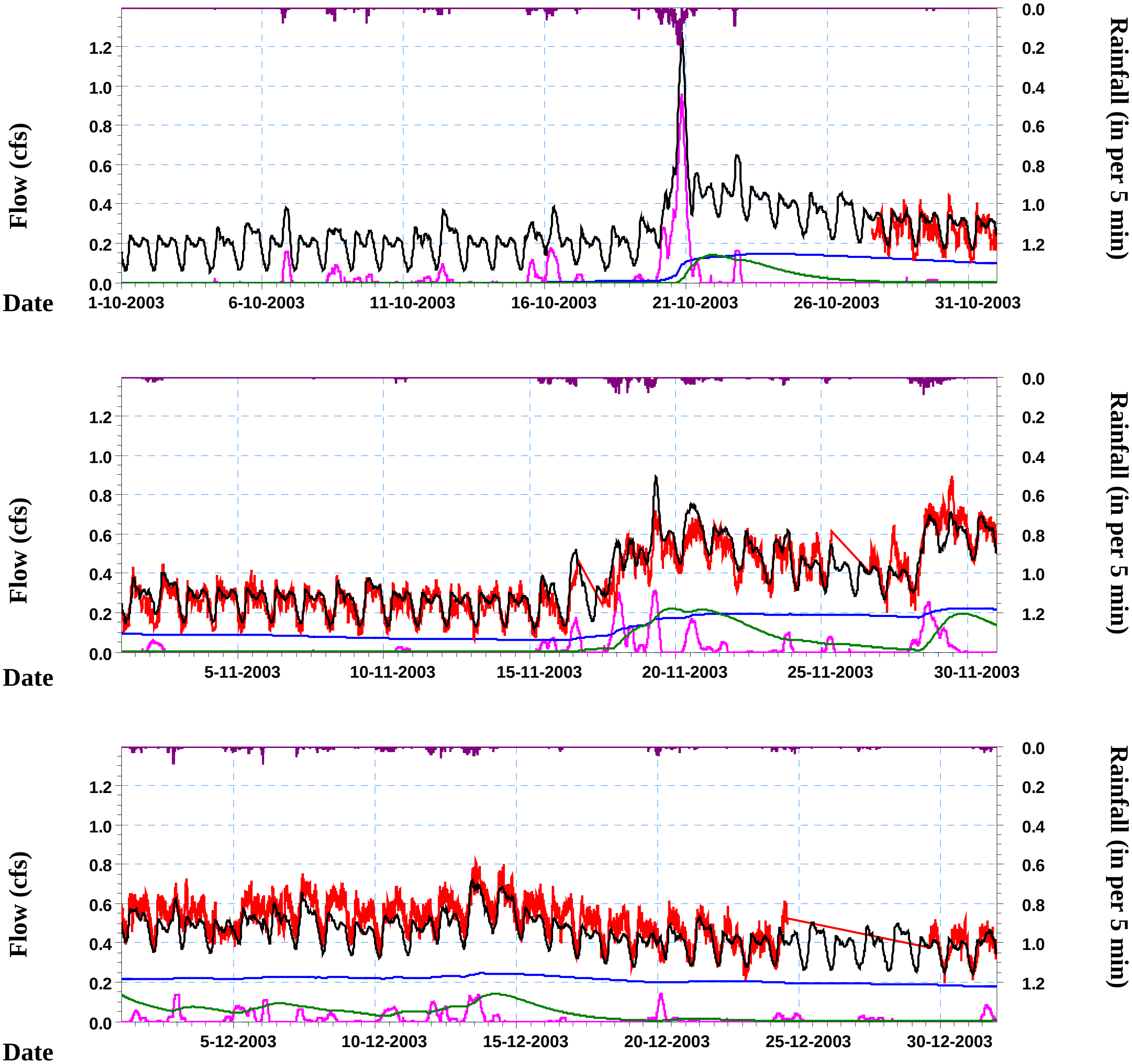


Legend:

Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)

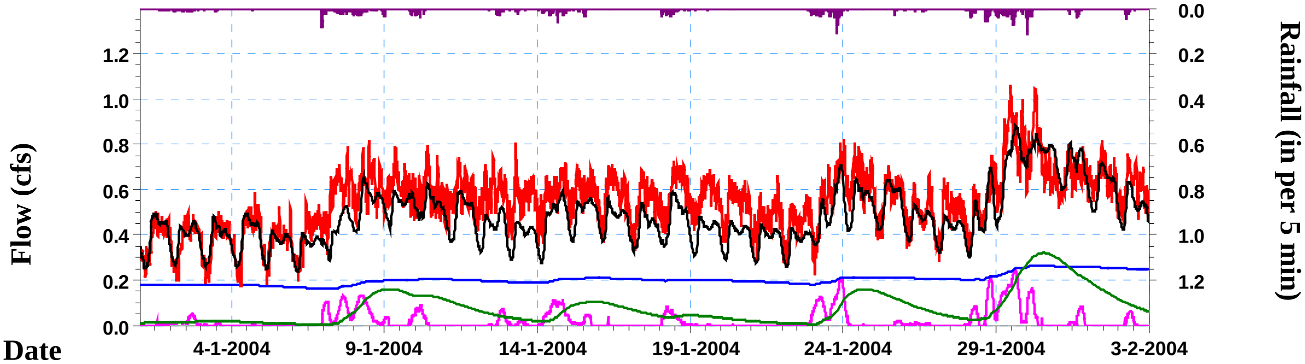
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration

Auburn Pilot A Basin (2003-2004 Monitoring Period)

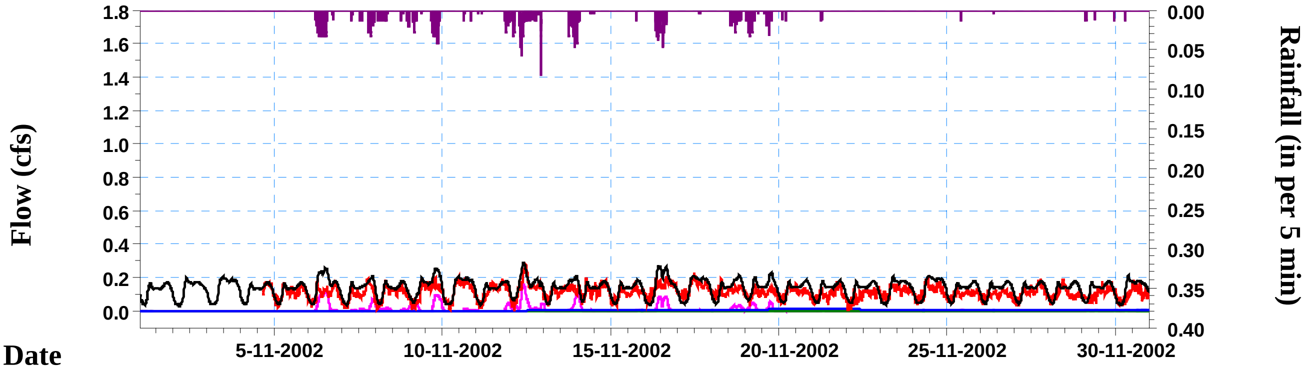


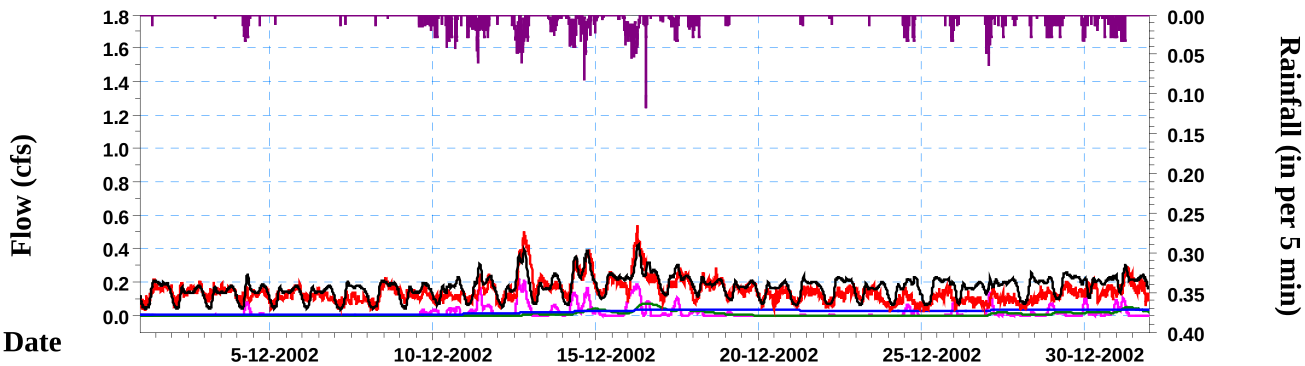
Legend:

Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration



Auburn Pilot B Basin (2002-2003 Monitoring Period)



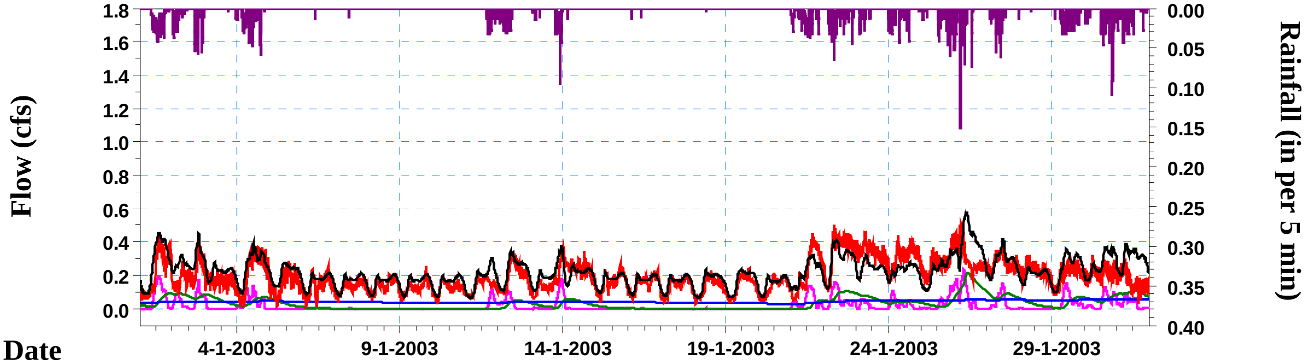


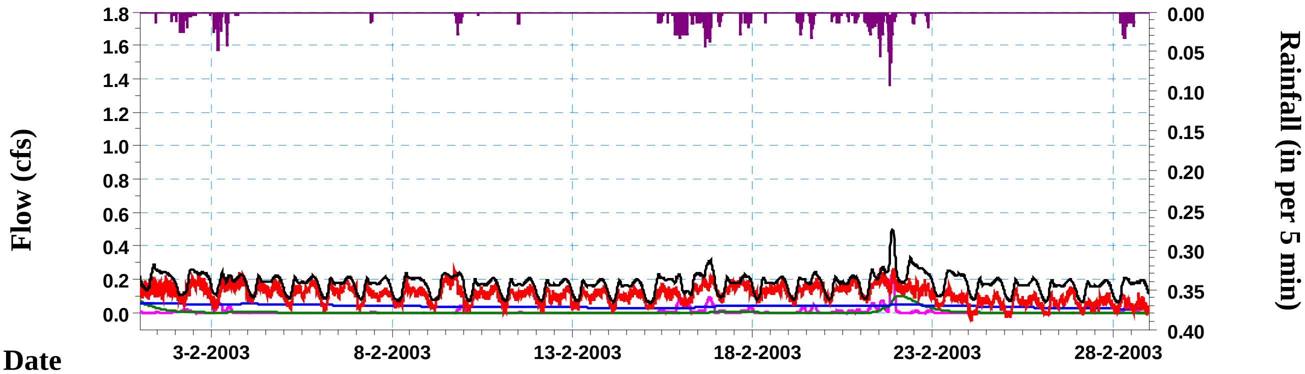
Legend: Measured Flow — Total Simulated Flow

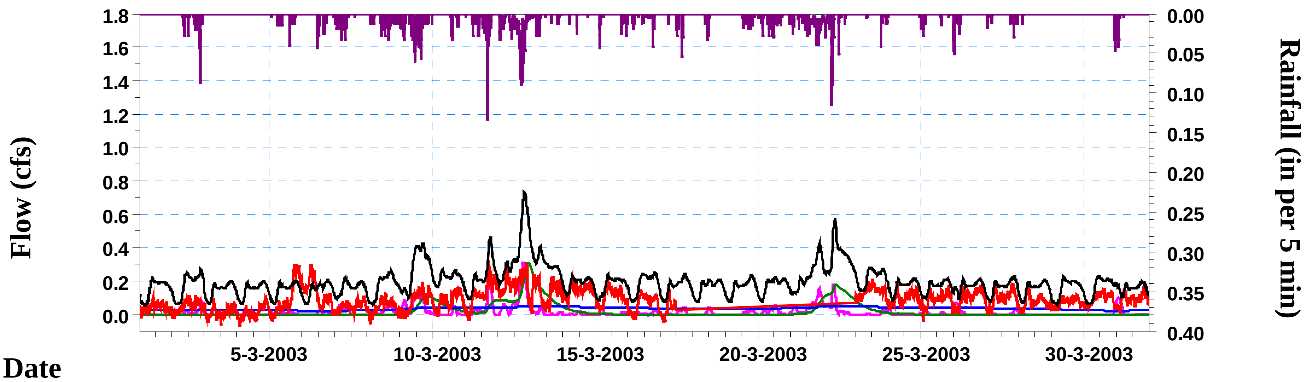
Measured Rainfall — Fast Response Component

Slow Infiltration

Date Format (dd-mm-yyyy) Rapid Infiltration







Legend:

Measured Flow

Measured Rainfall

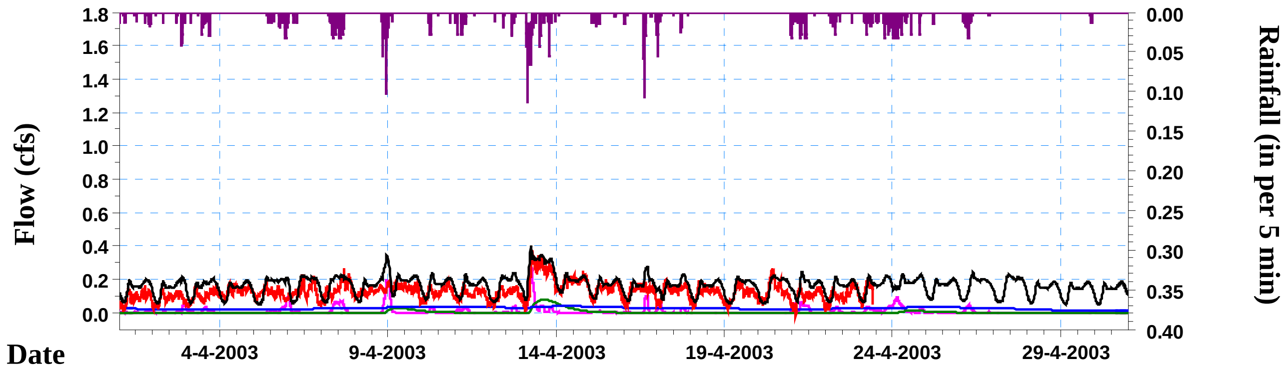
Date Format (dd-mm-yyyy)

Total Simulated Flow

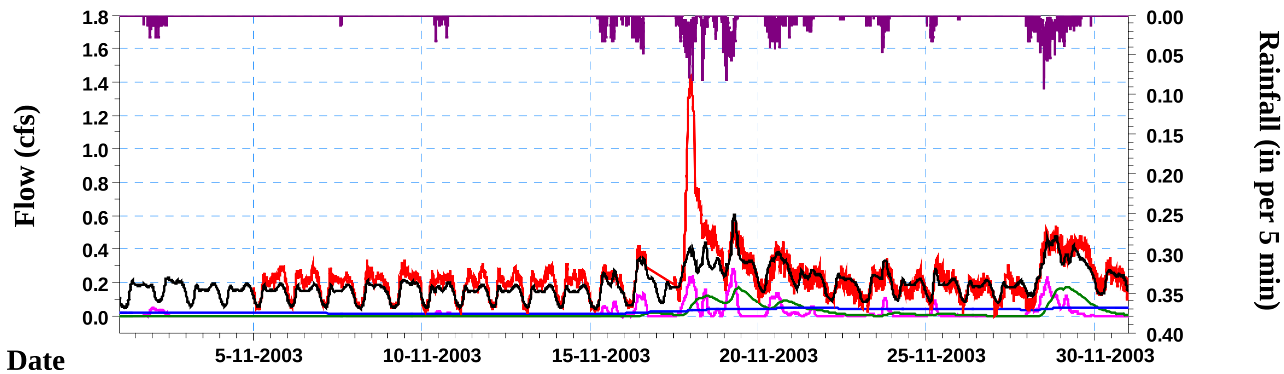
Fast Response Component

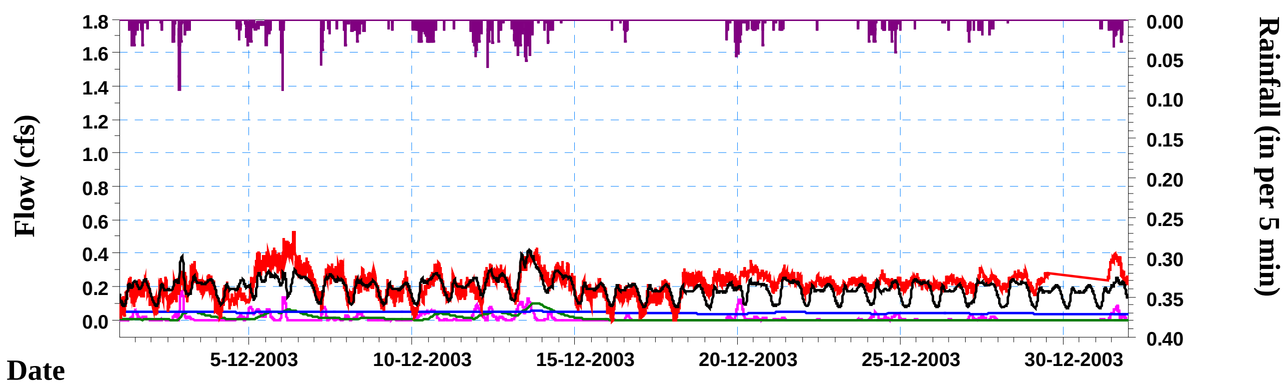
Slow Infiltration

Rapid Infiltration



Auburn Pilot B Basin (2003-2004 Monitoring Period)





Legend:

Measured Flow

Measured Rainfall

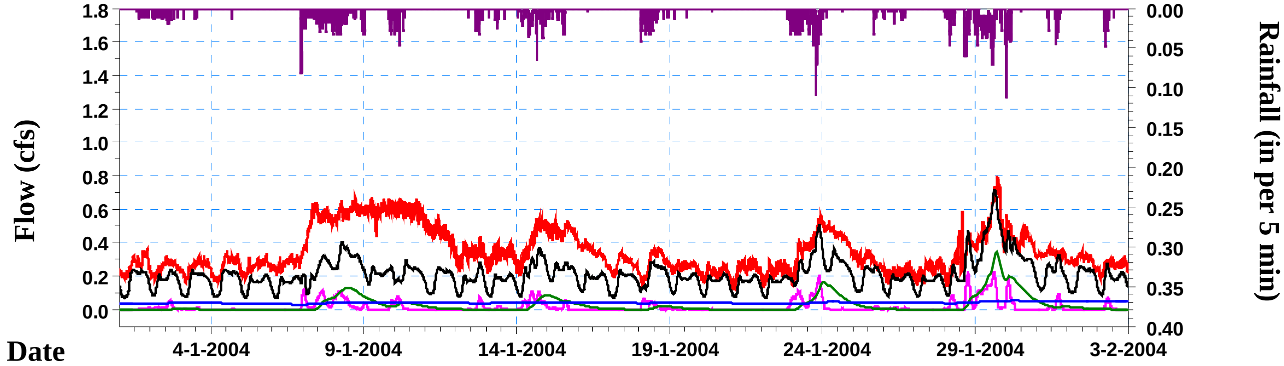
Date Format (dd-mm-yyyy)

Total Simulated Flow

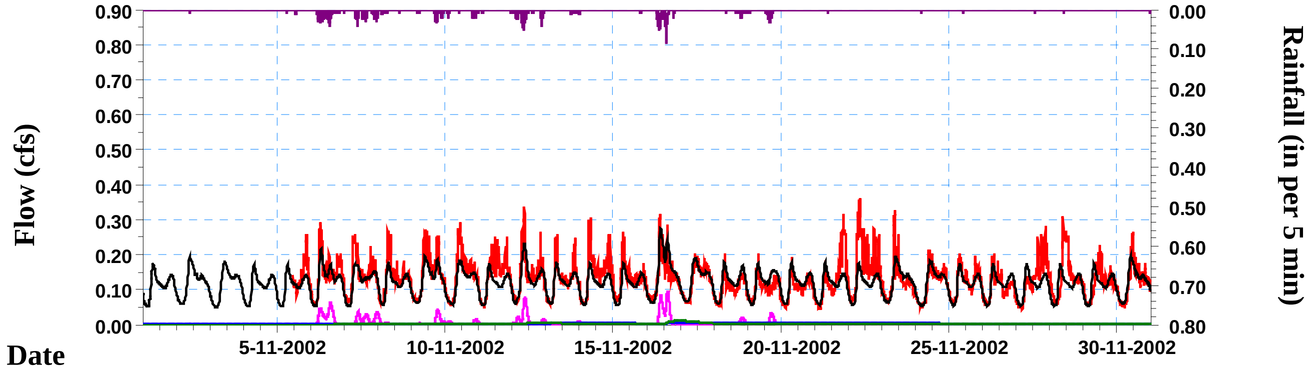
Fast Response Component

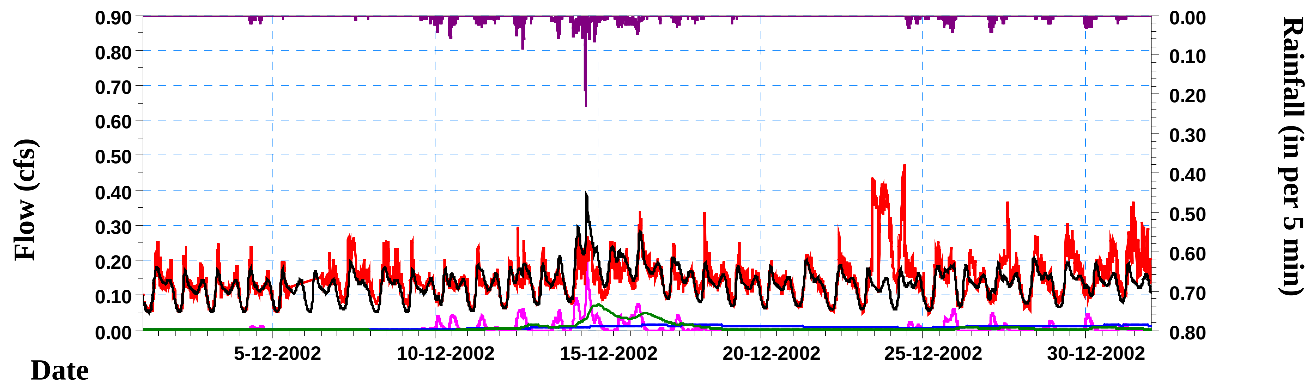
Slow Infiltration

Rapid Infiltration



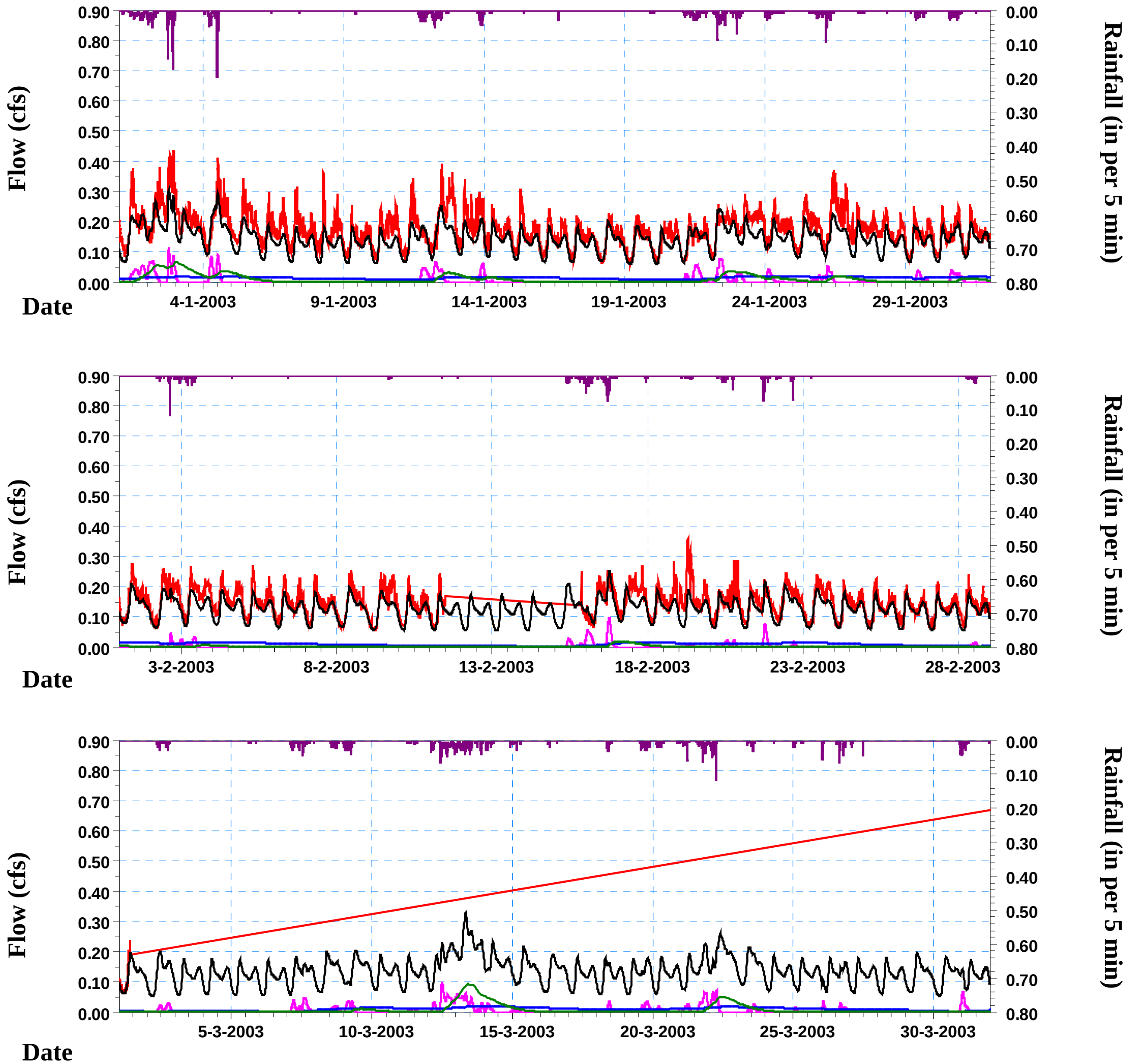
Brier Control Basin (2002-2003 Monitoring Period)





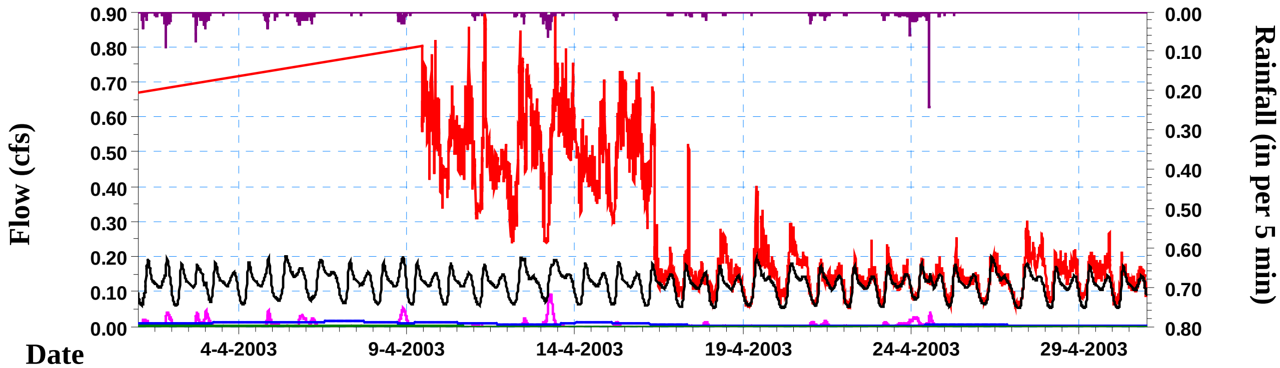
Legend:

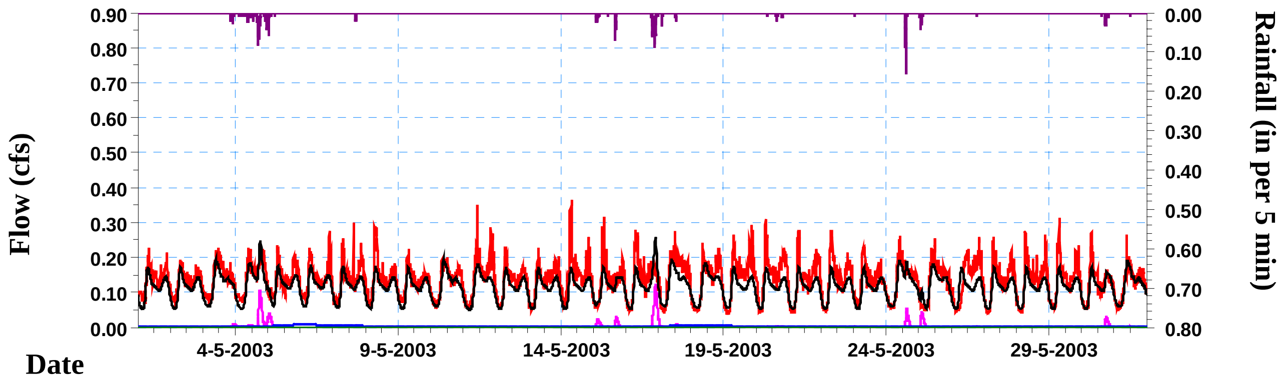
Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration



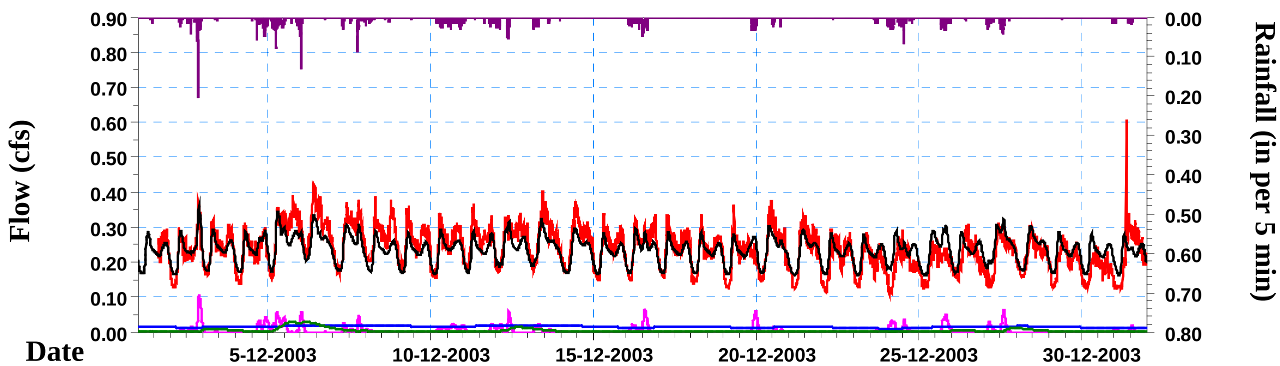
Legend:

Measured Flow		Total Simulated Flow	
Measured Rainfall		Fast Response Component	
		Slow Infiltration	
Date Format (dd-mm-yyyy)		Rapid Infiltration	



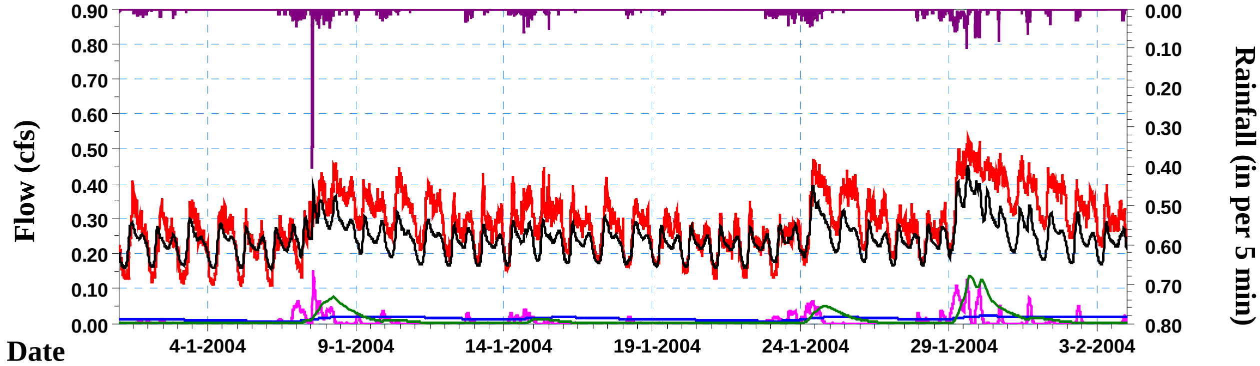


Brier Control Basin (2003-2004 Monitoring Period)

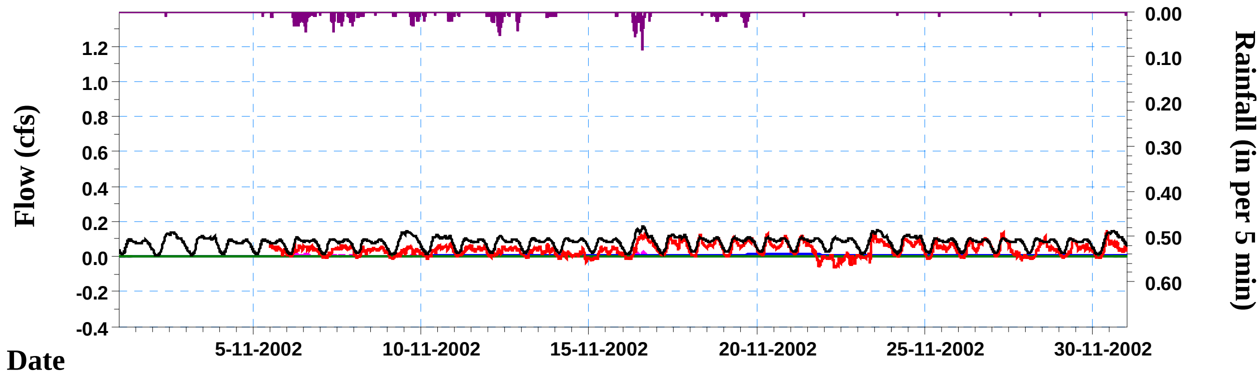


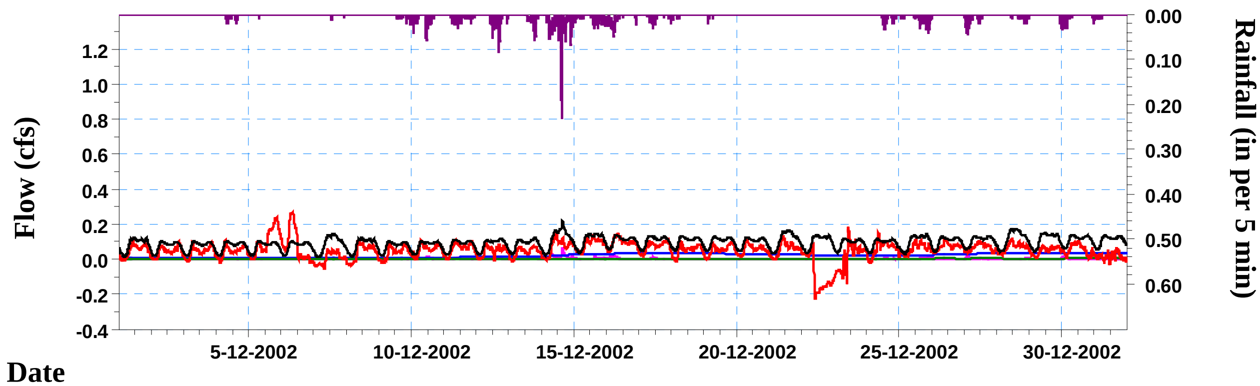
Legend: Measured Flow — Measured Rainfall — Total Simulated Flow — Fast Response Component — Slow Infiltration — Rapid Infiltration

Date Format (dd-mm-yyyy)



Brier Pilot Basin (2002-2003 Monitoring Period)

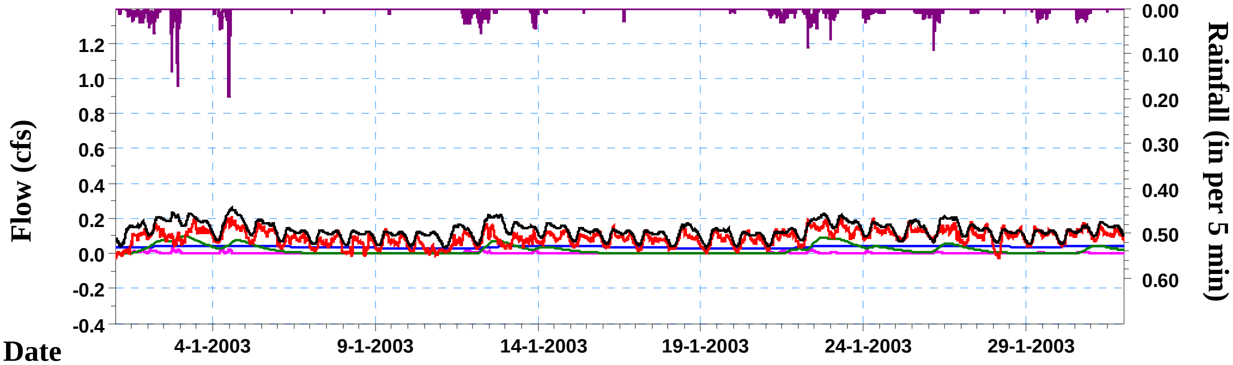


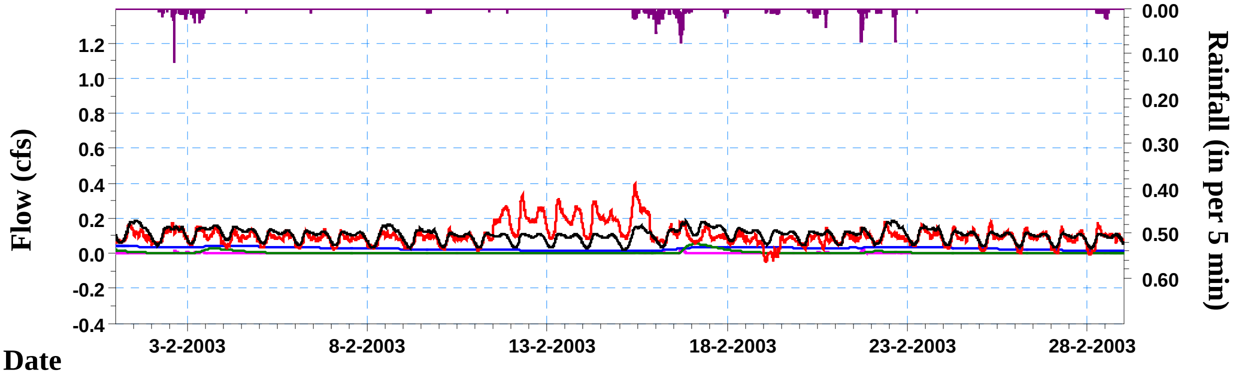


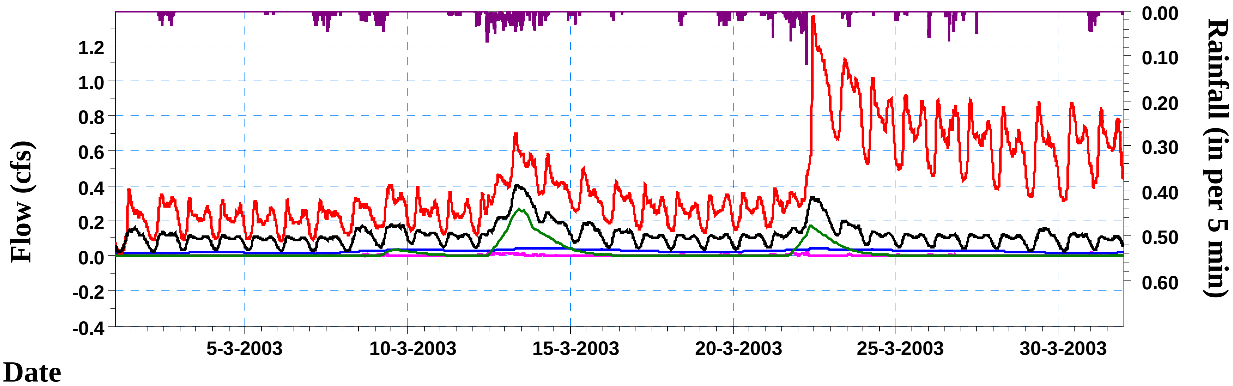
Legend:

Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)

Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration







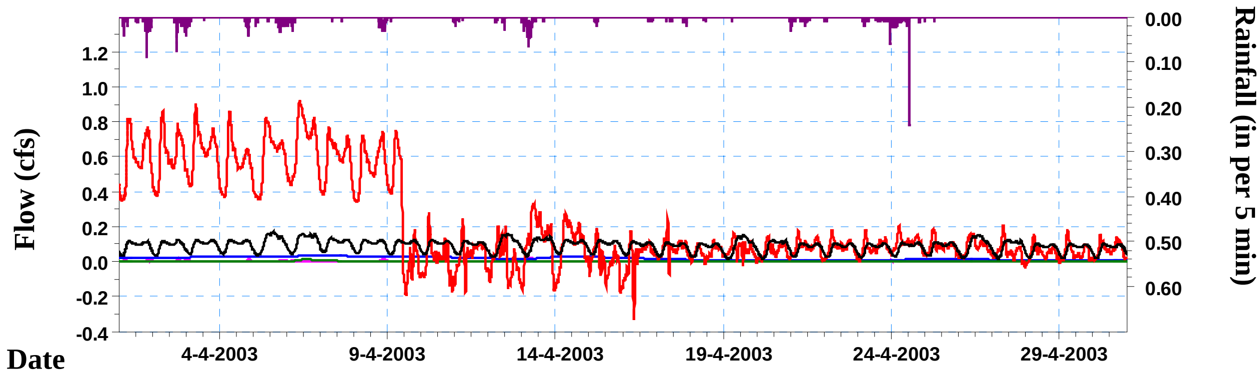
Legend:

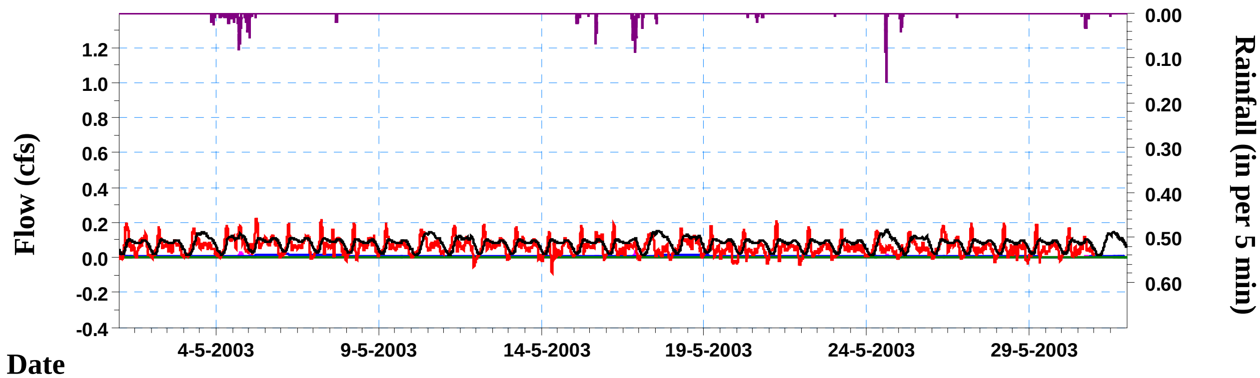
Measured Flow — Total Simulated Flow

Measured Rainfall — Fast Response Component

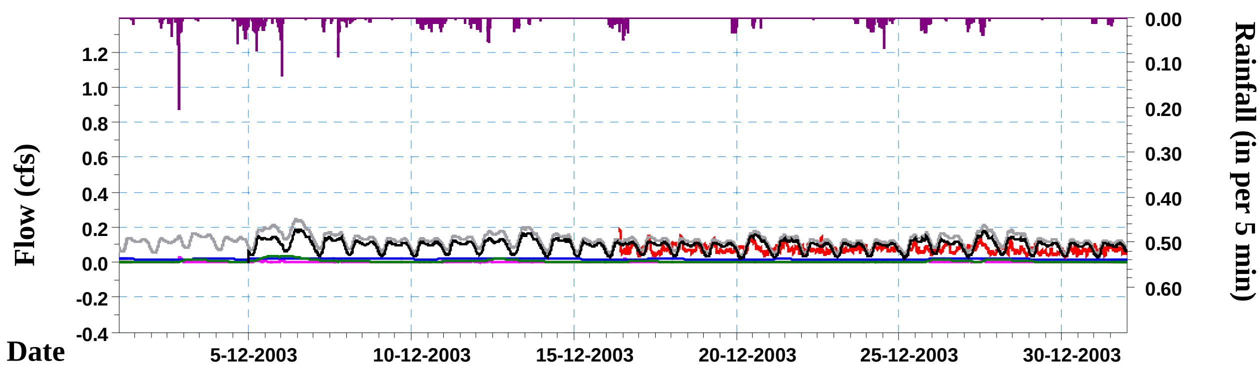
Slow Infiltration

Date Format (dd-mm-yyyy) — Rapid Infiltration



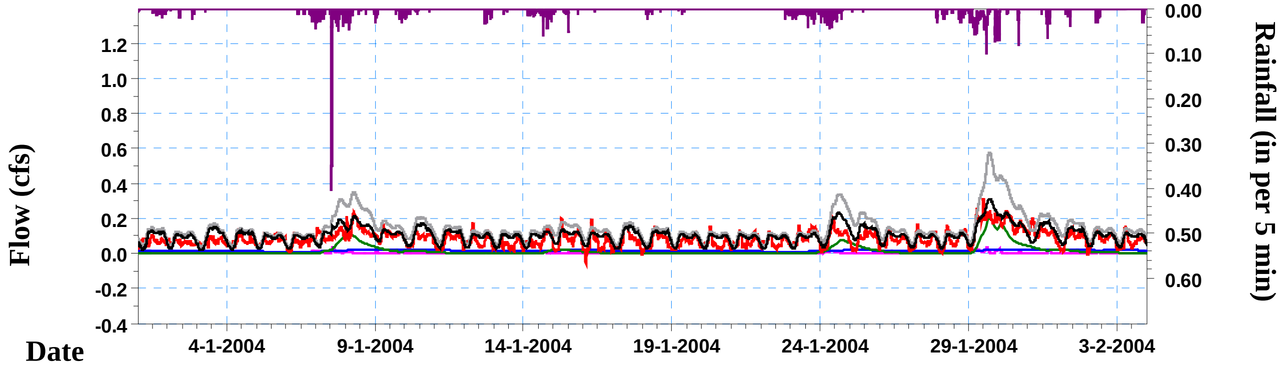


Brier Pilot Basin (2003-2004 Monitoring Period)

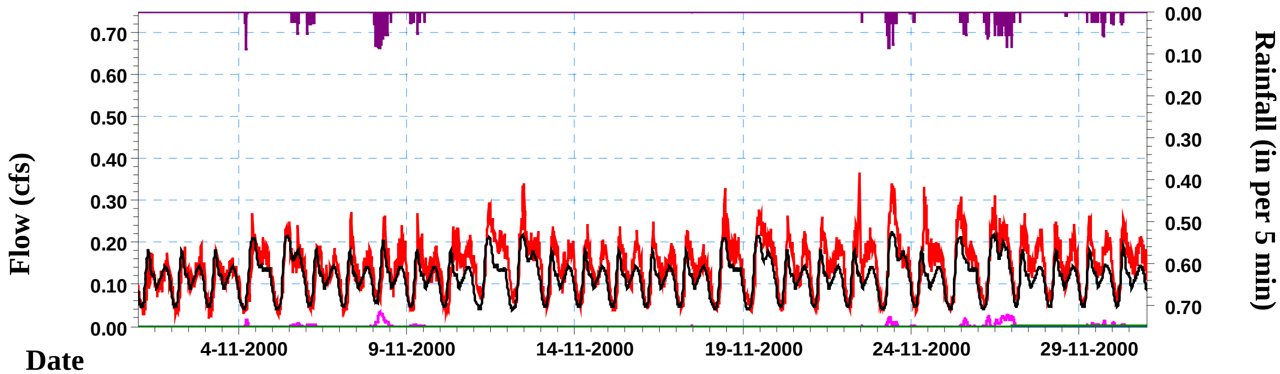


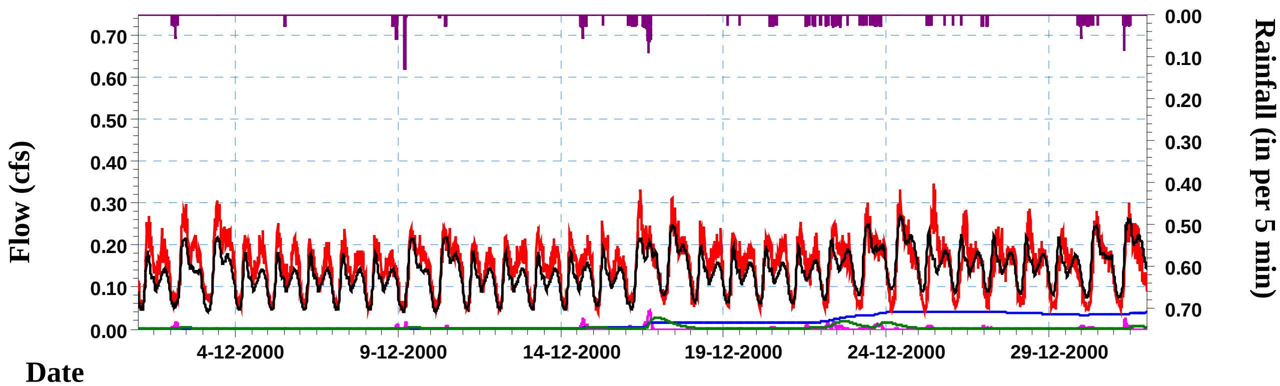
Legend: Measured Flow, Measured Rainfall, Total Simulated Flow, Fast Response Component, Slow Infiltration, Rapid Infiltration, Pre-rehabilitation Simulated Flow

Date Format (dd-mm-yyyy)

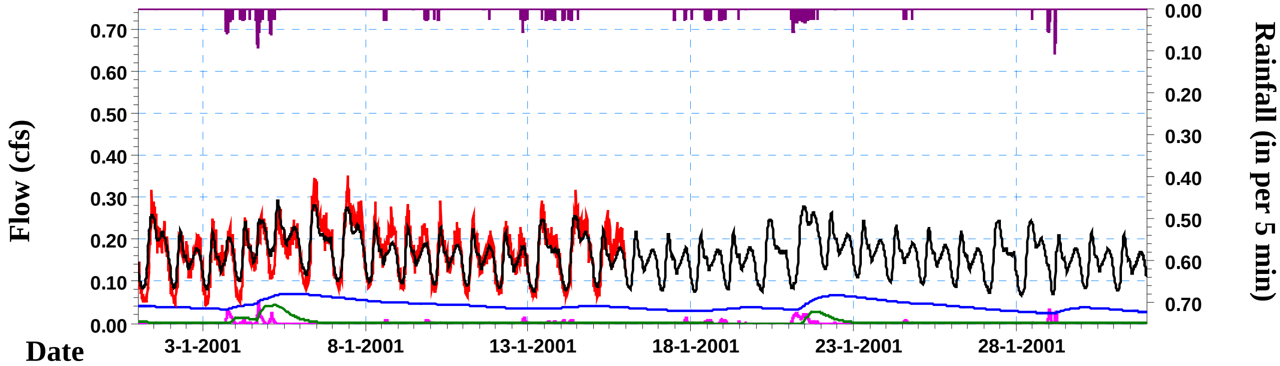


Coal Creek Control Basin (2000-2001 Monitoring Period)

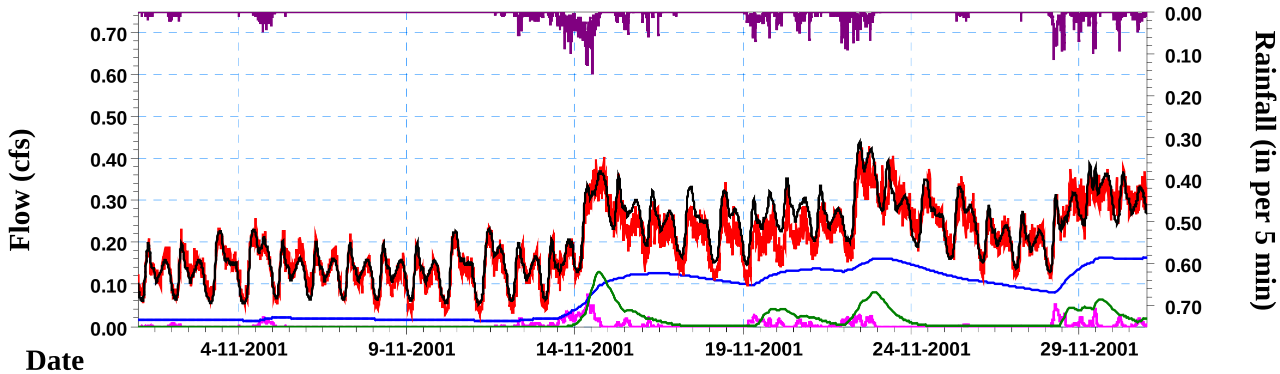


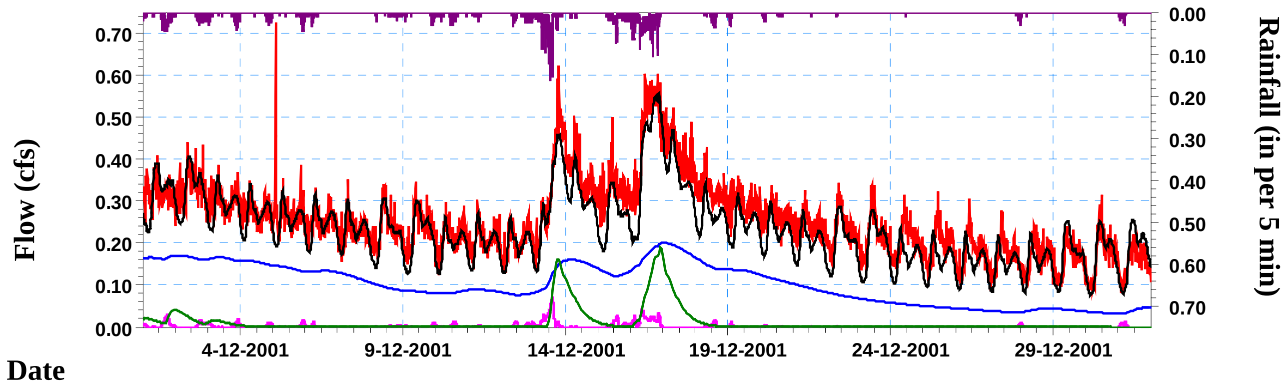


Legend: Measured Flow
Measured Rainfall
Total Simulated Flow
Fast Response Component
Slow Infiltration
Date Format (dd-mm-yyyy)
Rapid Infiltration
Pre-rehabilitation Simulated Flow



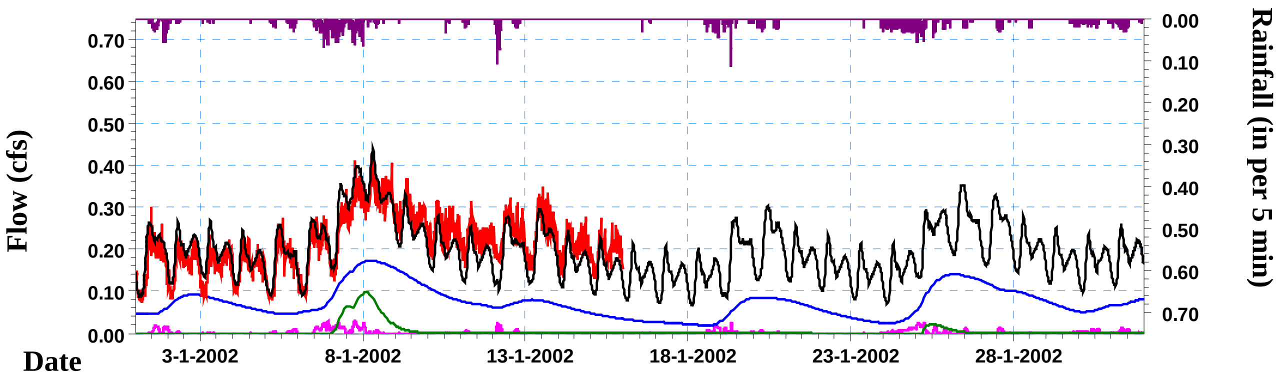
Coal Creek Control Basin (2001-2002 Monitoring Period)



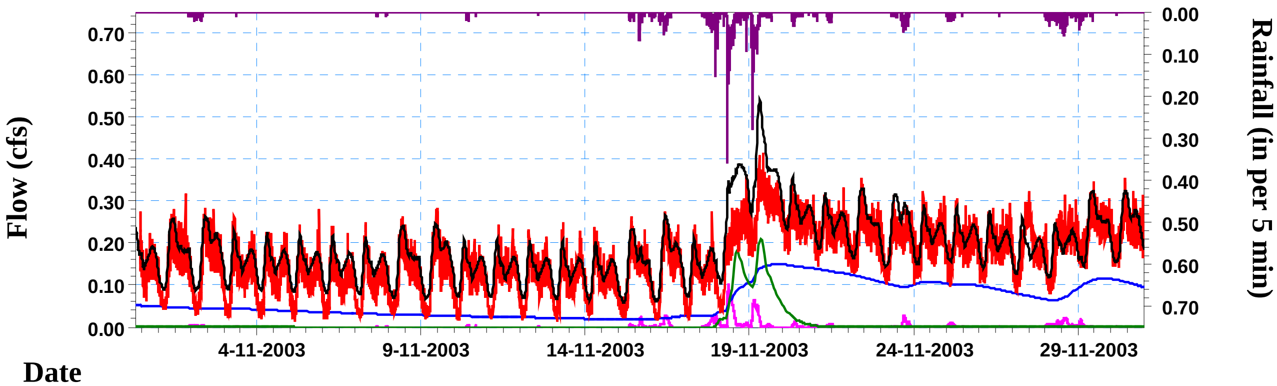


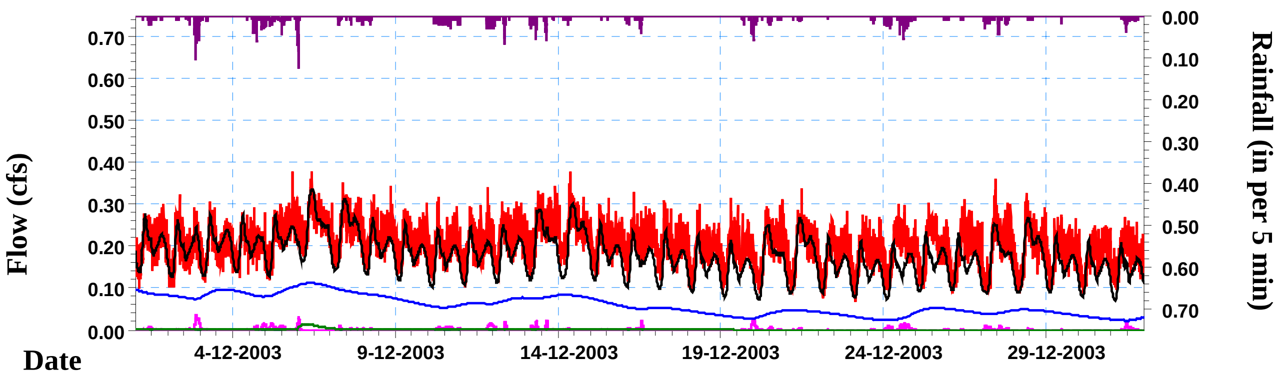
Legend:

Measured Flow
Measured Rainfall
Total Simulated Flow
Fast Response Component
Slow Infiltration
Date Format (dd-mm-yyyy)
Rapid Infiltration



Coal Creek Control Basin (2003-2004 Monitoring Period)

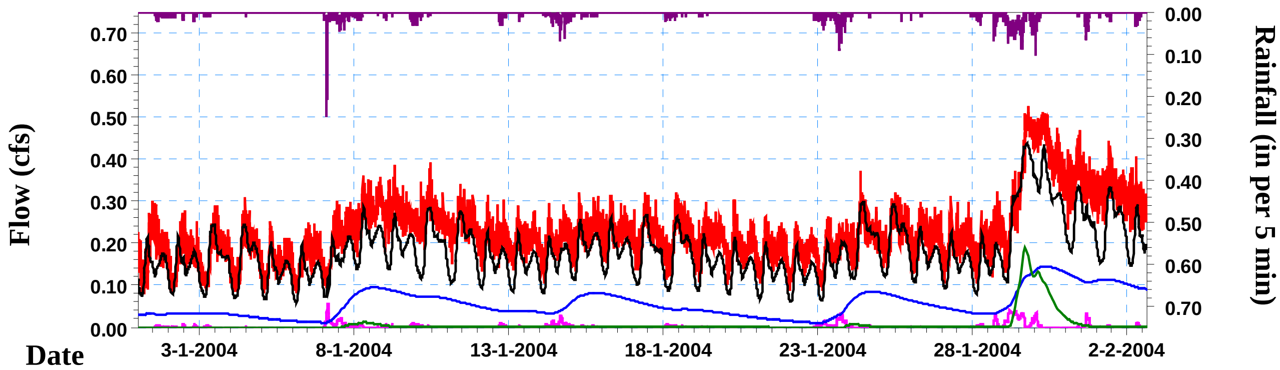




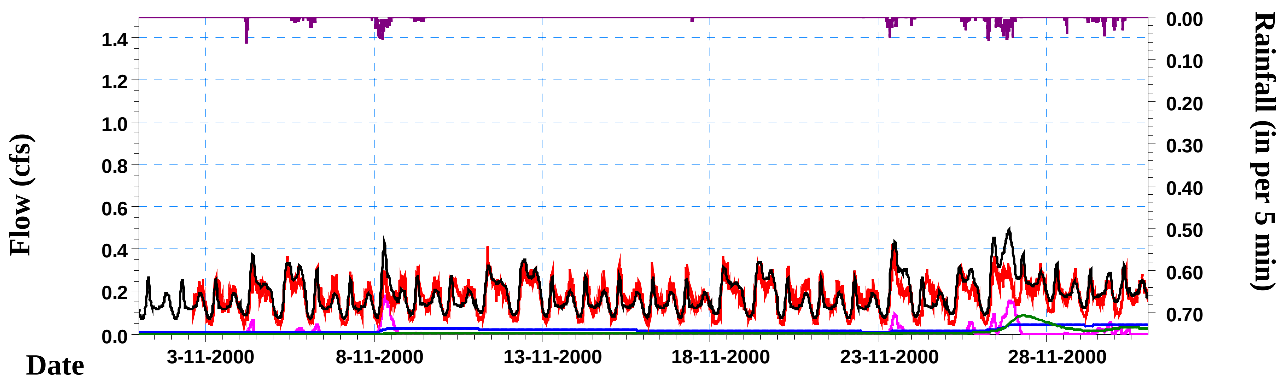
Legend:

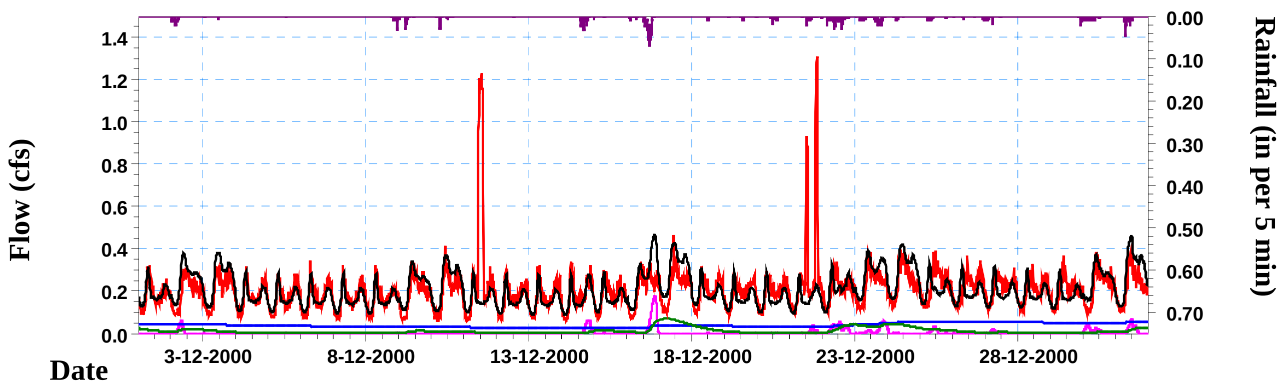
Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)

Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration

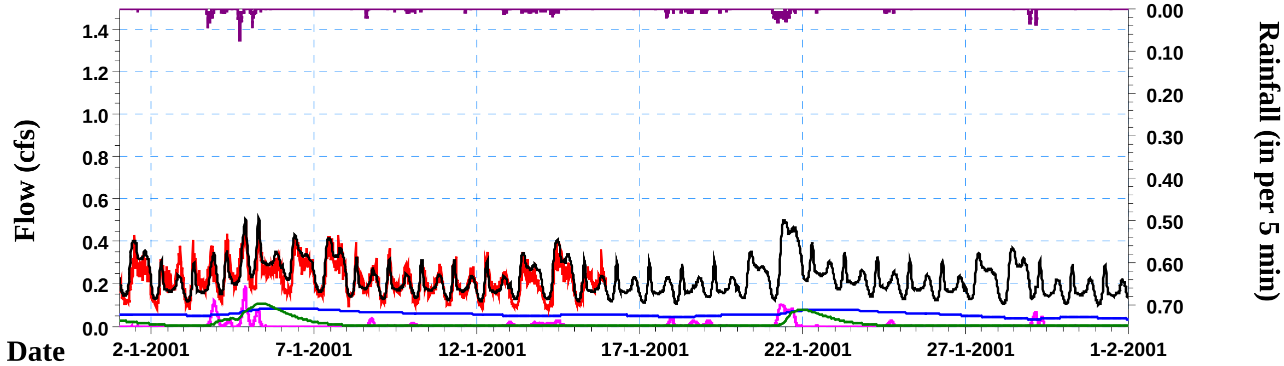


Coal Creek Pilot Basin (2000-2001 Monitoring Period)

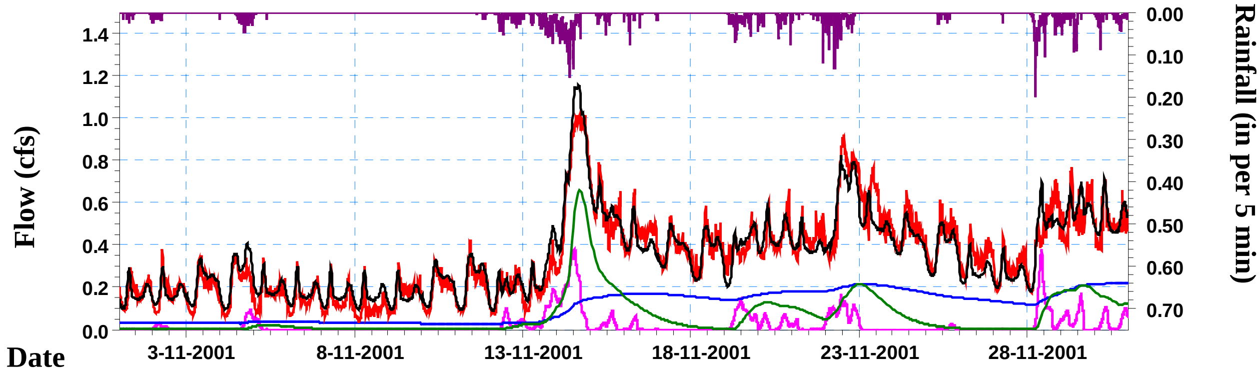


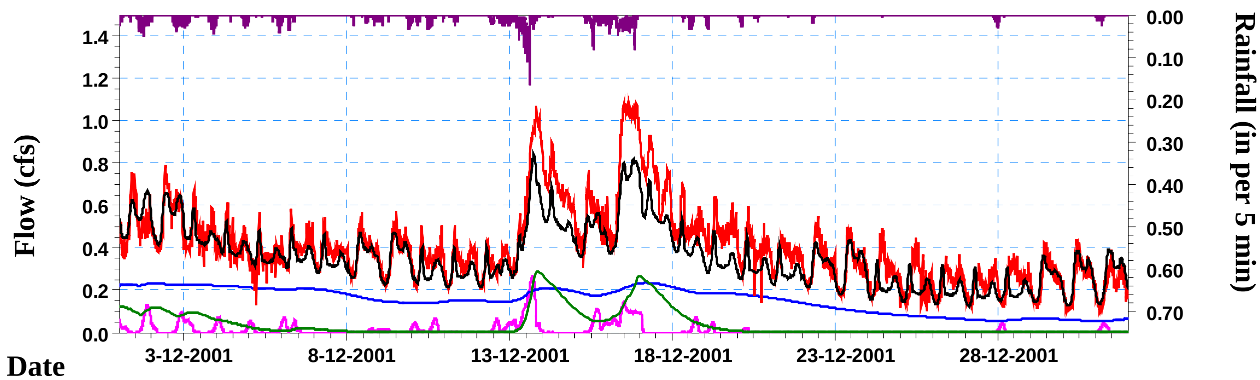


Legend: Measured Flow; Measured Rainfall; Date Format (dd-mm-yyyy); Total Simulated Flow; Fast Response Component; Slow Infiltration; Rapid Infiltration



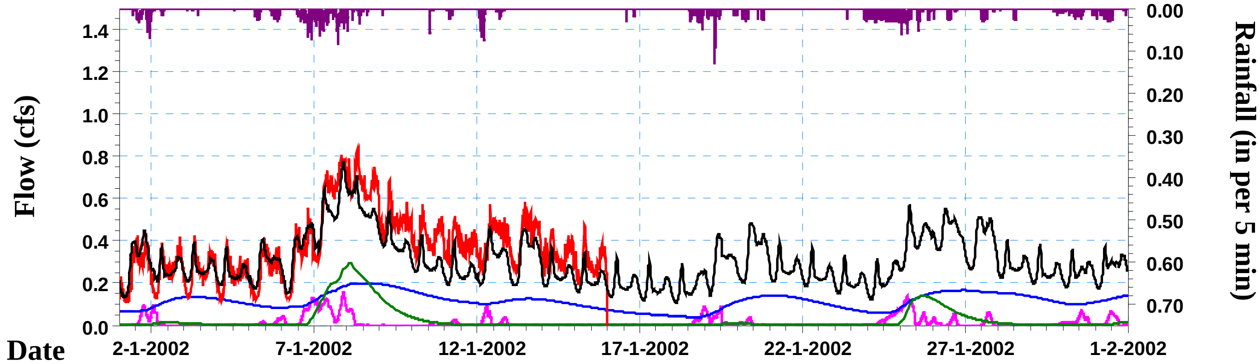
Coal Creek Pilot Basin (2001-2002 Monitoring Period)



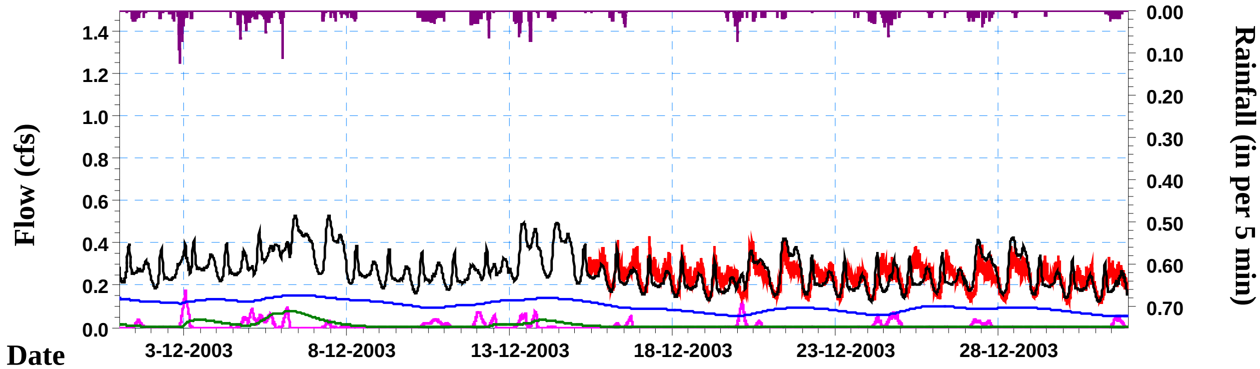


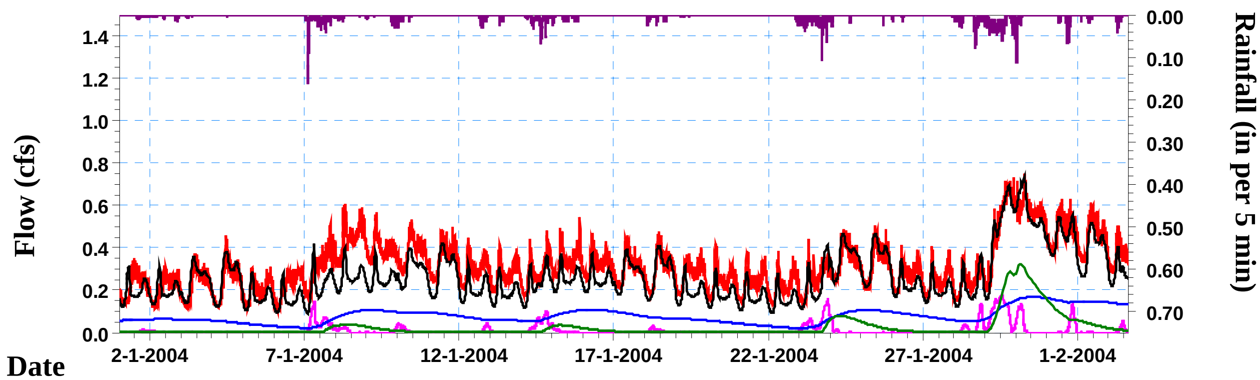
Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration



Coal Creek Pilot Basin (2003-2004 Monitoring Period)

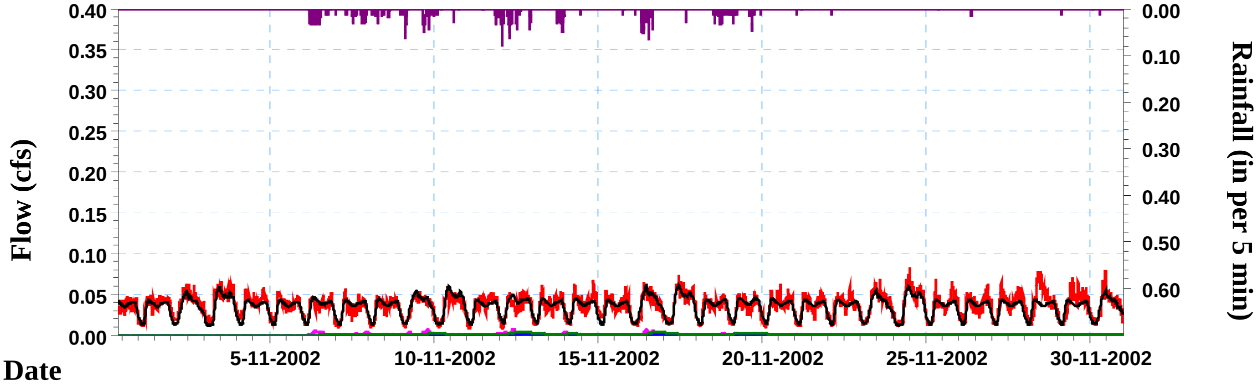


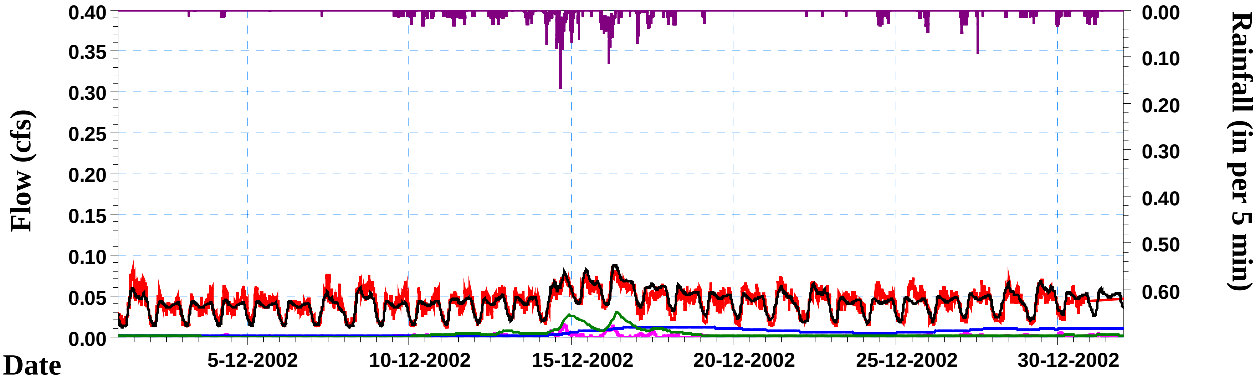


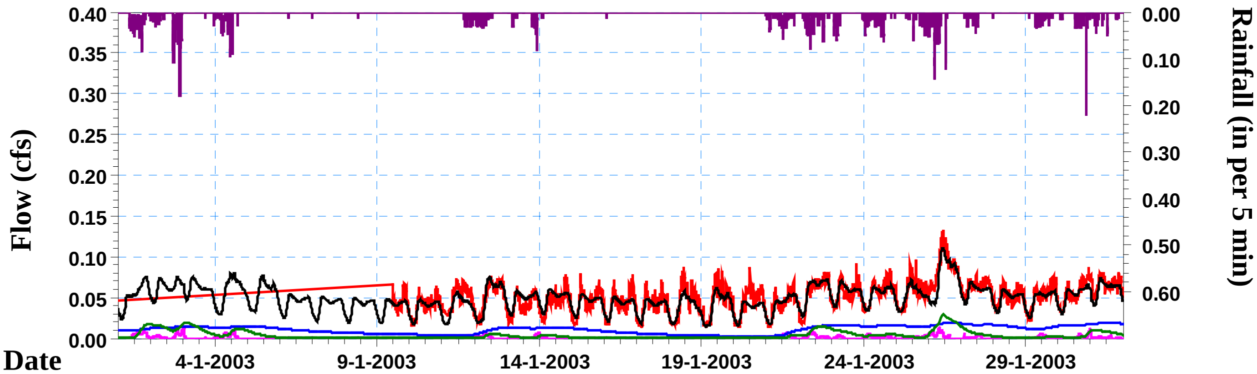
Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration

Kent Control Basin (2002-2003 Monitoring Period)

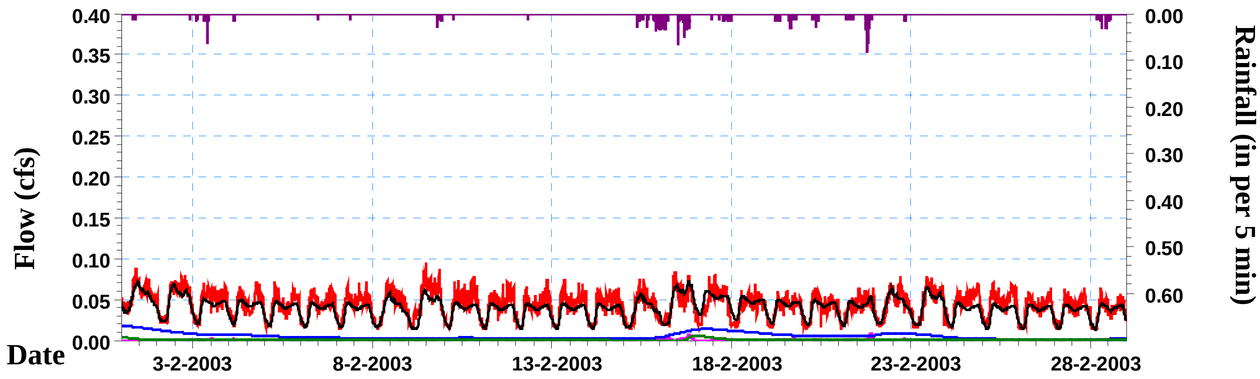


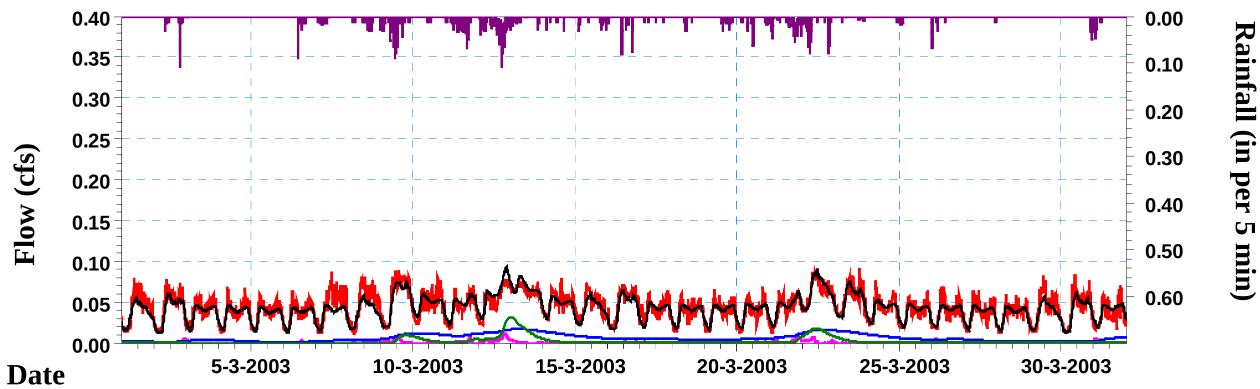


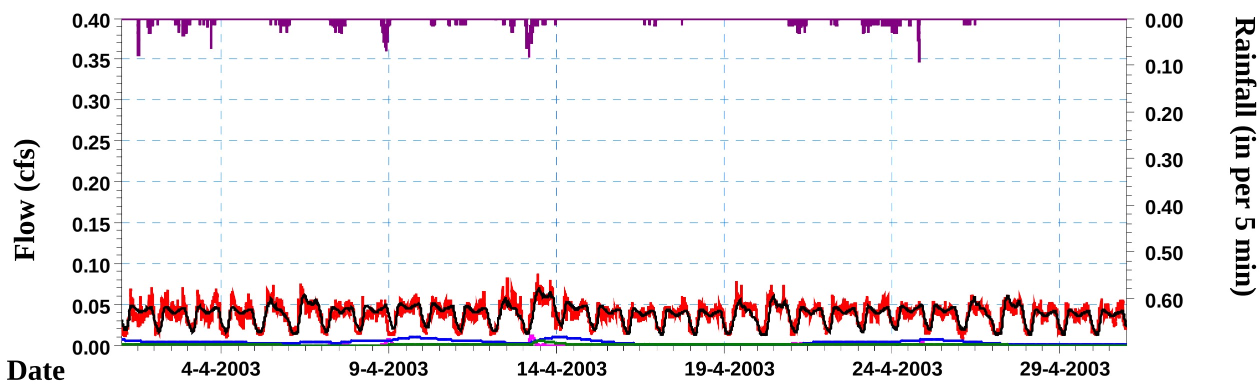


Legend: Measured Flow — Measured Rainfall — Total Simulated Flow — Fast Response Component — Slow Infiltration — Rapid Infiltration

Date Format (dd-mm-yyyy)

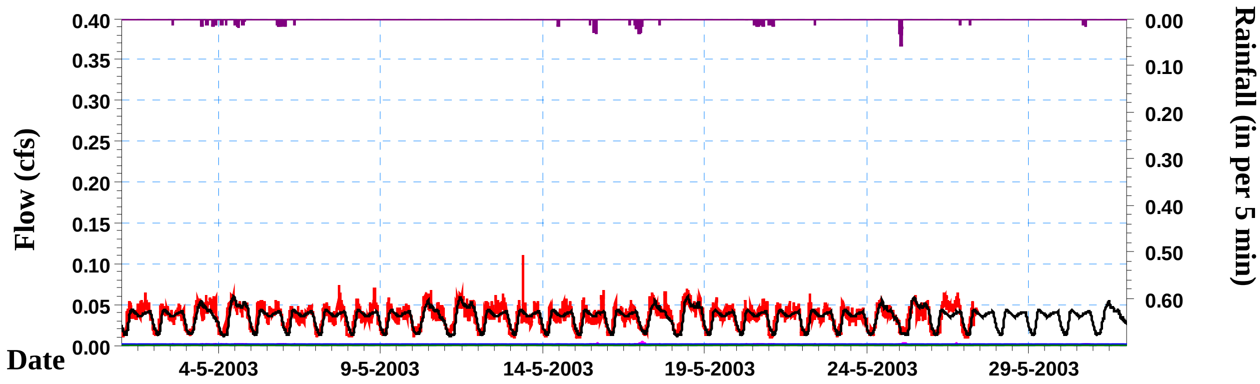




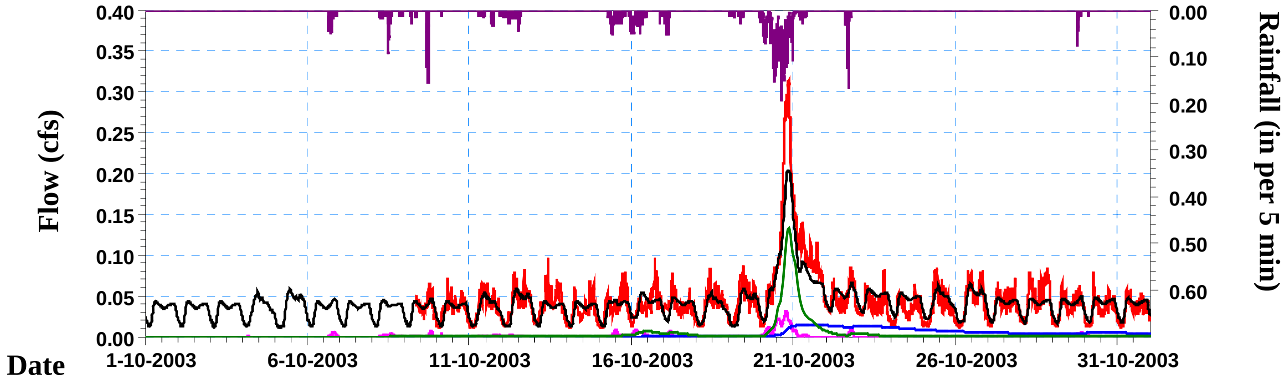


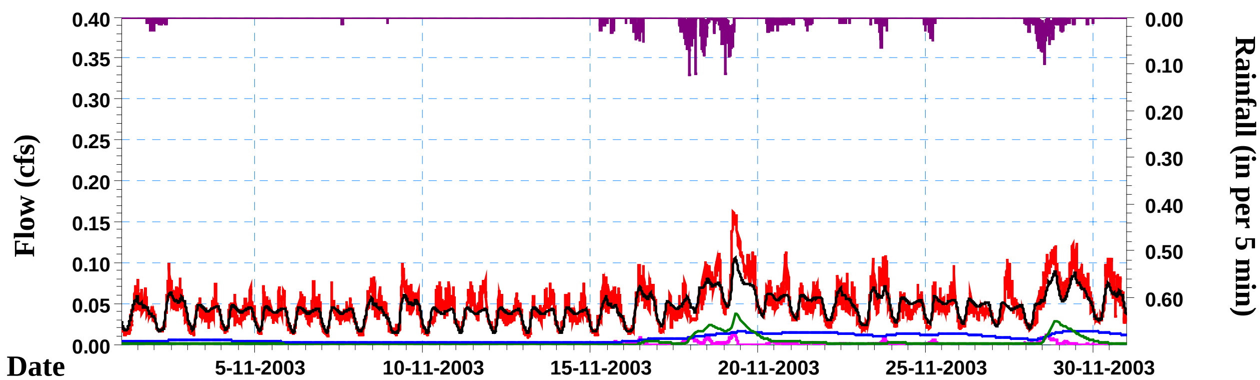
Legend: Measured Flow — Measured Rainfall — Date Format (dd-mm-yyyy)

Total Simulated Flow — Fast Response Component — Slow Infiltration — Rapid Infiltration



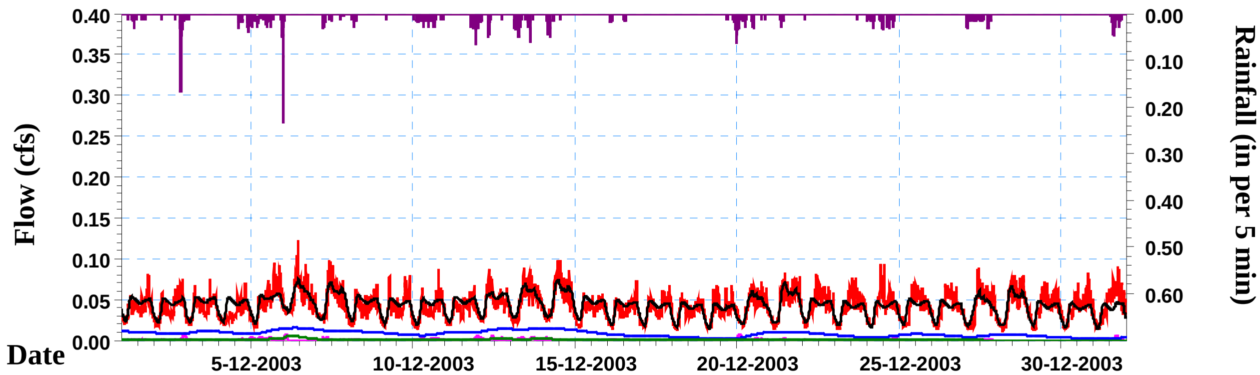
Kent Control Basin (2003-2004 Monitoring Period)

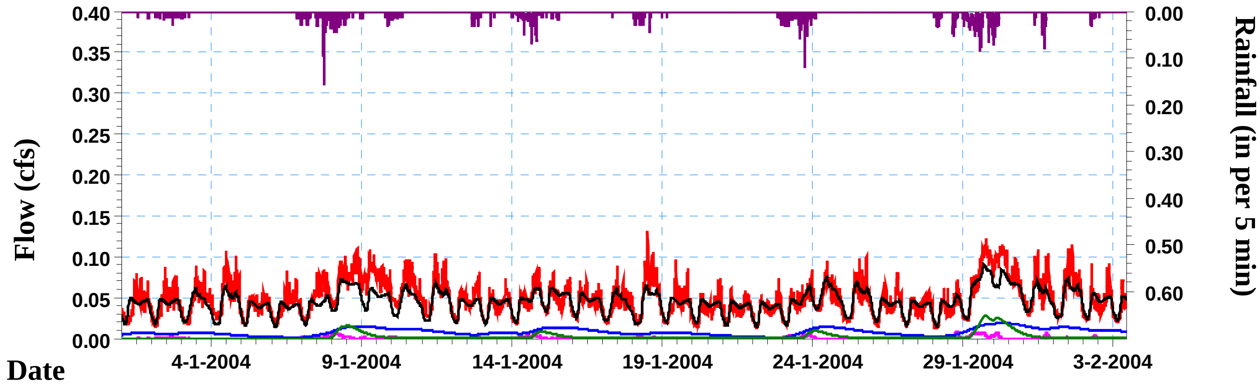




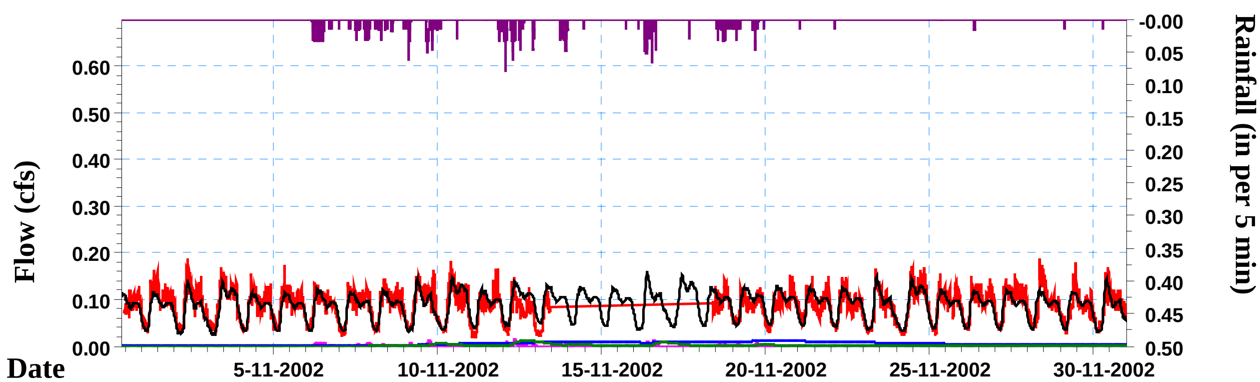
Legend: Measured Flow; Measured Rainfall; Total Simulated Flow; Fast Response Component; Slow Infiltration; Rapid Infiltration

Date Format (dd-mm-yyyy)





Kent Pilot Basin (2002-2003 Monitoring Period)



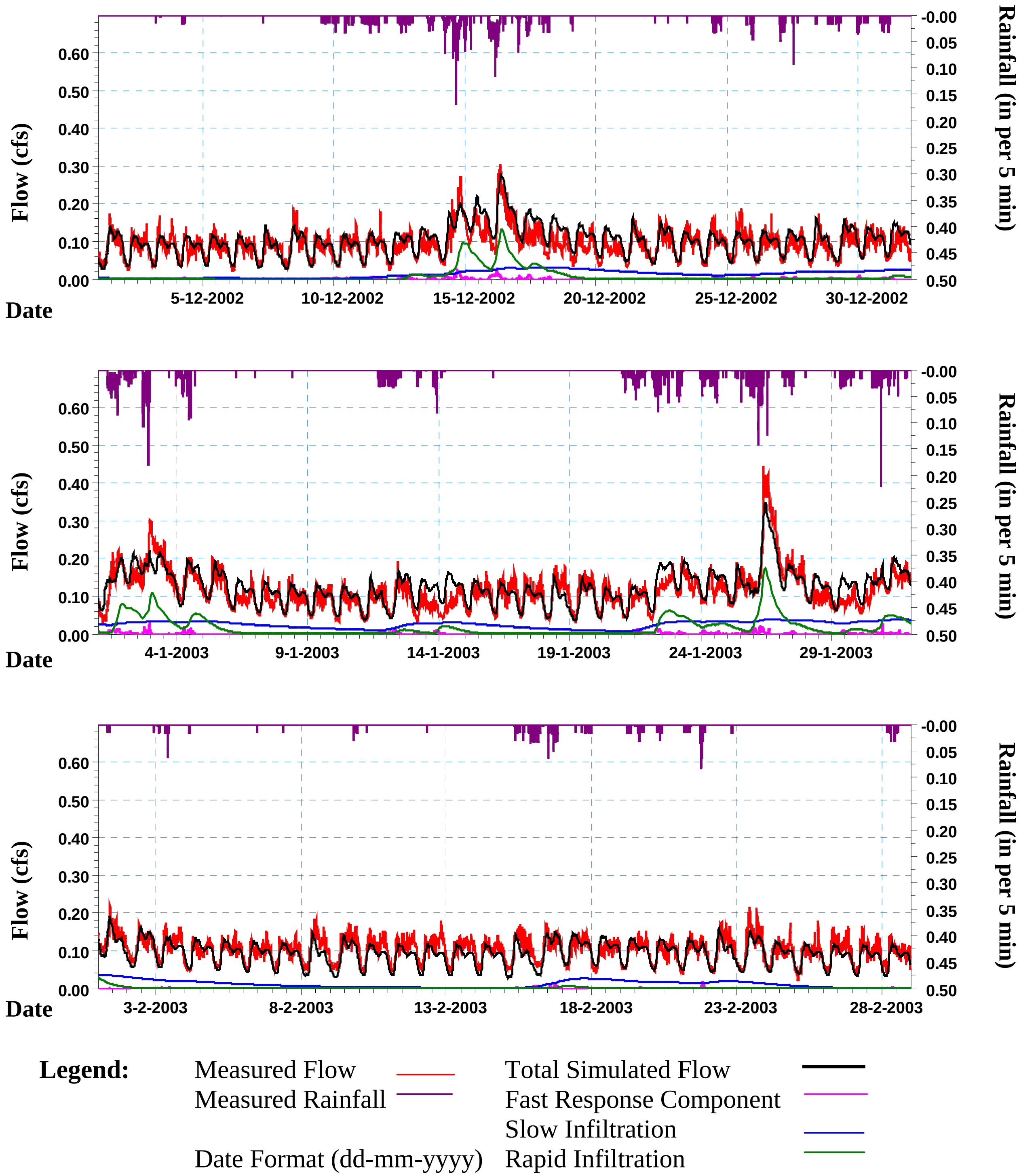
Legend:

Measured Flow — Total Simulated Flow

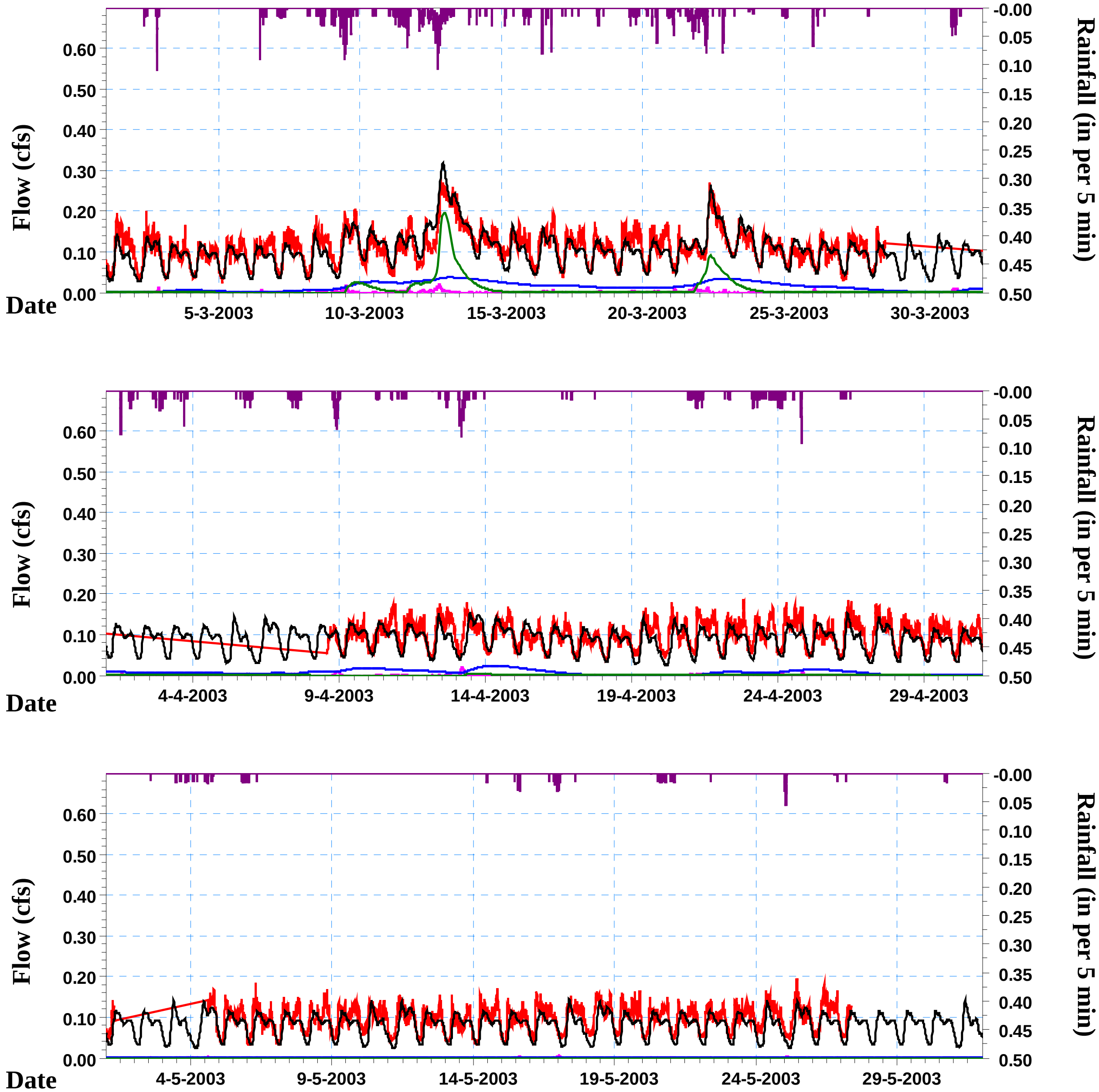
Measured Rainfall — Fast Response Component

Slow Infiltration

Date Format (dd-mm-yyyy) — Rapid Infiltration



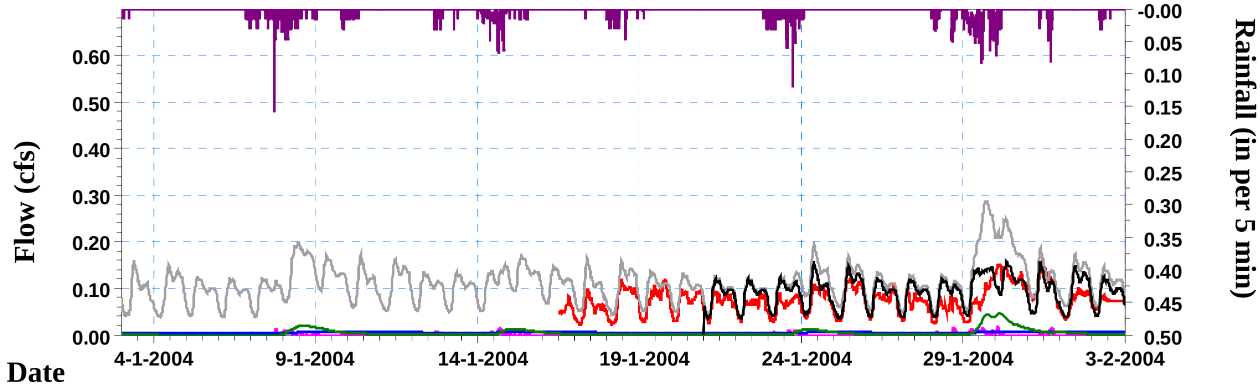
Flow (cfs)
Rainfall (in per 5 min)
Date
5-12-2002
10-12-2002
15-12-2002
20-12-2002
25-12-2002
30-12-2002
4-1-2003
9-1-2003
14-1-2003
19-1-2003
24-1-2003
29-1-2003
3-2-2003
8-2-2003
13-2-2003
18-2-2003
23-2-2003
28-2-2003
0.00
0.10
0.20
0.30
0.40
0.50
0.60
-0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
Legend:
Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration



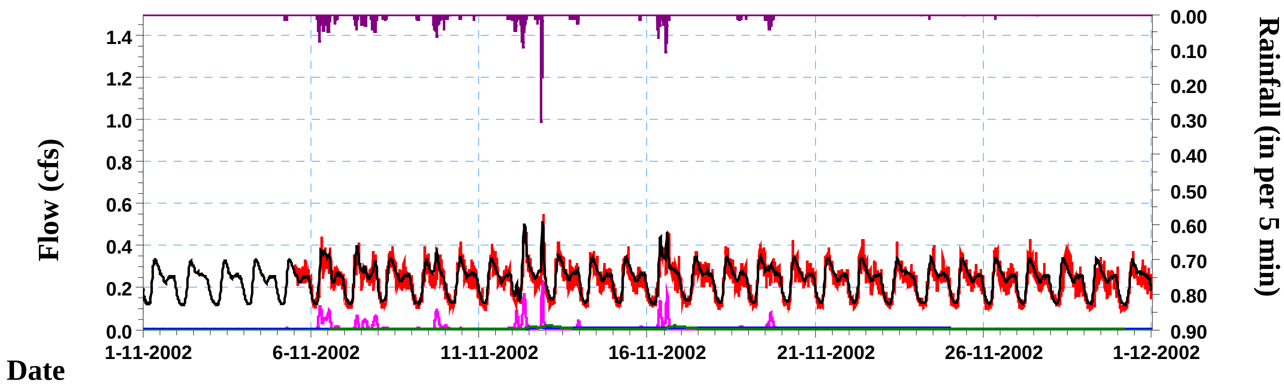
Legend:

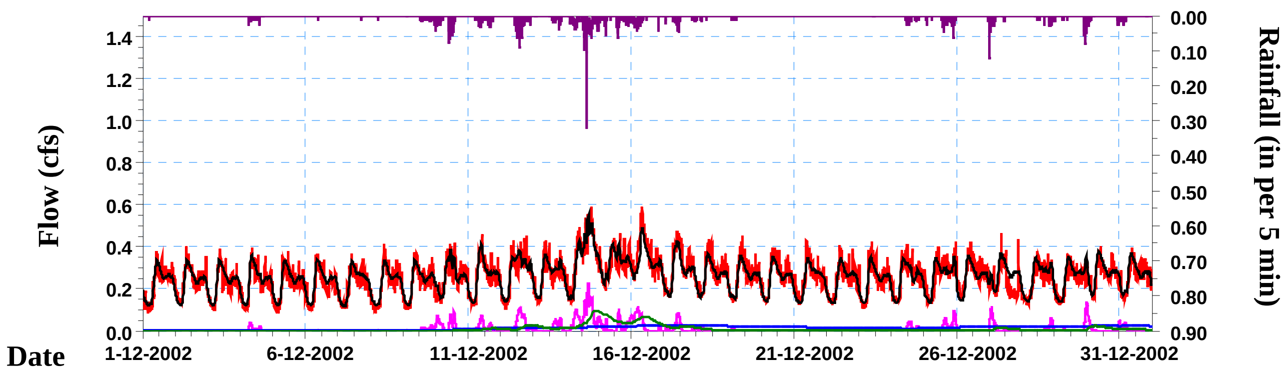
Measured Flow	red	Total Simulated Flow	black
Measured Rainfall	purple	Fast Response Component	magenta
		Slow Infiltration	blue
Date Format (dd-mm-yyyy)		Rapid Infiltration	green

Kent Pilot Basin (2003-2004 Monitoring Period)



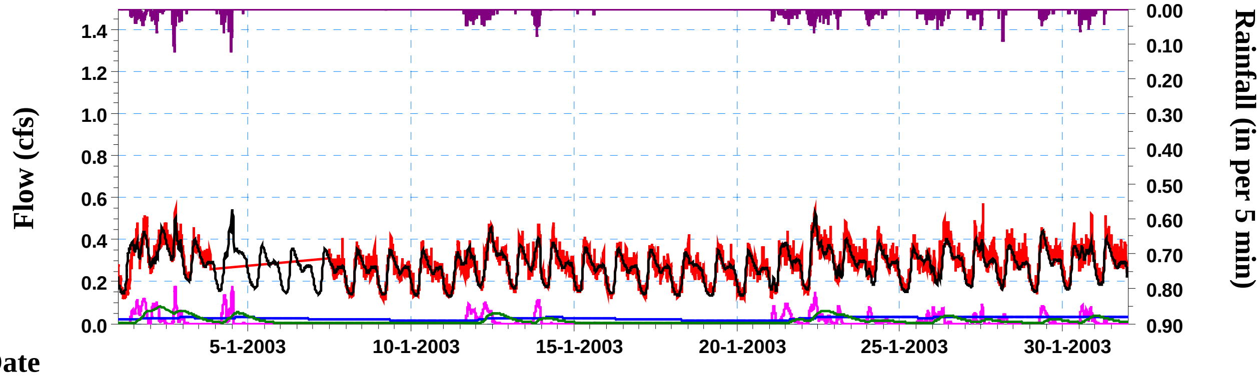
Kirkland Control Basin (2002-2003 Monitoring Period)

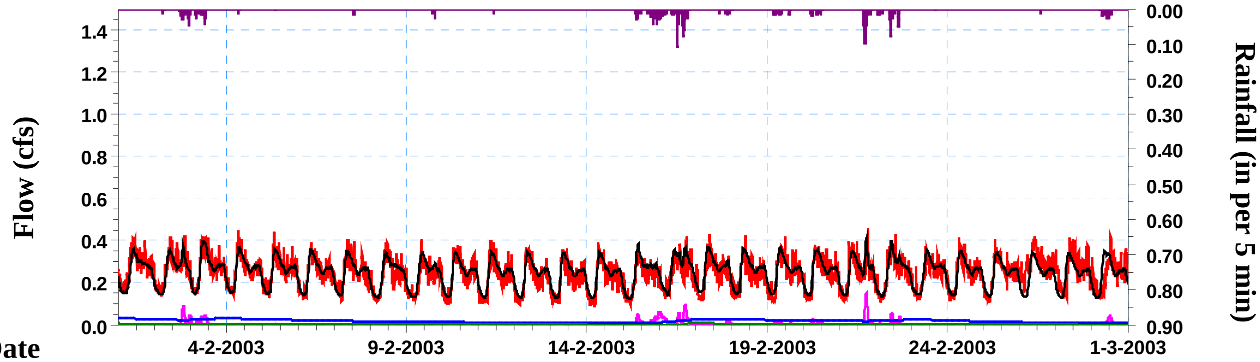


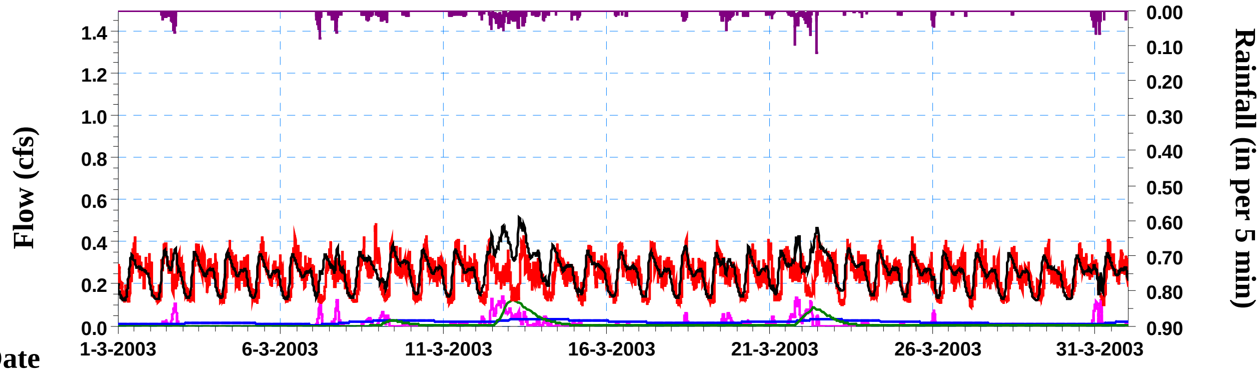


Legend: Measured Flow; Measured Rainfall; Total Simulated Flow; Fast Response Component; Slow Infiltration; Rapid Infiltration; Pre-rehabilitation Simulated Flow

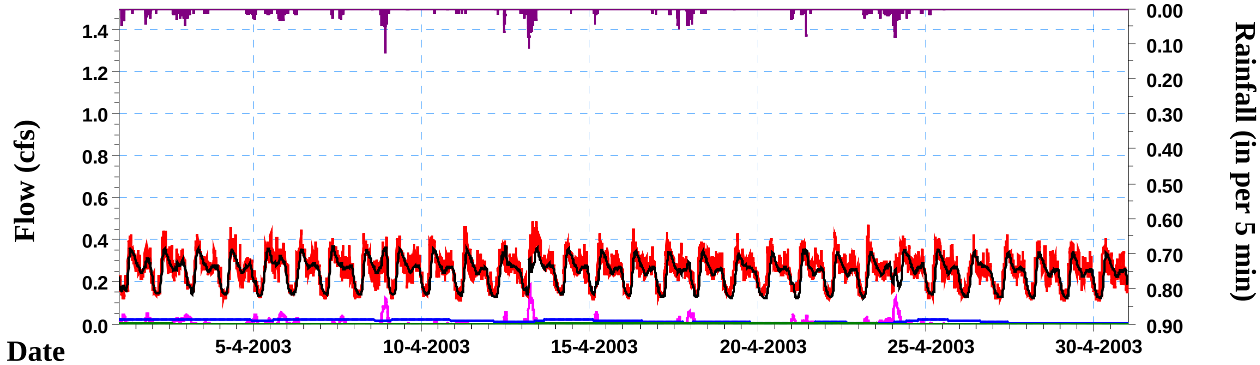
Date Format (dd-mm-yyyy)

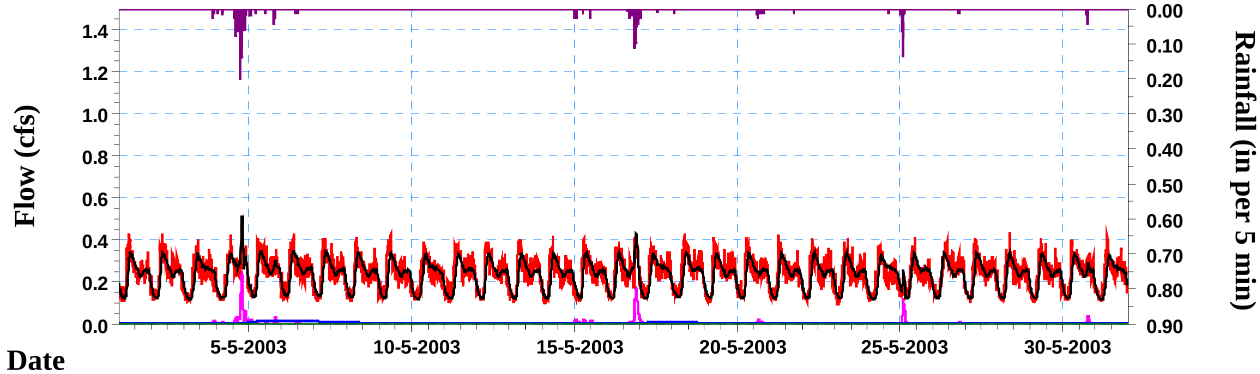


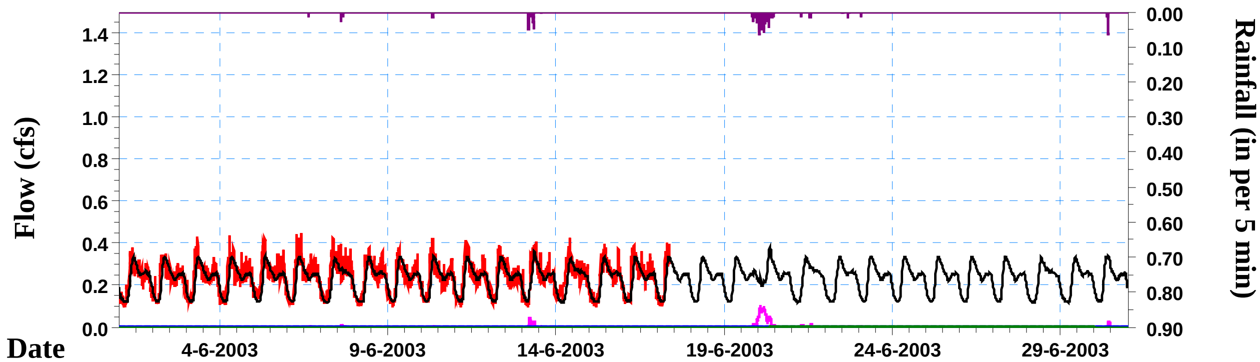




Legend: Measured Flow — Total Simulated Flow — Measured Rainfall — Fast Response Component — Slow Infiltration — Date Format (dd-mm-yyyy) Rapid Infiltration —



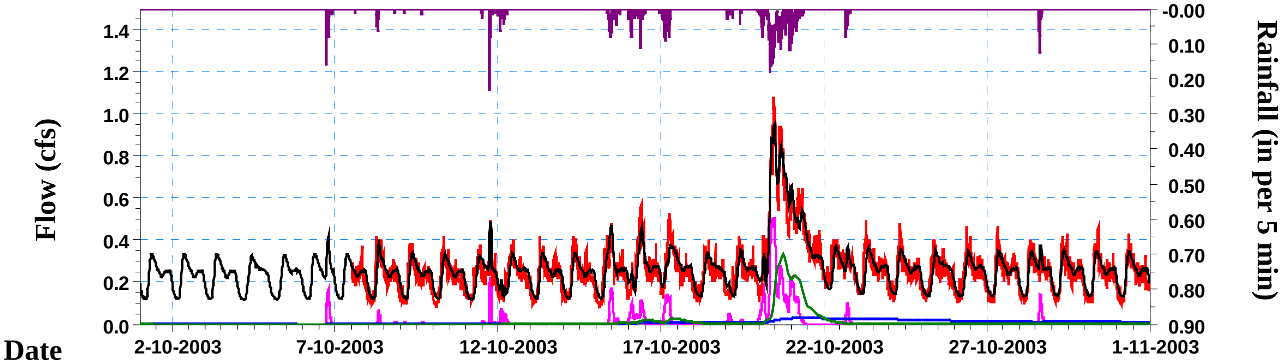


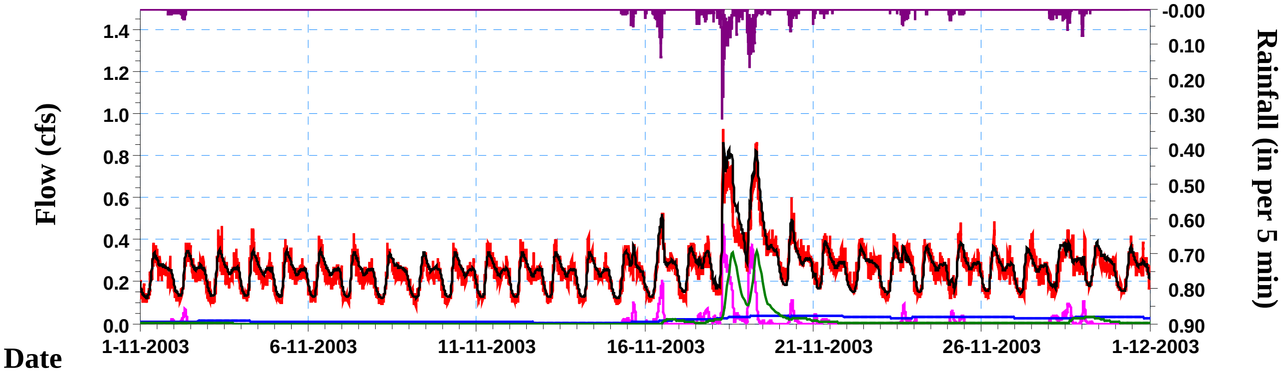


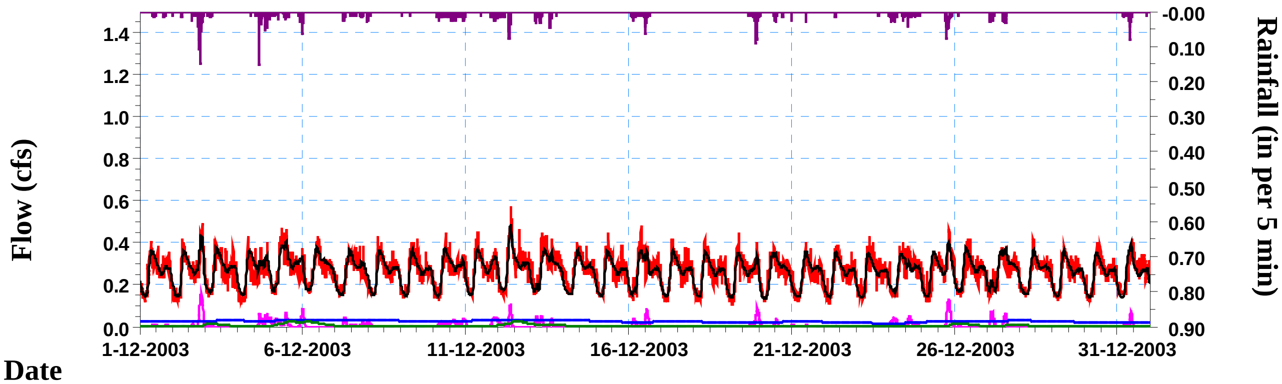
Legend: Measured Flow; Measured Rainfall; Total Simulated Flow; Fast Response Component; Slow Infiltration; Rapid Infiltration

Date Format (dd-mm-yyyy)

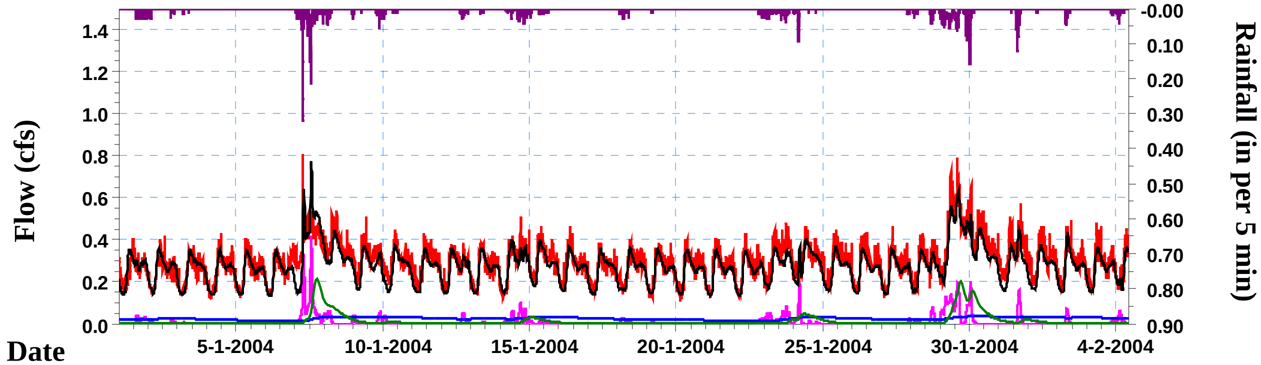
Kirkland Control Basin (2003-2004 Monitoring Period)



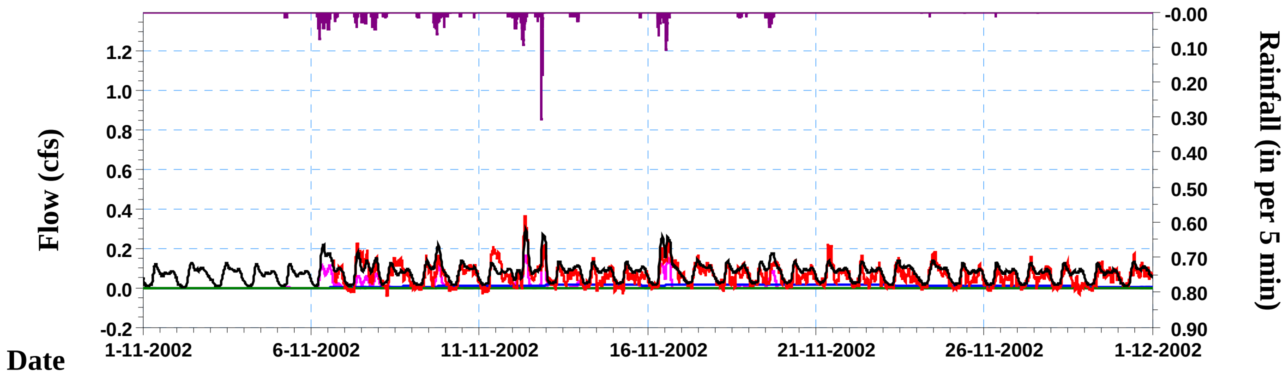


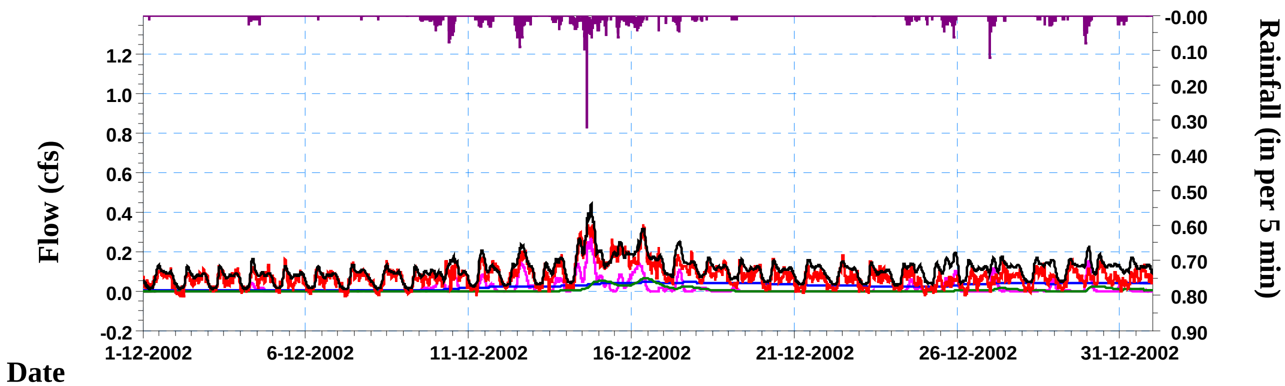


Legend: Measured Flow
Measured Rainfall
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration
Date Format (dd-mm-yyyy)



Kirkland Pilot Basin (2002-2003 Monitoring Period)

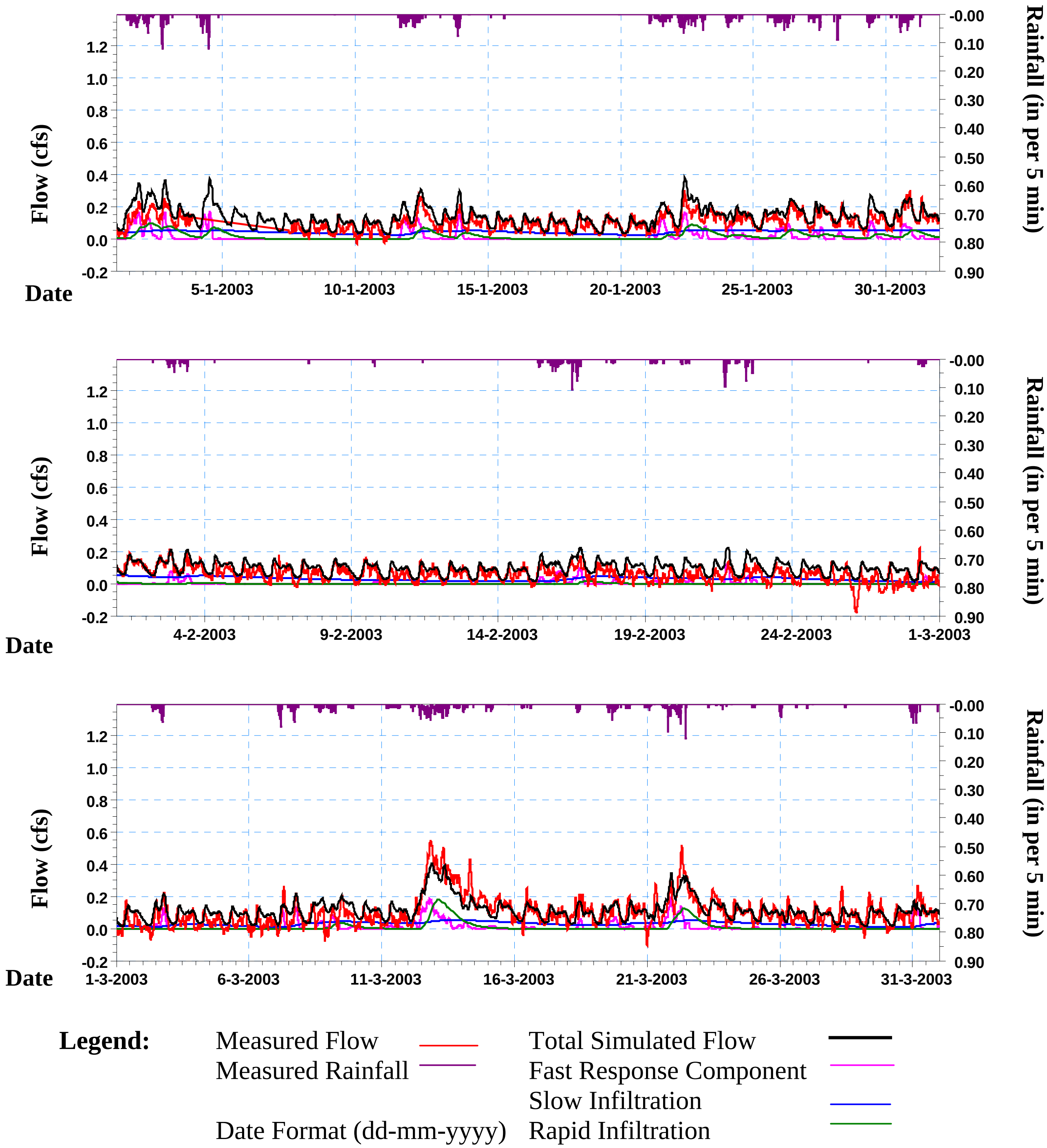


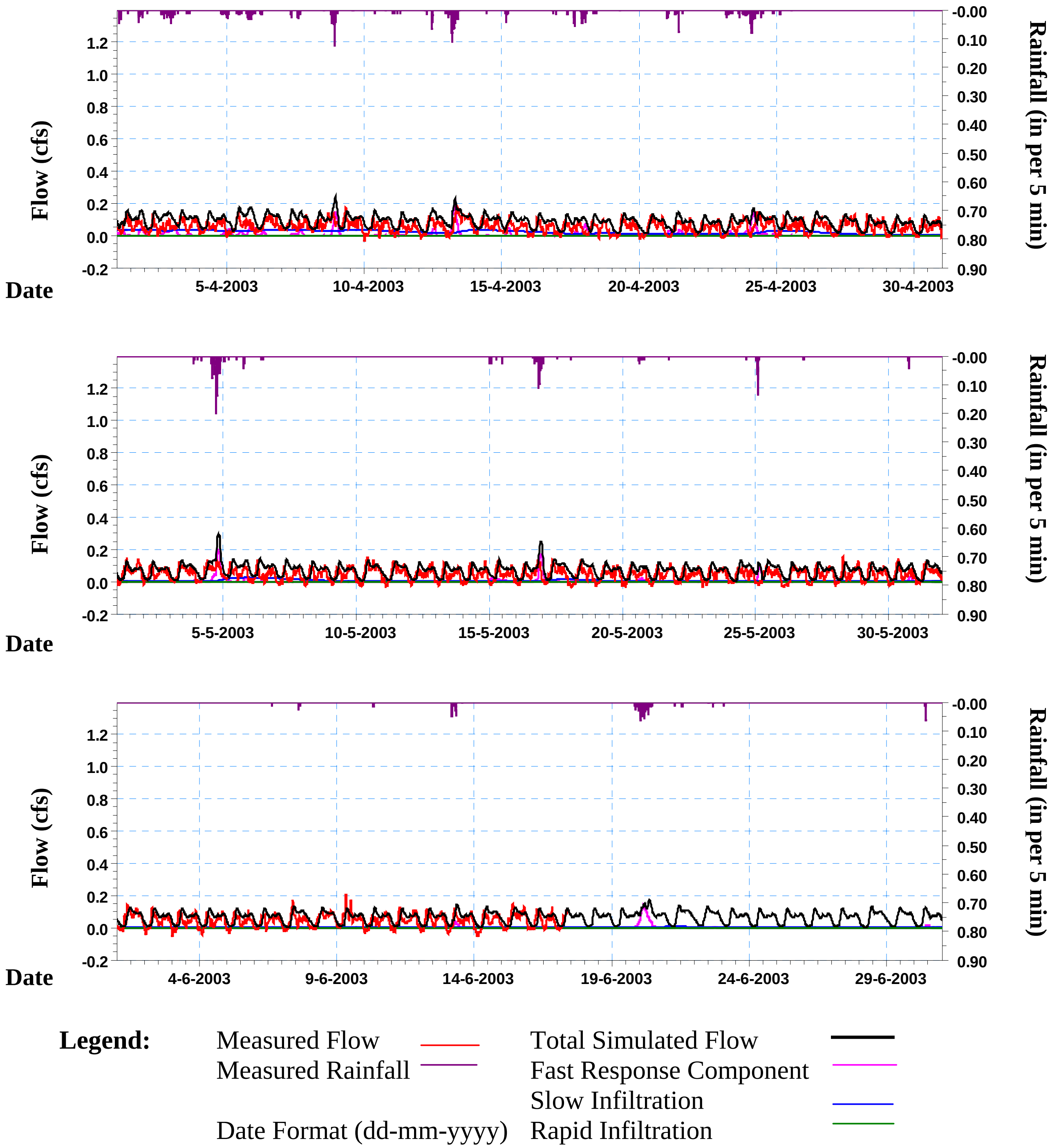


Legend:

Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)

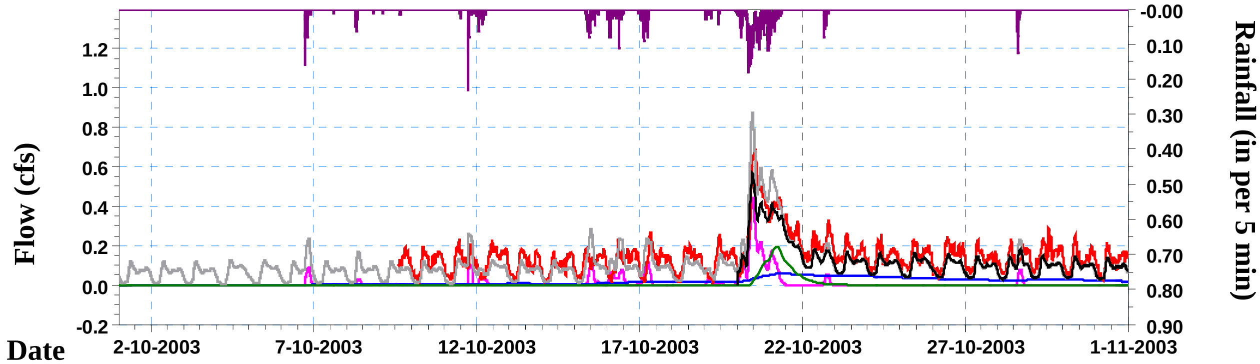
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration

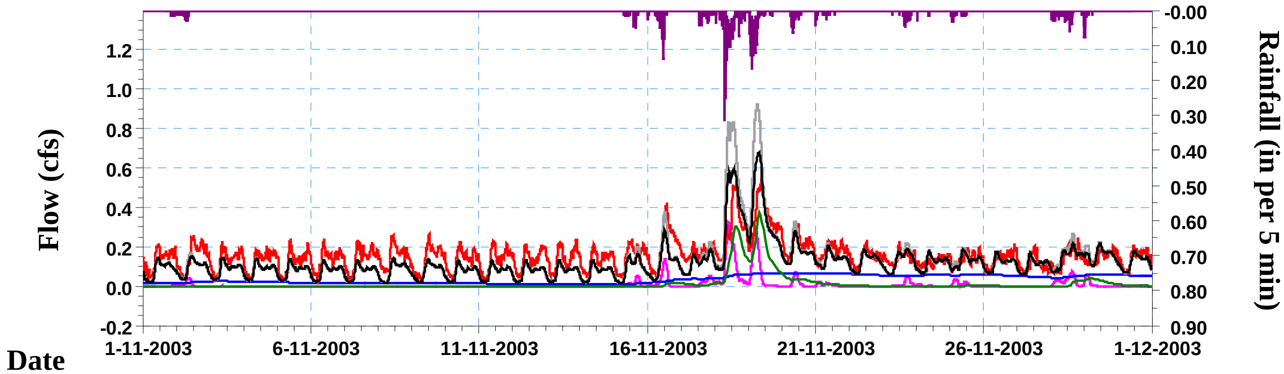

Flow (cfs)
Rainfall (in per 5 min)
Date
5-1-2003
10-1-2003
15-1-2003
20-1-2003
25-1-2003
30-1-2003
4-2-2003
9-2-2003
14-2-2003
19-2-2003
24-2-2003
1-3-2003
6-3-2003
11-3-2003
16-3-2003
21-3-2003
26-3-2003
31-3-2003
Legend:
Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration

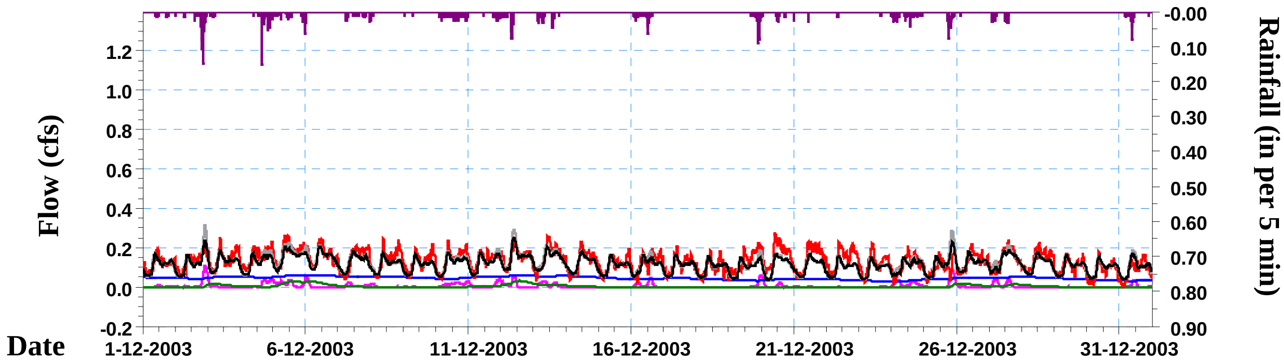


Flow (cfs)
Rainfall (in per 5 min)
Date
5-4-2003
10-4-2003
15-4-2003
20-4-2003
25-4-2003
30-4-2003
5-5-2003
10-5-2003
15-5-2003
20-5-2003
25-5-2003
30-5-2003
4-6-2003
9-6-2003
14-6-2003
19-6-2003
24-6-2003
29-6-2003
Legend:
Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration

Kirkland Pilot Basin (2003-2004 Monitoring Period)







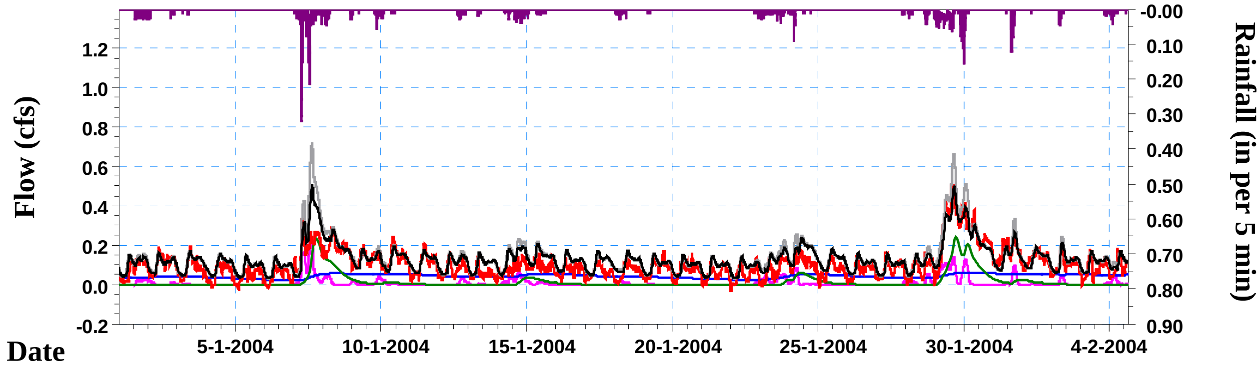
Legend: Measured Flow — Total Simulated Flow

Measured Rainfall — Fast Response Component

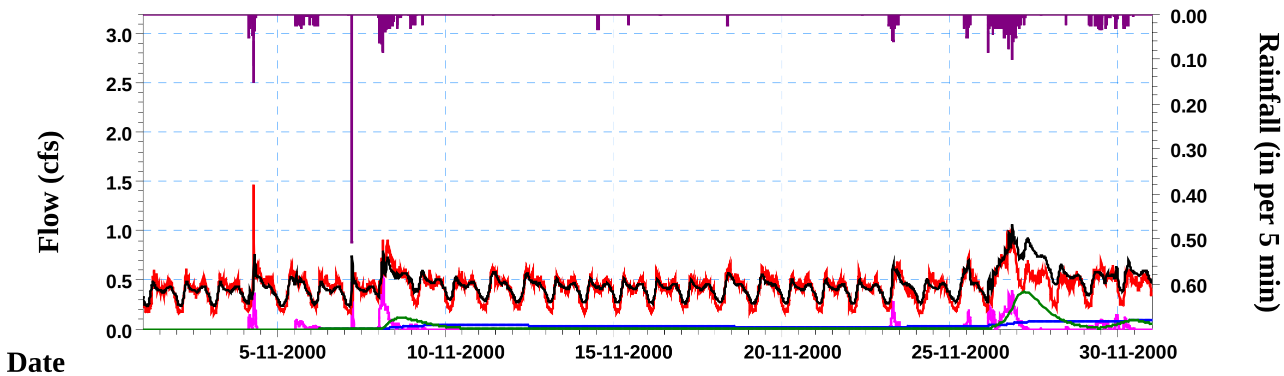
Slow Infiltration

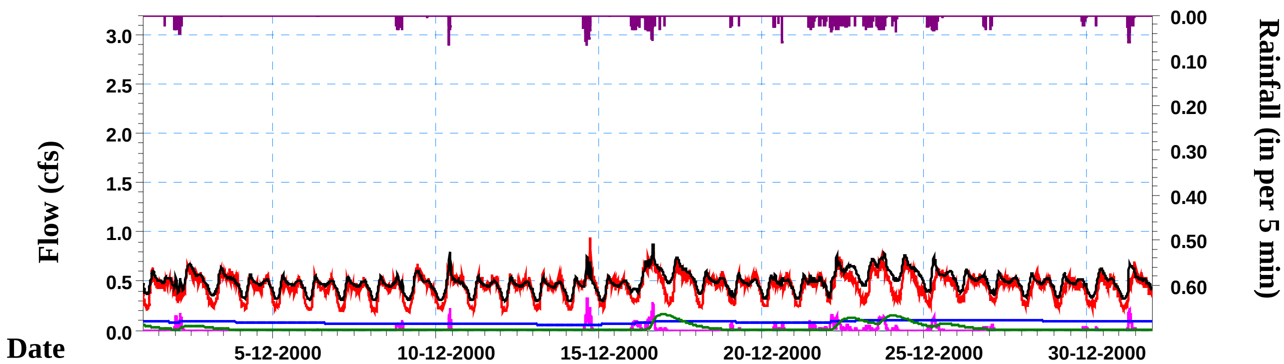
Date Format (dd-mm-yyyy) — Rapid Infiltration

Pre-rehabilitation Simulated Flow



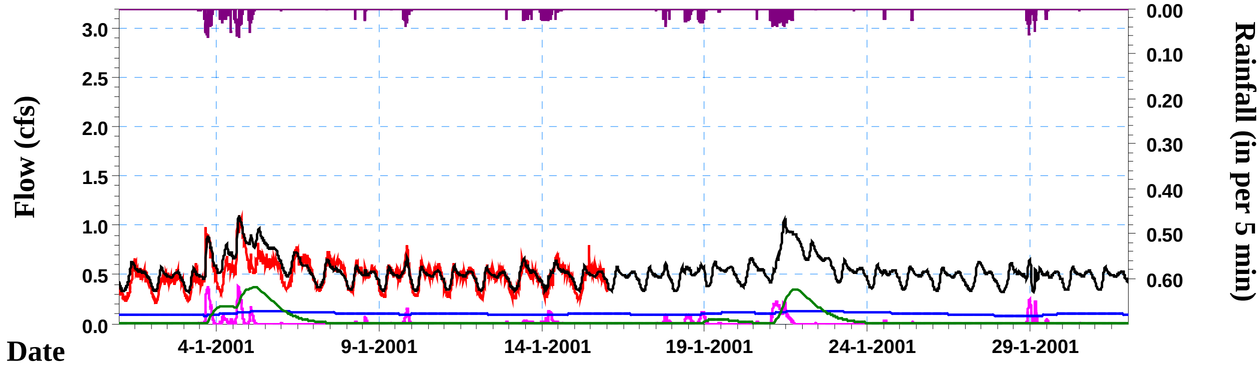
Lake Forest Park Control Basin (2000-2001 Monitoring Period)



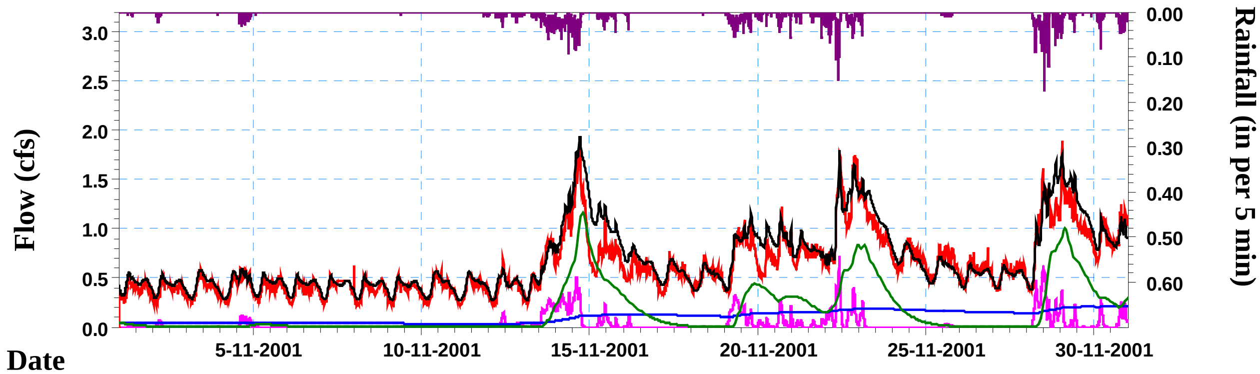


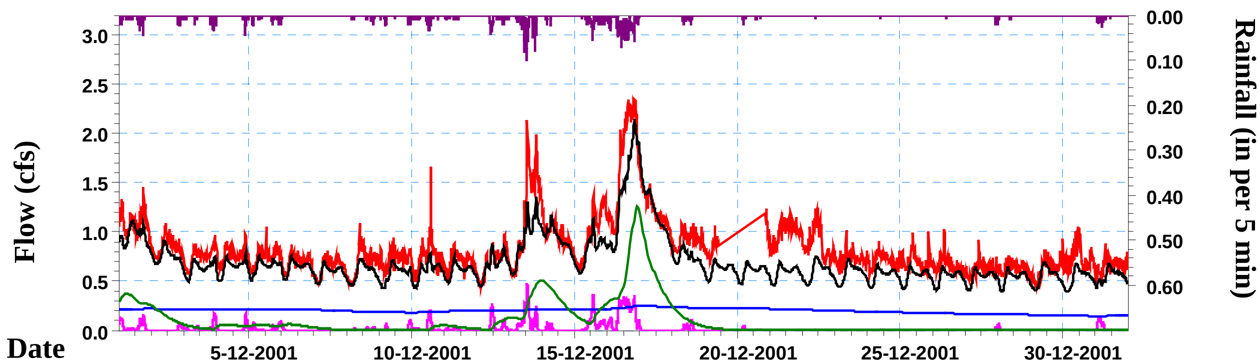
Legend:

Measured Flow
Measured Rainfall
Total Simulated Flow
Fast Response Component
Slow Infiltration
Date Format (dd-mm-yyyy)
Rapid Infiltration
Pre-rehabilitation Simulated Flow



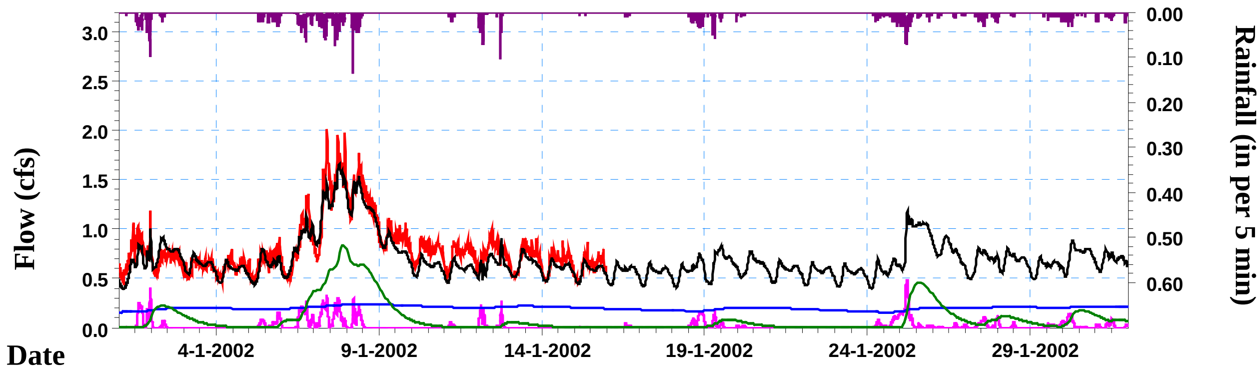
Lake Forest Park Control Basin (2001-2002 Monitoring Period)



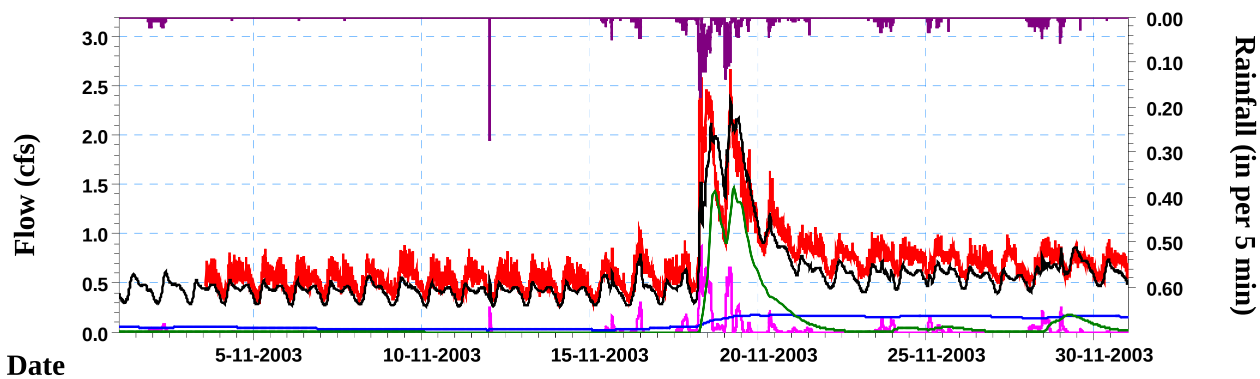


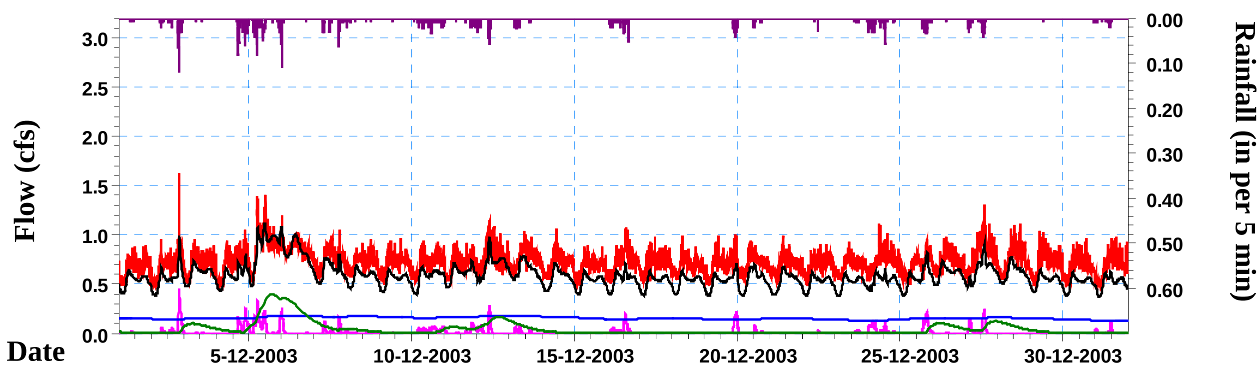
Legend:

Measured Flow		Total Simulated Flow	
Measured Rainfall		Fast Response Component	
		Slow Infiltration	
Date Format (dd-mm-yyyy)		Rapid Infiltration	



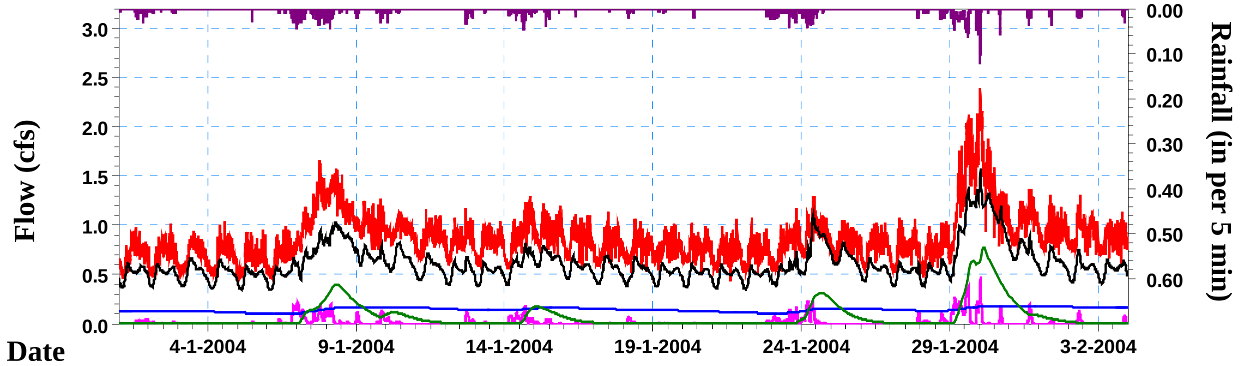
Lake Forest Park Control Basin (2003-2004 Monitoring Period)



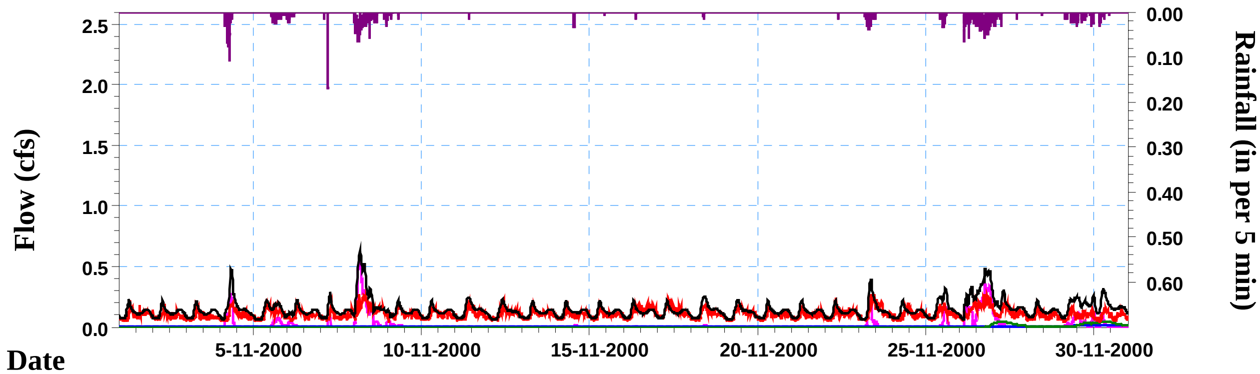


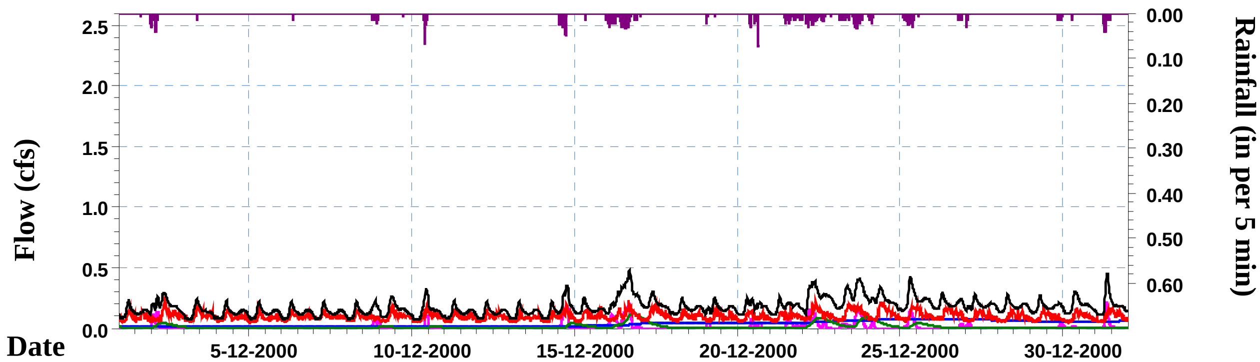
Legend: Measured Flow; Measured Rainfall; Total Simulated Flow; Fast Response Component; Slow Infiltration; Rapid Infiltration

Date Format (dd-mm-yyyy)



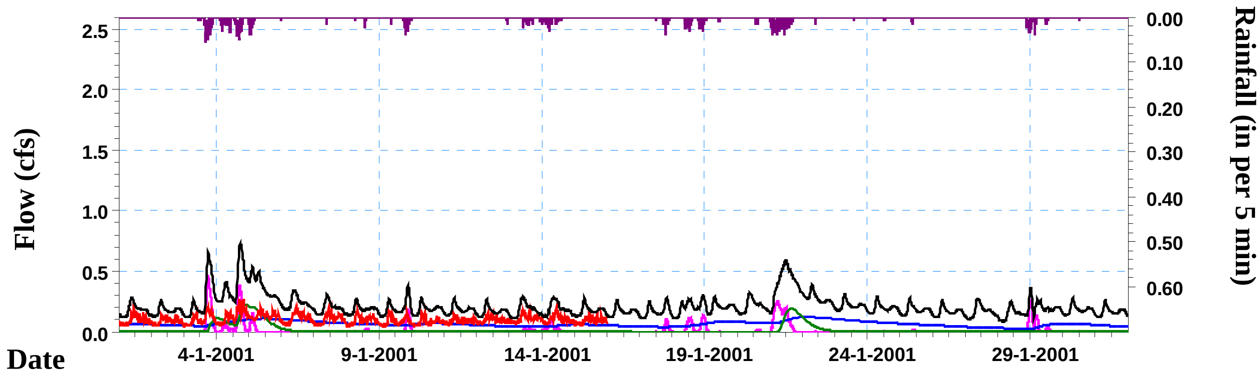
Lake Forest Park Pilot Basin (2000-2001 Monitoring Period)



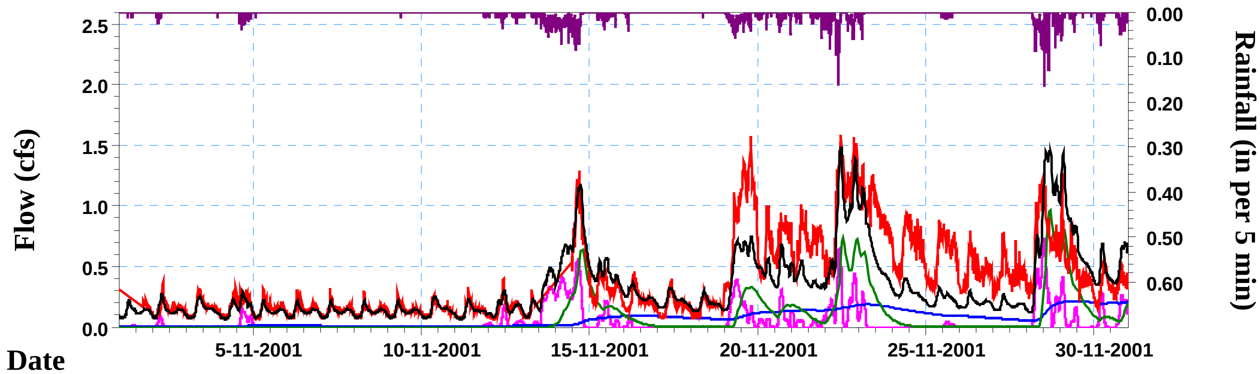


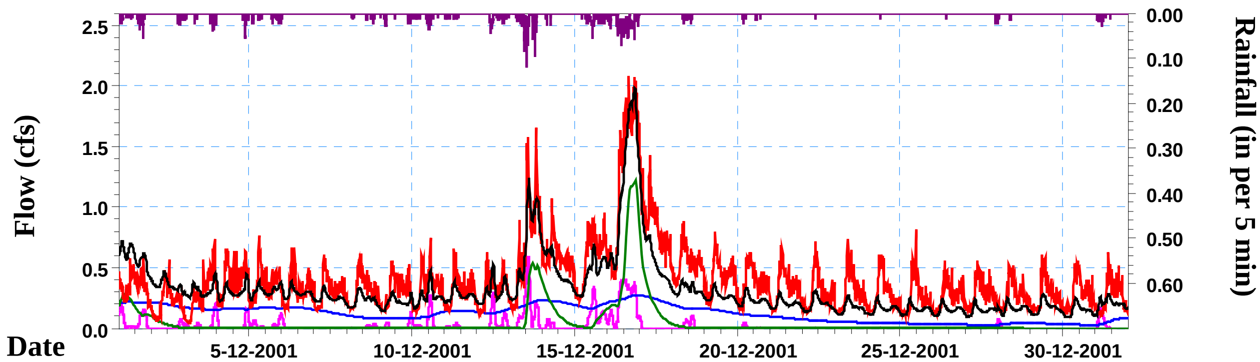
Legend:

Measured Flow — Total Simulated Flow
Measured Rainfall — Fast Response Component
Slow Infiltration
Date Format (dd-mm-yyyy) — Rapid Infiltration



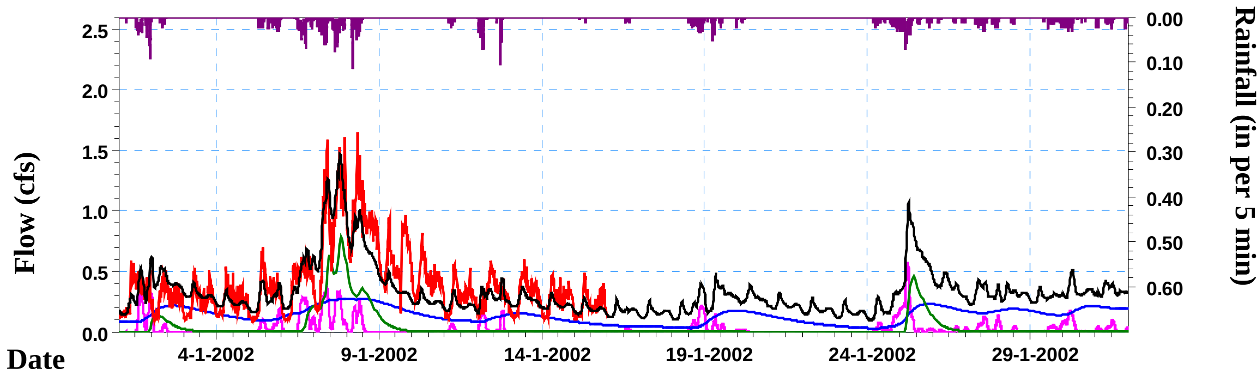
Lake Forest Park Pilot Basin (2001-2002 Monitoring Period)



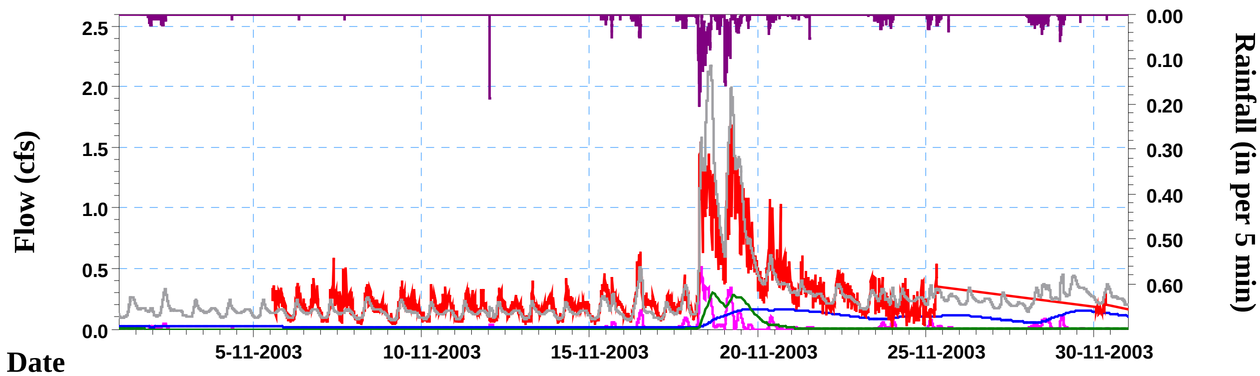


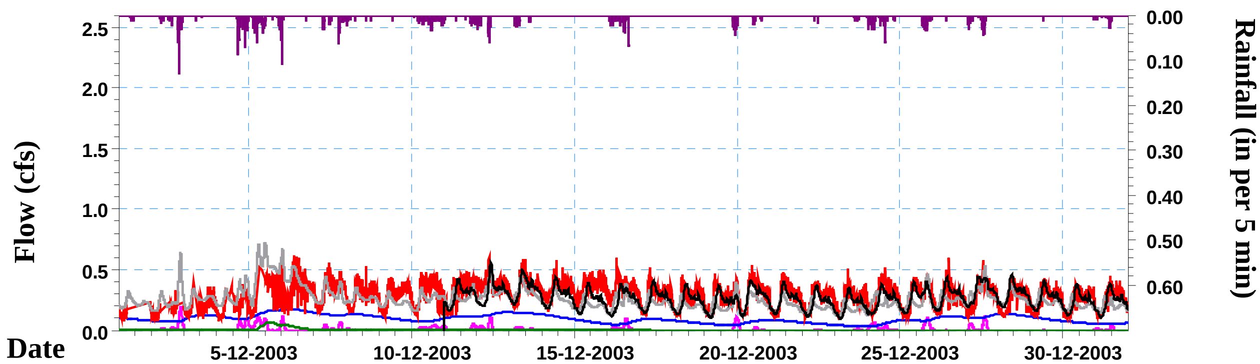
Legend: Measured Flow — Measured Rainfall — Total Simulated Flow — Fast Response Component — Slow Infiltration — Rapid Infiltration

Date Format (dd-mm-yyyy)



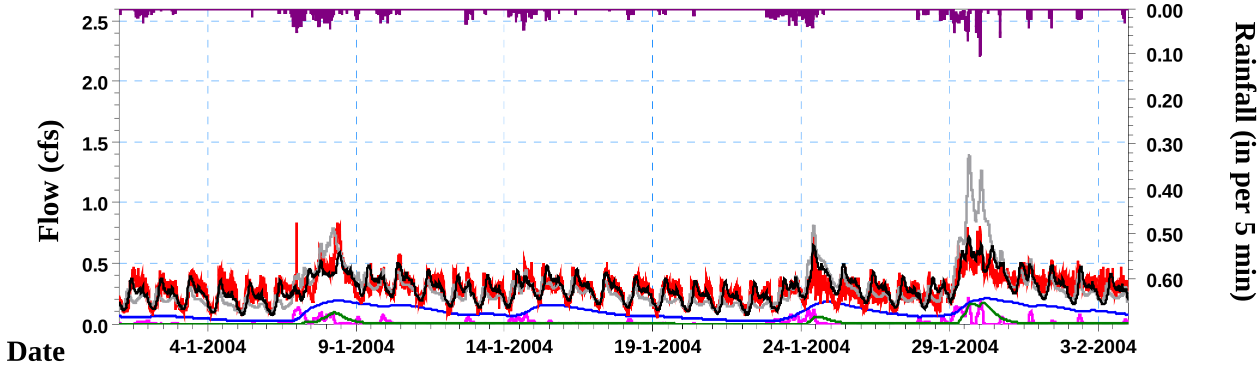
Lake Forest Park Pilot Basin (2003-2004 Monitoring Period)



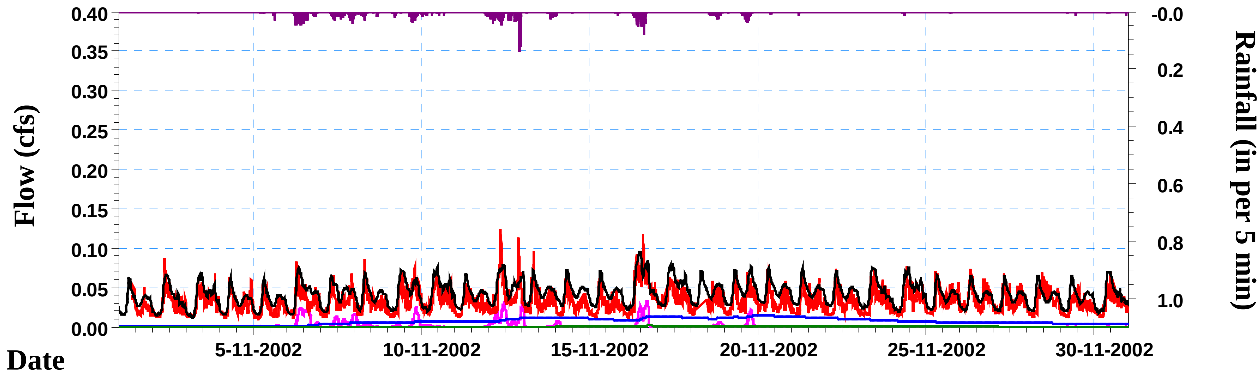


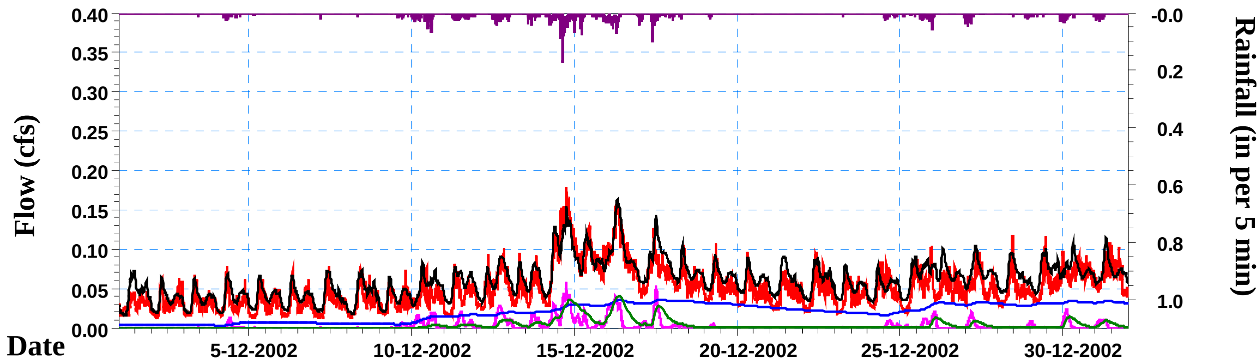
Legend:

Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)
Pre-rehabilitation Simulated Flow
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration

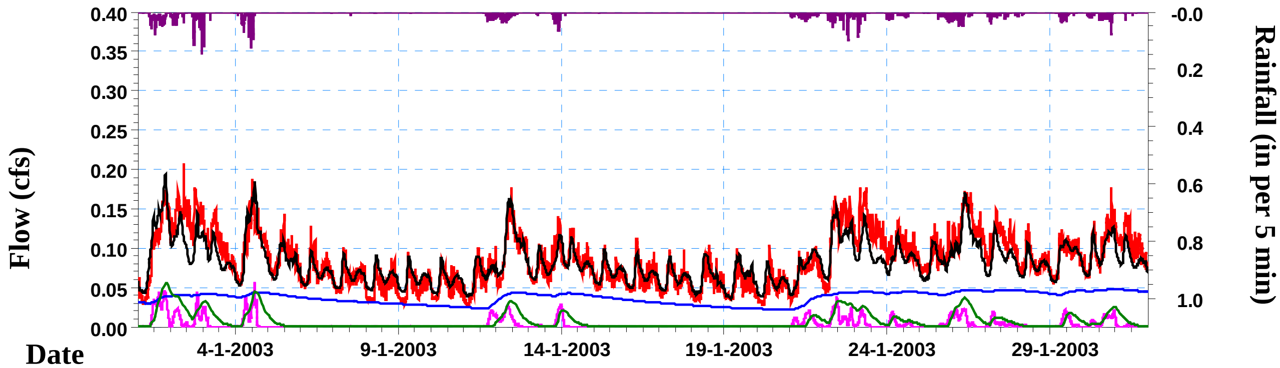


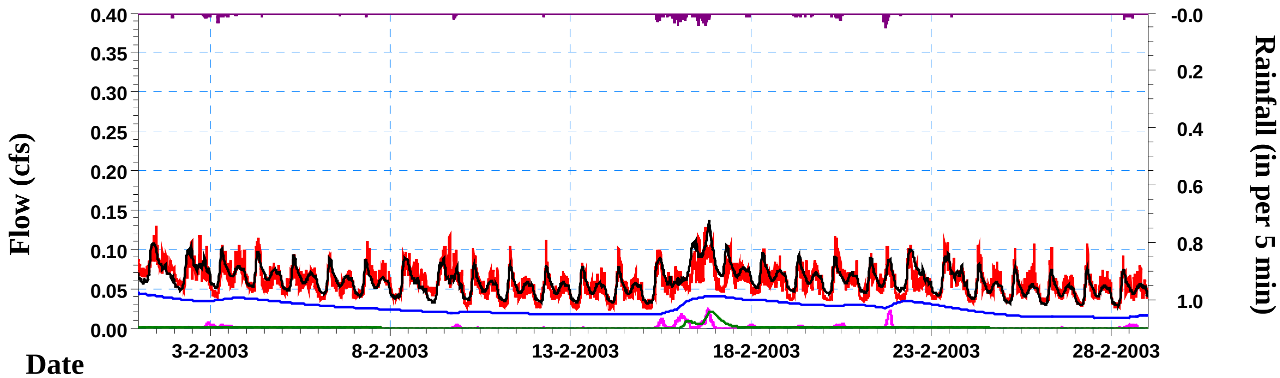
Mercer Island Control Basin (2002-2003 Monitoring Period)

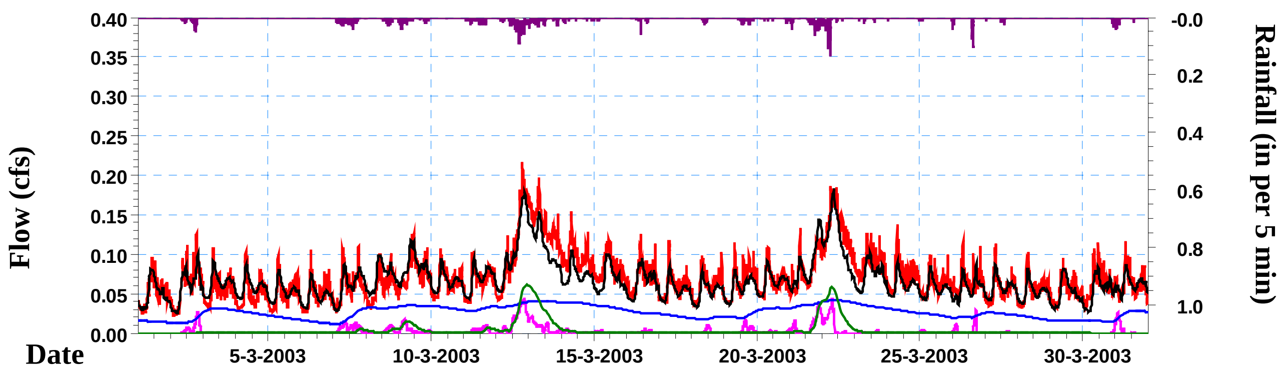




Legend: Measured Flow — Total Simulated Flow
Measured Rainfall — Fast Response Component
Slow Infiltration
Date Format (dd-mm-yyyy) Rapid Infiltration
Pre-rehabilitation Simulated Flow





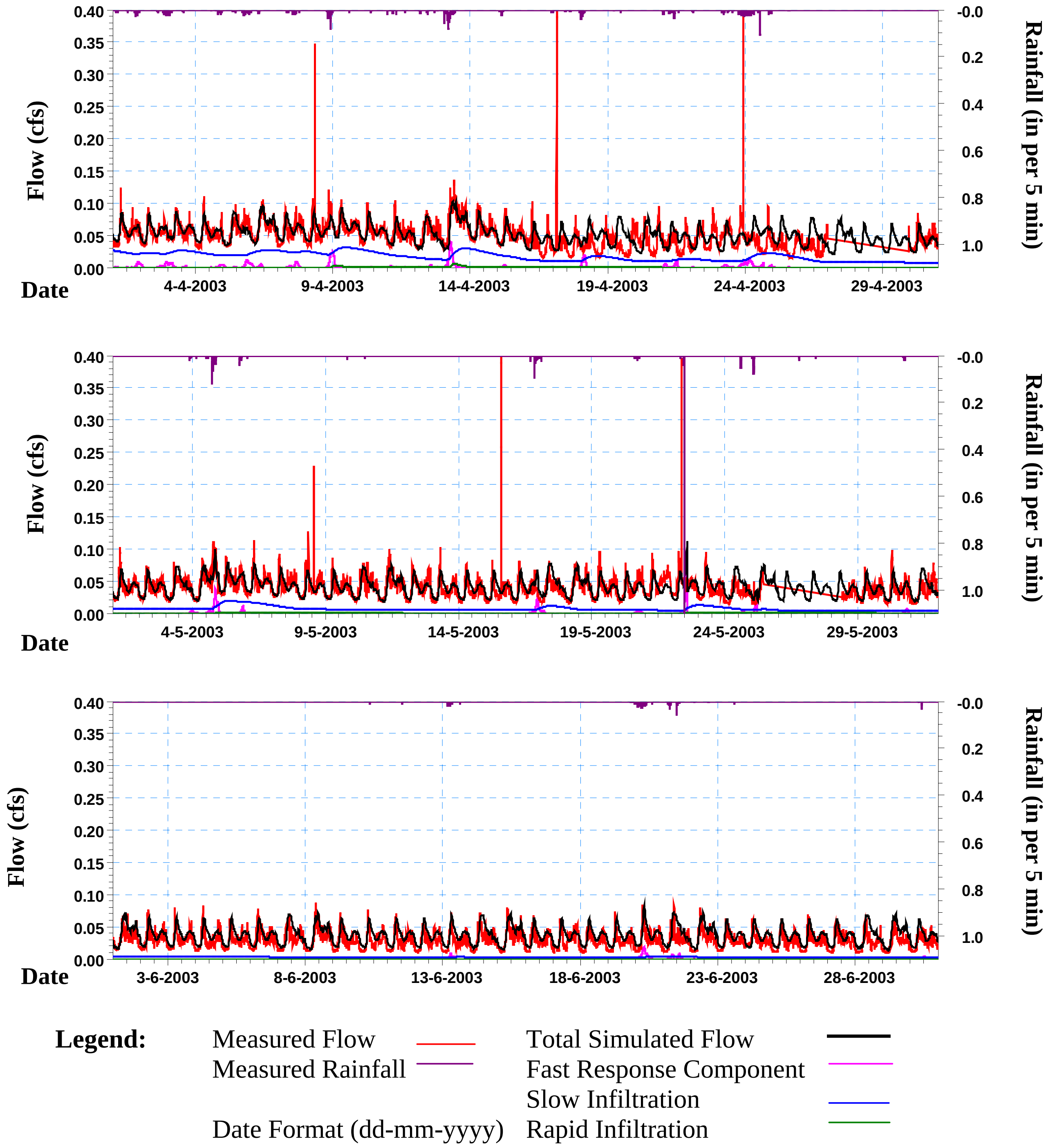


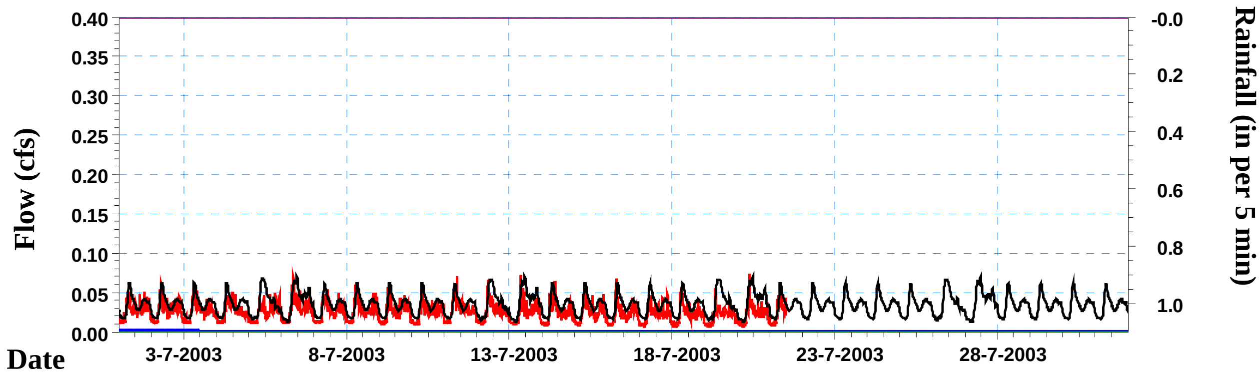
Legend:

Measured Flow
Measured Rainfall

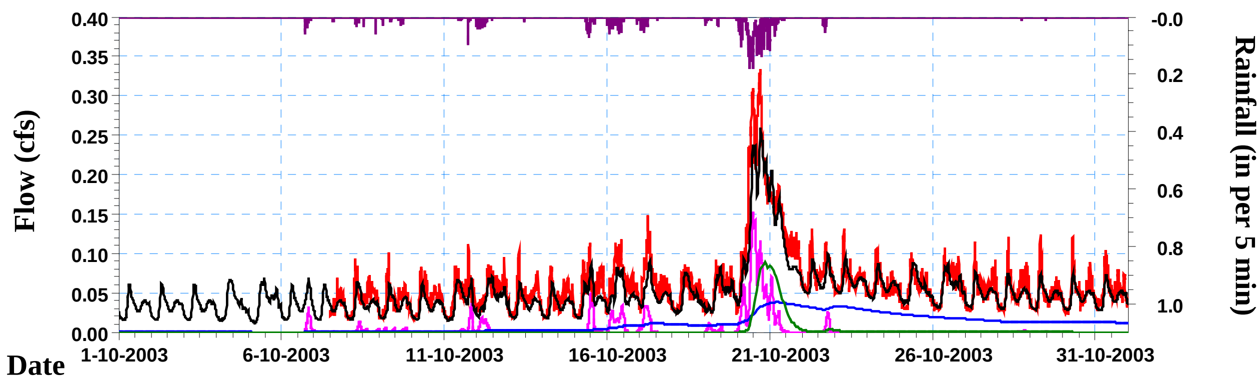
Date Format (dd-mm-yyyy)

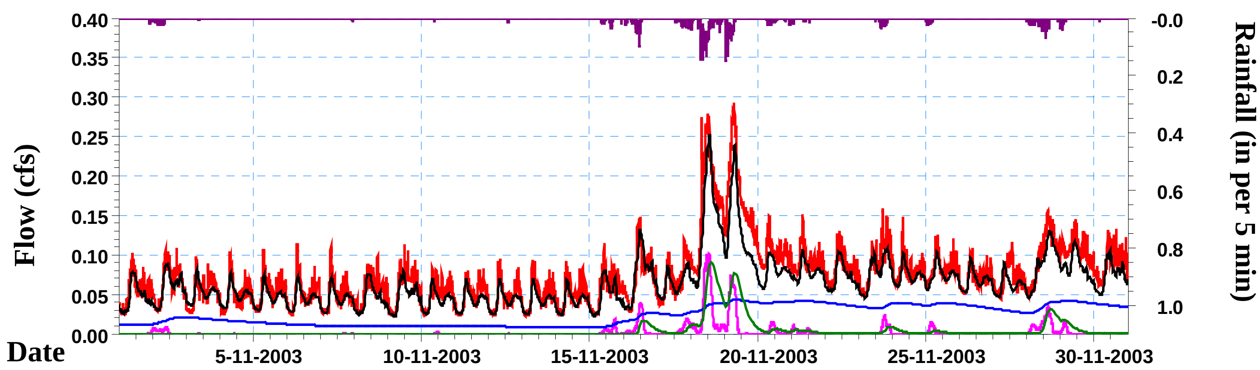
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration


Flow (cfs)
Rainfall (in per 5 min)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.0
0.2
0.4
0.6
0.8
1.0
Date
4-4-2003
9-4-2003
14-4-2003
19-4-2003
24-4-2003
29-4-2003
4-5-2003
9-5-2003
14-5-2003
19-5-2003
24-5-2003
29-5-2003
3-6-2003
8-6-2003
13-6-2003
18-6-2003
23-6-2003
28-6-2003
Legend:
Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration



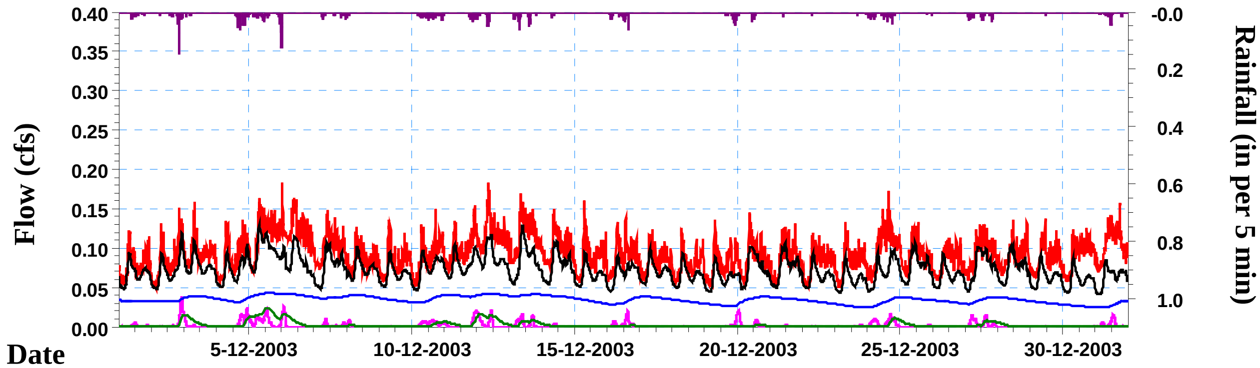
Mercer Island Control Basin (2003-2004 Monitoring Period)

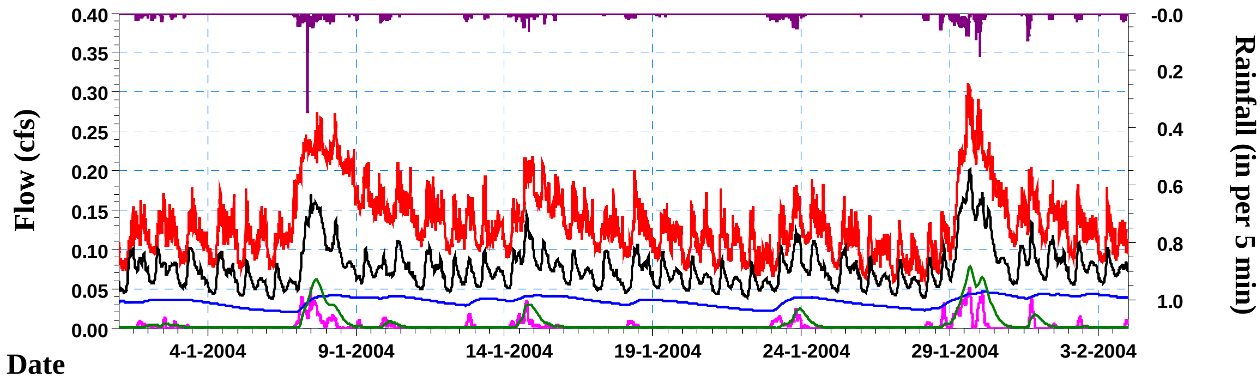




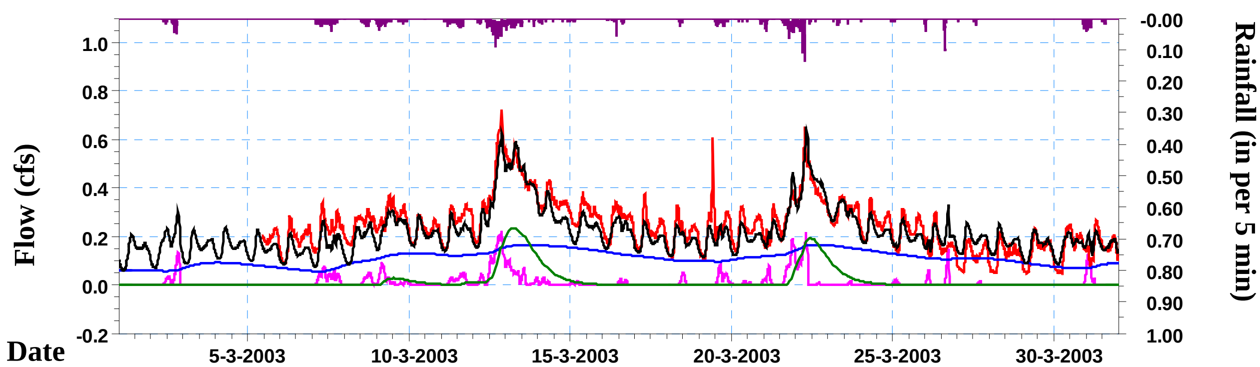
Legend:

Measured Flow — Total Simulated Flow
Measured Rainfall — Fast Response Component
Slow Infiltration
Date Format (dd-mm-yyyy) — Rapid Infiltration



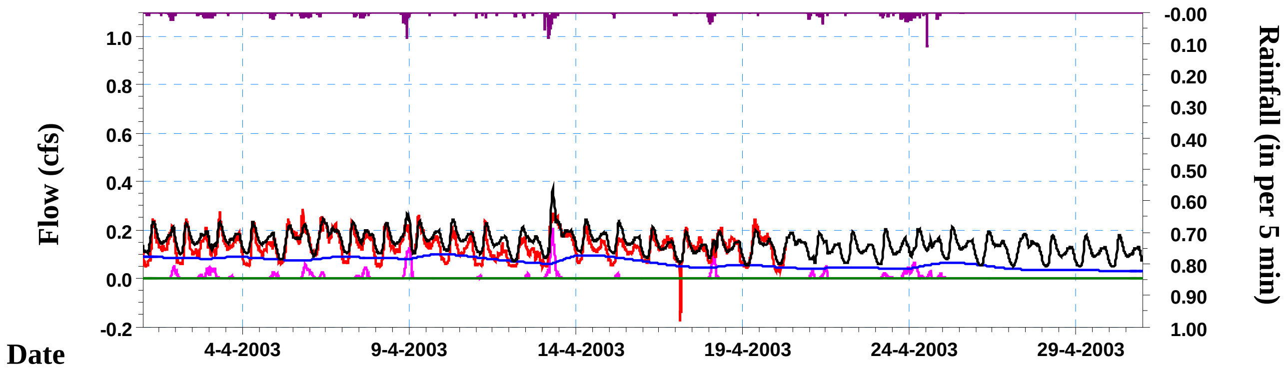


Mercer Island Pilot Basin (2002-2003 Monitoring Period)

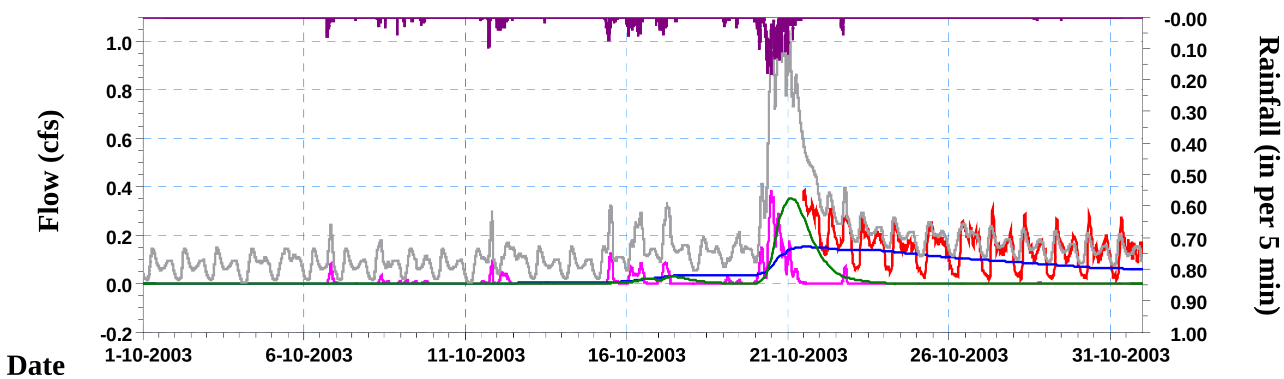


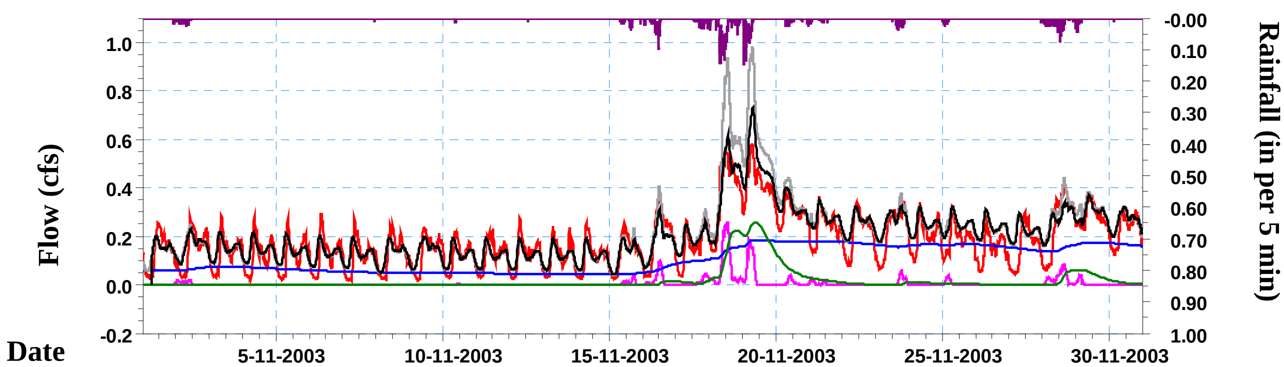
Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration

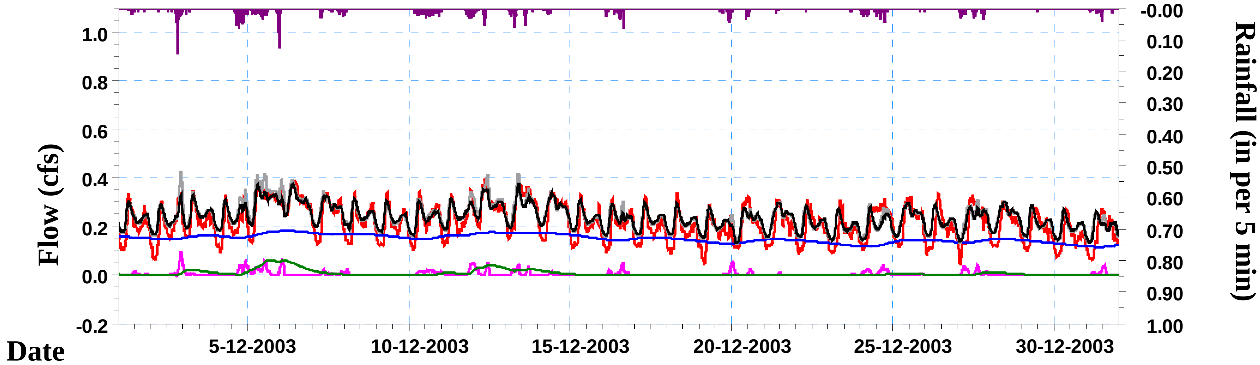


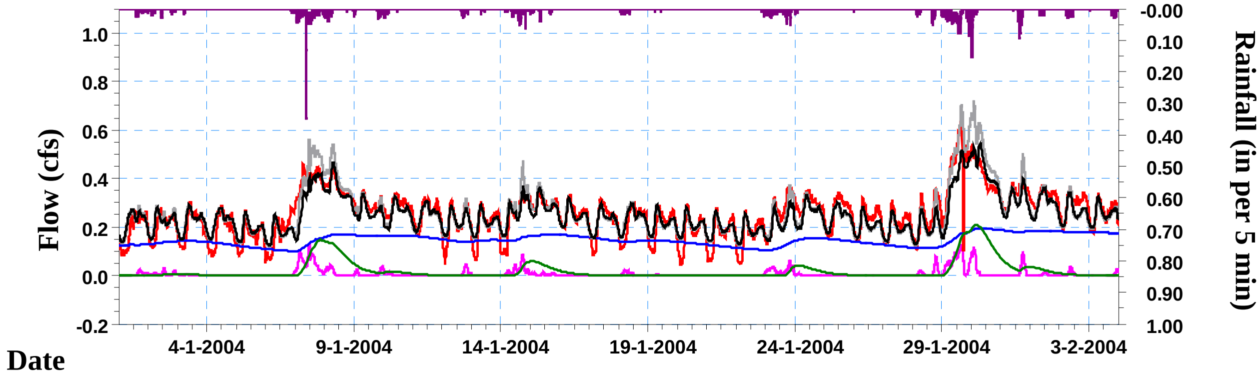
Mercer Island Pilot Basin (2003-2004 Monitoring Period)



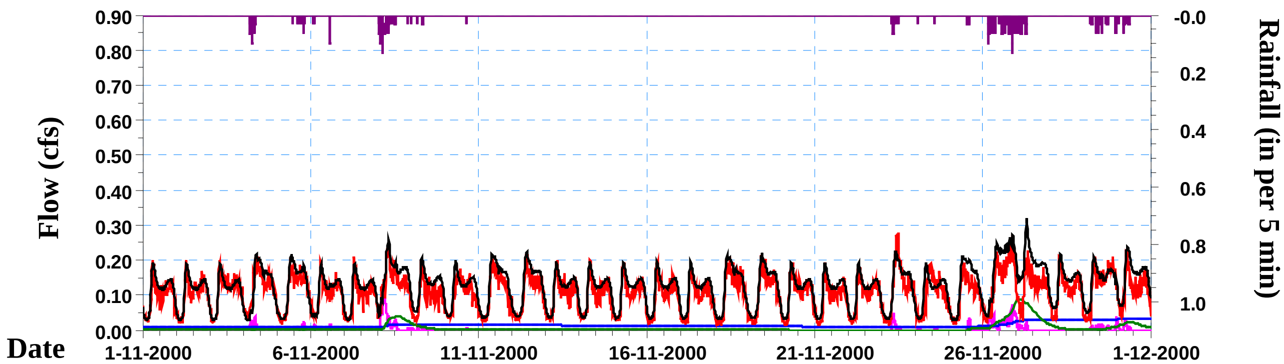


Legend: Measured Flow; Measured Rainfall; Total Simulated Flow; Fast Response Component; Slow Infiltration; Rapid Infiltration; Date Format (dd-mm-yyyy); Pre-rehabilitation Simulated Flow





Northshore Control Basin (2000-2001 Monitoring Period)



Legend: Measured Flow

Measured Rainfall

Total Simulated Flow

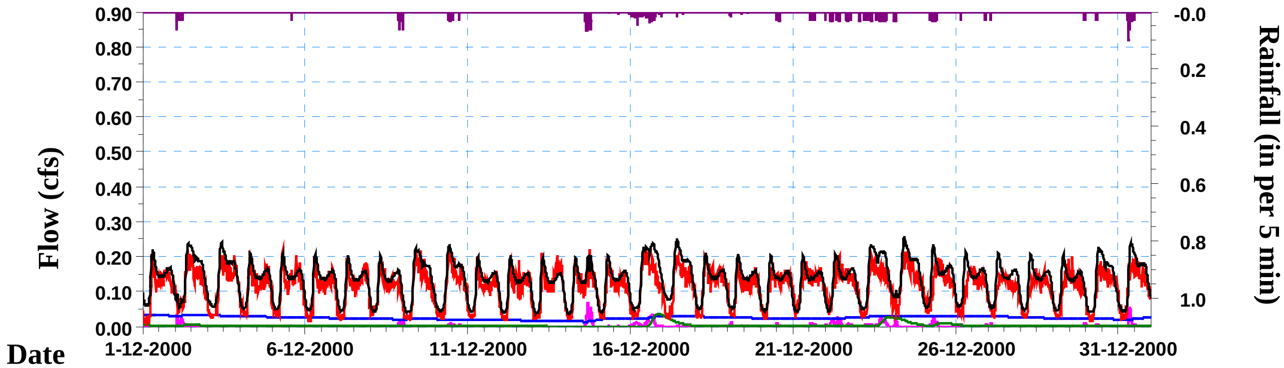
Fast Response Component

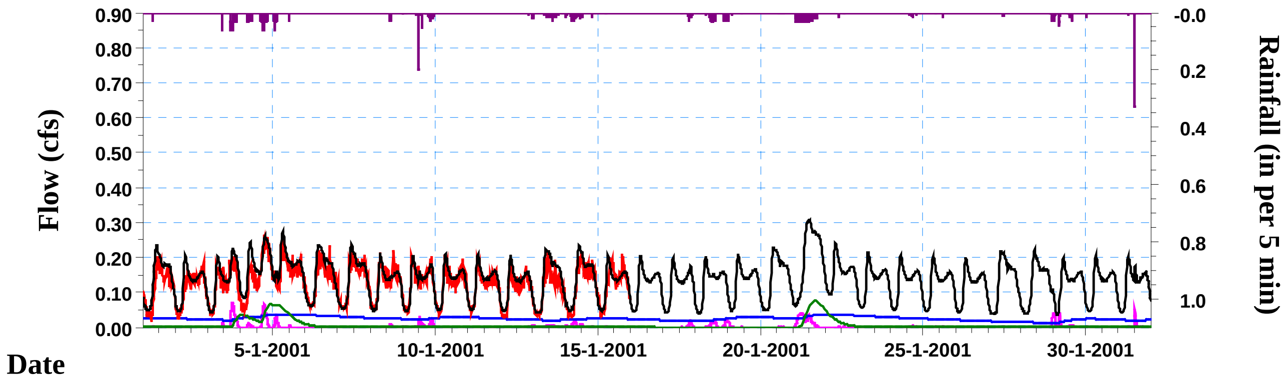
Slow Infiltration

Rapid Infiltration

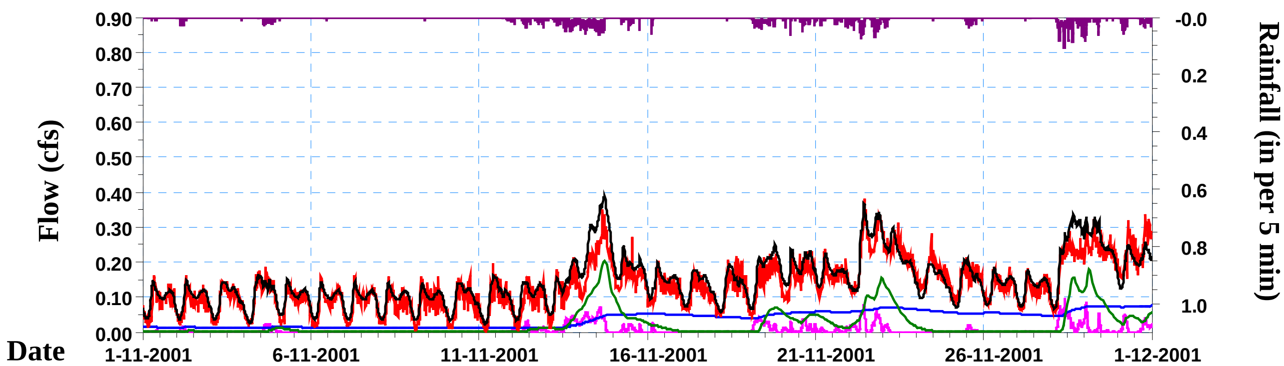
Date Format (dd-mm-yyyy)

Pre-rehabilitation Simulated Flow



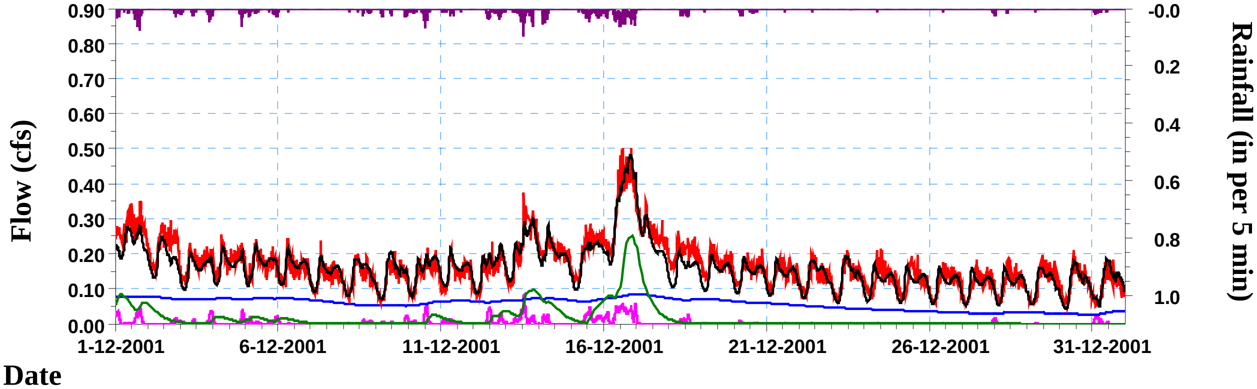


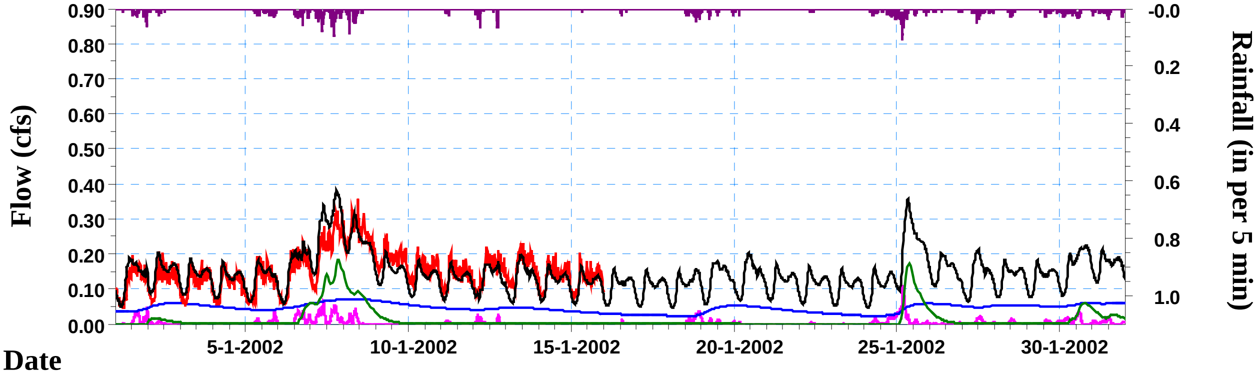
Northshore Control Basin (2001-2002 Monitoring Period)



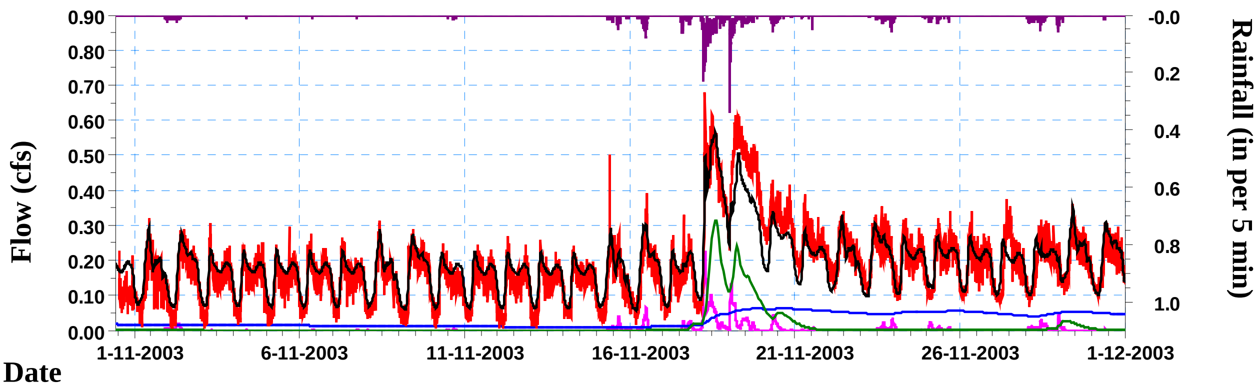
Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration





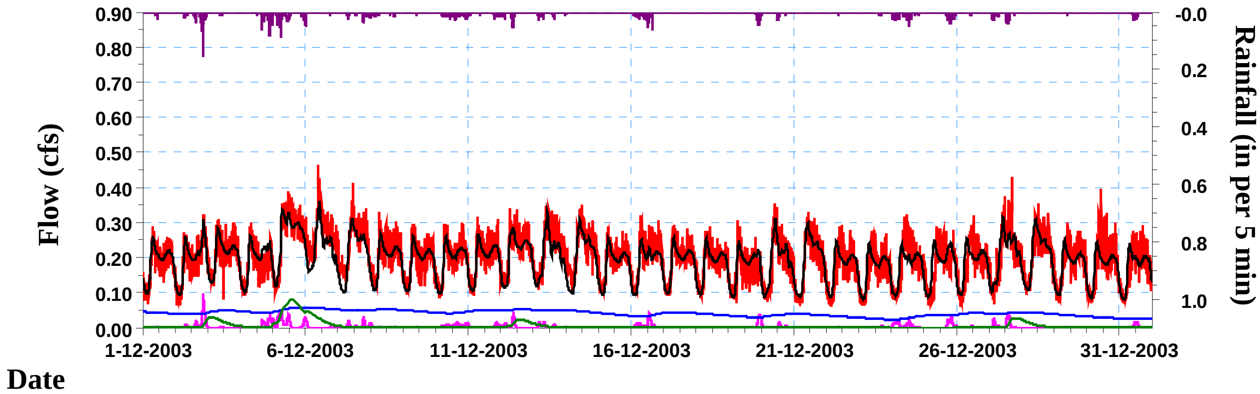
Northshore Control Basin (2003-2004 Monitoring Period)

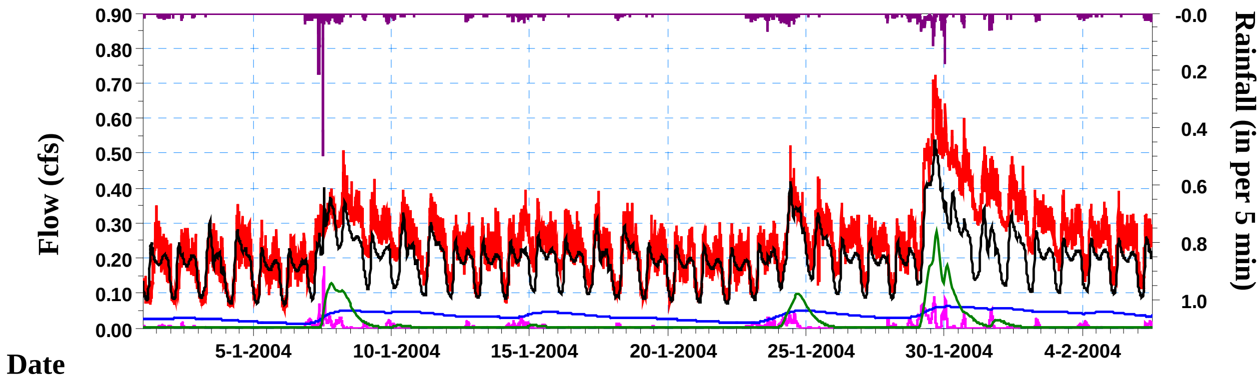


Legend:

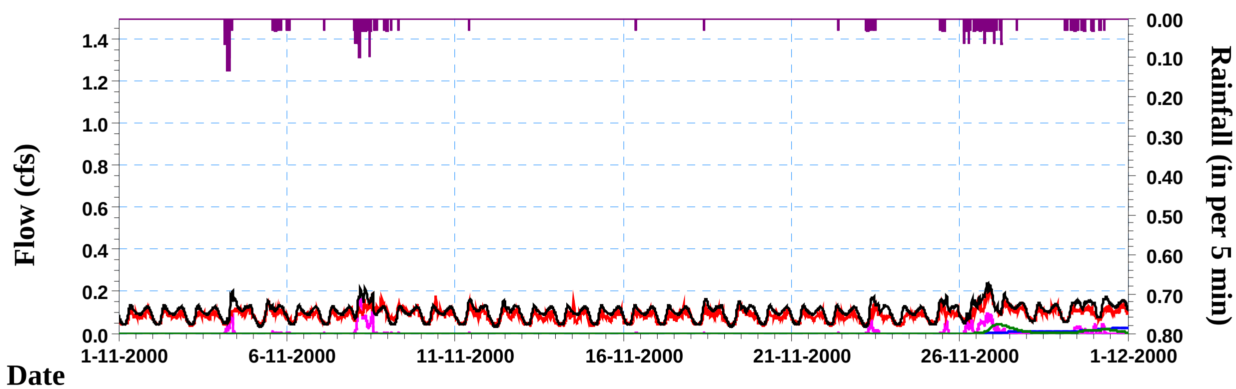
Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)

Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration

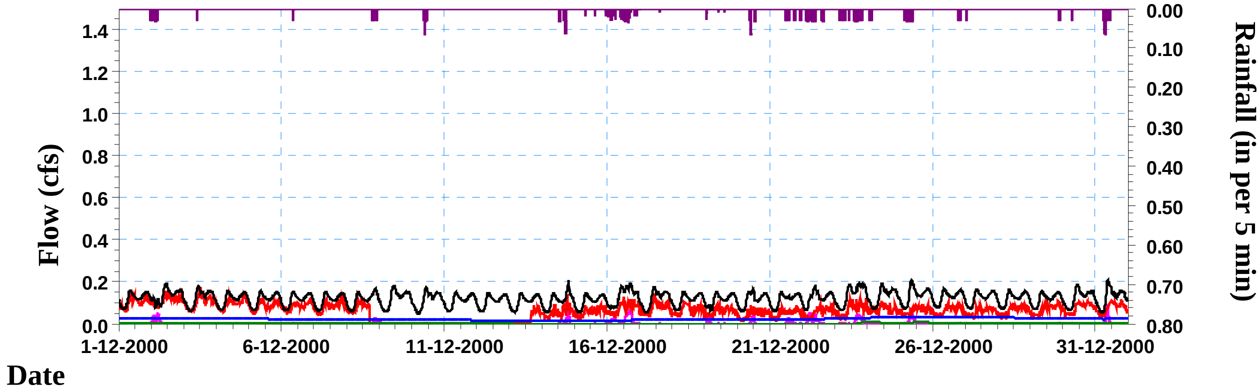


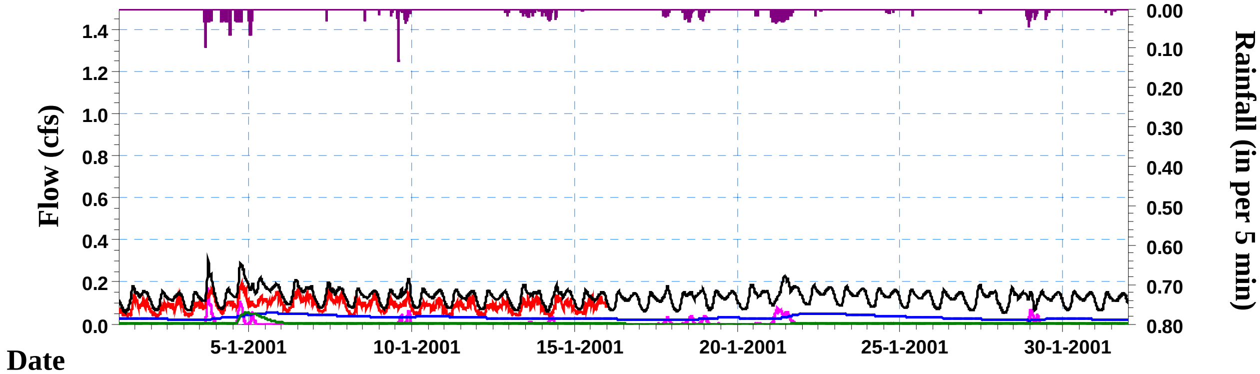


Northshore Pilot Basin (2000-2001 Monitoring Period)

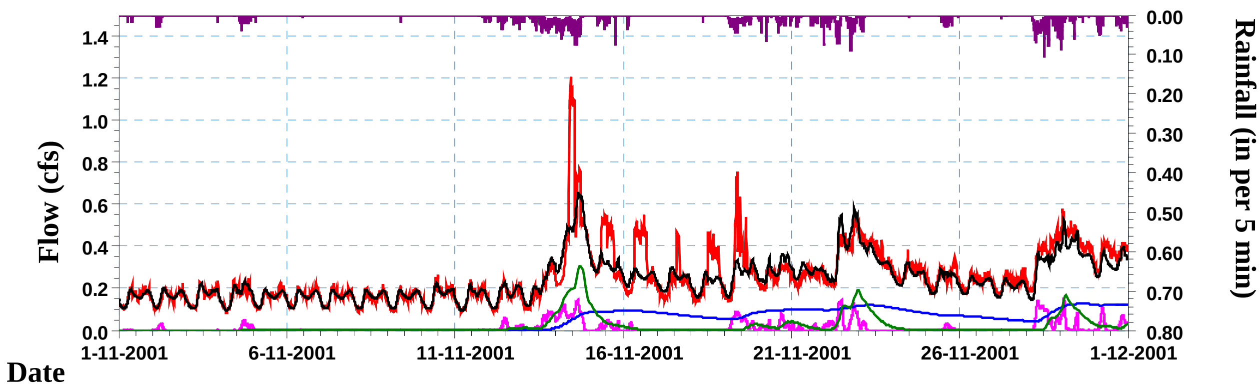


Legend: Measured Flow — Measured Rainfall — Total Simulated Flow — Fast Response Component — Slow Infiltration — Rapid Infiltration — Date Format (dd-mm-yyyy)



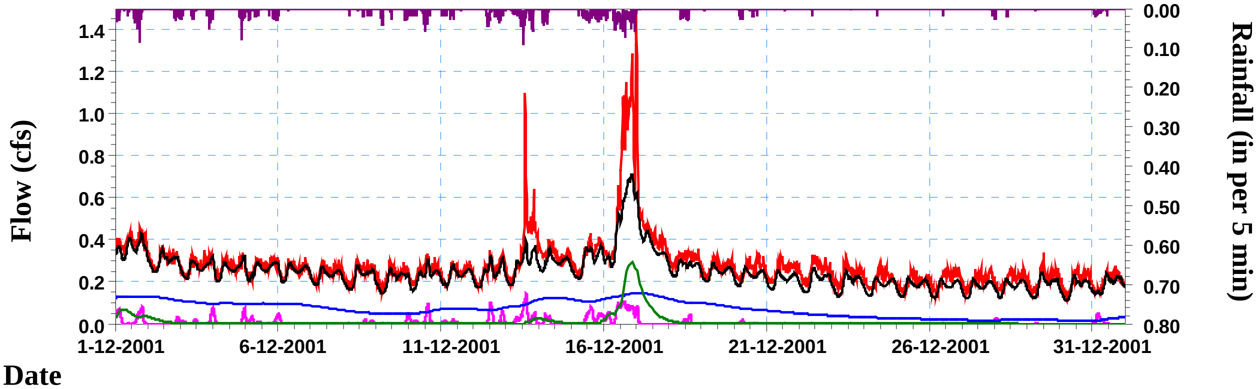


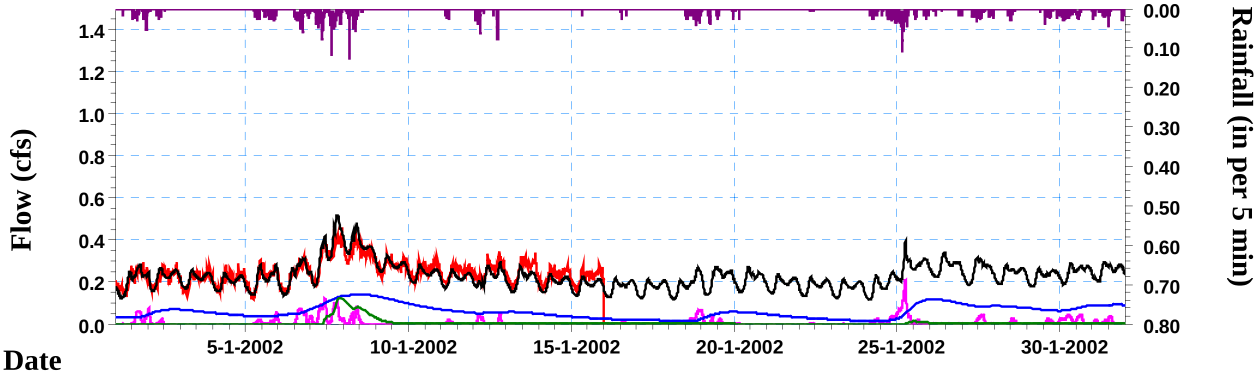
Northshore Pilot Basin (2001-2002 Monitoring Period)



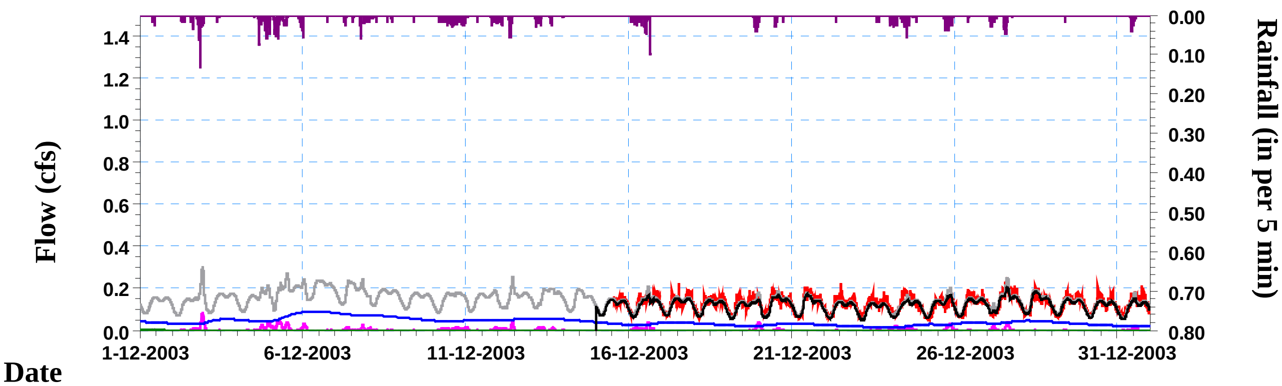
Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration



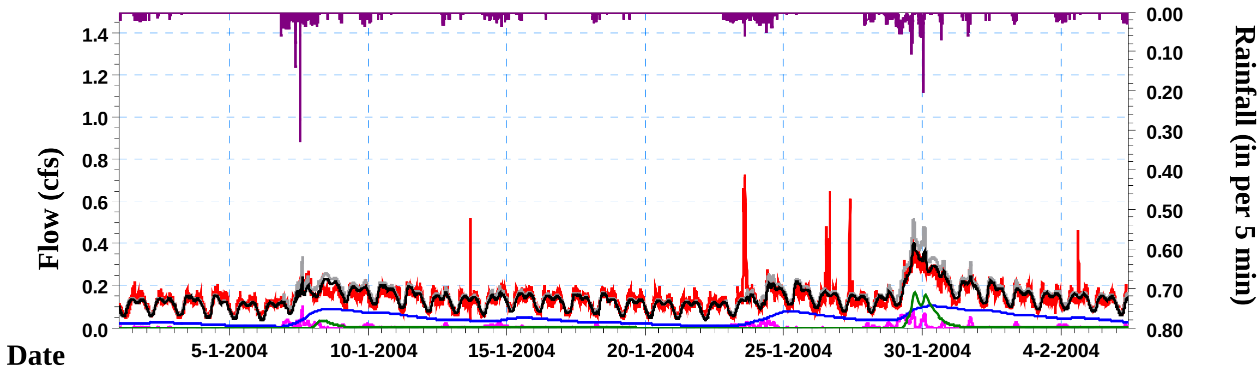


Northshore Pilot Basin (2003-2004 Monitoring Period)

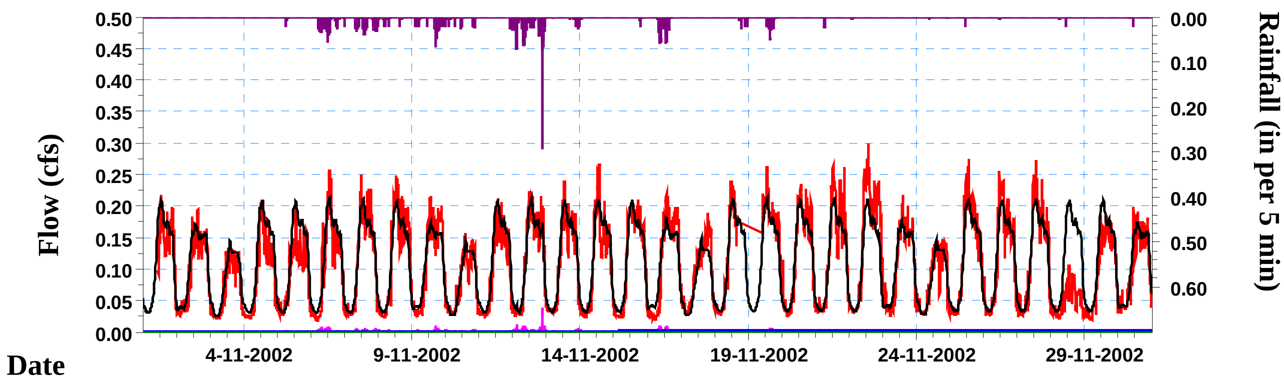


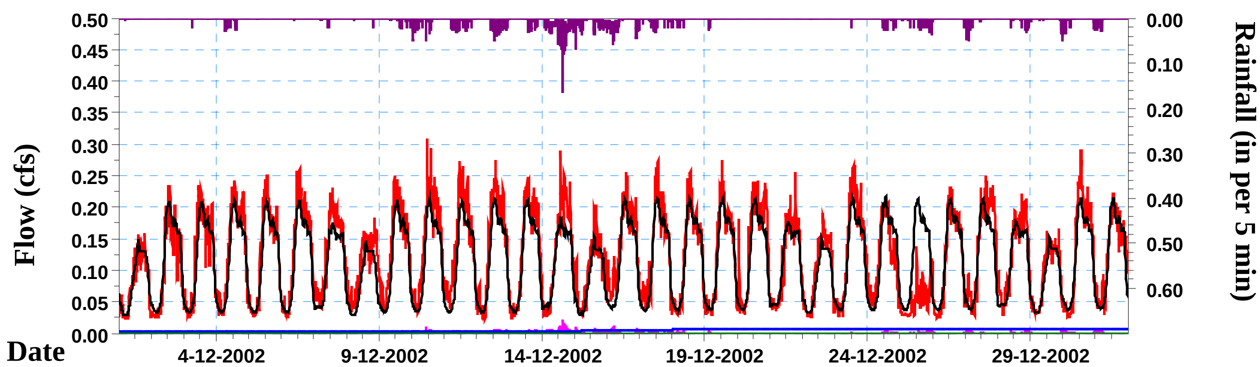
Legend:

Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)
Pre-rehabilitation Simulated Flow
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration



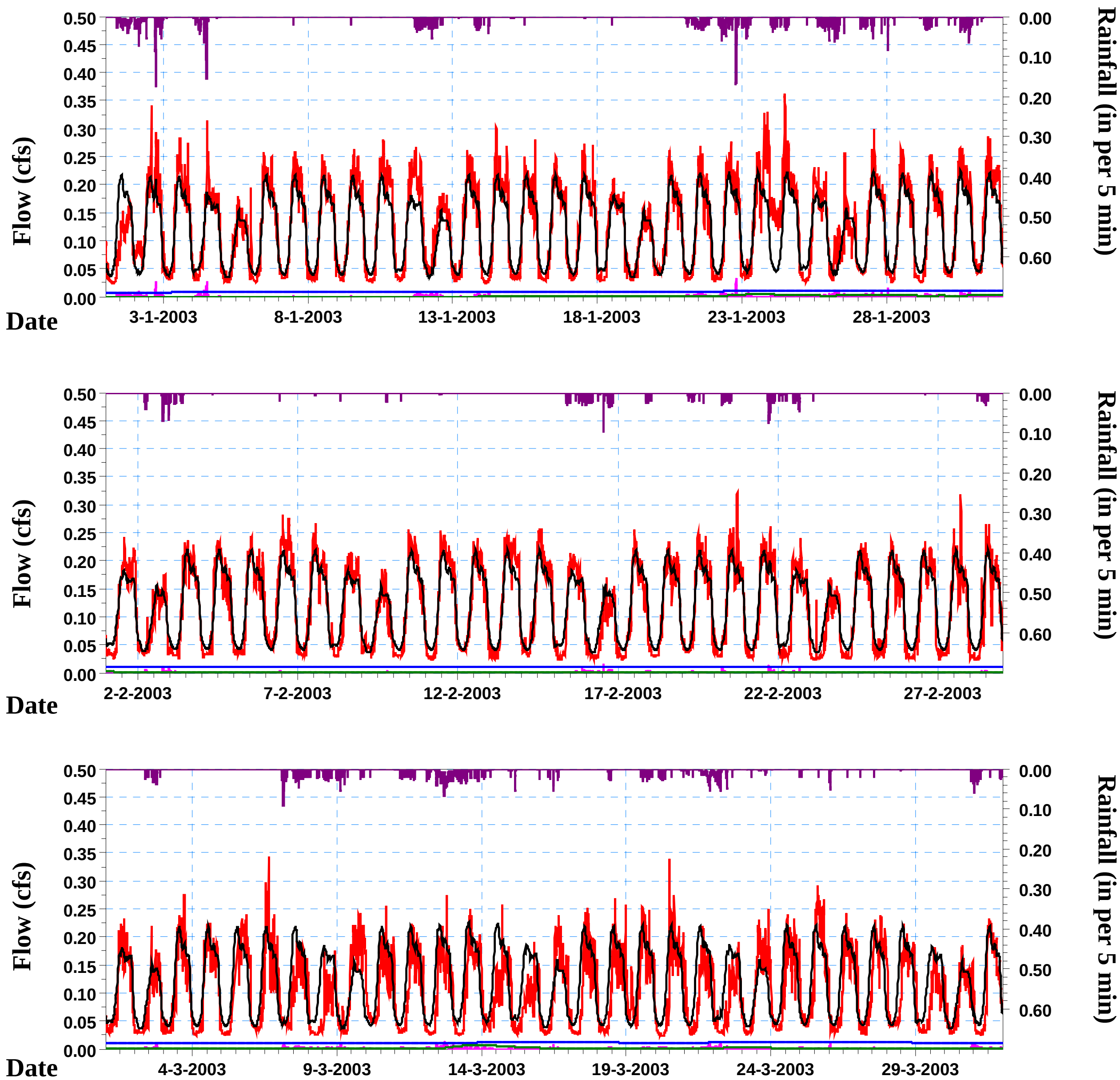
Redmond Control Basin (2002-2003 Monitoring Period)





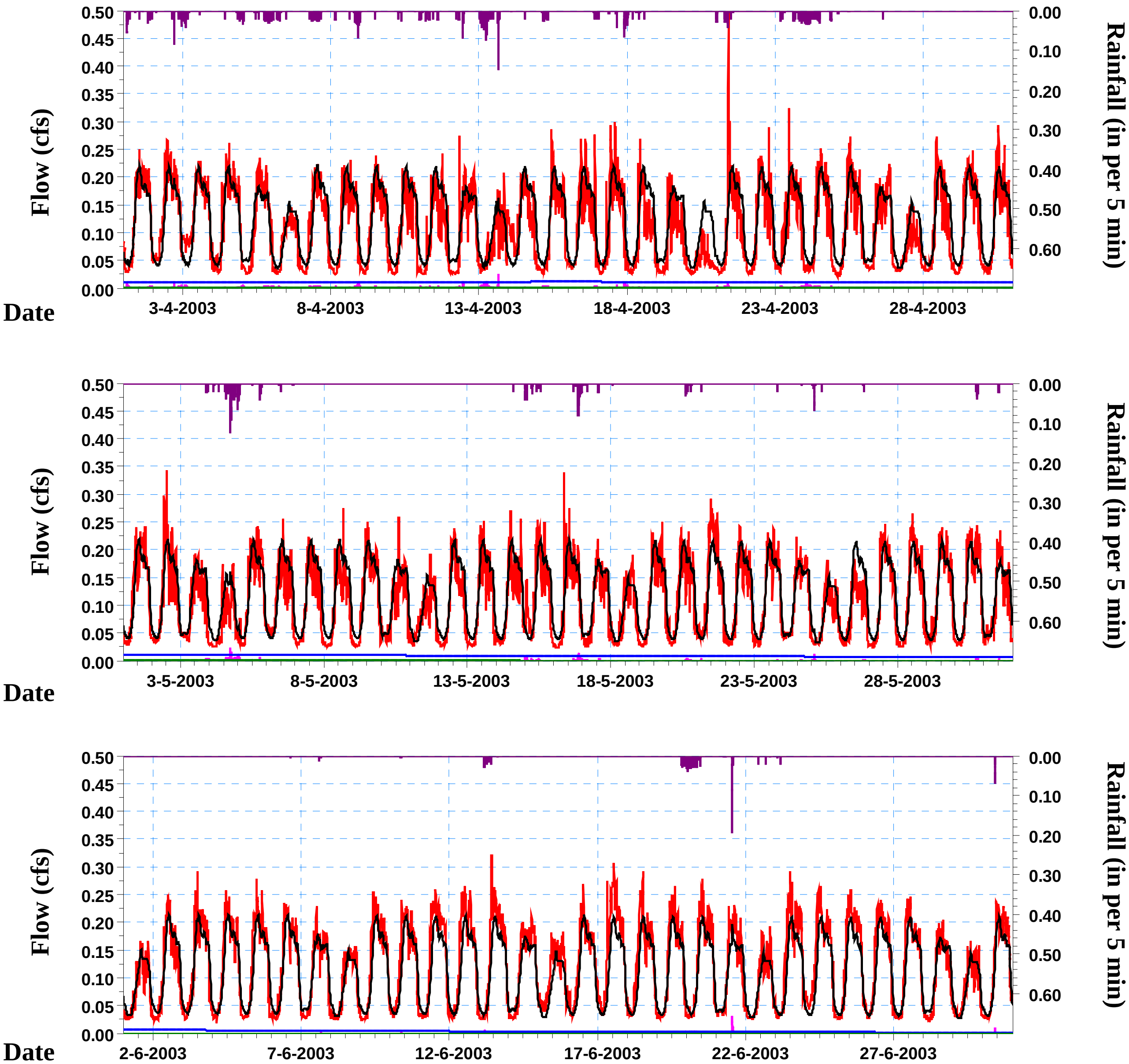
Legend:

Measured Flow
Measured Rainfall
Total Simulated Flow
Fast Response Component
Slow Infiltration
Date Format (dd-mm-yyyy)
Rapid Infiltration
Pre-rehabilitation Simulated Flow



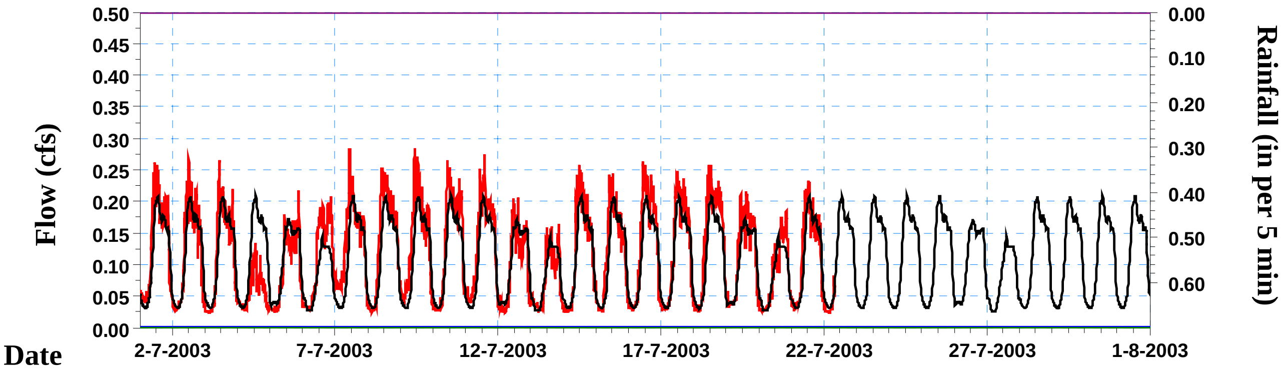
Legend: Measured Flow — Measured Rainfall — Total Simulated Flow — Fast Response Component — Slow Infiltration — Rapid Infiltration

Date Format (dd-mm-yyyy)

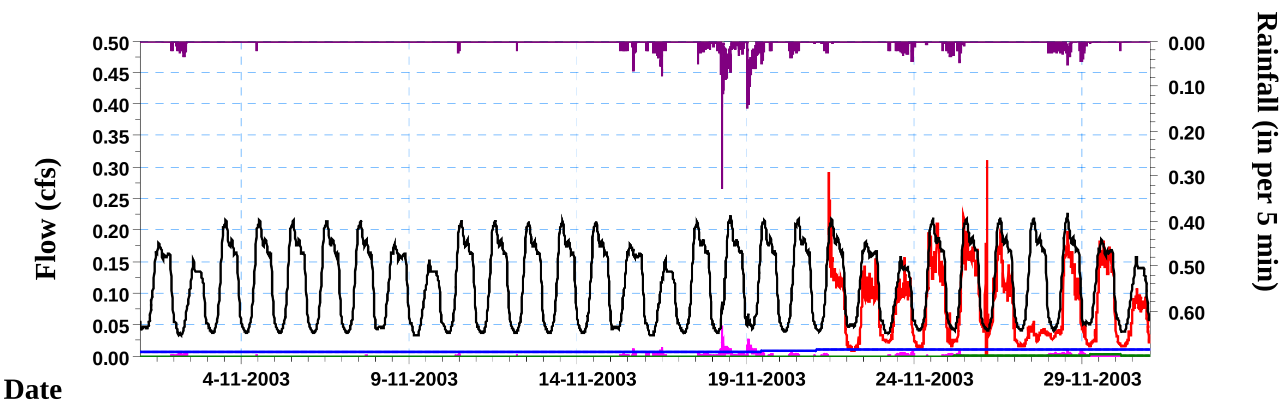


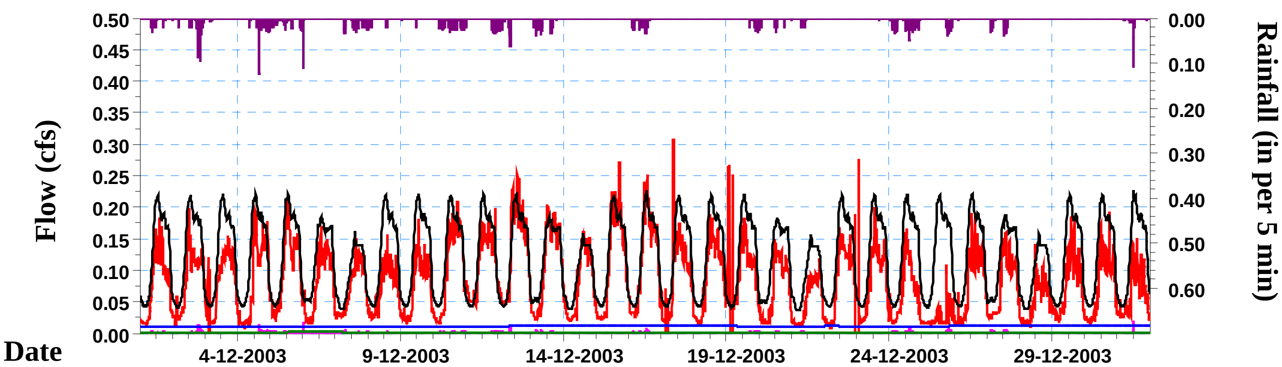
Legend: Measured Flow — Measured Rainfall — Total Simulated Flow — Fast Response Component — Slow Infiltration — Rapid Infiltration

Date Format (dd-mm-yyyy)



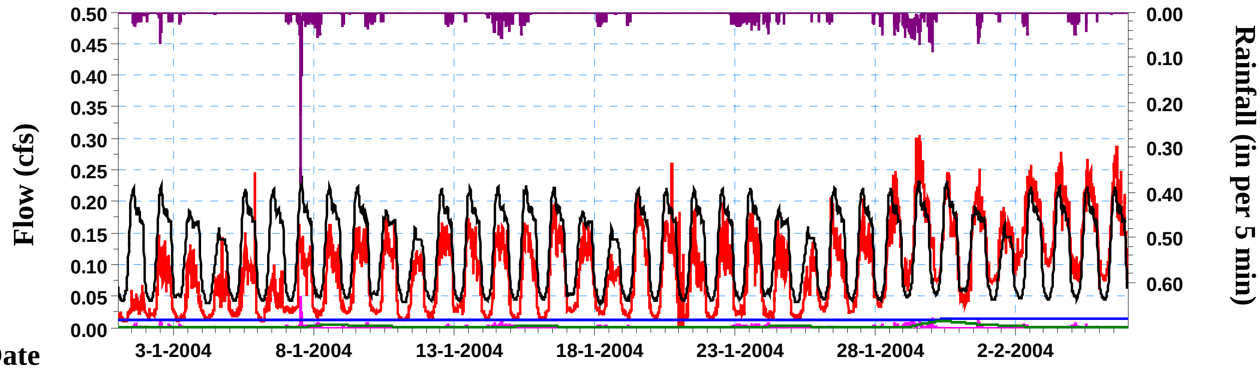
Redmond Control Basin (2003-2004 Monitoring Period)



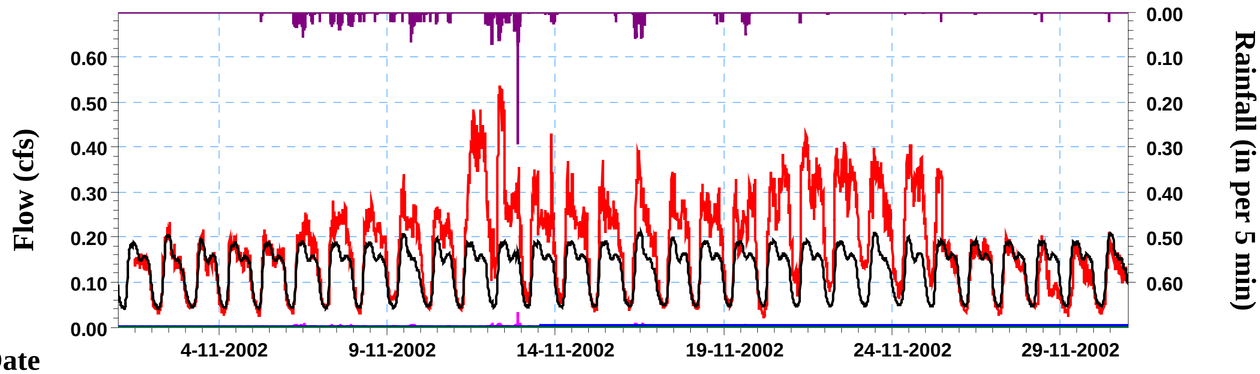


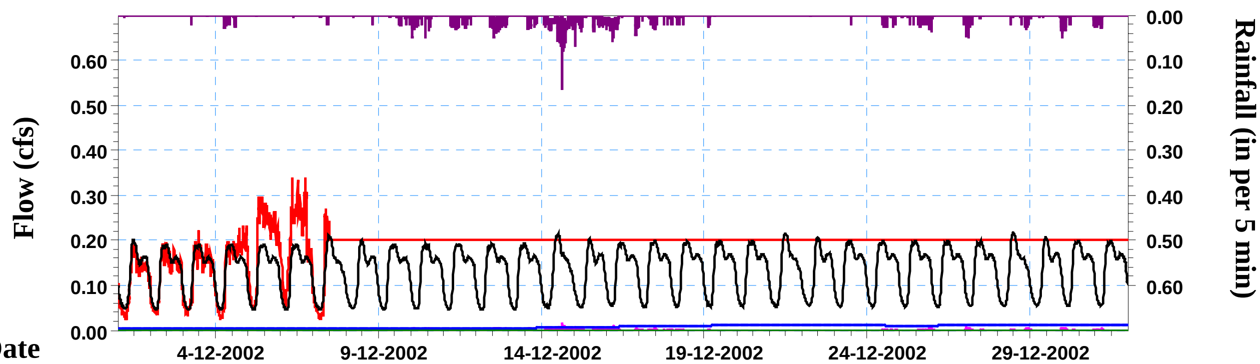
Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration



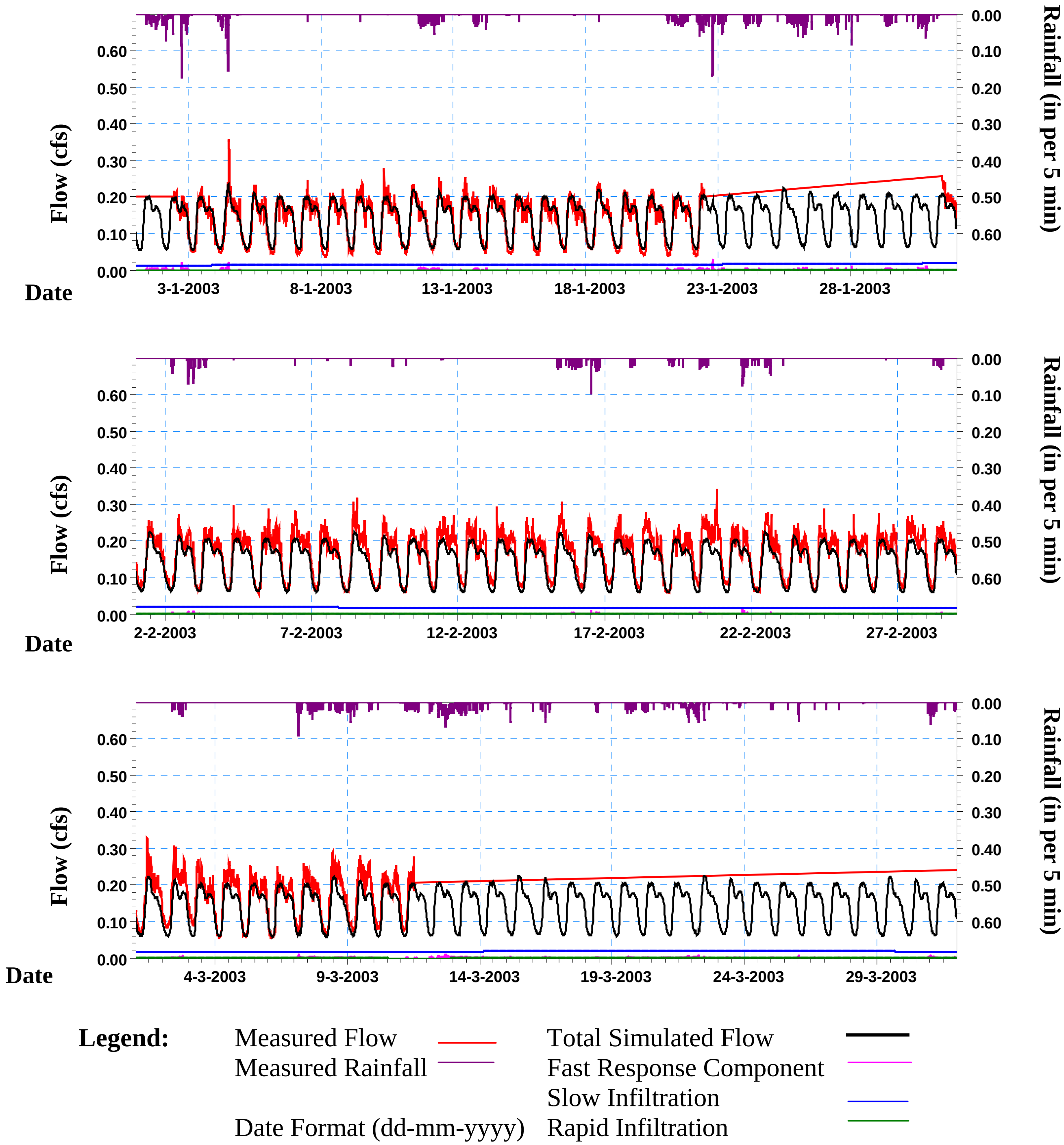
Redmond Pilot A Basin (2002-2003 Monitoring Period)



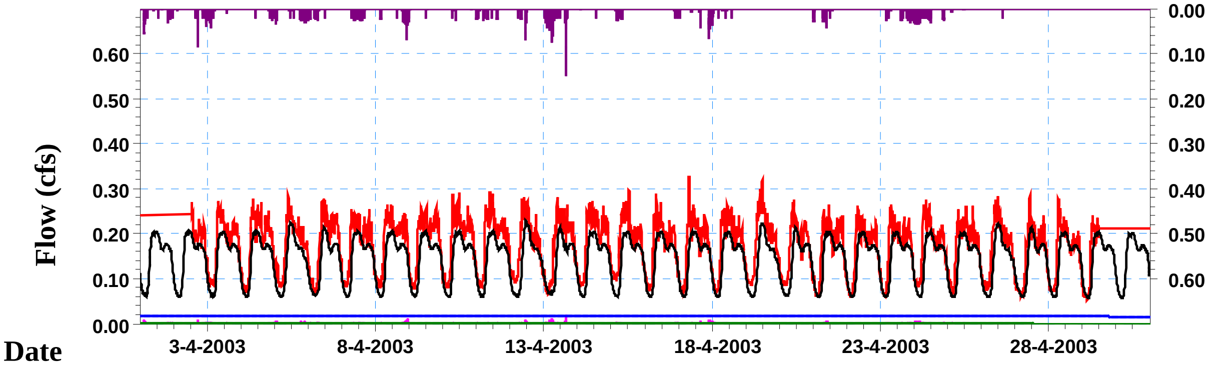


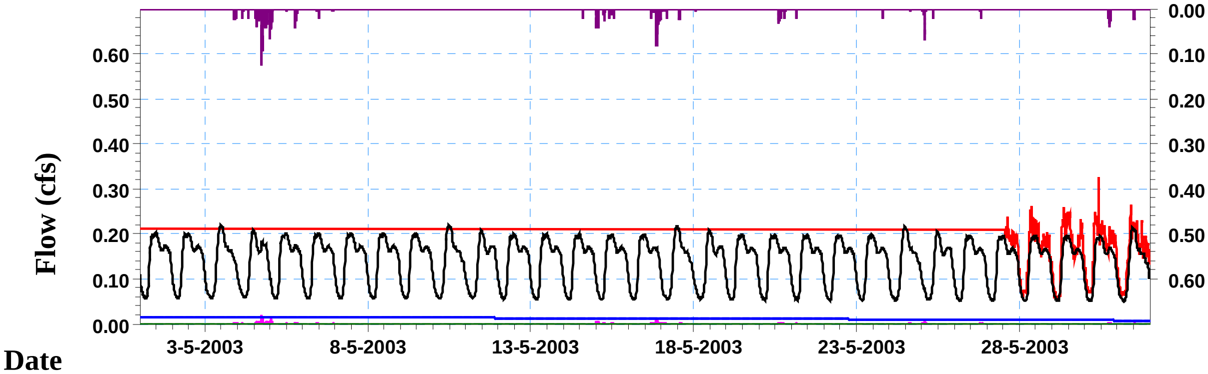
Legend:

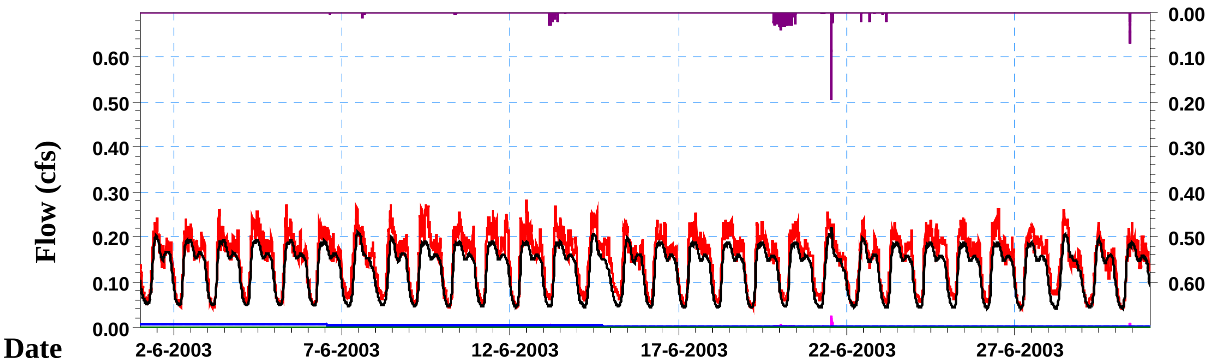
Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration



Flow (cfs)
Rainfall (in per 5 min)
Date
3-1-2003
8-1-2003
13-1-2003
18-1-2003
23-1-2003
28-1-2003
2-2-2003
7-2-2003
12-2-2003
17-2-2003
22-2-2003
27-2-2003
4-3-2003
9-3-2003
14-3-2003
19-3-2003
24-3-2003
29-3-2003
Legend:
Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration



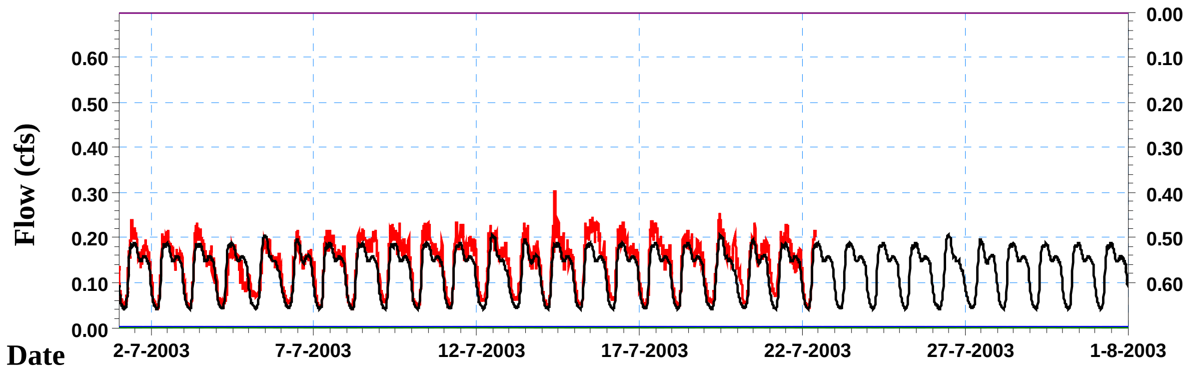




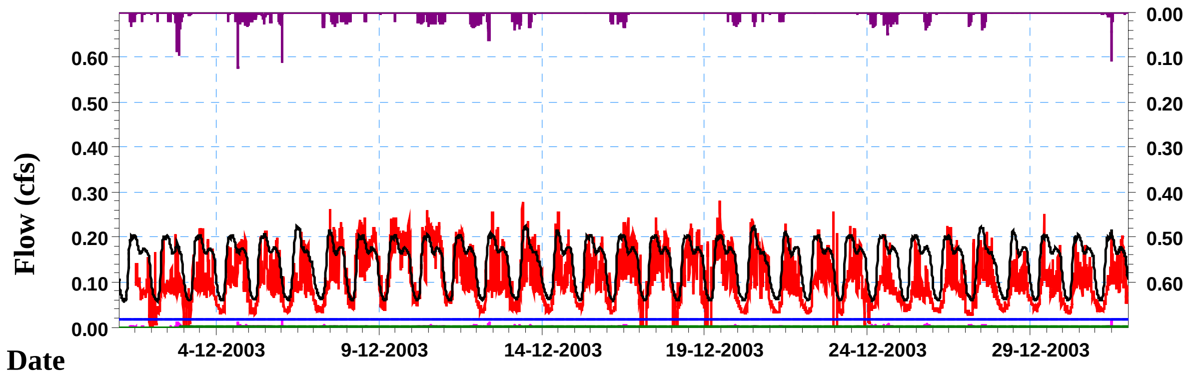
Legend:

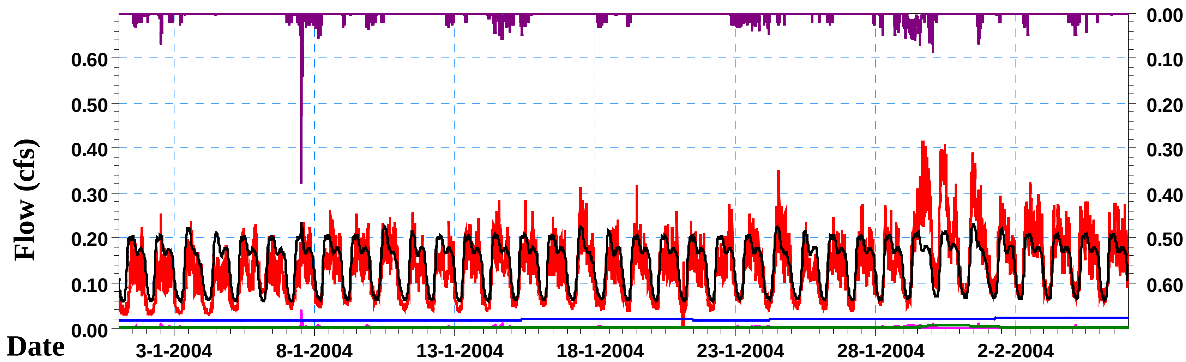
Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)

Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration



Redmond Pilot A Basin (2003-2004 Monitoring Period)

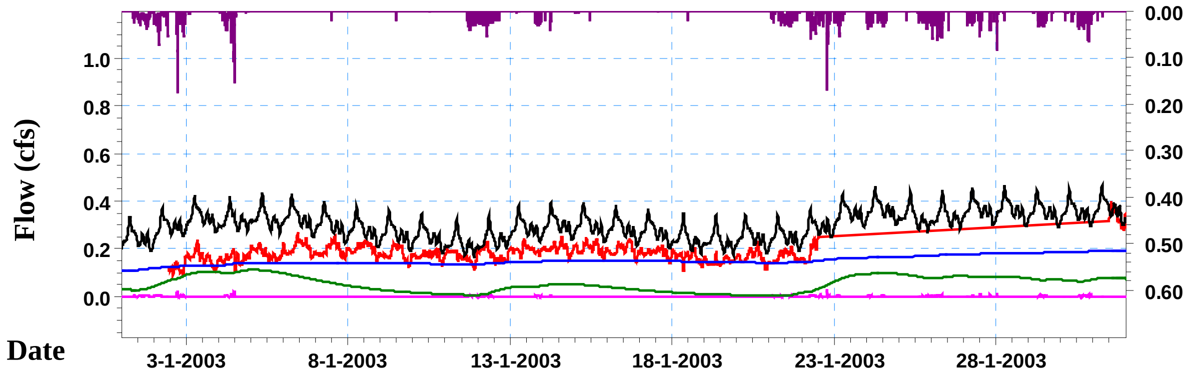


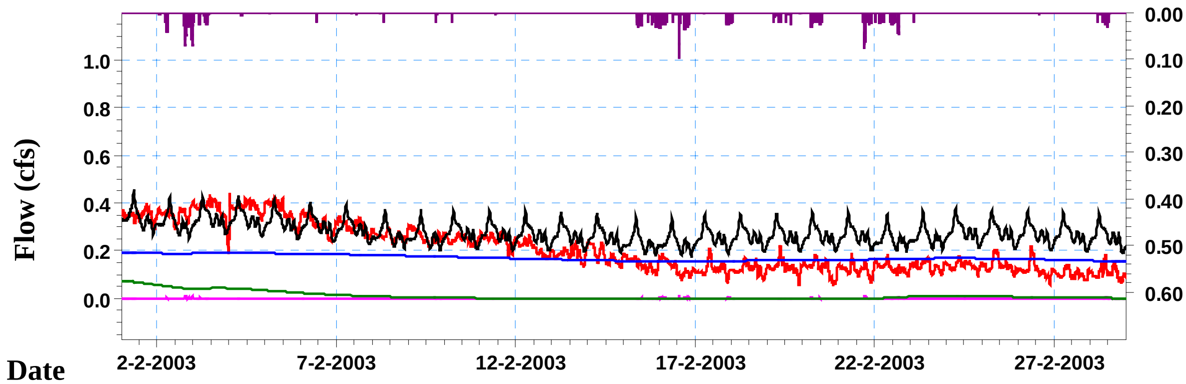


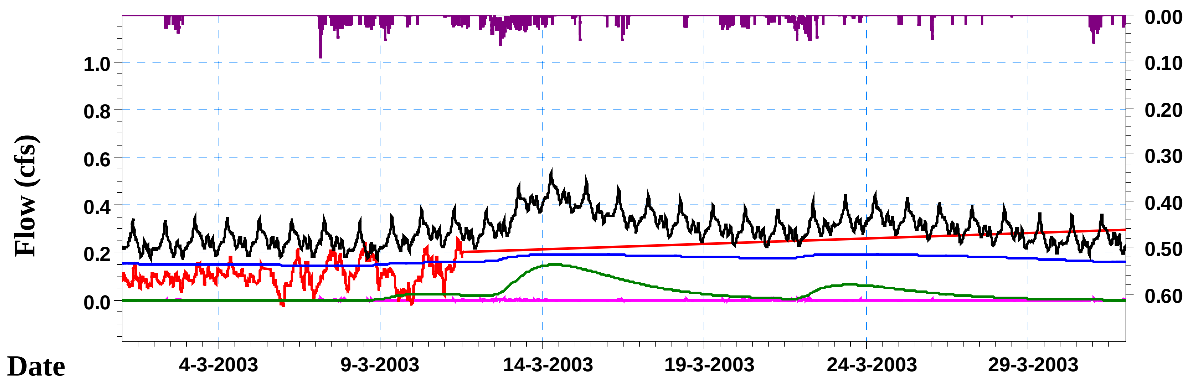
Legend: Measured Flow, Measured Rainfall, Total Simulated Flow, Fast Response Component, Slow Infiltration, Rapid Infiltration

Date Format (dd-mm-yyyy)

Redmond Pilot B Basin (2002-2003 Monitoring Period)

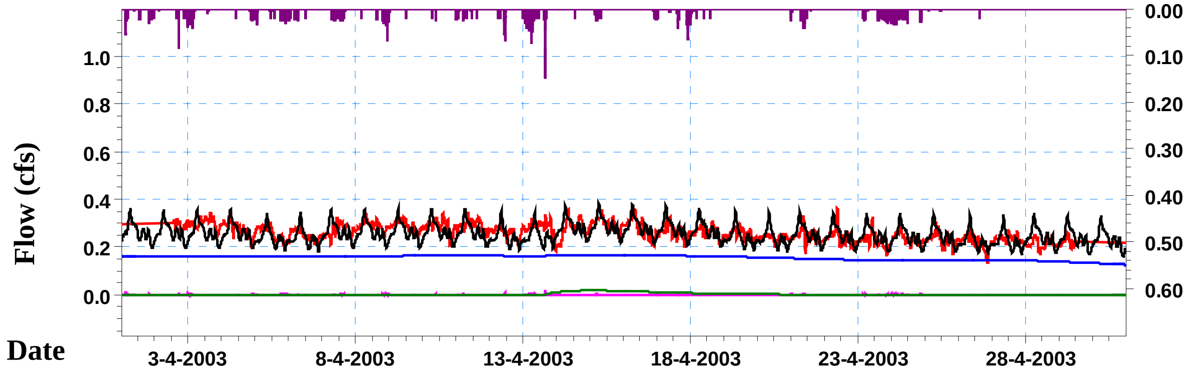


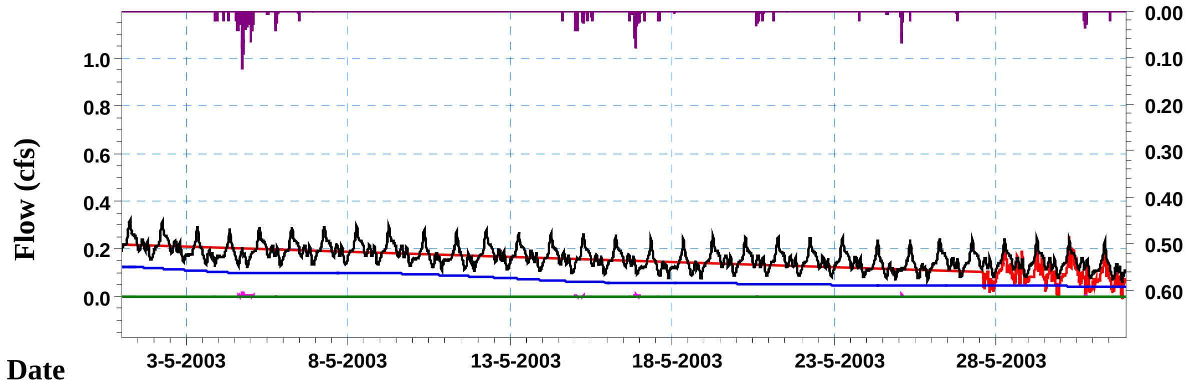




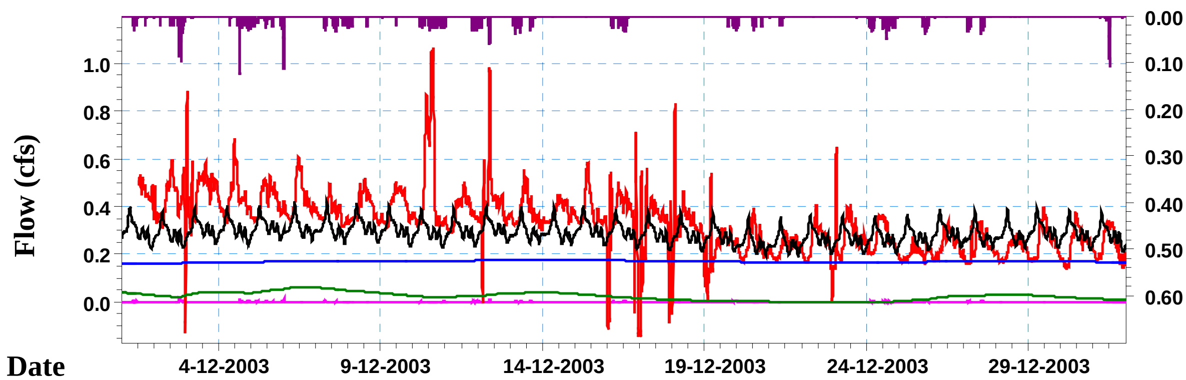
Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration



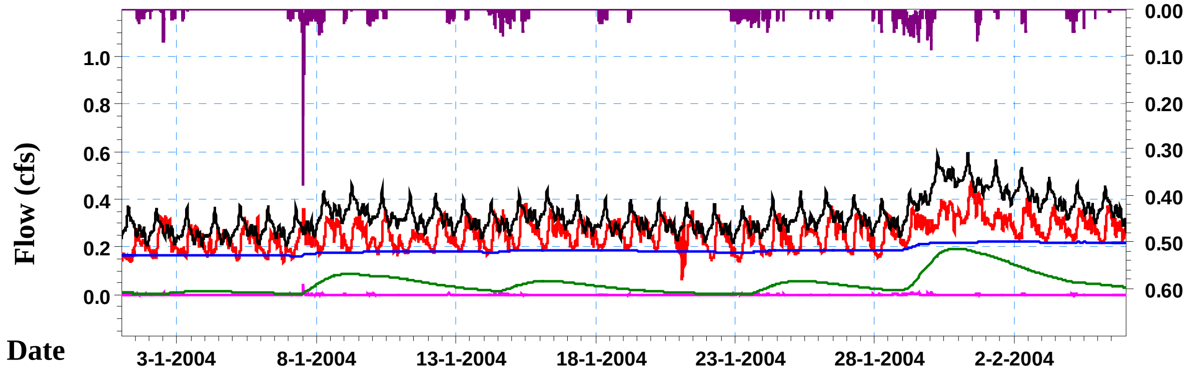


Redmond Pilot B Basin (2003-2004 Monitoring Period)

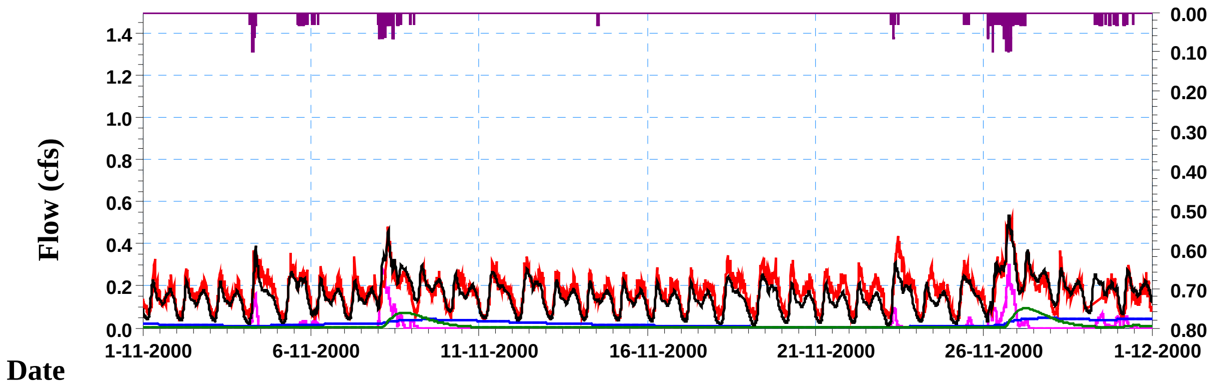


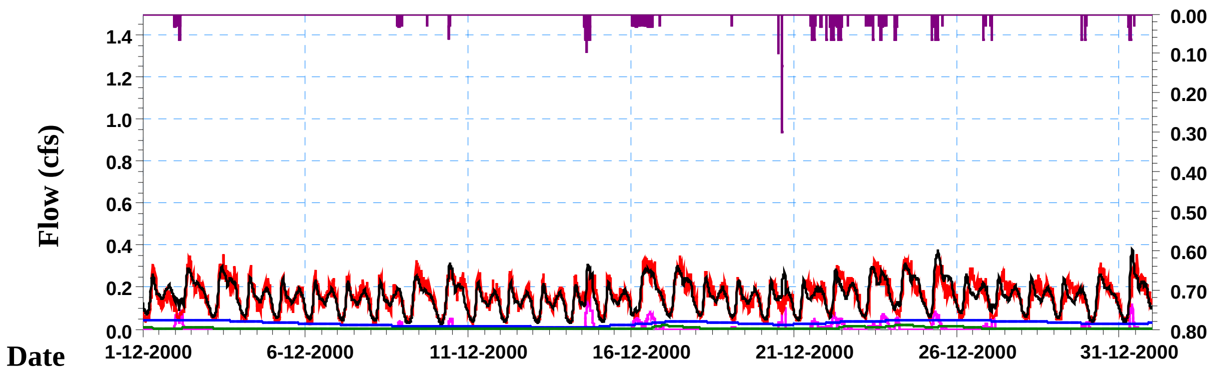
Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration

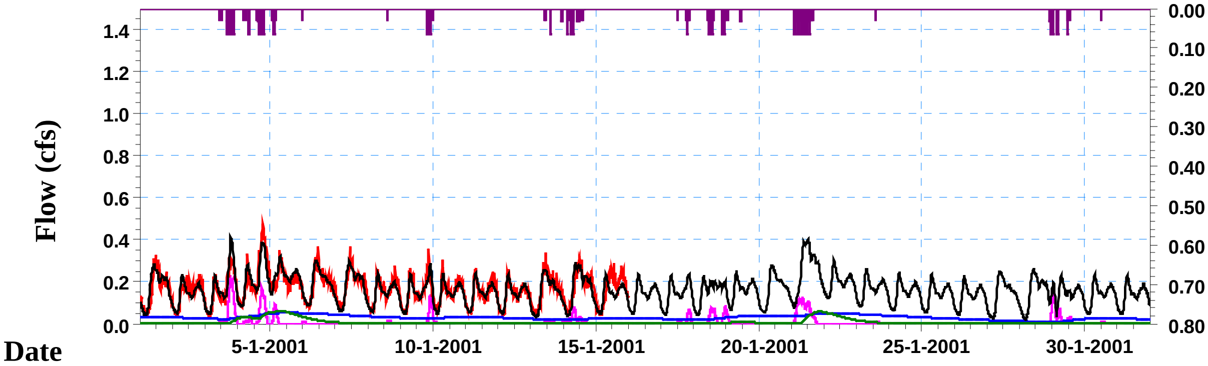


Ronald Control Basin (2000-2001 Monitoring Period)

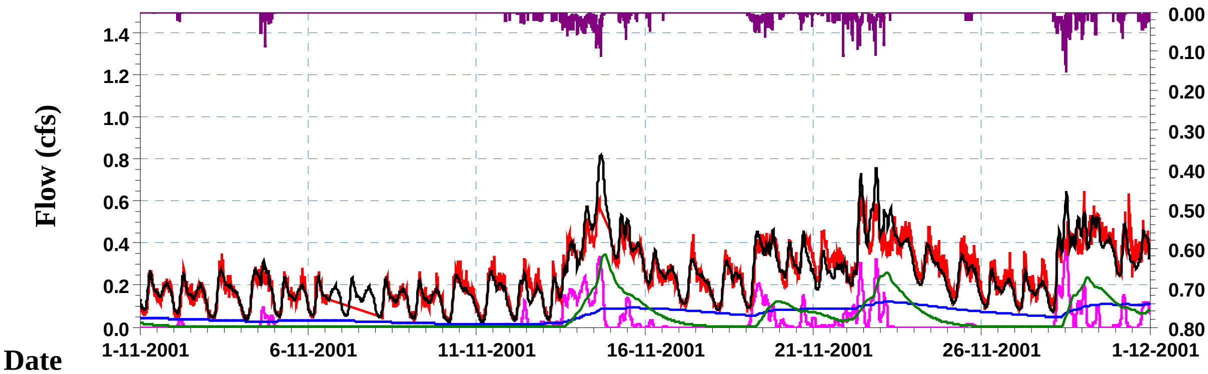


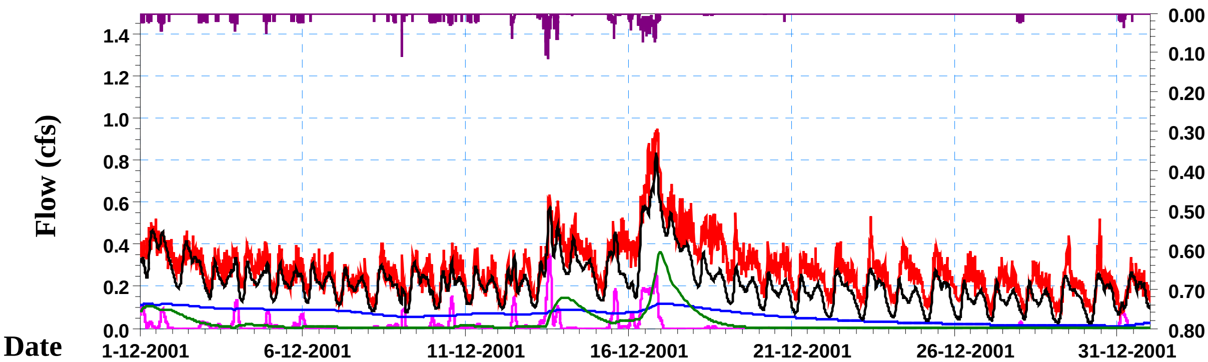


Legend: Measured Flow; Measured Rainfall; Date Format (dd-mm-yyyy); Total Simulated Flow; Fast Response Component; Slow Infiltration; Rapid Infiltration



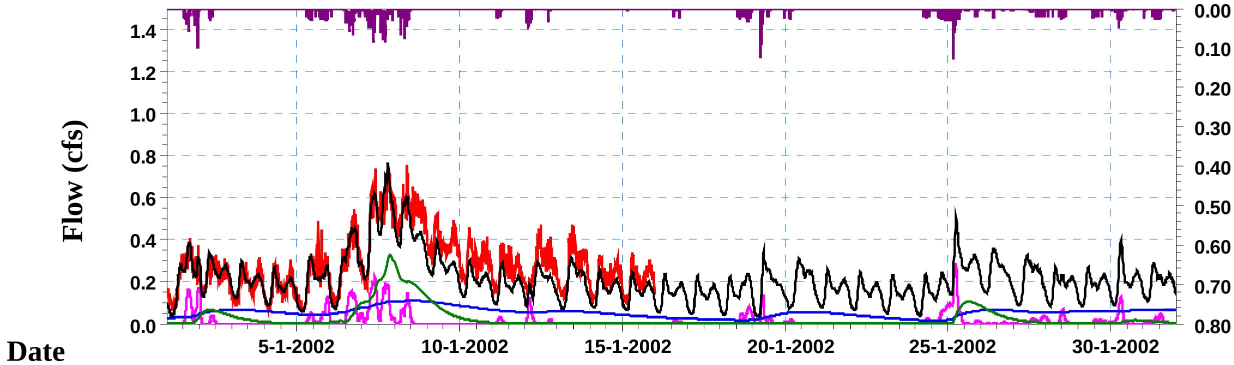
Ronald Control Basin (2001-2002 Monitoring Period)



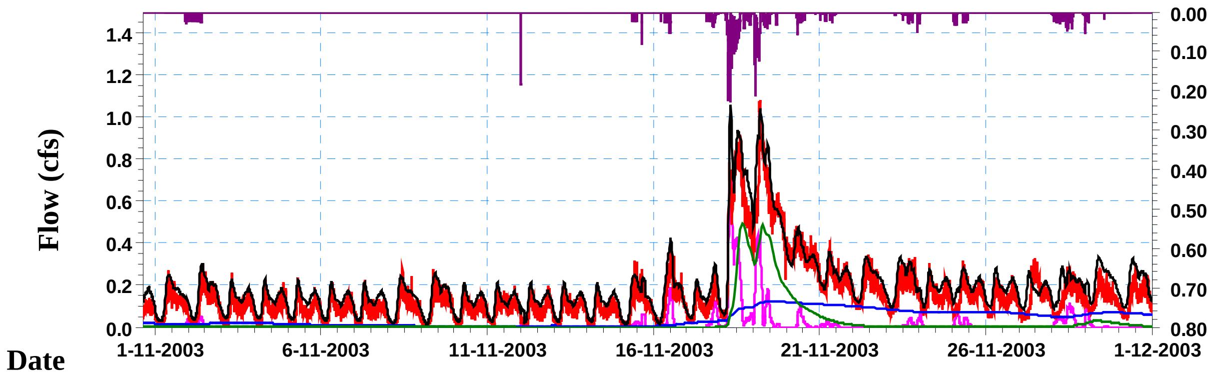


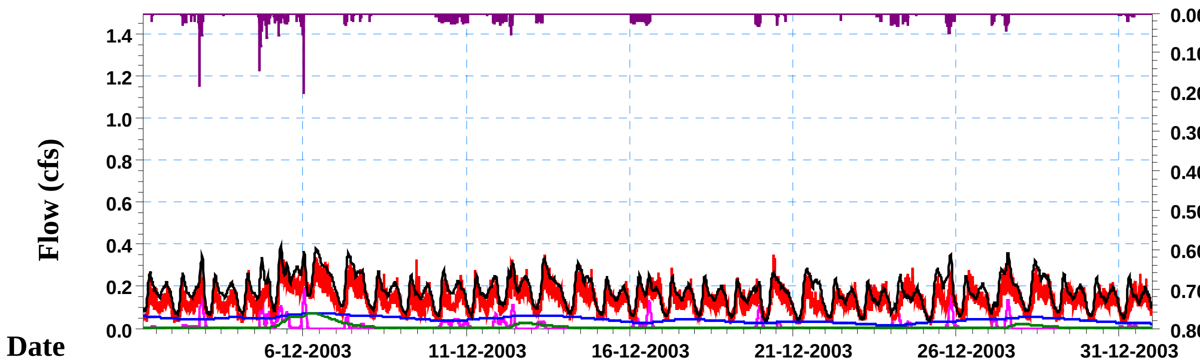
Legend:

Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration



Ronald Control Basin (2003-2004 Monitoring Period)





Legend:

Measured Flow

Measured Rainfall

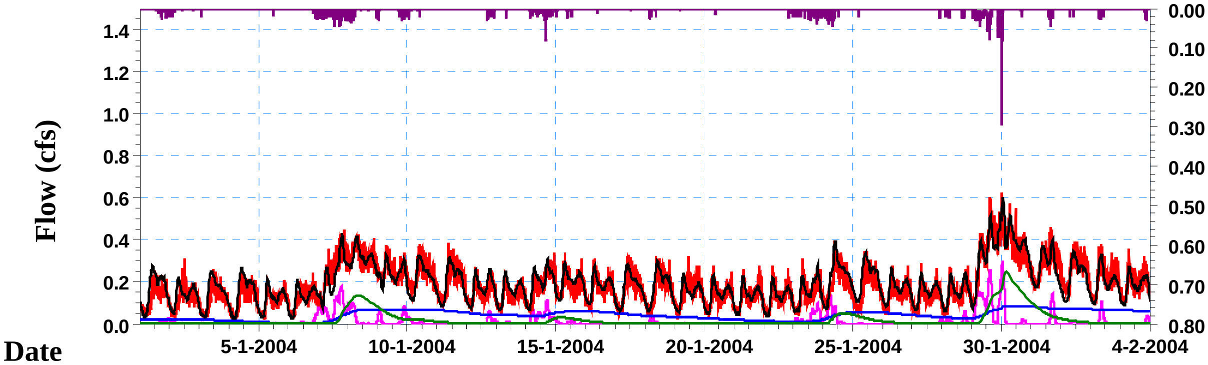
Date Format (dd-mm-yyyy)

Total Simulated Flow

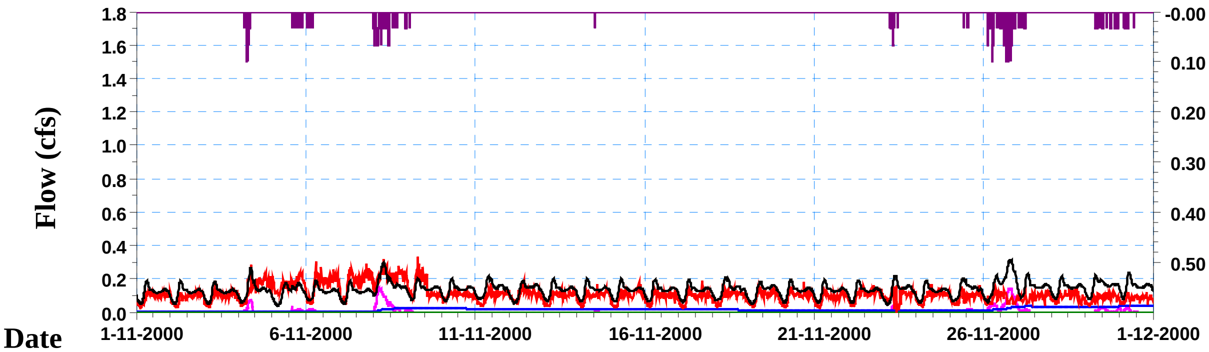
Fast Response Component

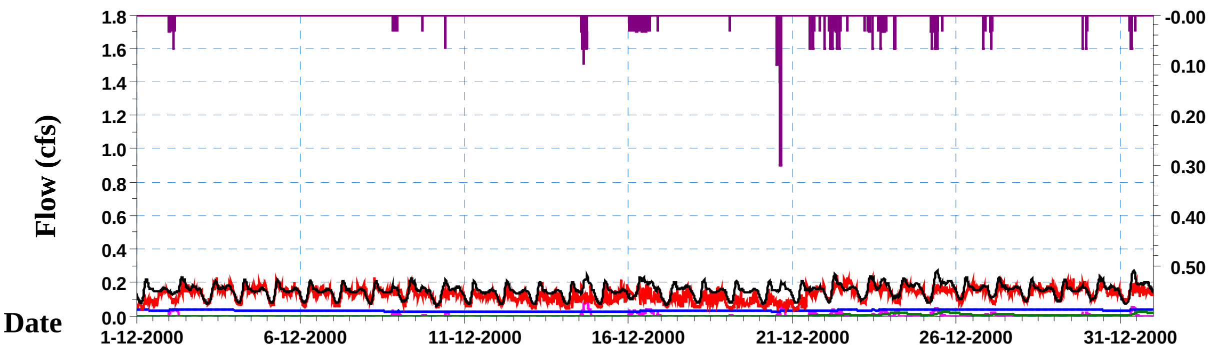
Slow Infiltration

Rapid Infiltration

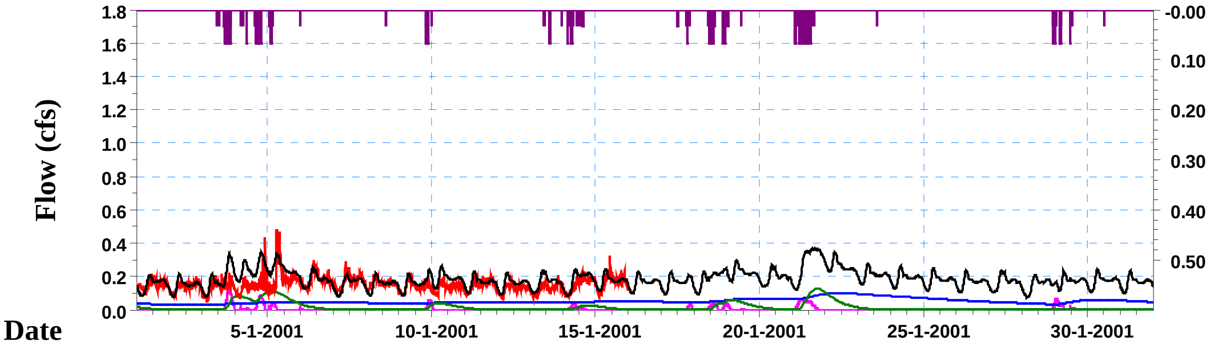


Ronald Pilot Basin (2000-2001 Monitoring Period)

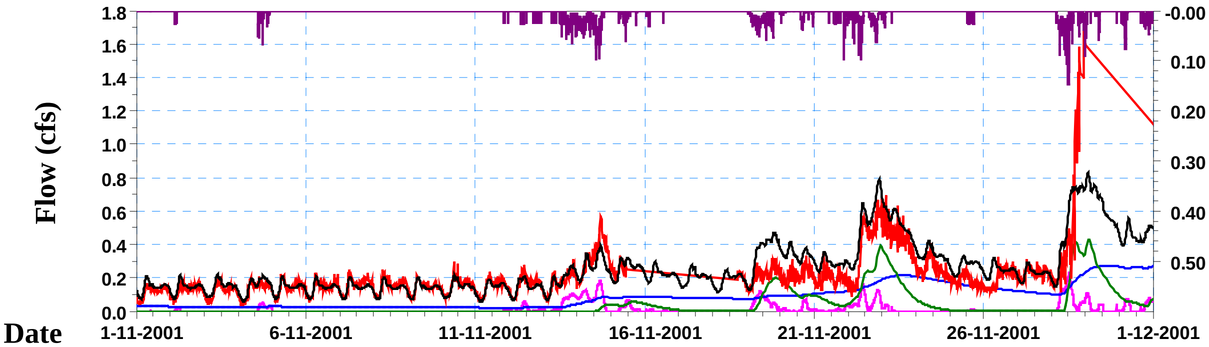


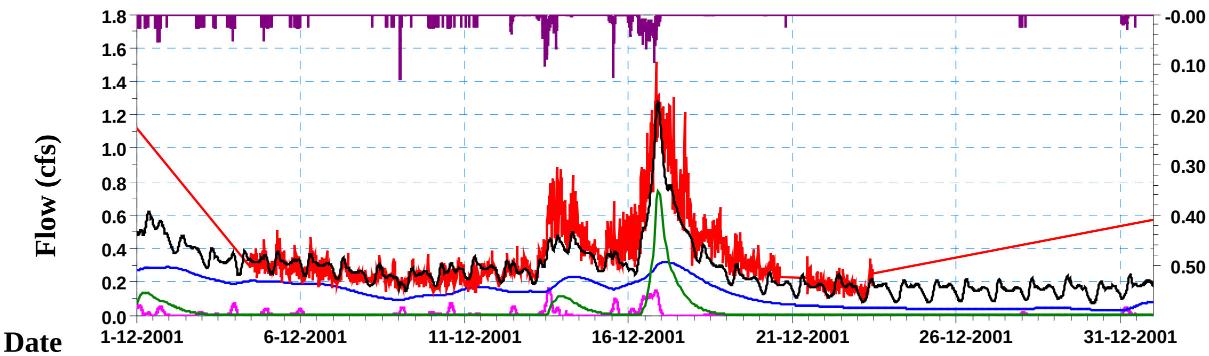


Legend:	Measured Flow	Total Simulated Flow
	Measured Rainfall	Fast Response Component
		Slow Infiltration
	Date Format (dd-mm-yyyy)	Rapid Infiltration



Ronald Pilot Basin (2001-2002 Monitoring Period)

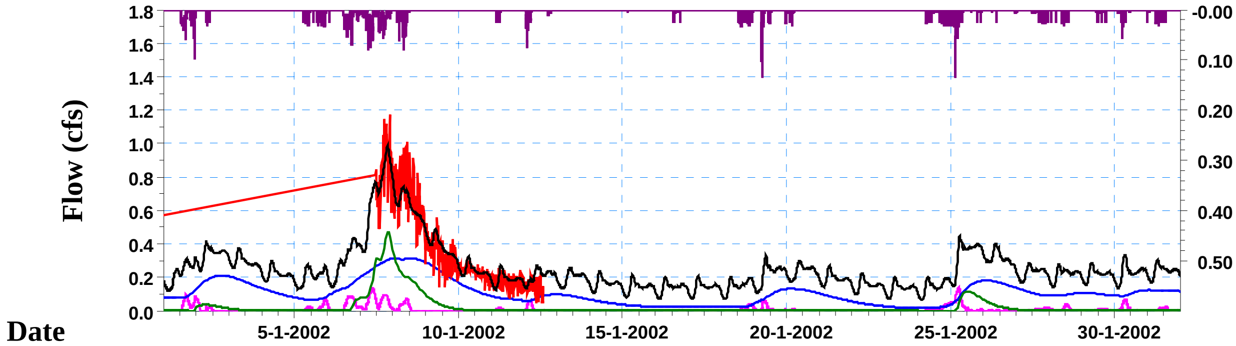




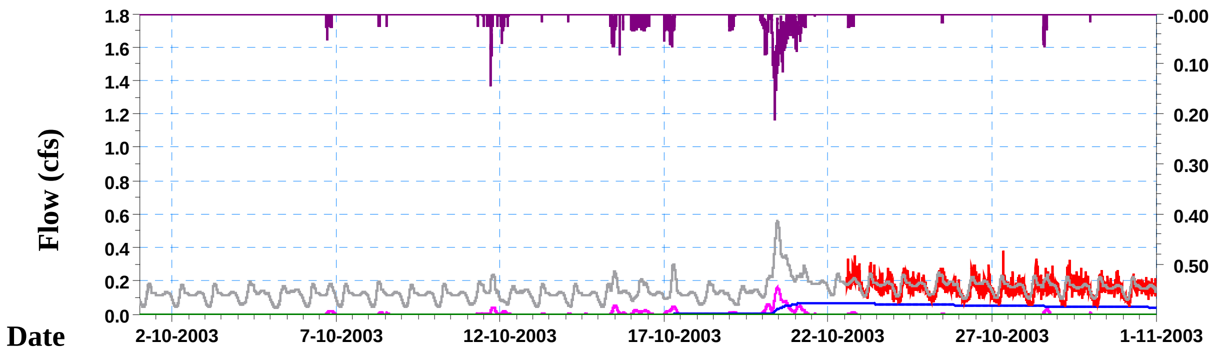
Legend:

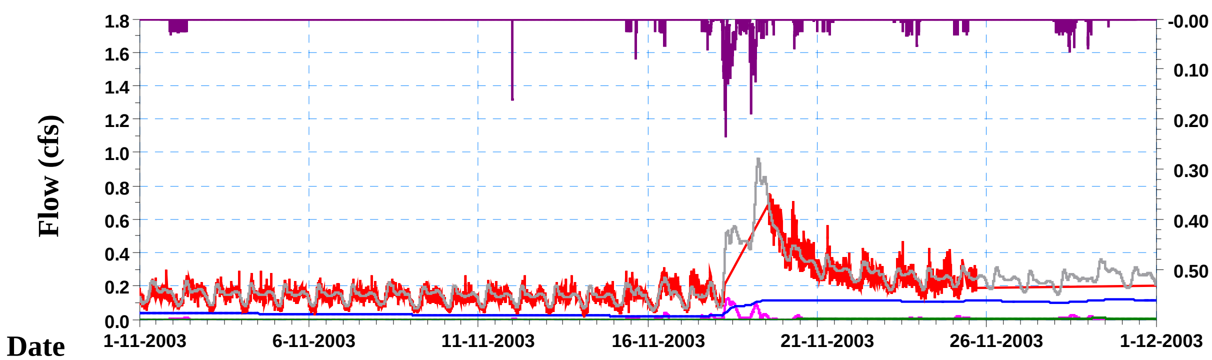
Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)

Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration



Ronald Pilot Basin (2003-2004 Monitoring Period)





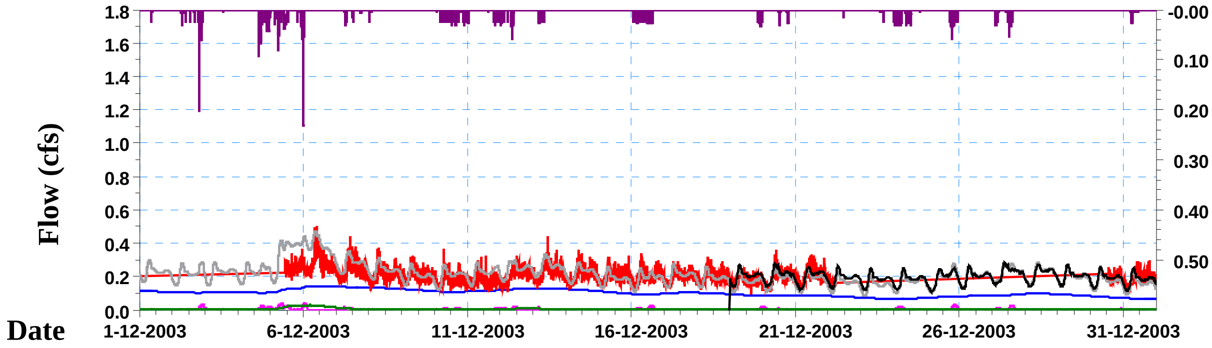
Legend: Measured Flow — Total Simulated Flow

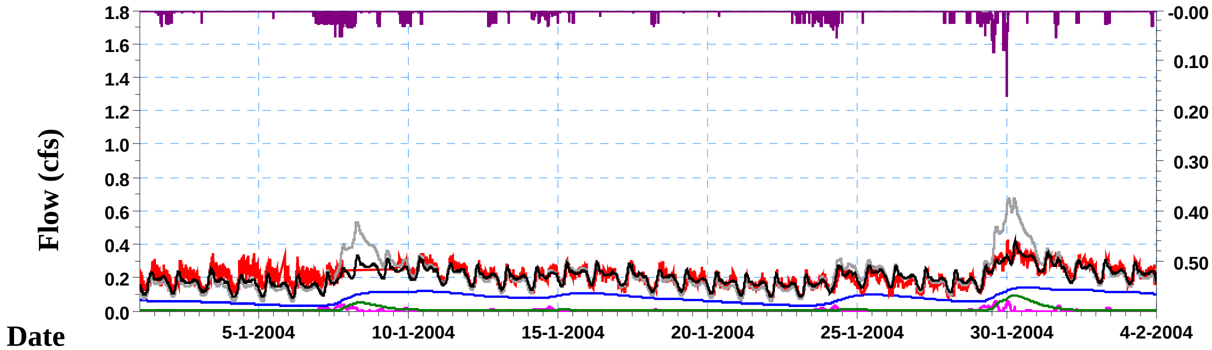
Measured Rainfall — Fast Response Component

Slow Infiltration

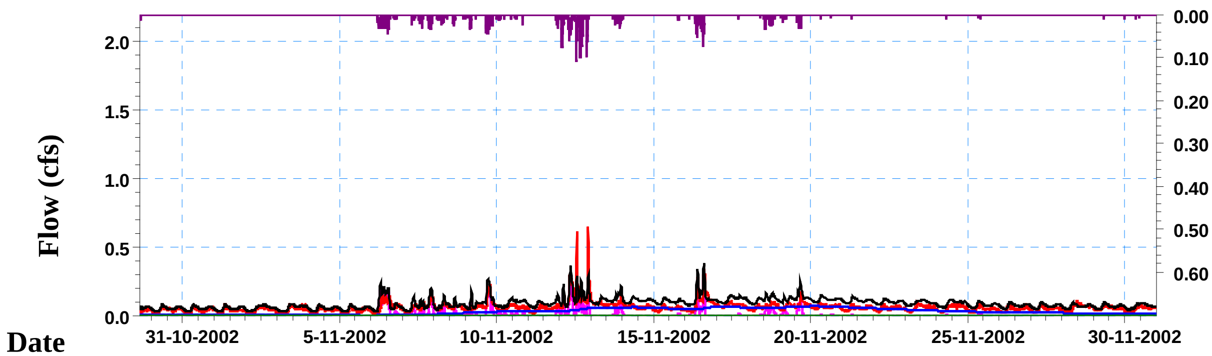
Date Format (dd-mm-yyyy) Rapid Infiltration

Pre-rehabilitation Simulated Flow



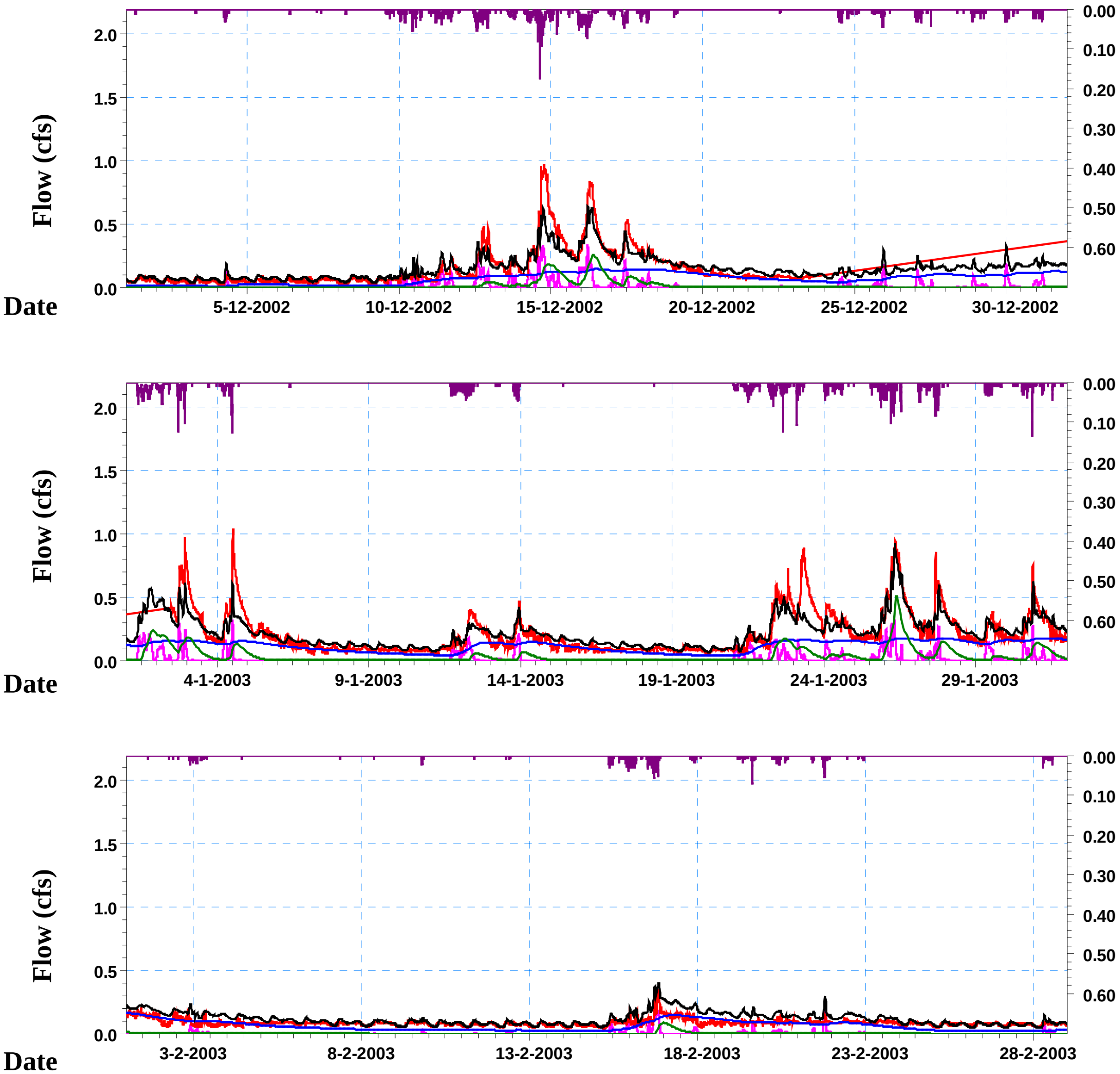


Skyway Control Basin (2002-2003 Monitoring Period)



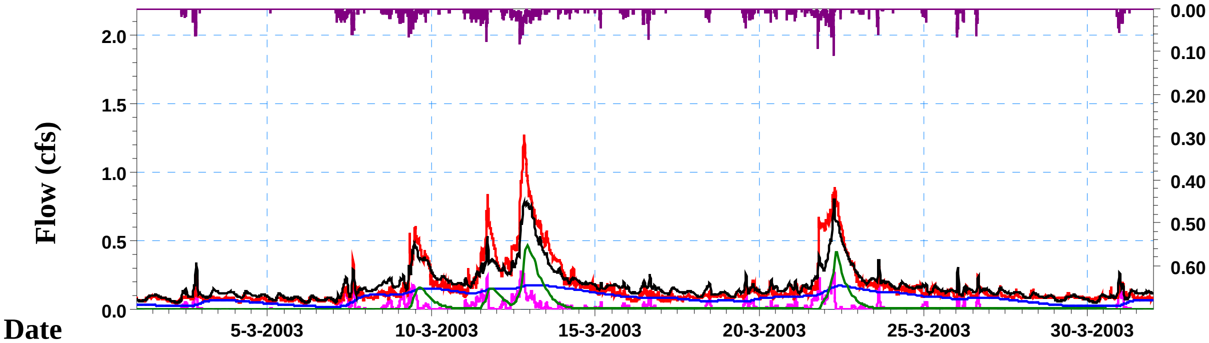
Legend:

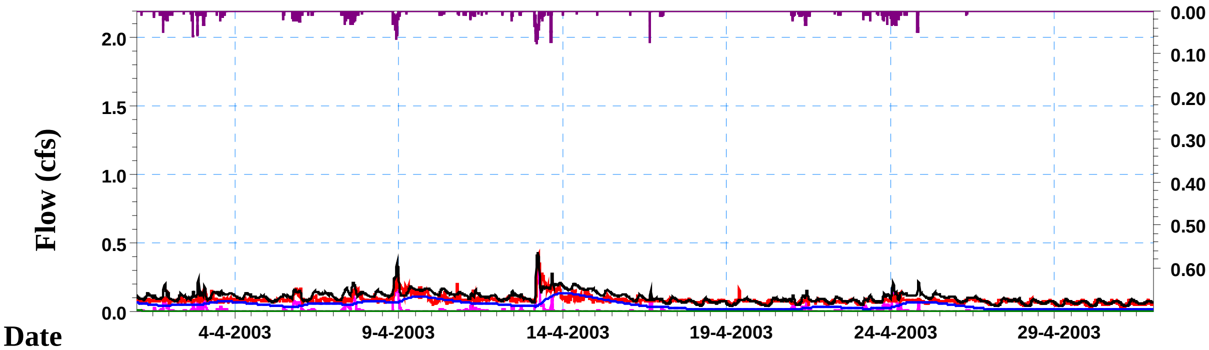
Measured Flow
Measured Rainfall
Total Simulated Flow
Fast Response Component
Slow Infiltration
Date Format (dd-mm-yyyy)
Rapid Infiltration
Pre-rehabilitation Simulated Flow



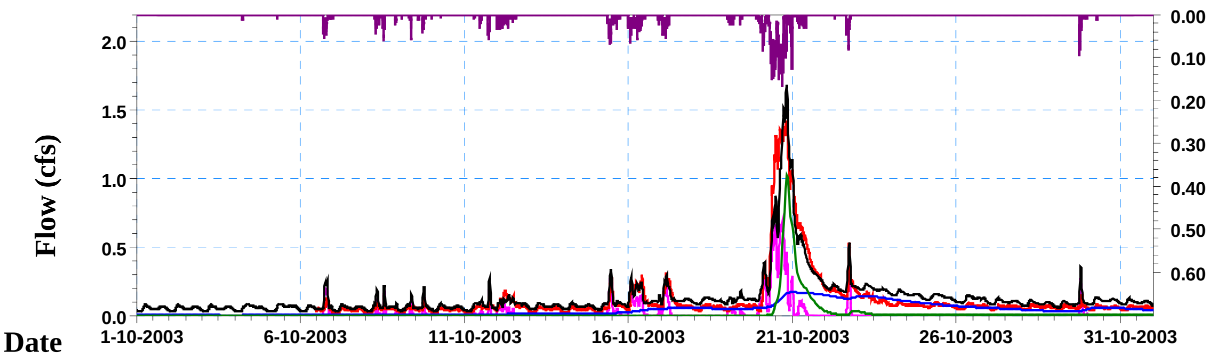
Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration





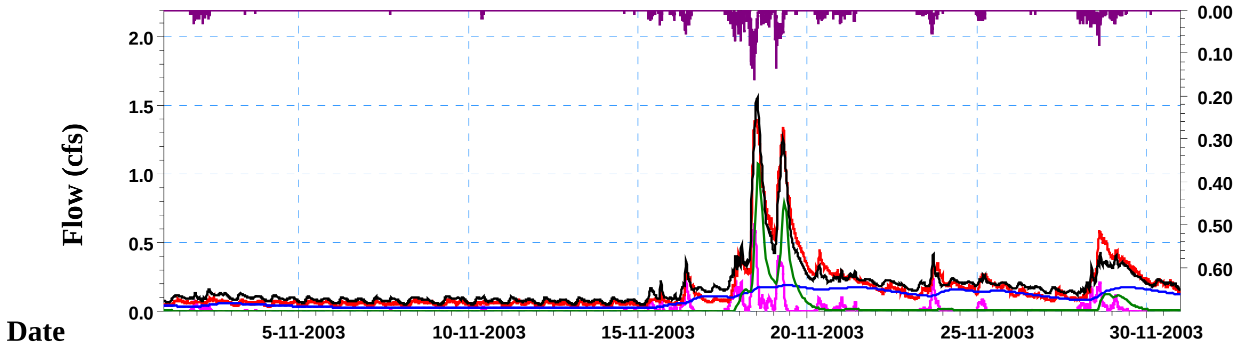
Skyway Control Basin (2003-2004 Monitoring Period)

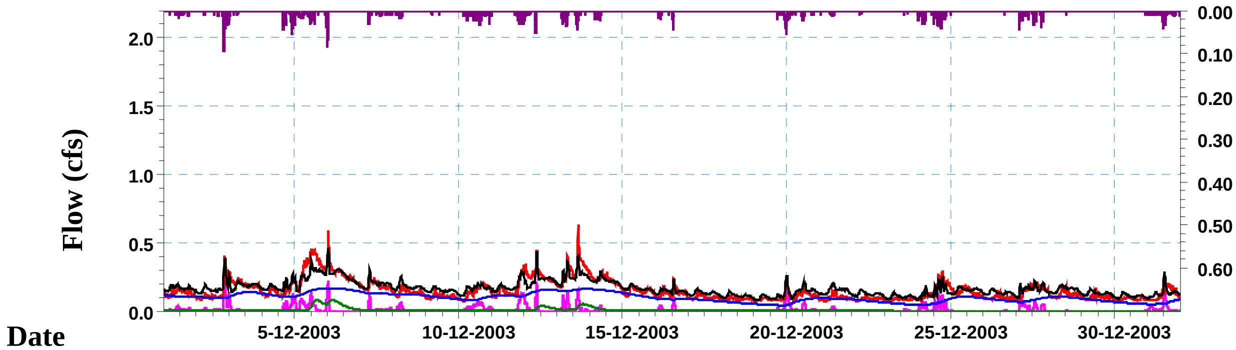


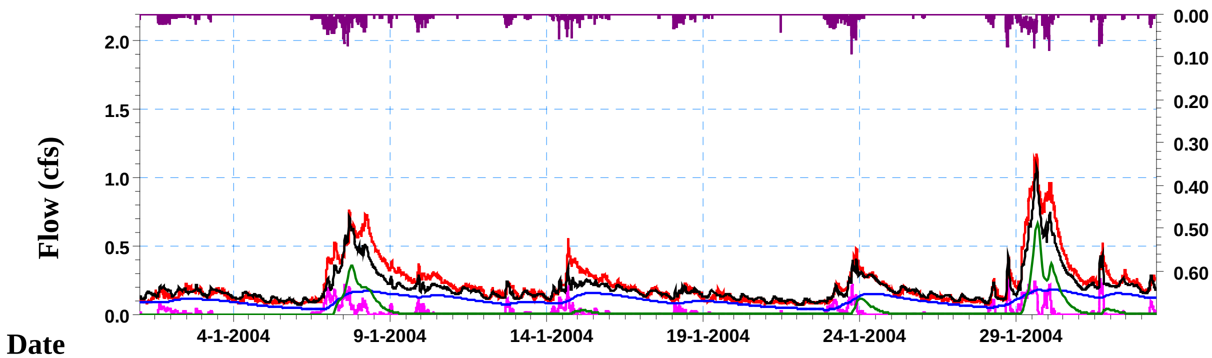
Legend:

Measured Flow
Measured Rainfall
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration

Date Format (dd-mm-yyyy)







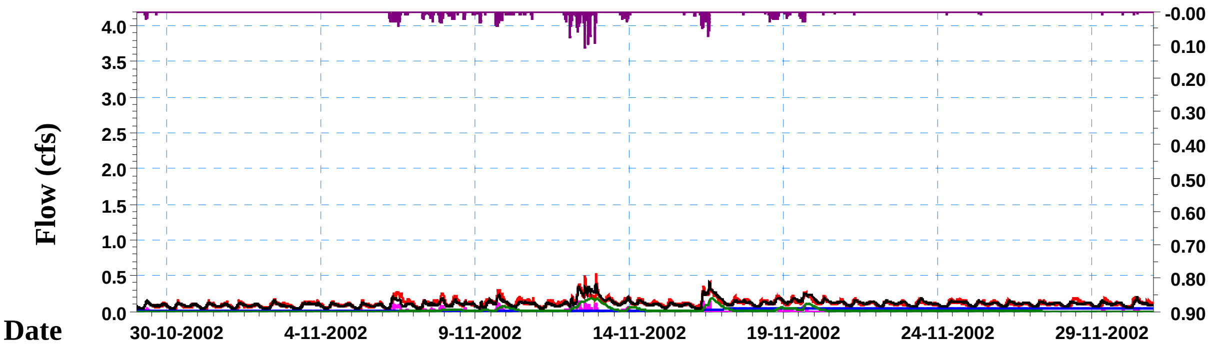
Legend: Measured Flow — Total Simulated Flow

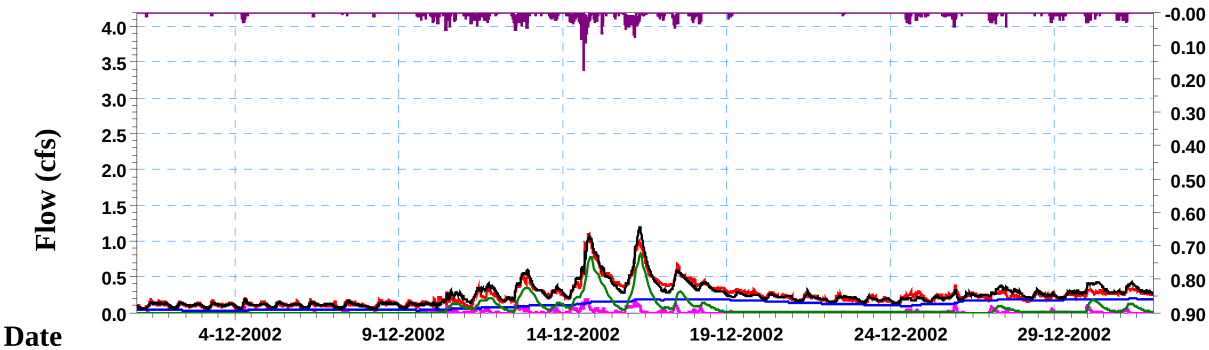
Measured Rainfall — Fast Response Component

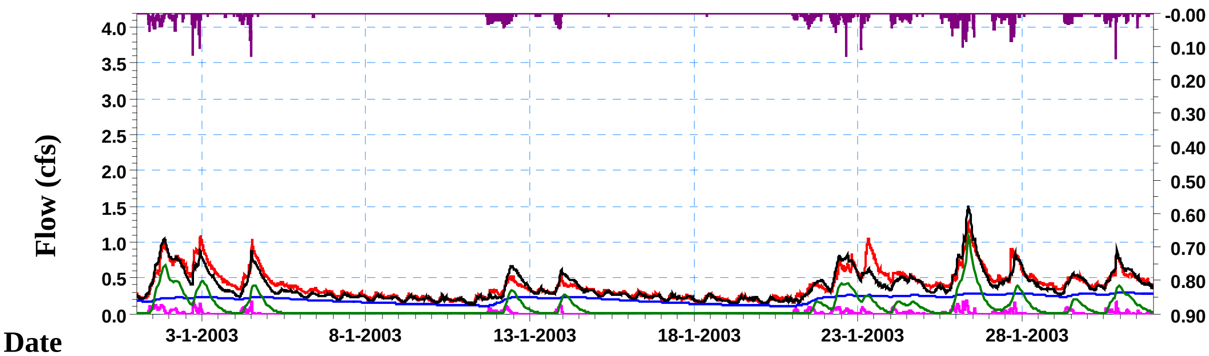
Slow Infiltration

Date Format (dd-mm-yyyy) — Rapid Infiltration

Skyway Pilot Basin (2002-2003 Monitoring Period)

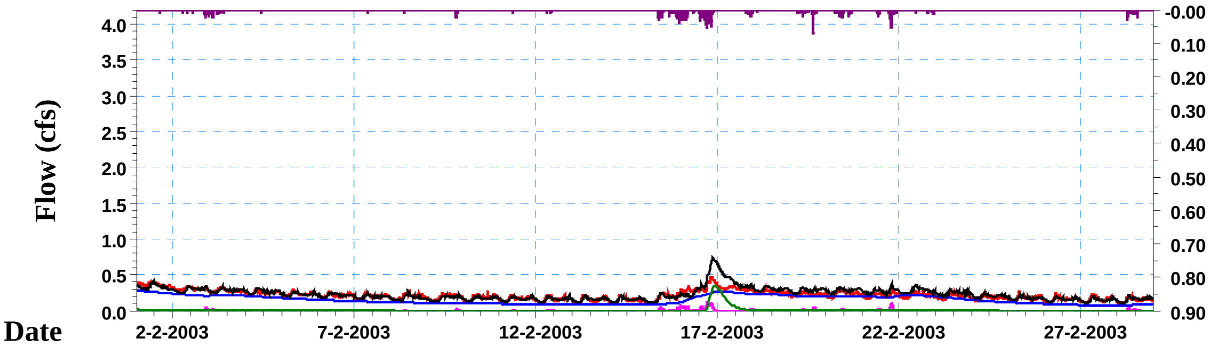


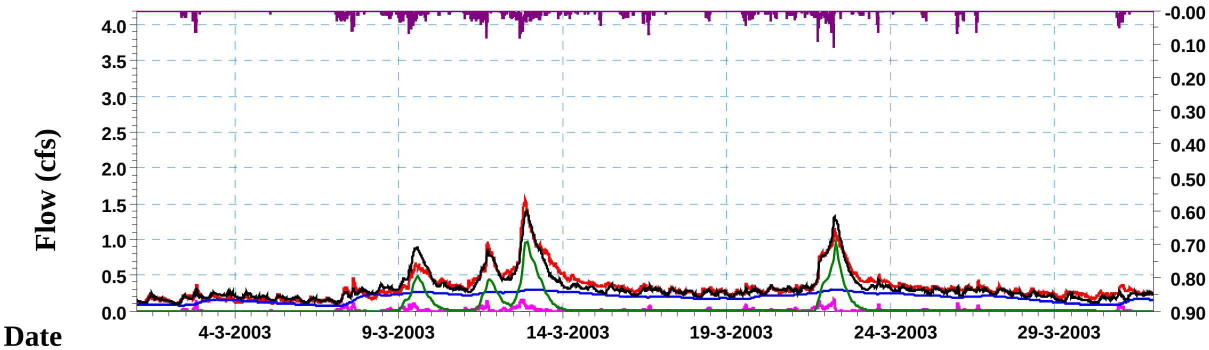


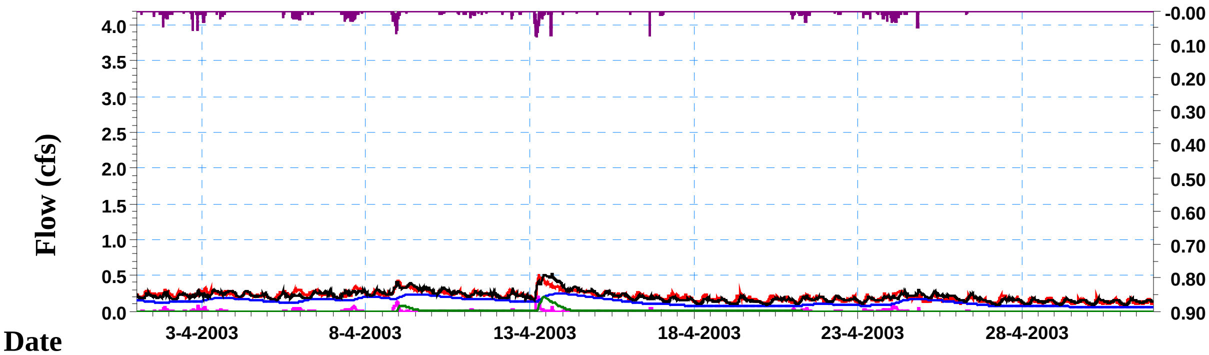


Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration



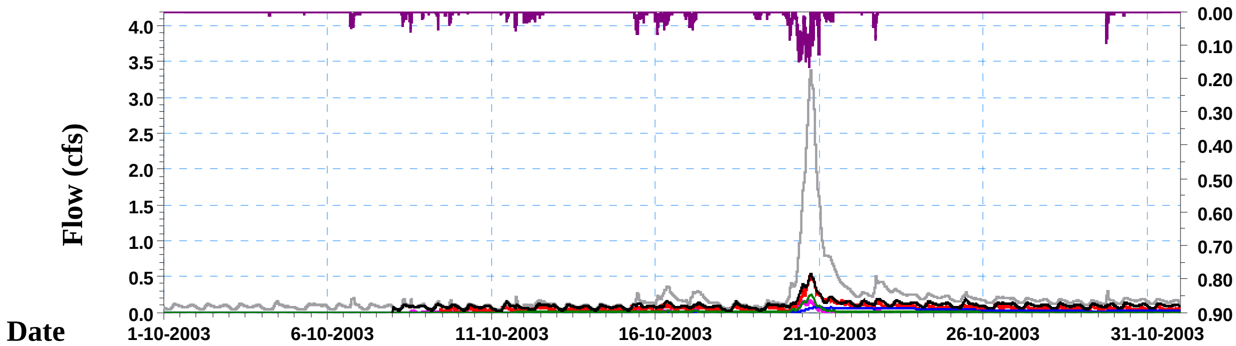


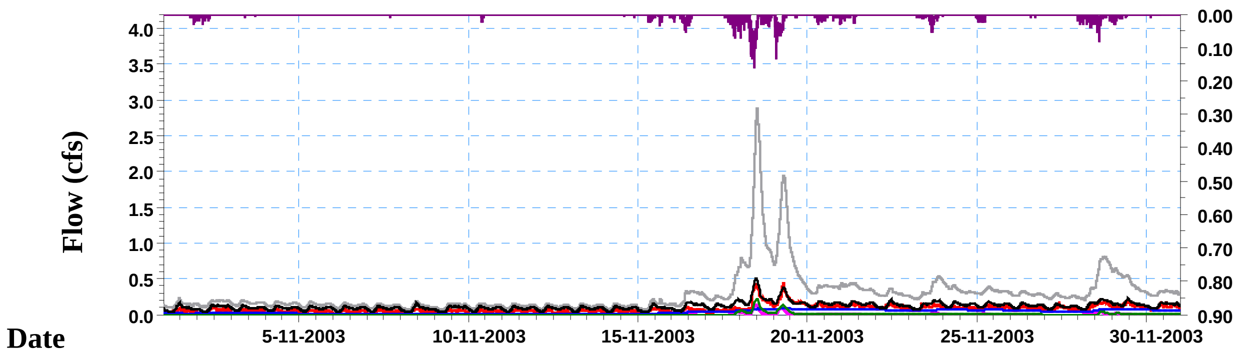


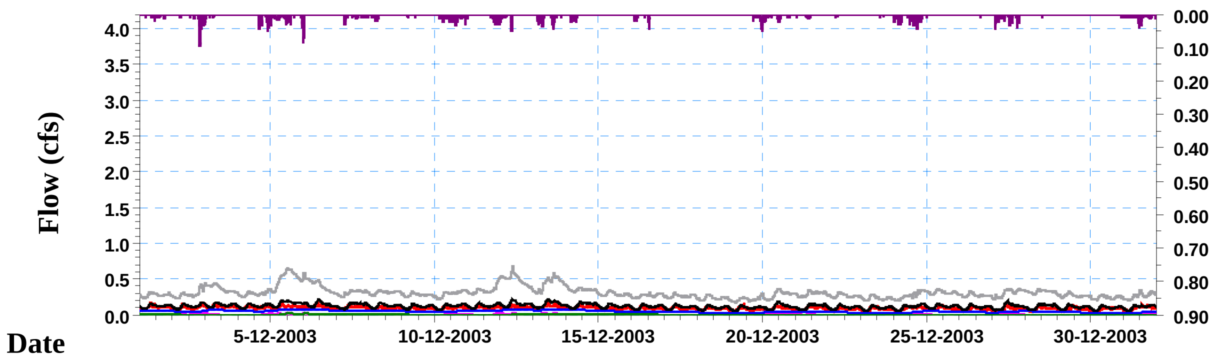
Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration

Skyway Pilot Basin (2003-2004 Monitoring Period)







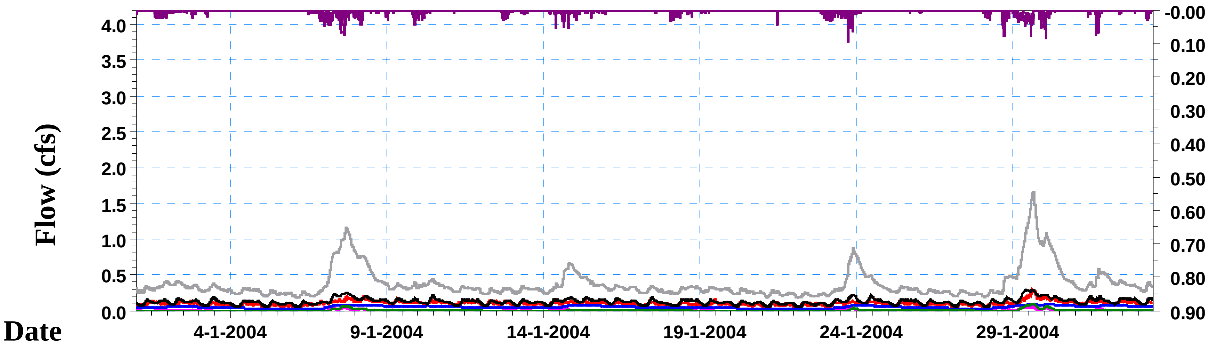
Legend:

Measured Flow
Measured Rainfall

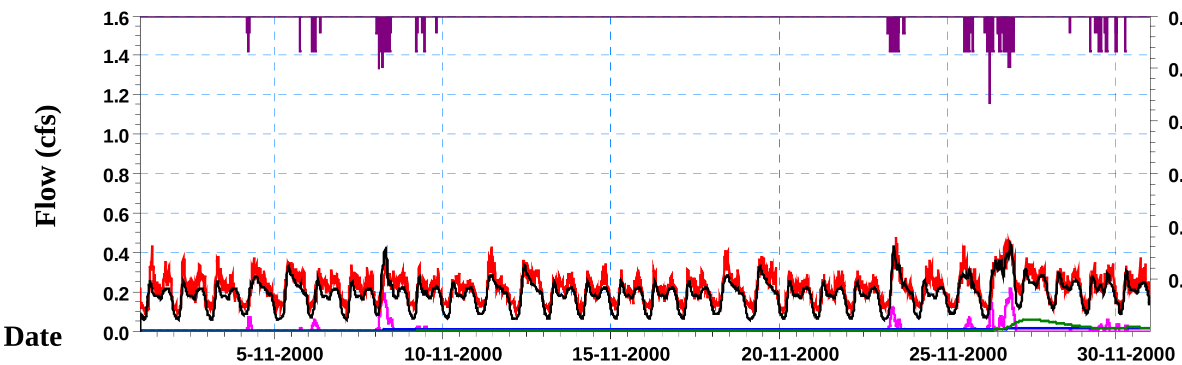
Total Simulated Flow
Fast Response Component
Slow Infiltration

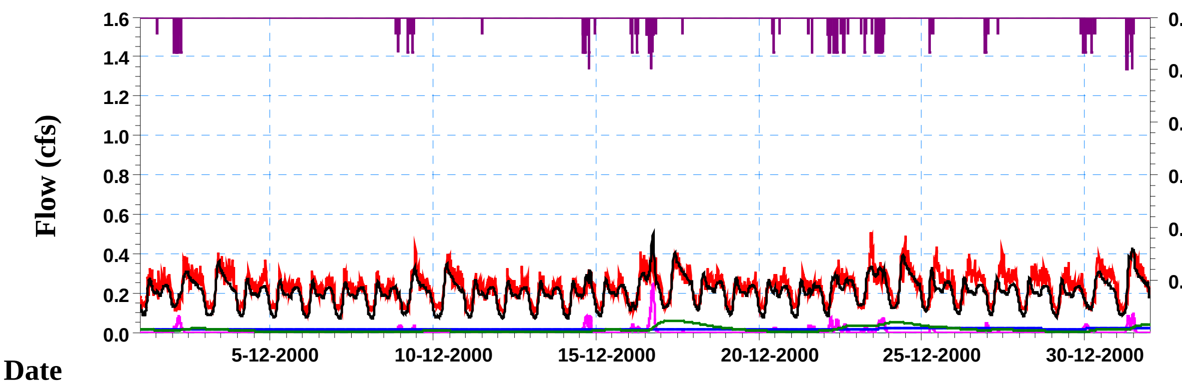
Date Format (dd-mm-yyyy)
Rapid Infiltration

Pre-rehabilitation Simulated Flow



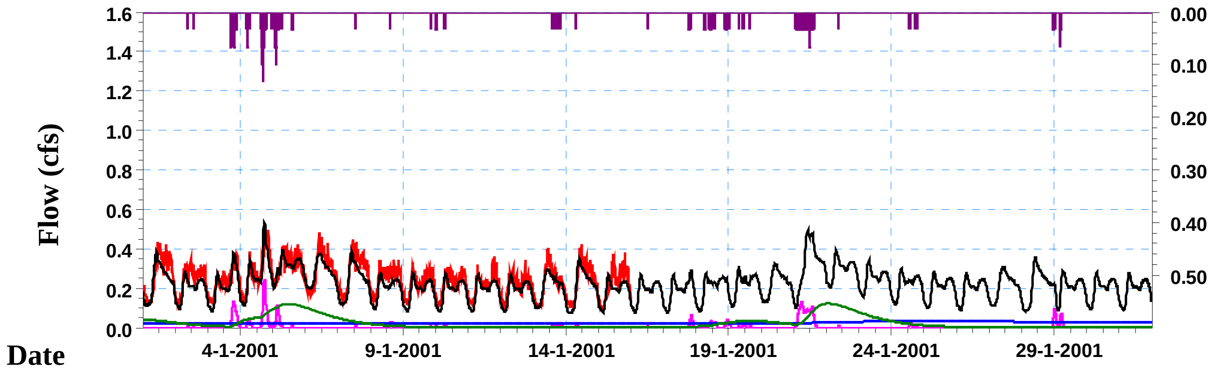
Val Vue Control Basin (2000-2001 Monitoring Period)



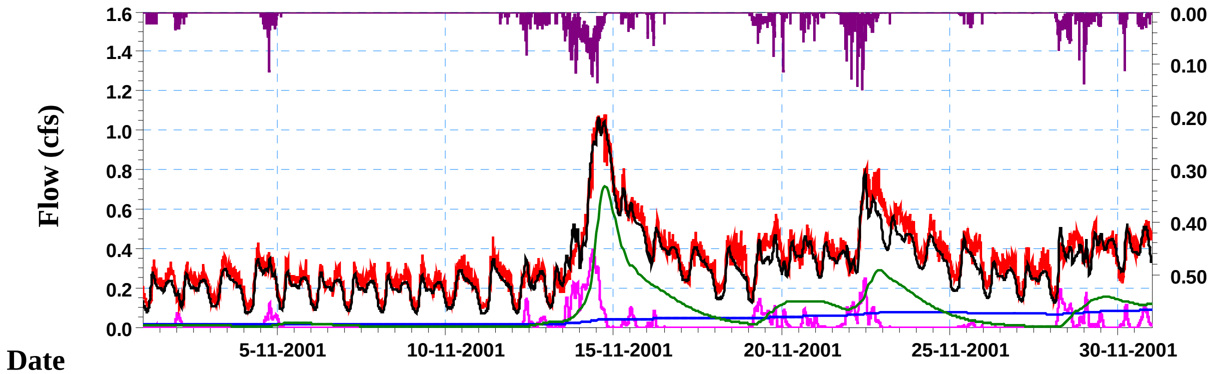


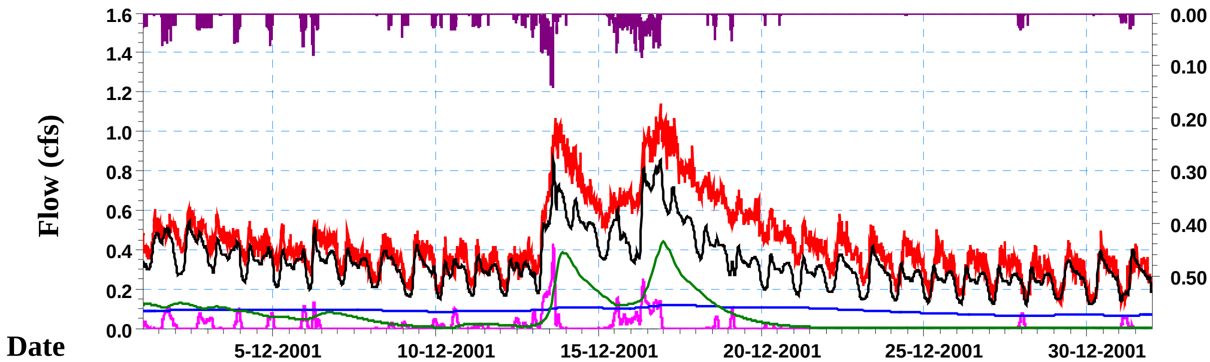
Legend:

Measured Flow
Measured Rainfall
Date Format (dd-mm-yyyy)
Pre-rehabilitation Simulated Flow
Total Simulated Flow
Fast Response Component
Slow Infiltration
Rapid Infiltration



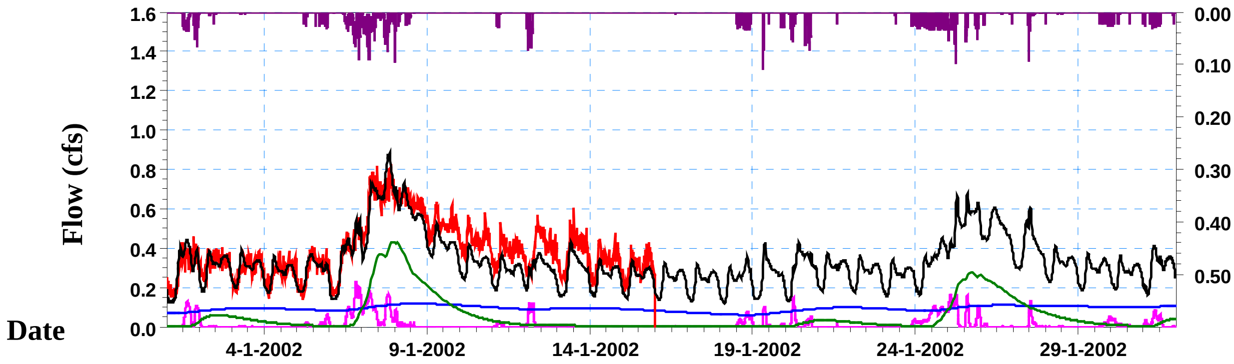
Val Vue Control Basin (2001-2002 Monitoring Period)



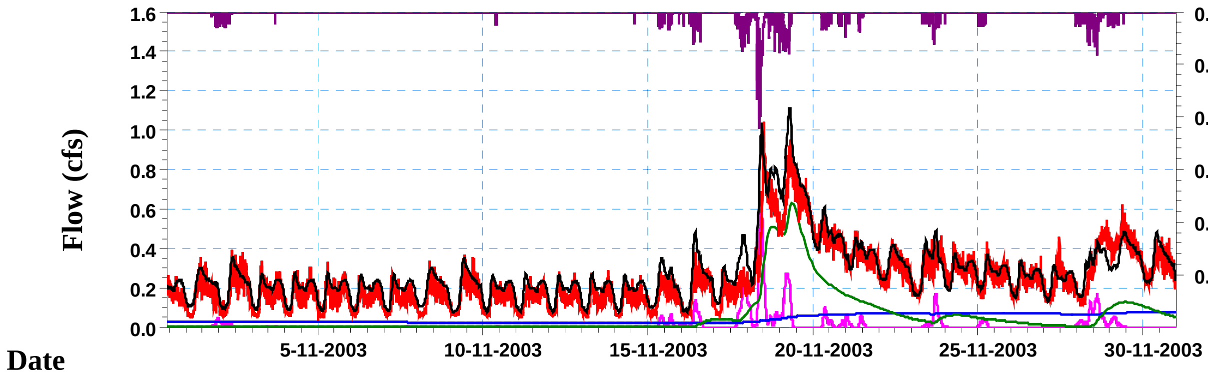


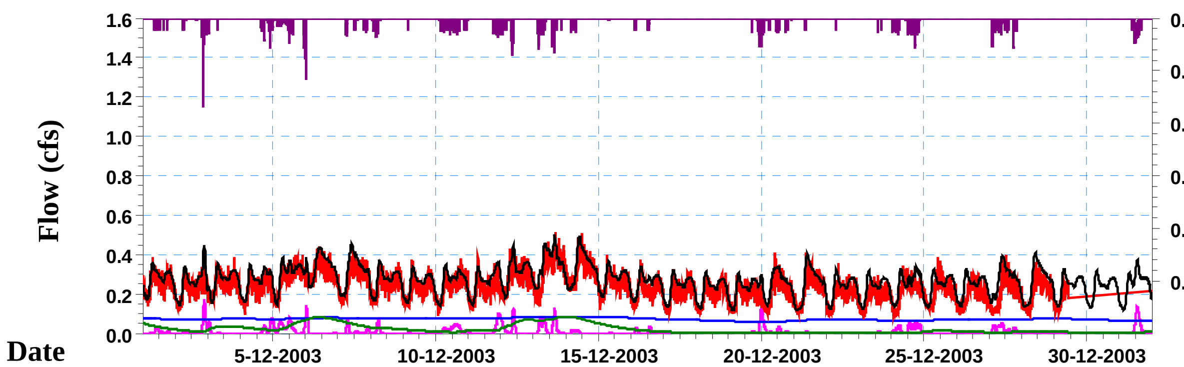
Legend: Measured Flow — Measured Rainfall — Total Simulated Flow — Fast Response Component — Slow Infiltration — Rapid Infiltration —

Date Format (dd-mm-yyyy)



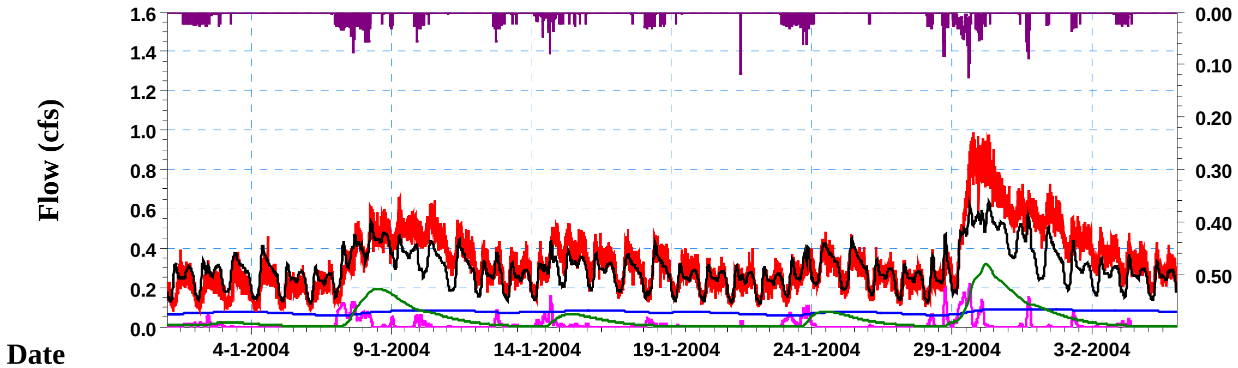
Val Vue Control Basin (2003-2004 Monitoring Period)



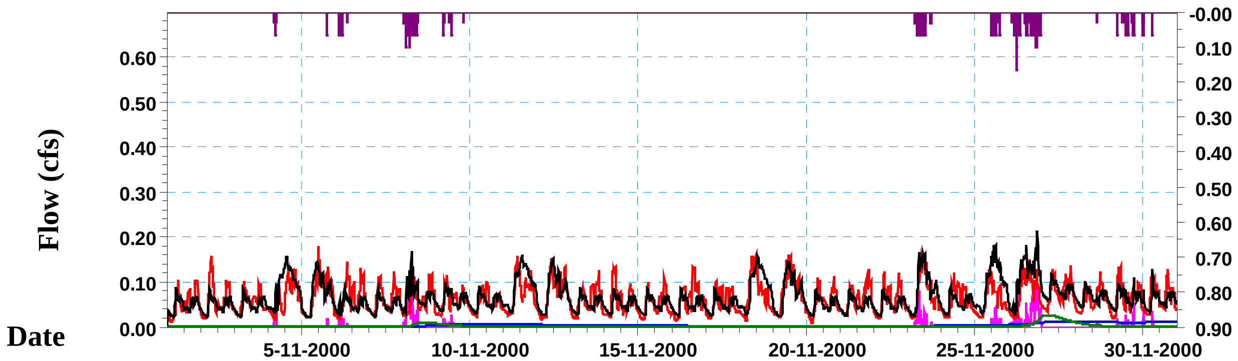


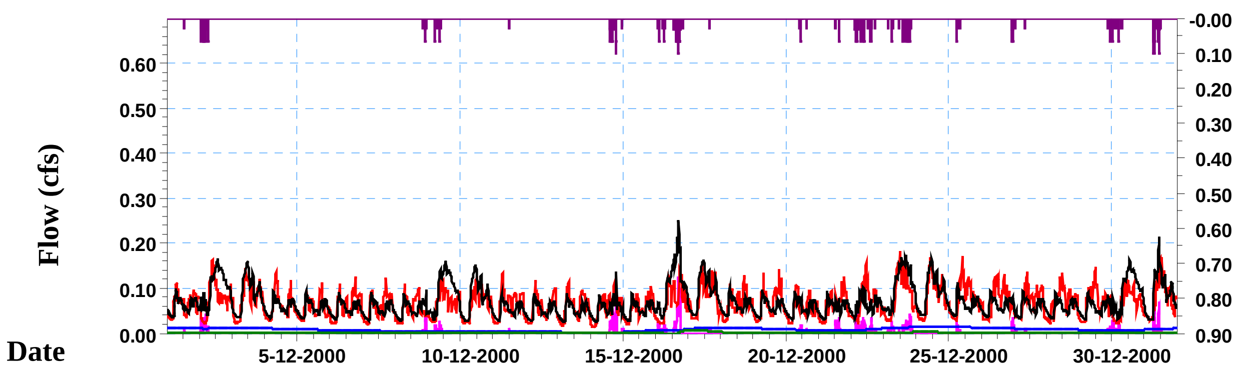
Legend:

Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration



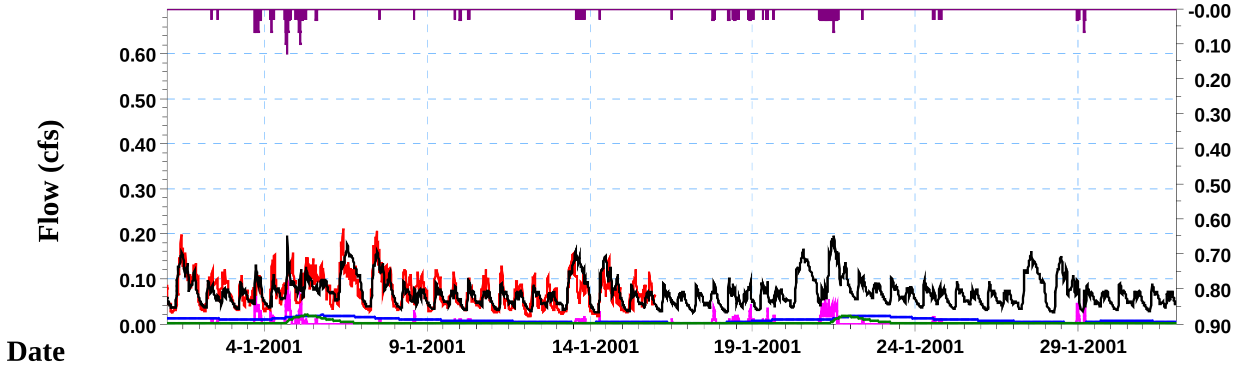
Val Vue Pilot Basin (2000-2001 Monitoring Period)



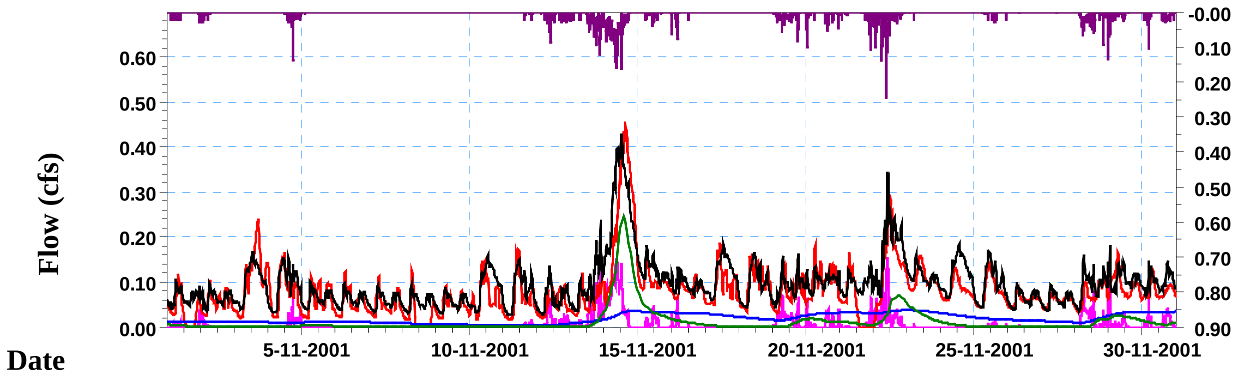


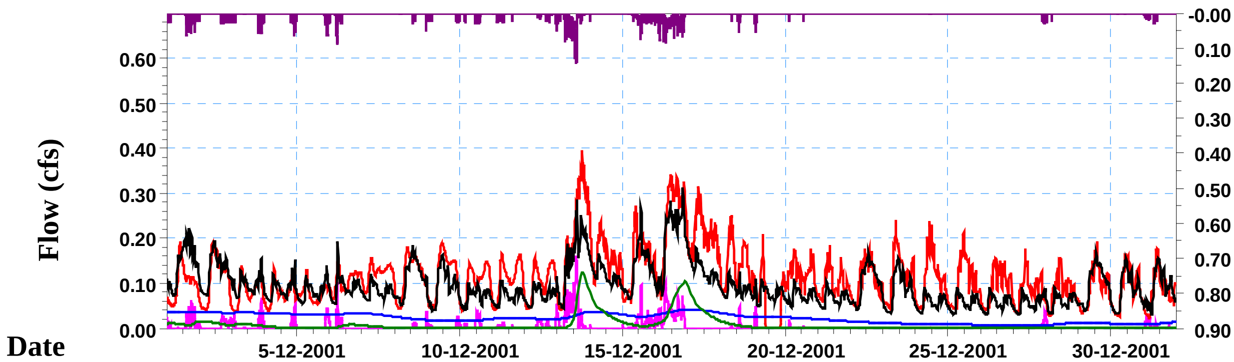
Legend: Measured Flow — Measured Rainfall — Total Simulated Flow — Fast Response Component — Slow Infiltration — Rapid Infiltration

Date Format (dd-mm-yyyy)



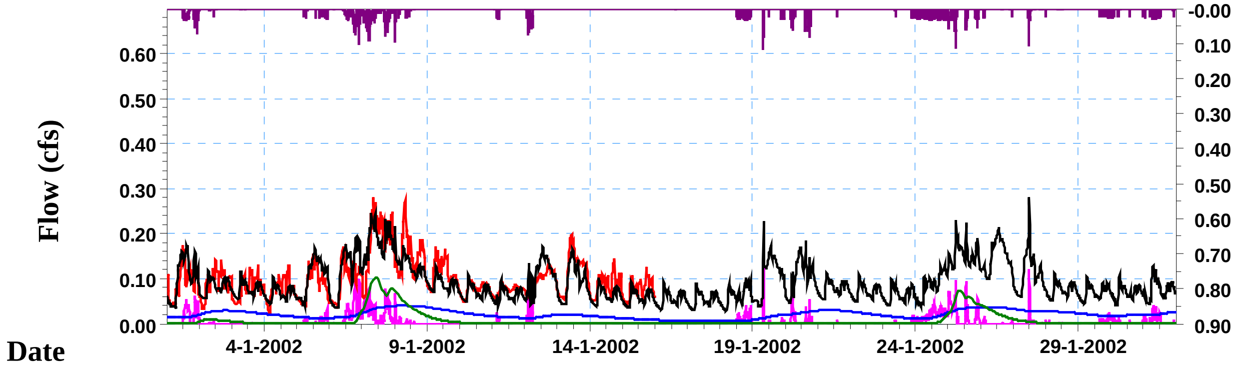
Val Vue Pilot Basin (2001-2002 Monitoring Period)



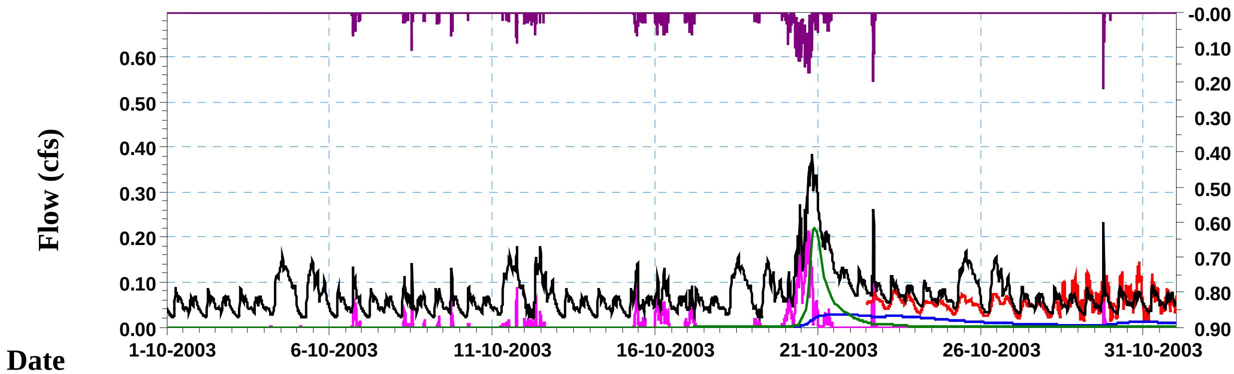


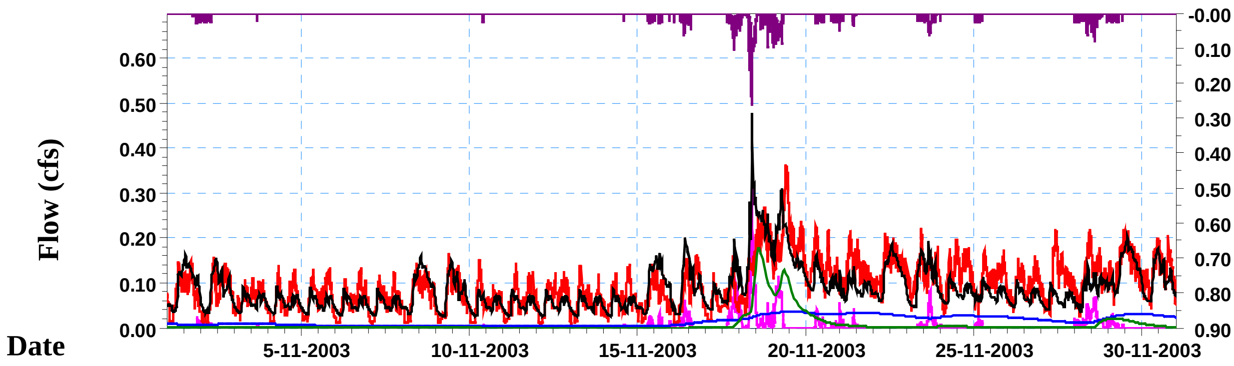
Legend:

Measured Flow — Total Simulated Flow
Measured Rainfall — Fast Response Component
Slow Infiltration
Date Format (dd-mm-yyyy) — Rapid Infiltration



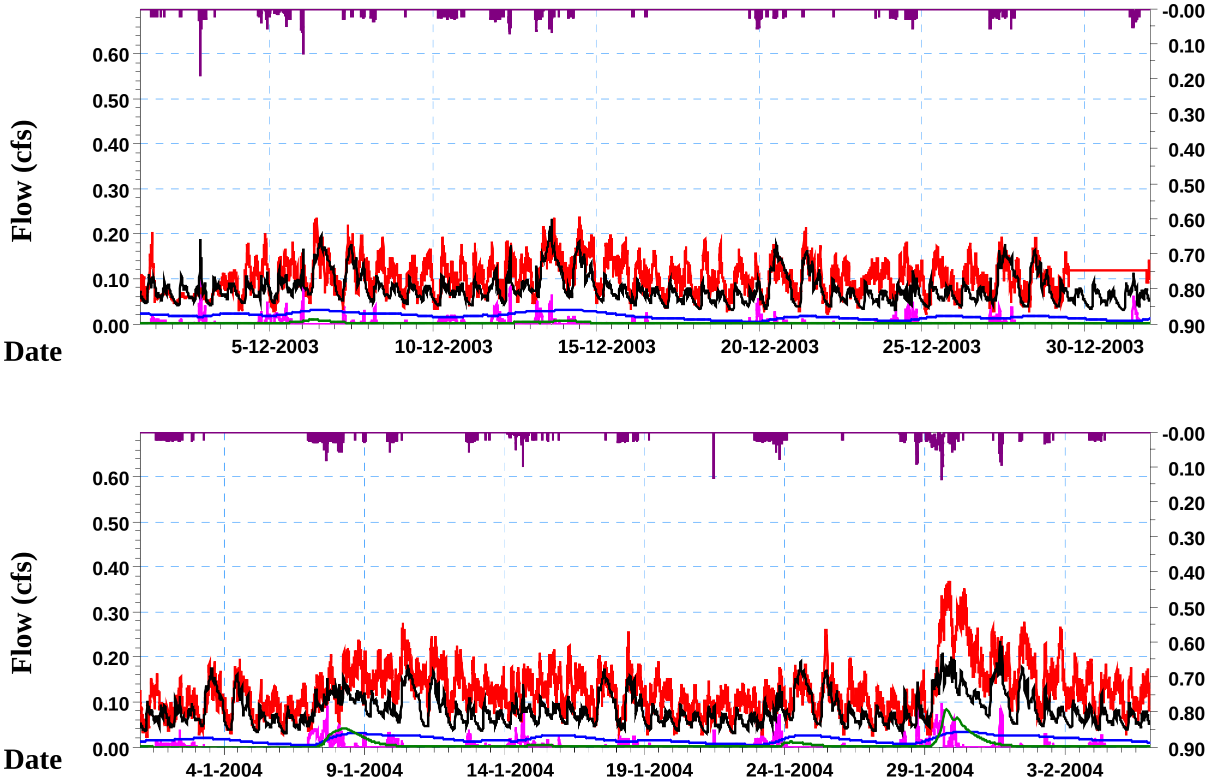
Val Vue Pilot Basin (2003-2004 Monitoring Period)



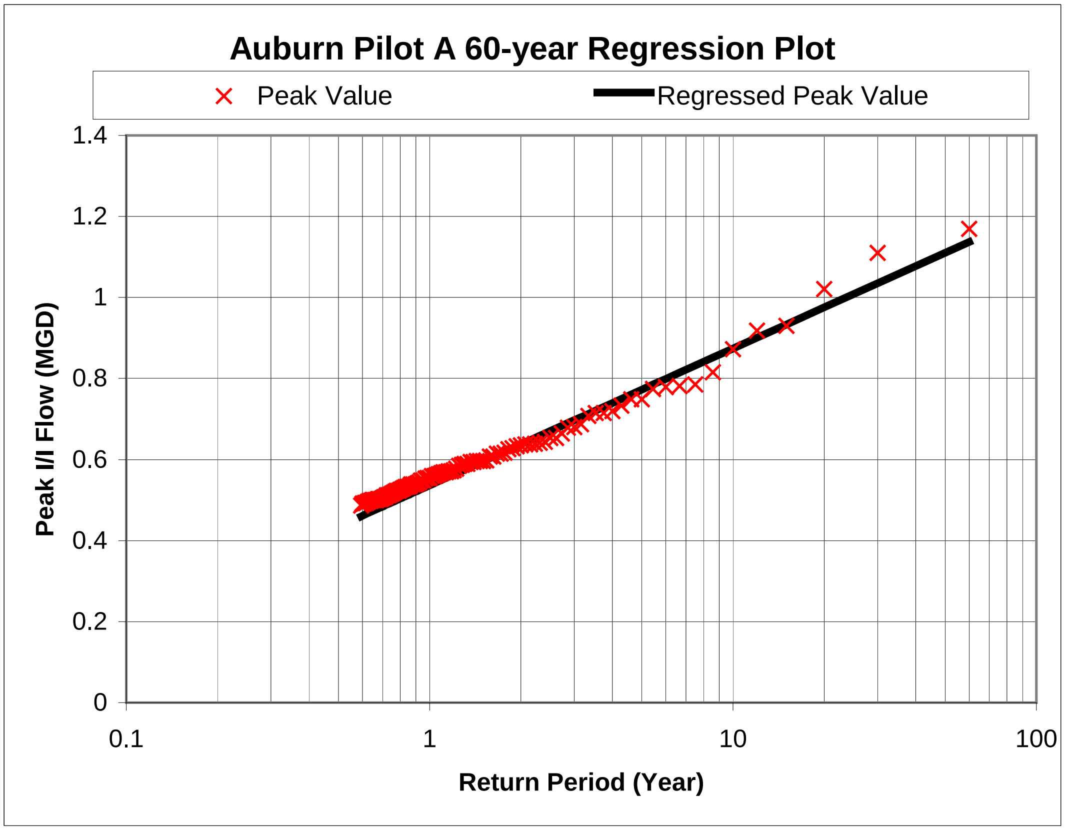


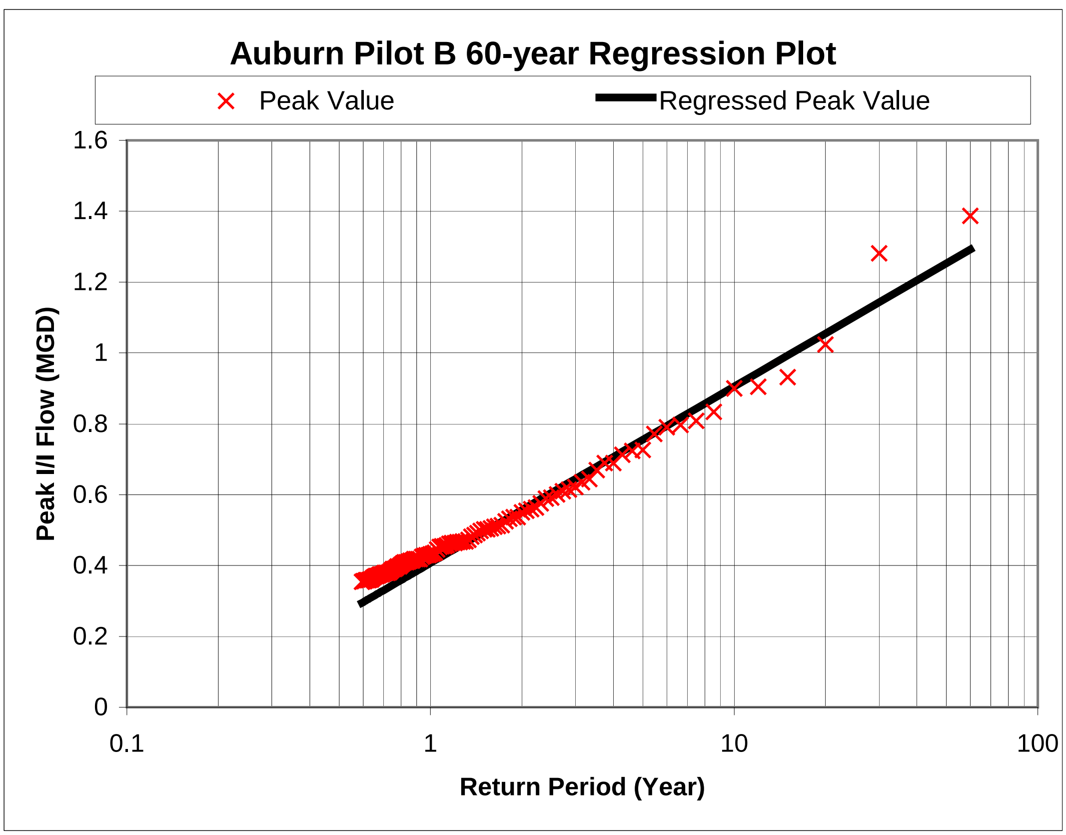
Legend:

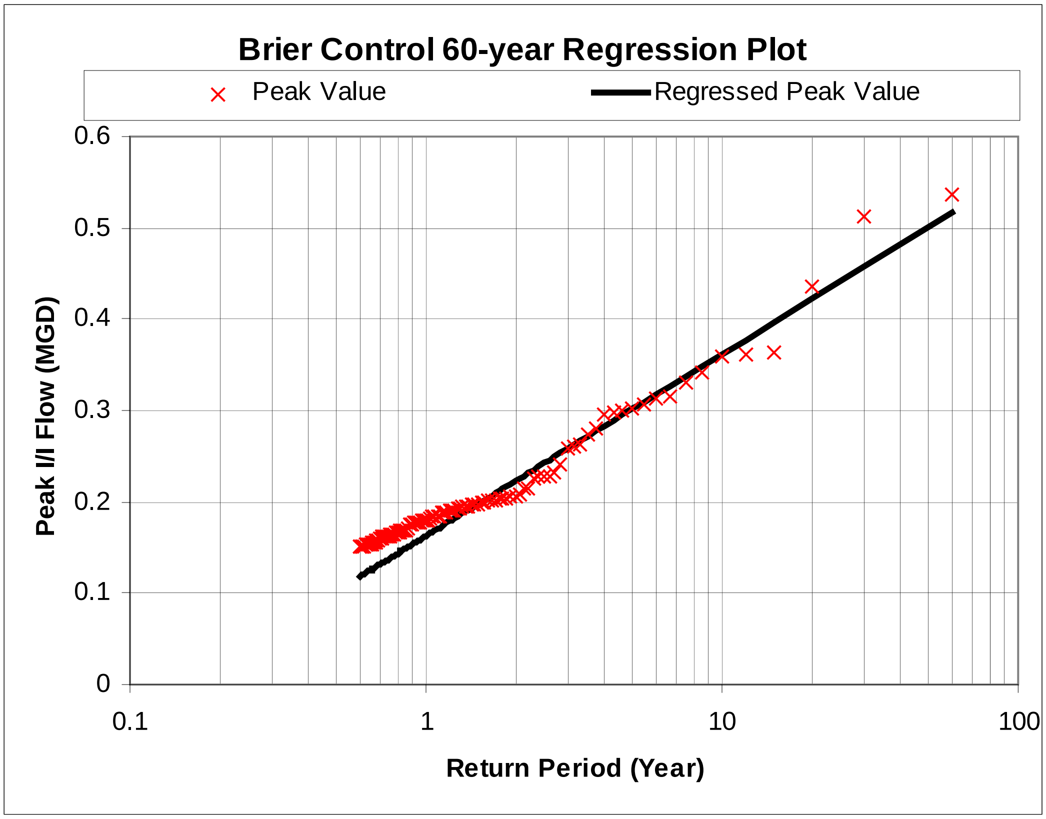
Measured Flow	Total Simulated Flow
Measured Rainfall	Fast Response Component
	Slow Infiltration
Date Format (dd-mm-yyyy)	Rapid Infiltration



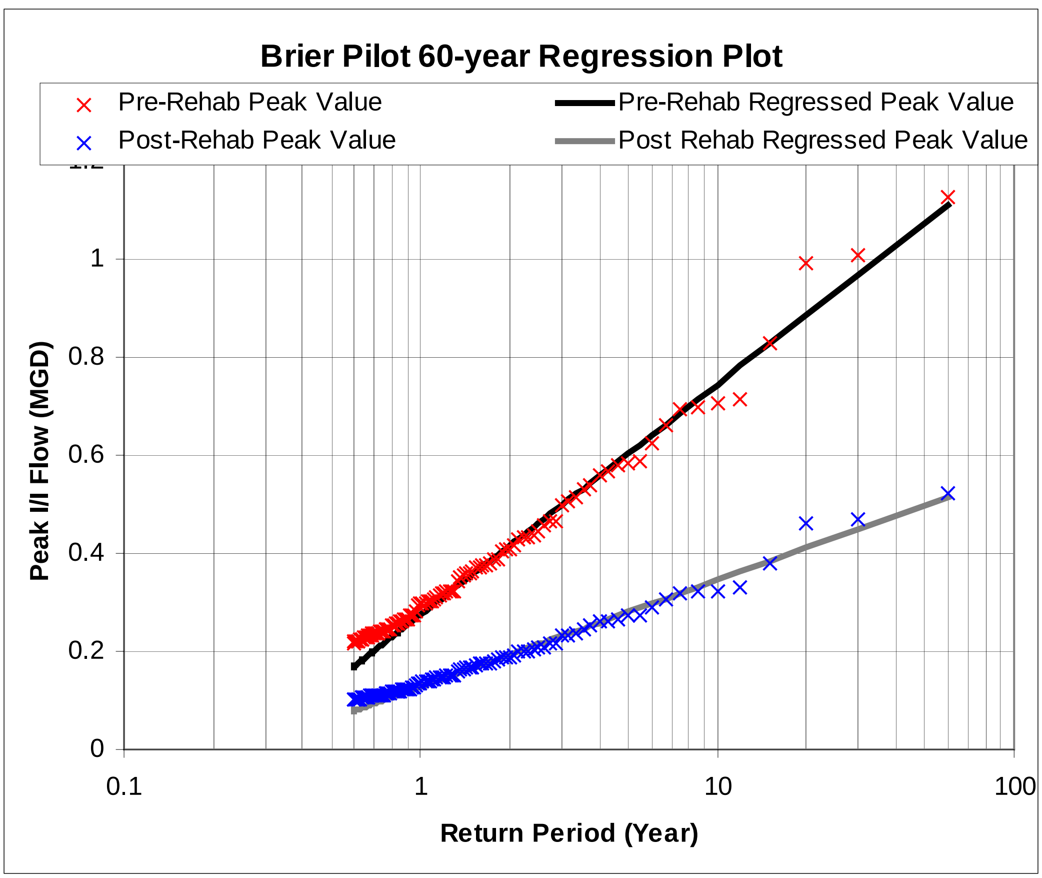
Legend: Measured Flow, Measured Rainfall, Date Format (dd-mm-yyyy), Total Simulated Flow, Fast Response Component, Slow Infiltration, Rapid Infiltration


Auburn Pilot A 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
Return Period (Year)

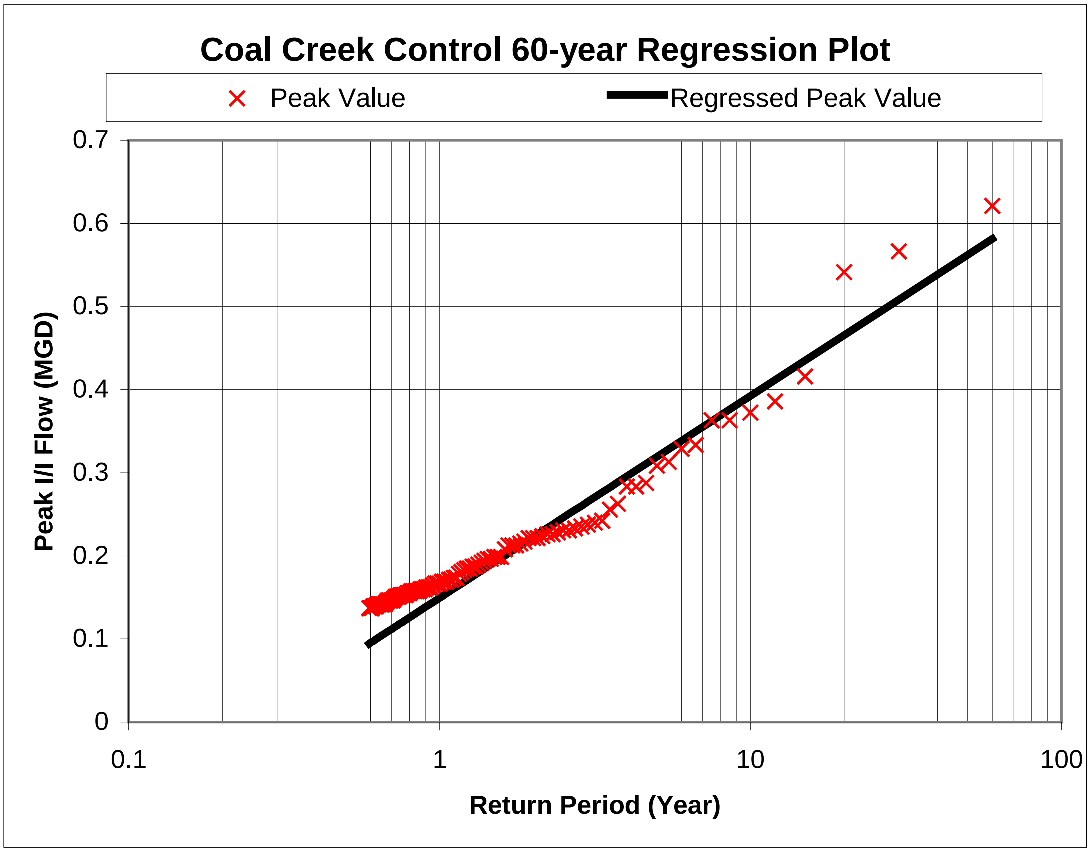

Auburn Pilot B 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
Return Period (Year)

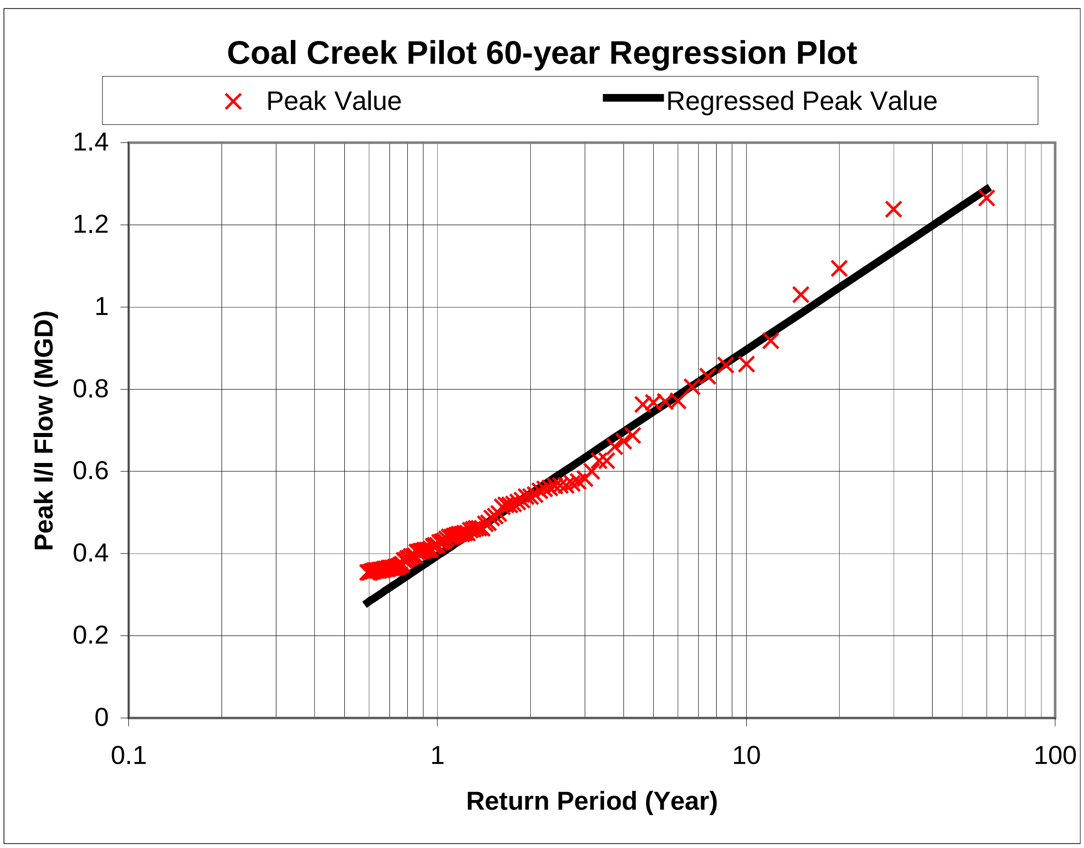


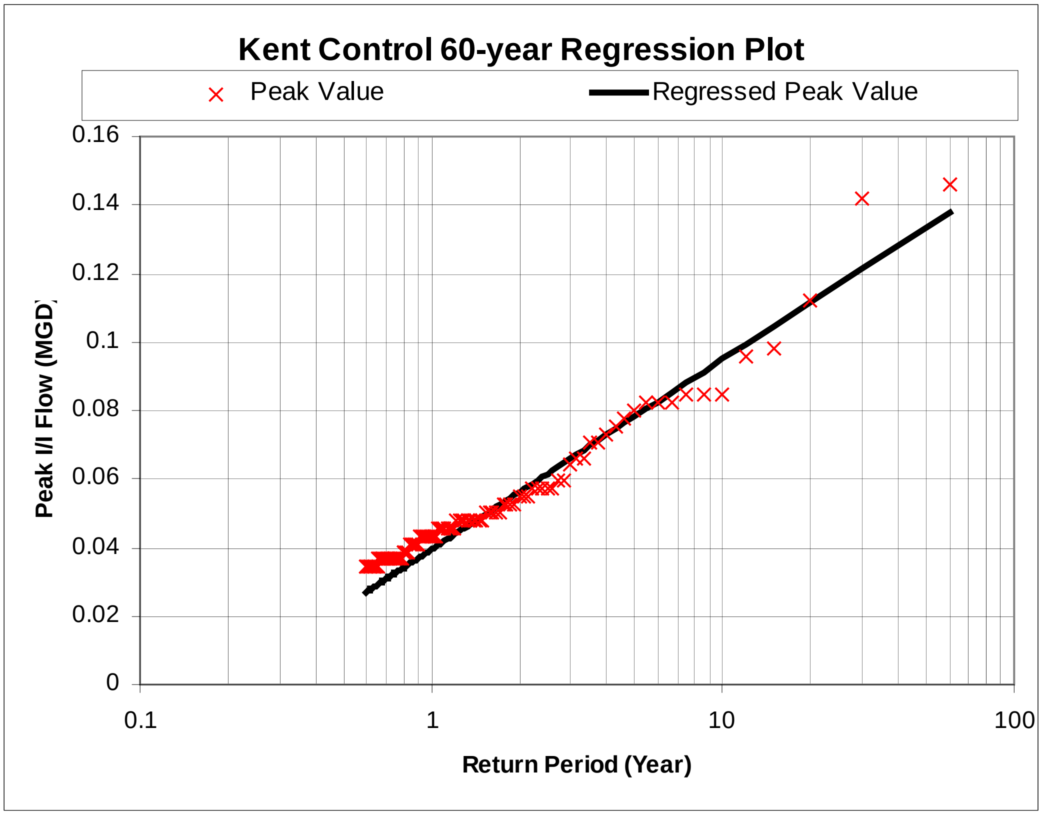
Brier Control 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
1
10
100
Return Period (Year)

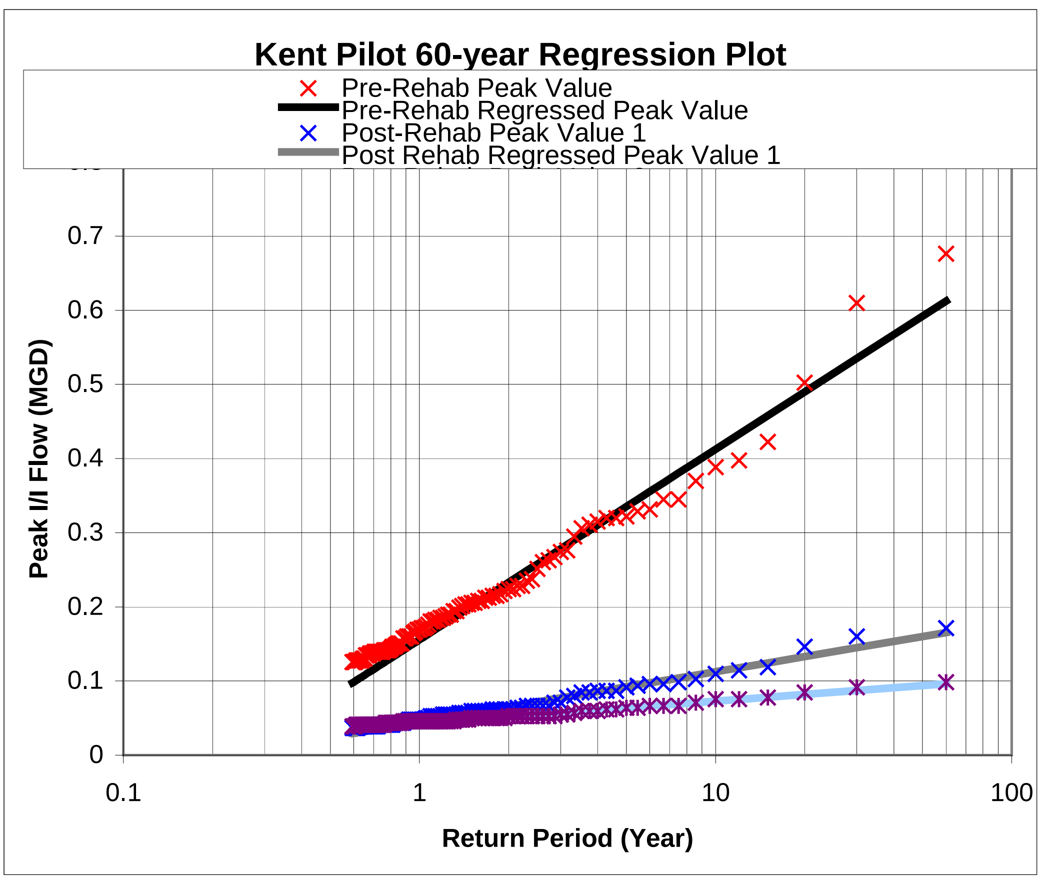


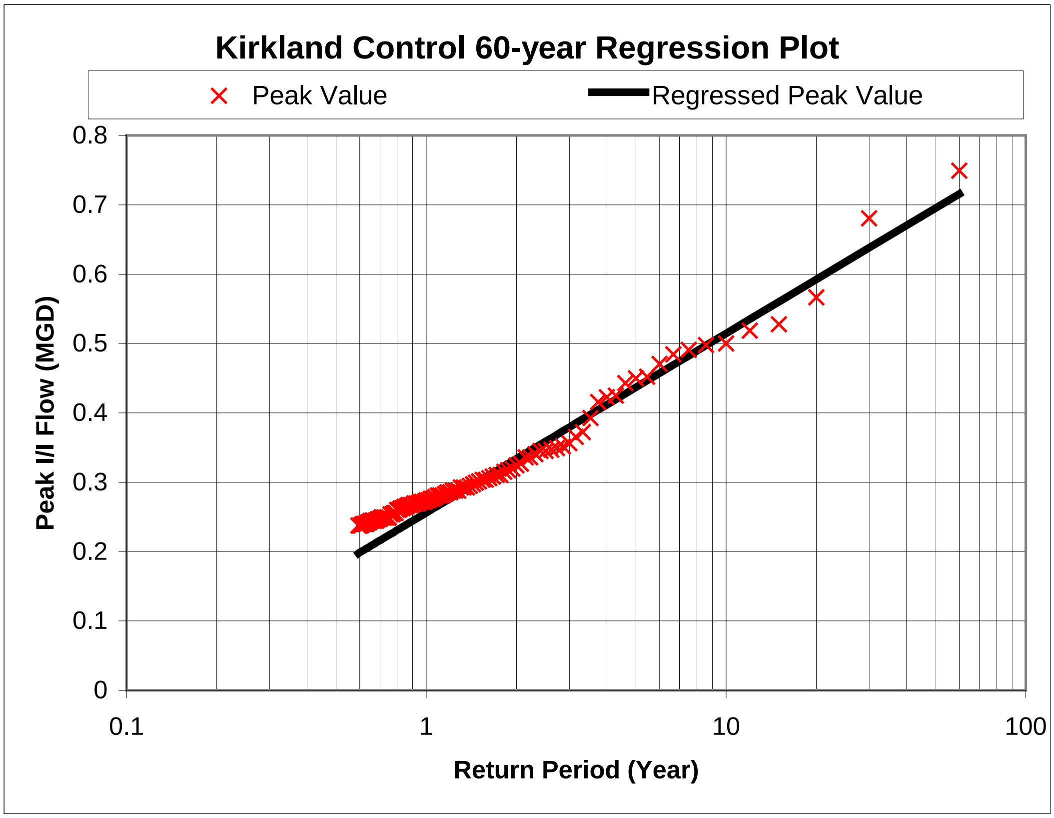
Brier Pilot 60-year Regression Plot
Pre-Rehab Peak Value
Post-Rehab Peak Value
Pre-Rehab Regressed Peak Value
Post Rehab Regressed Peak Value
Peak I/I Flow (MGD)
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
Return Period (Year)

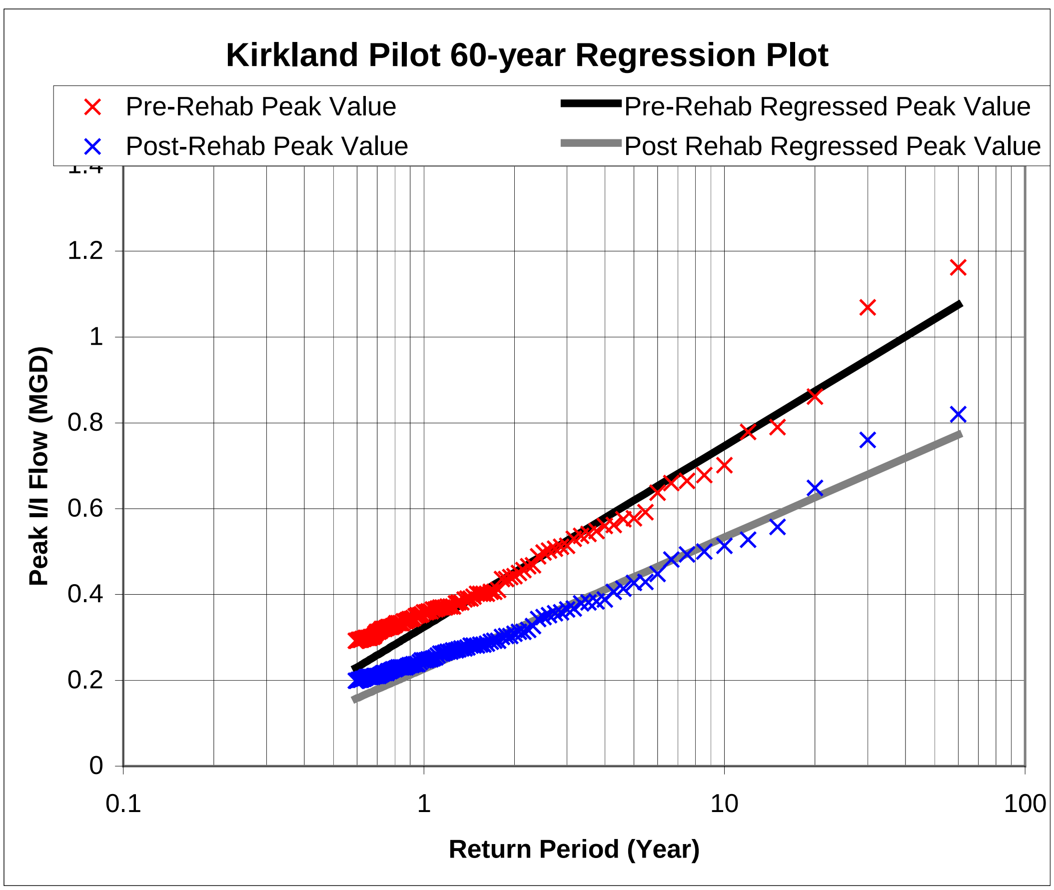

Coal Creek Control 60-year Regression Plot
Peak Value
Regressed Peak Value
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Peak I/I Flow (MGD)
0.1
1
10
100
Return Period (Year)

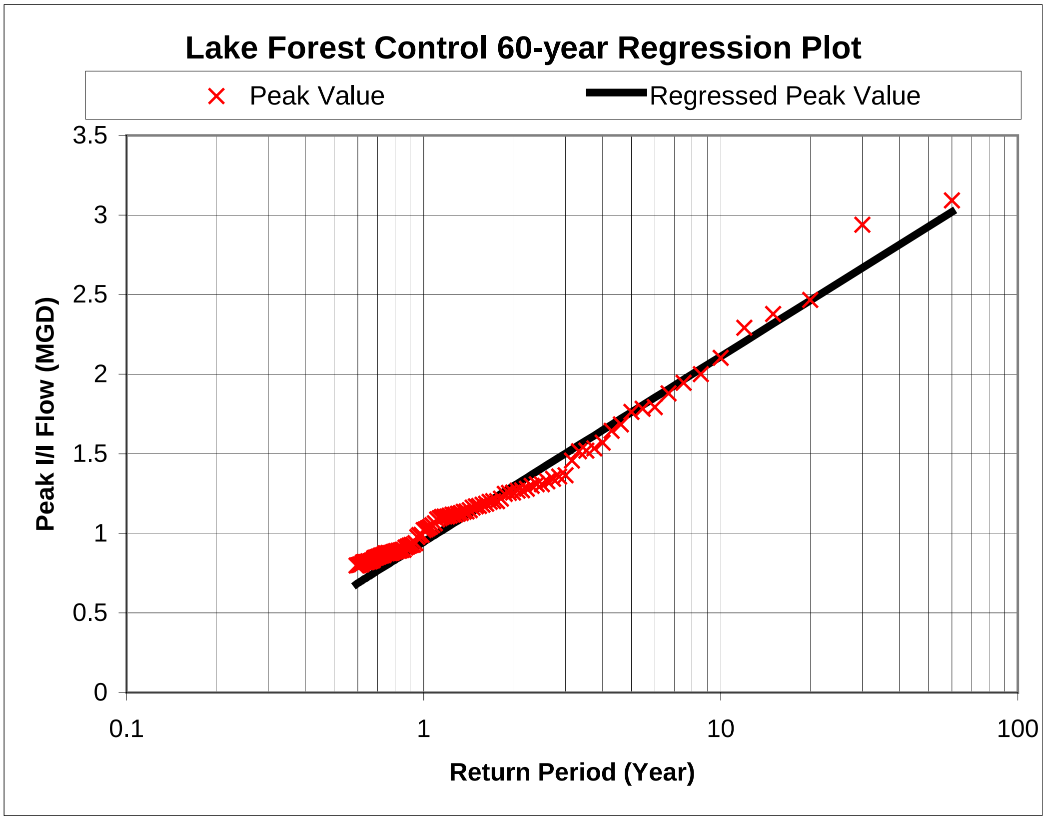

Coal Creek Pilot 60-year Regression Plot
Peak Value
Regressed Peak Value
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Peak I/I Flow (MGD)
0.1
1
10
100
Return Period (Year)

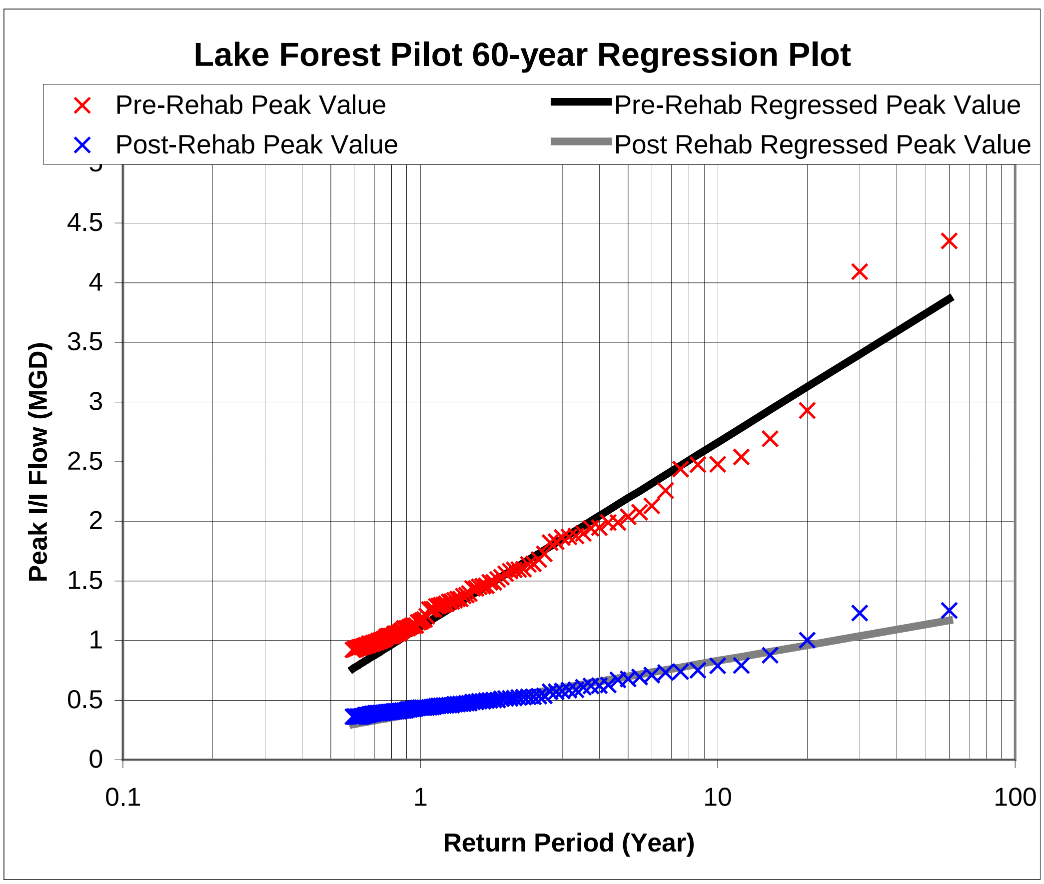

Kent Control 60-year Regression Plot
Peak Value
Regressed Peak Value
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Peak I/I Flow (MGD)
0.1
1
10
100
Return Period (Year)

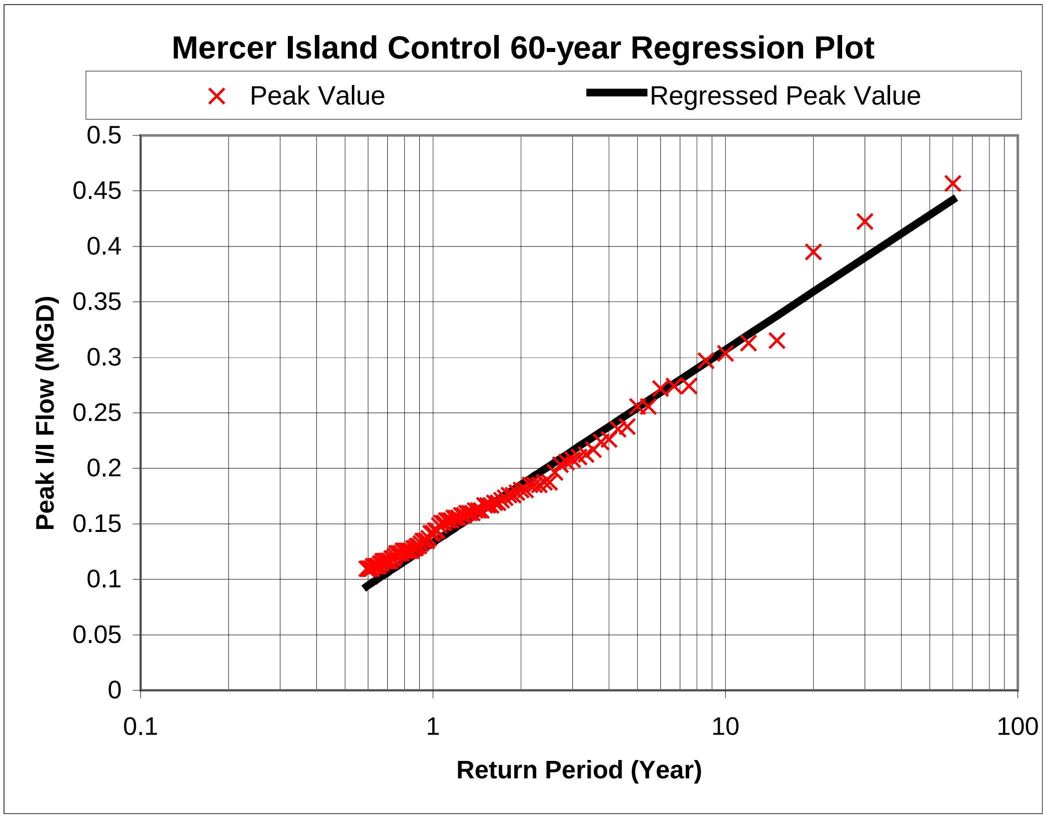

Kent Pilot 60-year Regression Plot
Pre-Rehab Peak Value
Pre-Rehab Regressed Peak Value
Post-Rehab Peak Value 1
Post Rehab Regressed Peak Value 1
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Peak I/I Flow (MGD)
0.1
1
10
100
Return Period (Year)

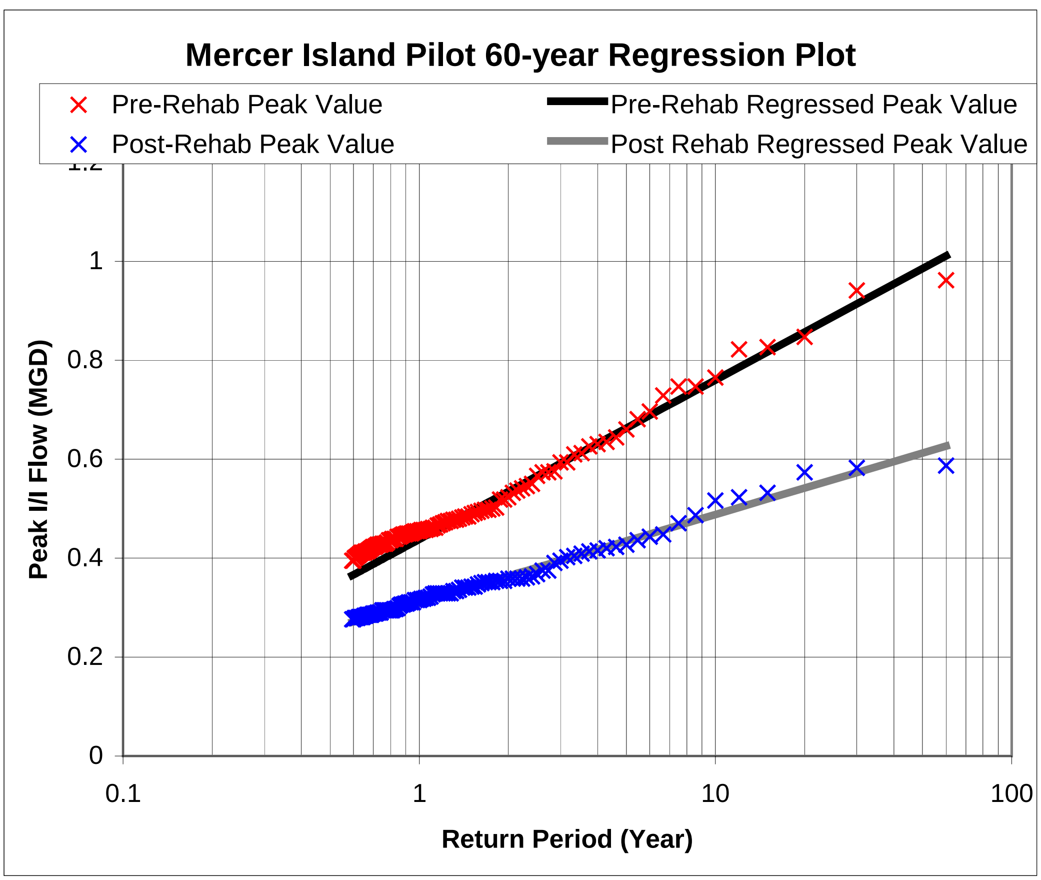

Kirkland Control 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
1
10
100
Return Period (Year)

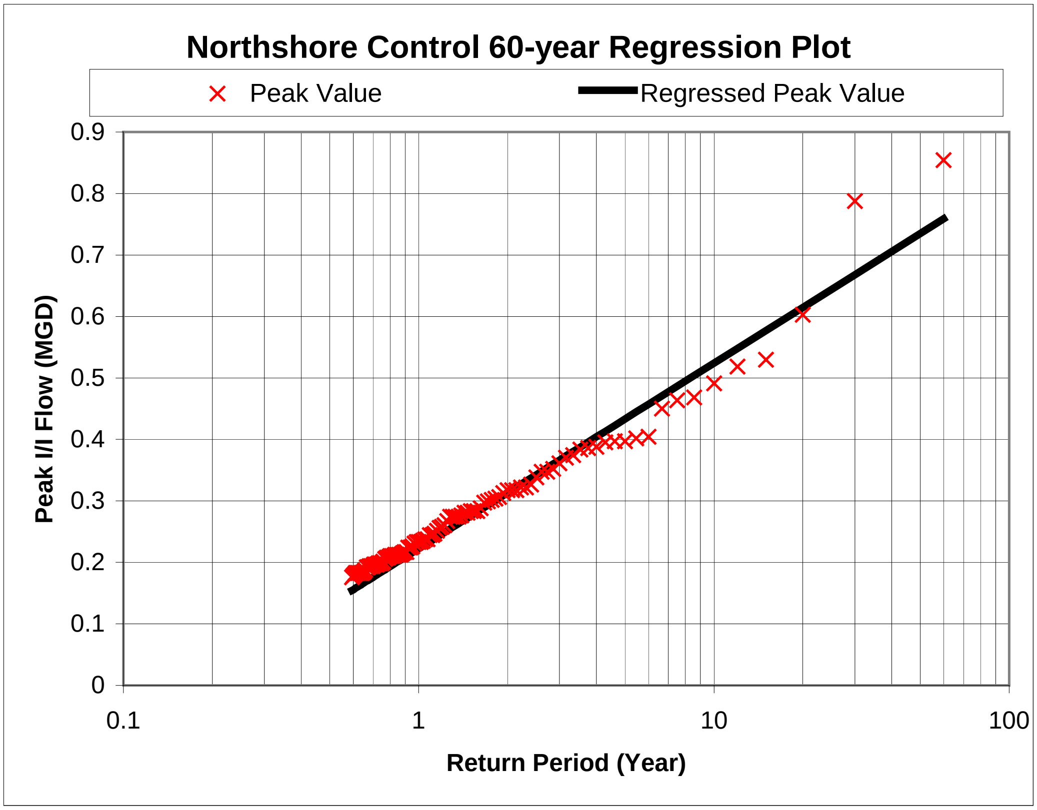

Kirkland Pilot 60-year Regression Plot
Pre-Rehab Peak Value
Pre-Rehab Regressed Peak Value
Post-Rehab Peak Value
Post Rehab Regressed Peak Value
Peak I/I Flow (MGD)
1.2
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
Return Period (Year)

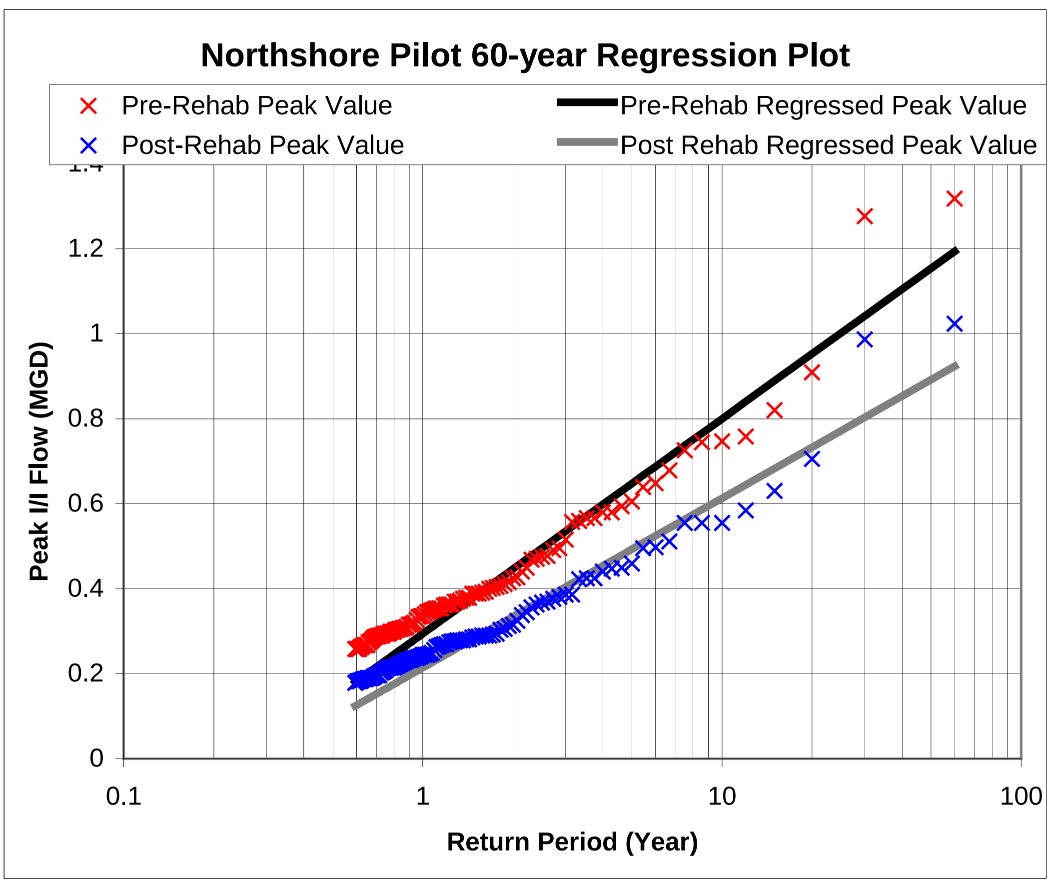

Lake Forest Control 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
Return Period (Year)
0
0.5
1
1.5
2
2.5
3
3.5
0.1
1
10
100

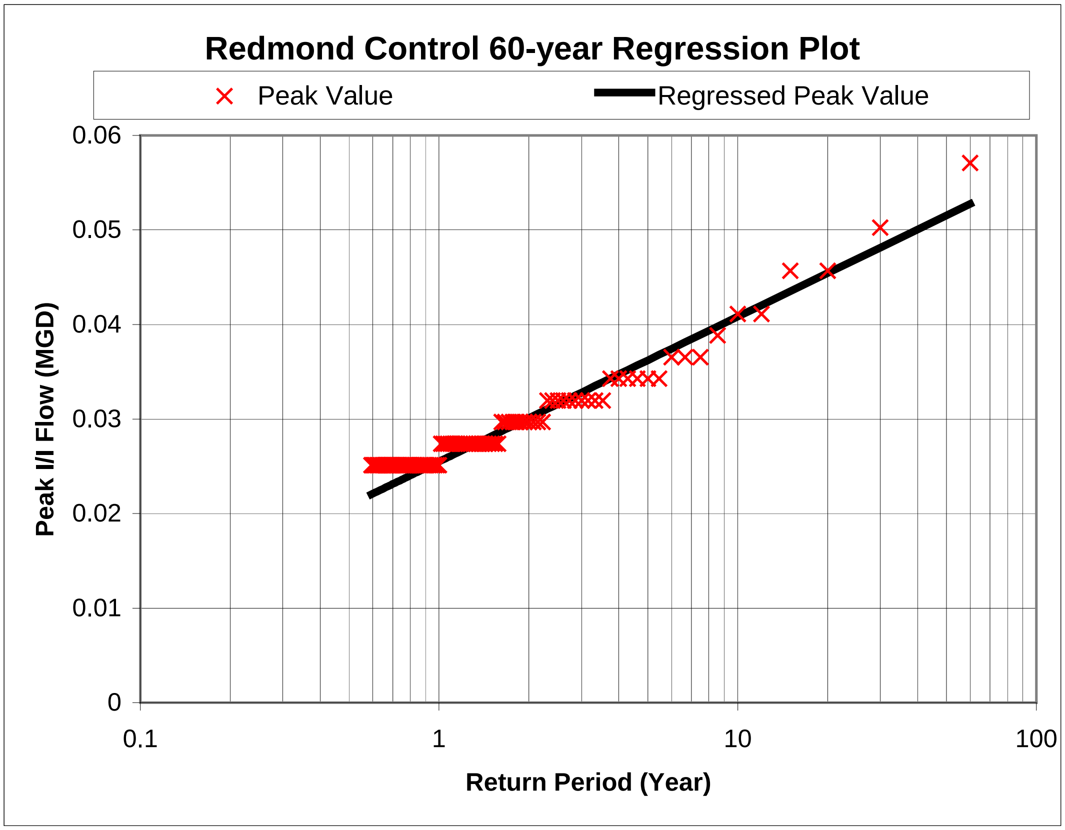

Lake Forest Pilot 60-year Regression Plot
Pre-Rehab Peak Value
Post-Rehab Peak Value
Pre-Rehab Regressed Peak Value
Post Rehab Regressed Peak Value
Peak I/I Flow (MGD)
Return Period (Year)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0.1
1
10
100

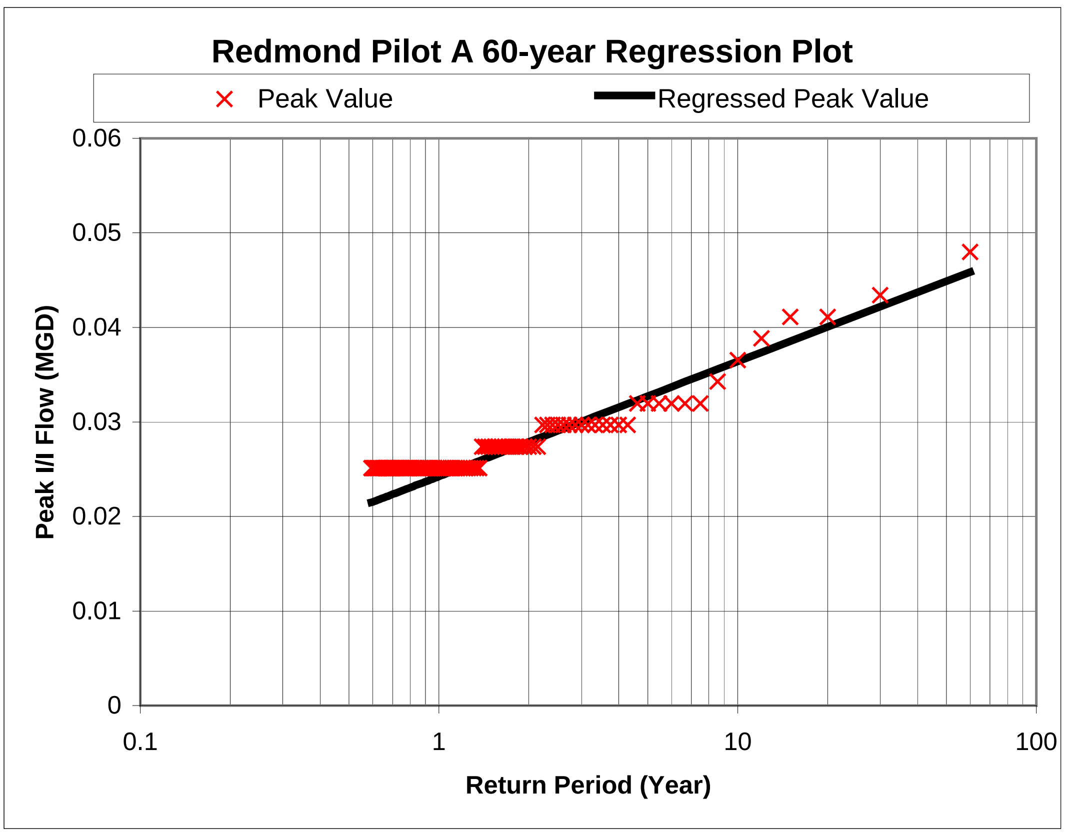

Mercer Island Control 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.1
1
10
100
Return Period (Year)

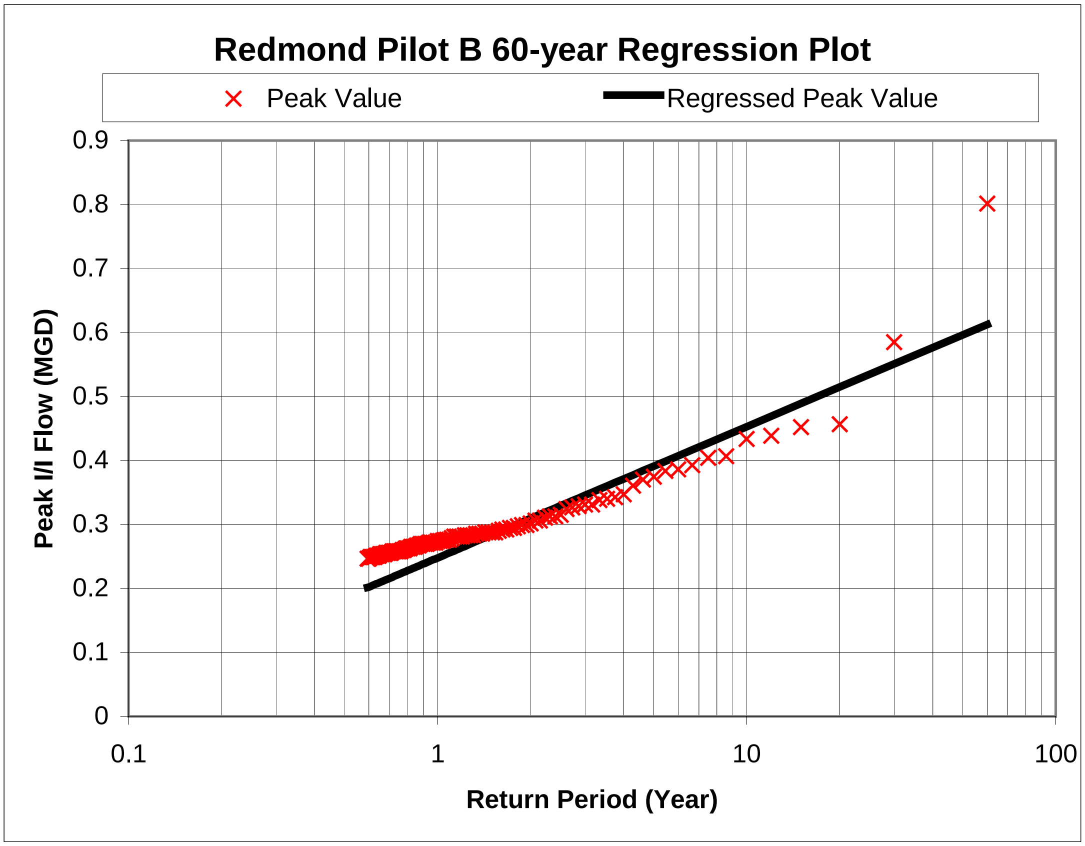

Mercer Island Pilot 60-year Regression Plot
Pre-Rehab Peak Value
Post-Rehab Peak Value
Pre-Rehab Regressed Peak Value
Post Rehab Regressed Peak Value
Peak I/I Flow (MGD)
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
Return Period (Year)

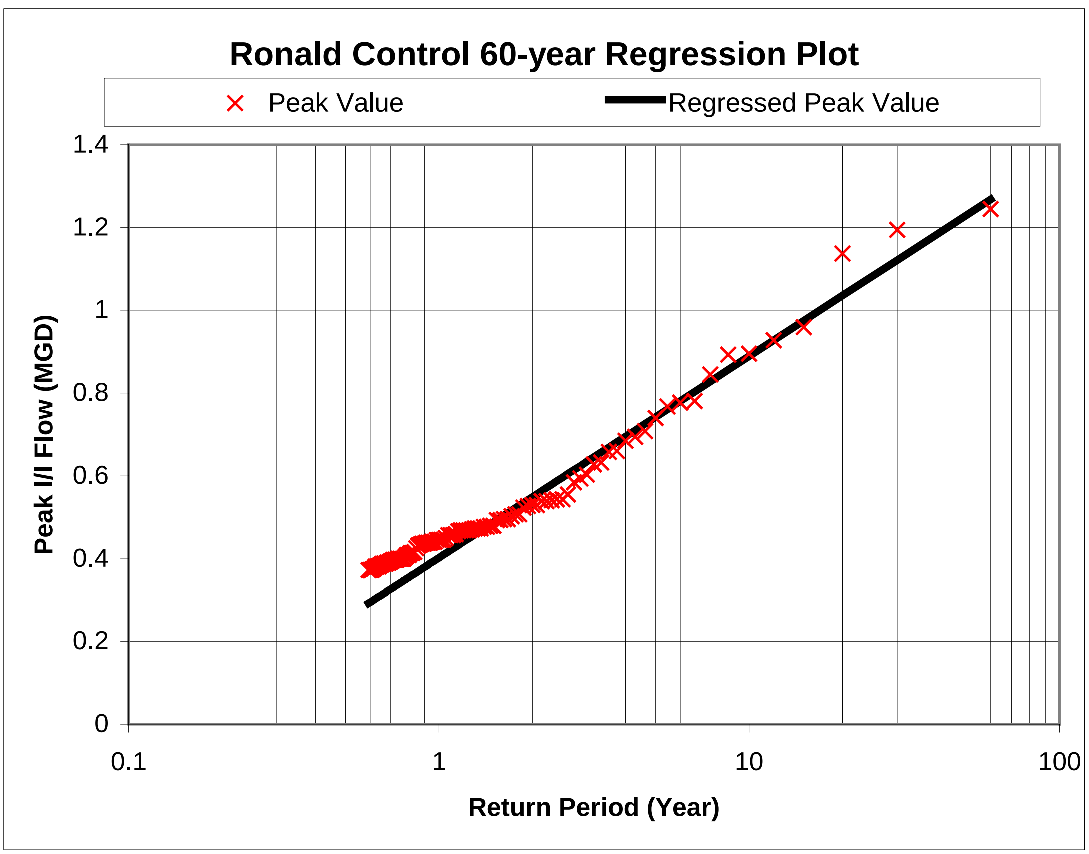

Northshore Control 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
1
10
100
Return Period (Year)

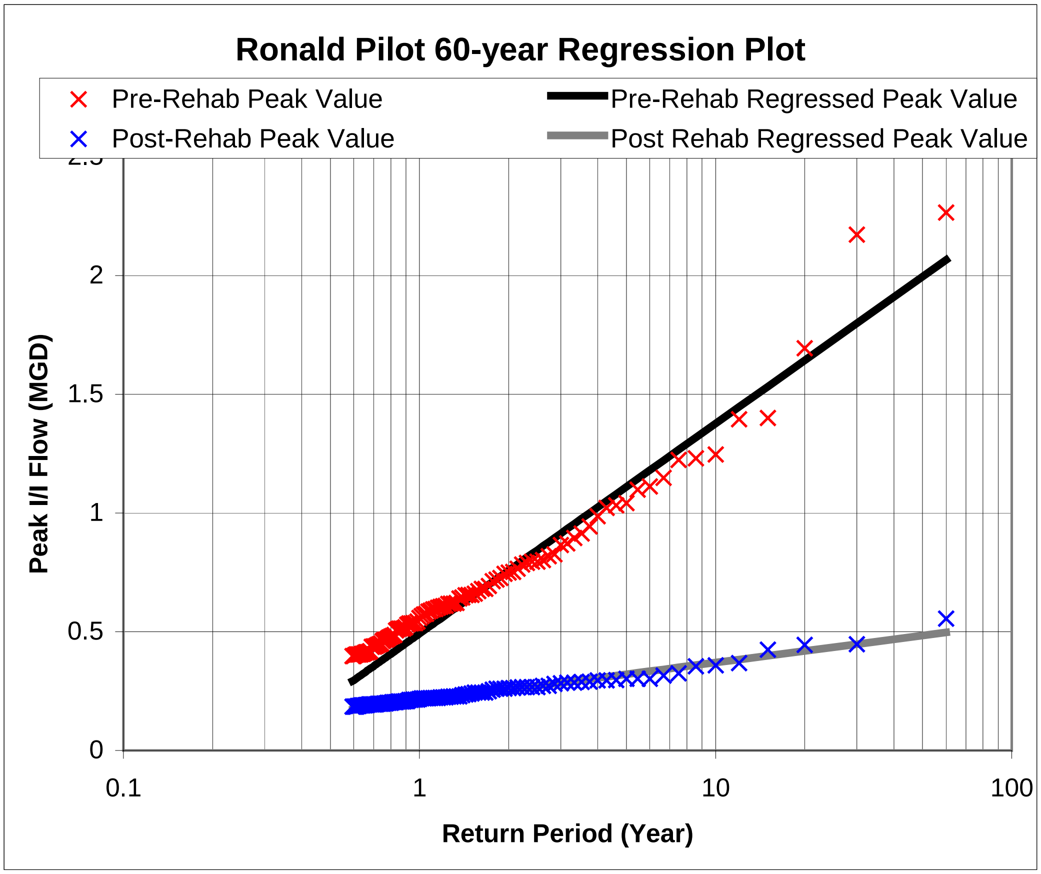

Northshore Pilot 60-year Regression Plot
Pre-Rehab Peak Value
Pre-Rehab Regressed Peak Value
Post-Rehab Peak Value
Post Rehab Regressed Peak Value
Peak I/I Flow (MGD)
1.2
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
Return Period (Year)

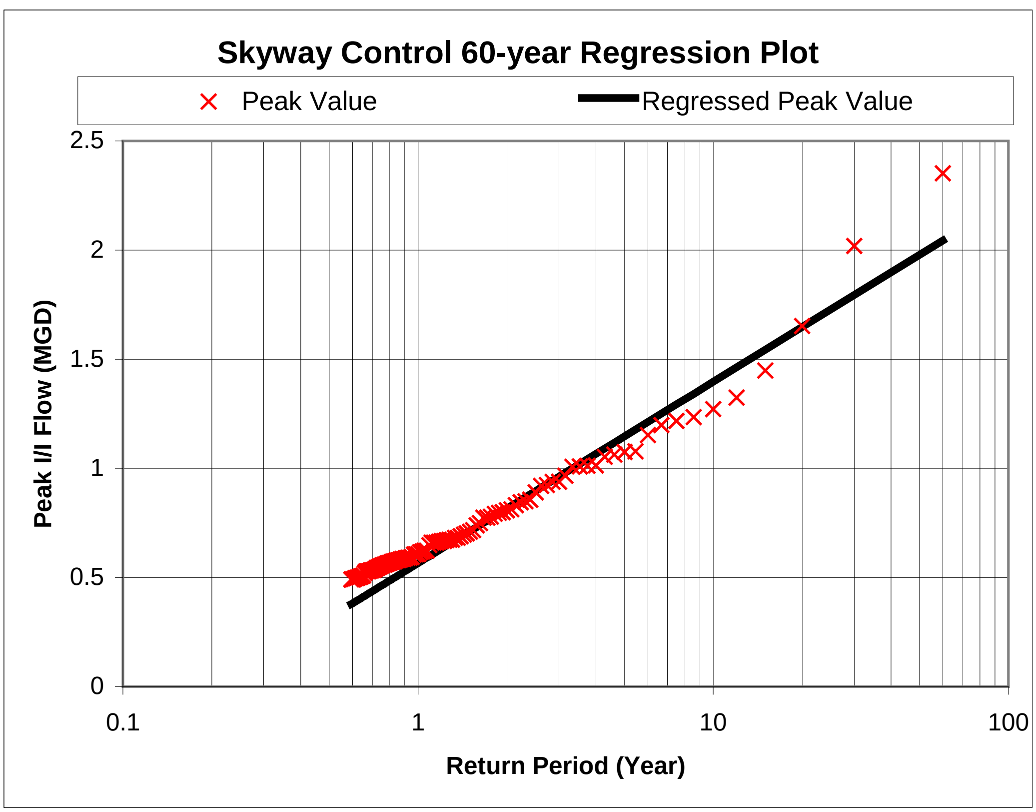

Redmond Control 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
0.06
0.05
0.04
0.03
0.02
0.01
0
0.1
1
10
100
Return Period (Year)

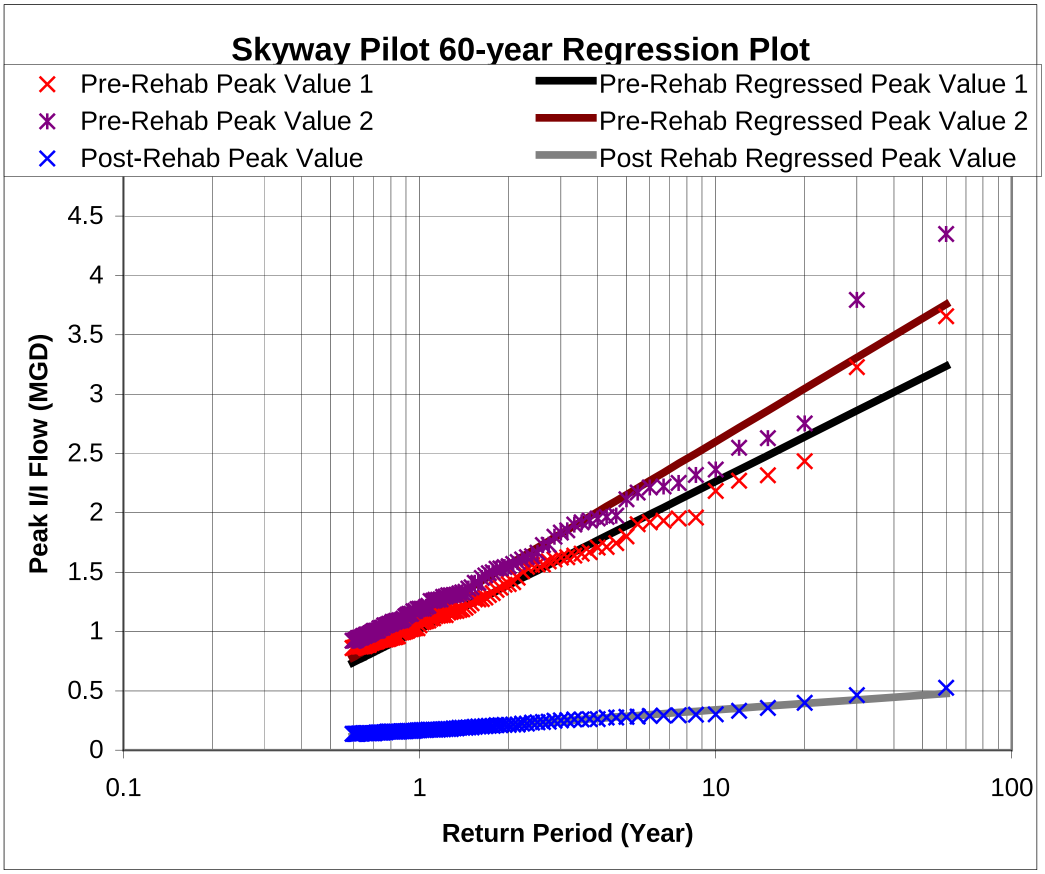

Redmond Pilot A 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
0.06
0.05
0.04
0.03
0.02
0.01
0
0.1
1
10
100
Return Period (Year)


Redmond Pilot B 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
1
10
100
Return Period (Year)

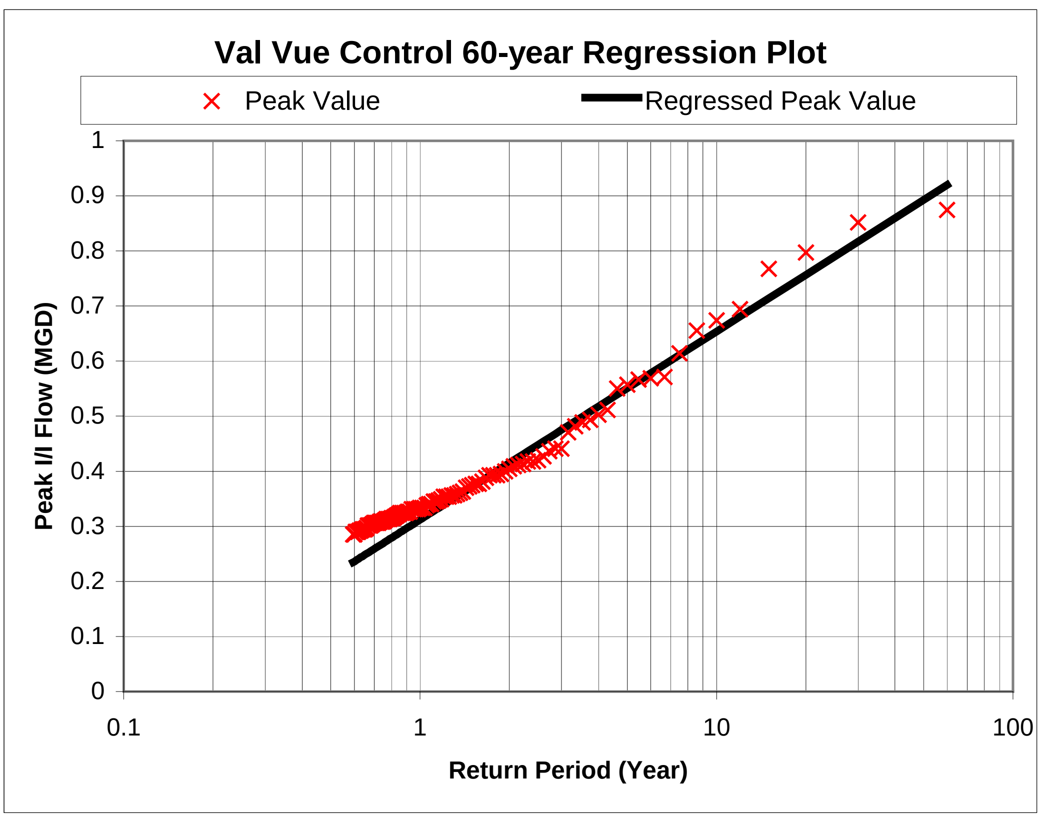

Ronald Control 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
Return Period (Year)


Ronald Pilot 60-year Regression Plot
Pre-Rehab Peak Value
Pre-Rehab Regressed Peak Value
Post-Rehab Peak Value
Post Rehab Regressed Peak Value
Peak I/I Flow (MGD)
2
1.5
1
0.5
0
0.1
1
10
100
Return Period (Year)

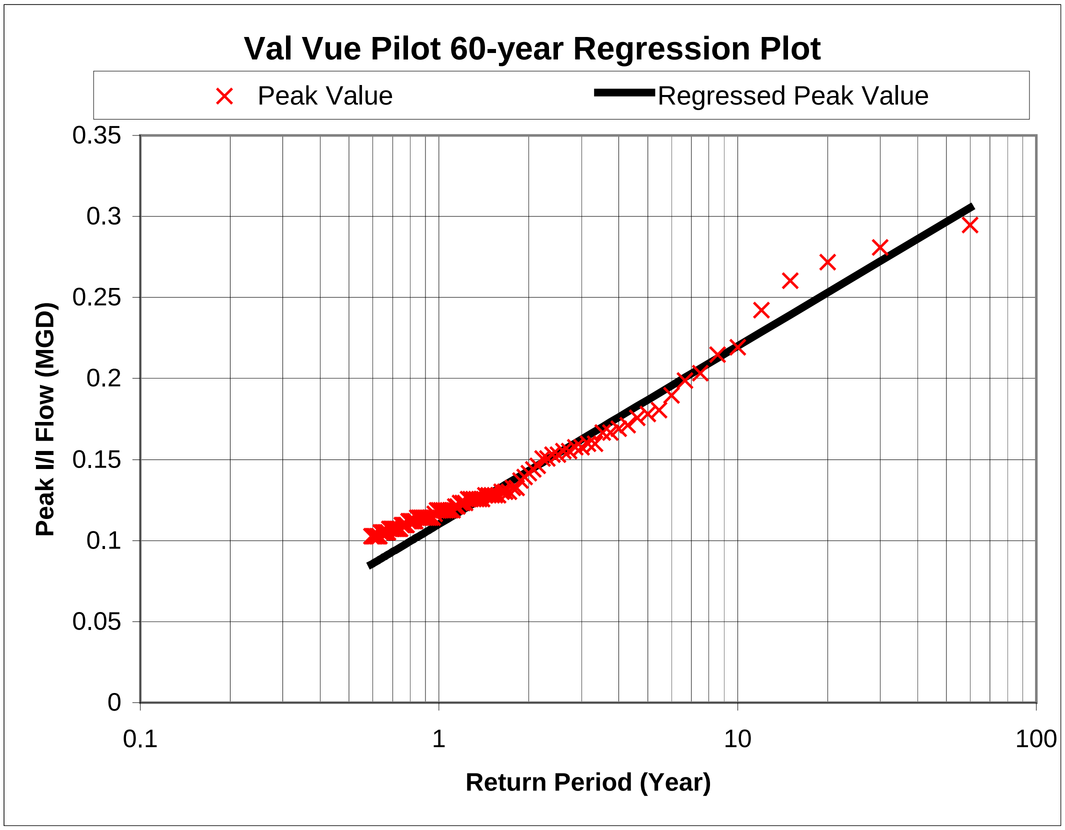

Skyway Control 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
2.5
2
1.5
1
0.5
0
0.1
1
10
100
Return Period (Year)



Skyway Pilot 60-year Regression Plot
Pre-Rehab Peak Value 1
Pre-Rehab Peak Value 2
Post-Rehab Peak Value
Pre-Rehab Regressed Peak Value 1
Pre-Rehab Regressed Peak Value 2
Post Rehab Regressed Peak Value
Peak I/I Flow (MGD)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.1
1
10
100
Return Period (Year)



Val Vue Control 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
1
10
100
Return Period (Year)



Val Vue Pilot 60-year Regression Plot
Peak Value
Regressed Peak Value
Peak I/I Flow (MGD)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.1
1
10
100
Return Period (Year)