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State of Washington

Quality Assurance Project Plan

Crab Creek
Alternate Water Supply Route Study:
Water Quality Monitoring

July 2009

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Quality Assurance Project Plan

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Alternate Water Supply Route Study:
Water Quality Monitoring

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ERO – Eastern Regional Office
EOS – Eastern Operations Section
EAP - Environmental Assessment Program

Table of Contents

Abstract

Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance (QA) Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives.

The need for alternate water supply (feed) routes to supply water to Potholes Reservoir results from increased demand for water, lower irrigation return, and a desire to fulfill obligations in the 1945 Columbia Basin Project agreement. One component of this QA Project Plan is to develop a feed route which moves water from Billy Clapp Lake via Middle Crab Creek to Potholes Reservoir.

Ecology, the Quincy-Columbia Basin Irrigation District, and the U.S. Bureau of Reclamation have agreed to cooperatively monitor water quality along portions of the feed routes during 2009-2012. The purpose of the monitoring is to assess the current condition of the water and to measure effects of the increased streamflows along the new feed routes.

Ecology's Environmental Assessment Program will monitor six surface water sites within middle Crab Creek and up to five wells in the Crab Creek watershed to establish baseline conditions and monitor impacts to surface water and groundwater. These locations will be monitored for four years, 2009-12. Constituents measured will include nutrients, conductivity, pH, temperature, alkalinity, and turbidity. Data will be summarized in a memo to Ecology's Water Quality Program.

Background

The Columbia Basin Project was authorized by Congress in 1945 for the irrigation of 1,029,000 acres. Currently, about 671,000 acres are served by the Project. The Project was designed so that return flows from irrigation on the northern half of the Project area would be captured in Potholes Reservoir and used to irrigate the south half of the Project area. However, it was determined that irrigation development in the north half was not capable of providing the return flows needed to provide a full supply of water for the south end of the Project. To correct this problem, a feed route was developed to move water from Banks Lake to Potholes Reservoir.

Feeding is done early and late in the April-October irrigation season when demand for irrigation water is low and the East Low Canal is operating at less than full capacity. At these times, the "unused" capacity is used to carry feed water to Potholes Reservoir.

This route is the primary route; however, improvements in irrigation efficiency in the northern half of the Project have led to lower returns. In addition, demand for irrigation has increased. As a result, the demand on Potholes Reservoir is greater and the amount of "unused" capacity in the East Low Canal has declined. These factors have led to the need for a supplemental feed route to supply more water to Potholes Reservoir.

The feed routes currently identified are:

- Upper Crab Creek from Pinto Dam to Moses Lake.
- The West Canal using the W20 Lateral to Moses Lake.
- The West Canal to Potholes Reservoir using the Frenchman Hills Wasteway**.**

For the Crab Creek Supplemental Feed Route alternative, water would be discharged from Billy Clapp Lake to Brook Lake and routed down middle Crab Creek, increasing the volume of water typically conveyed down the stream at certain times of the year. Appendix A contains the executive summary of the project. Appendix B summarizes historic flows in the watershed.

The 2006 Washington State Legislature passed the Columbia River Basin Water Management Act, an act relating to water resource management in the Columbia River Basin (Chapter 90.90 Revised Code of Washington [RCW]). The Act directs Ecology to "aggressively pursue the development of water supplies to benefit both in-stream and out-of-stream uses." The Act also establishes the Columbia River Basin Water Supply Development Account and authorizes its use to assess, plan, and develop new storage; improve or alter operation of existing storage facilities; implement conservation projects; or undertake any other actions designed to provide access to new water supplies within the Columbia River Basin.

Ecology, the Quincy-Columbia Basin Irrigation District, and the U.S. Bureau of Reclamation have agreed to work cooperatively to assess the water quality impacts of this project. Reclamation will do monitoring along Rocky Ford Creek. The Quincy-Columbia Basin Irrigation District will monitor along the West Canal and Frenchman Hills feed route. Ecology's Water Quality Program will work with Ecology's Environmental Assessment Program to monitor the Crab Creek alternate feed route.

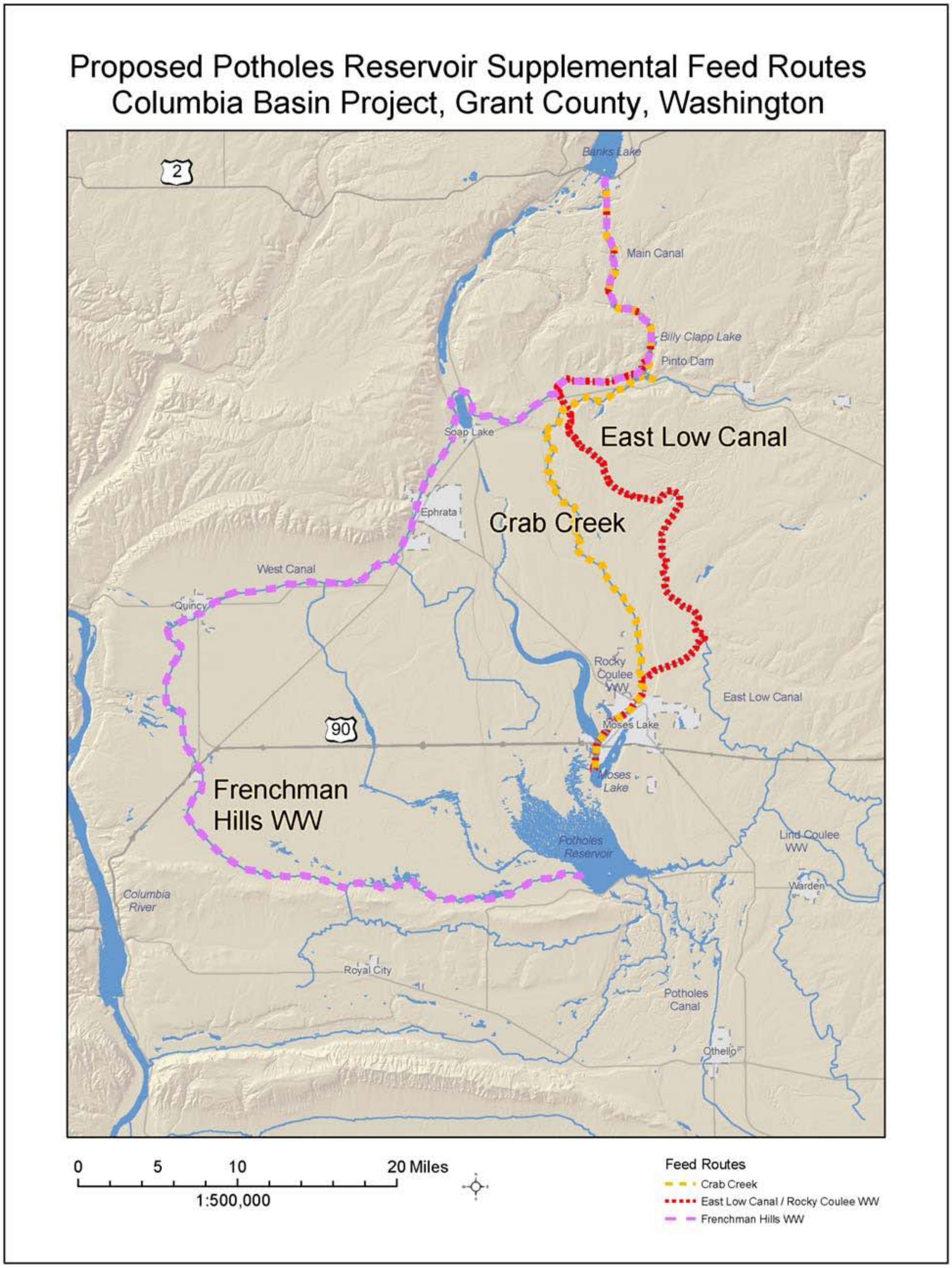

Figure 1. Proposed Alternate Feed Routes.

Crab Creek is one of the few perennial streams in the Columbia Basin of central Washington, flowing 163 miles from the northeastern Columbia River Plateau to the Columbia River. Crab Creek is separated into Upper Crab Creek, which runs from the creek's source to Moses Lake, and Lower Crab Creek, which runs from Potholes Reservoir to the Columbia River. Upper Crab Creek was dry before the project and remains intermittent today. The Crab Creek Watershed (5097 mi^2) has been transformed by the large scale irrigation of the project that has raised water table levels, significantly extending the length of Crab Creek and creating additional waterways and reservoirs.

Historic Water Quality Information

Other Agencies

From the programmatic Environmental Impact Statement (EIS):Impacts of the program on Water Quality (USBR, FONSI, 2007)

"The Crab Creek route will require modifications to the outlet at Pinto Dam to minimize the potential for erosion; modifications to the outlet of Brook Lake to prevent inundation of the toe drains at Pinto Dam; modifications (deepening) to the Crab Creek channel from Brook Lake to Round Lake; and replacement of culverts at Stratford Road. Erosion and sedimentation are likely to occur with channel modification and construction and the higher flows associated with the Crab Creek alternative. The Crab Creek channel may enlarge in response to higher flows causing erosion in excess of what currently occurs as the channel changes shape to meet a new "channel forming" flow. These sediment inputs to water bodies, even if short-term, may be significant. Inputs of sediment to any water body may increase turbidity until the site is revegetated. Inputs of fine sediment may also affect the substrate condition in streams. The level of impact will vary with the amount of sediment input into the water body. Additionally, the import of non-native soils may affect the chemistry of nearby surface waters.

Given the hydraulic continuity between ground water and surface water over some reaches in this stream, it is expected that impacts may include short-term changes to shallow ground water levels and ground water/surface water interaction associated with channel modifications. Some of the water discharged into Crab Creek will infiltrate into ground water, reducing the increase in flow in Crab Creek. The ground water is expected to resurface in Rocky Ford Creek, increasing surface water flow in that stream.

The Supplemental Feed Route alternatives will all involve linking water bodies and conveyance facilities that have different water quality. Ultimately, water quality in Potholes Reservoir could change because the timing of the additional flows in the Supplemental Feed Routes would change. Depending on the feed route chosen, water quality in Lake Roosevelt, Banks Lake, Billy Clapp Lake, Brook Lake, Upper Crab Creek, Moses Lake, Rocky Ford Creek, Rocky Coulee Creek, West Canal, and the Frenchman Hills Wasteway all have the potential to impact water quality in Potholes Reservoir.

The Crab Creek alternative is not expected to increase the temperature of the water flowing into the receiving areas. However, the Crab Creek route could decrease Rocky Coulee Creek's *temperature by potentially increasing ground water inputs from the additional infiltration from Crab Creek.*

The temperature of water delivered to Moses Lake could have an influence on lake dynamics and trophic state. Depending on the timing of delivery, larger inflows of cooler water could improve water quality and existing eutrophic or hypereutrophic conditions present during the summer months. The additional water fed through the lake in the summer months could dilute the concentration of total phosphorus and reduce algal mass. However, the Crab Creek alternative may introduce additional phosphorus as it migrates through the Adrian Sink from Crab Creek to Rocky Ford Creek. The Crab Creek alternative could increase water circulation and flush phosphorus from the main arm of the lake below the mouth of Rocky Ford Creek. Increased sediment loads could increase nutrient or other contaminant loads and further degrade water quality."

Ecology

Ecology's ambient monitoring program has a limited set of water quality data from lower Crab Creek (site 41A110). It is attached as Appendix C. Additional data from monitoring work conducted in support of the Moses Lake Total Maximum Daily Load (TMDL) study (unpublished) is available from Ecology's Environmental Information Management (EIM) database.

Project Goals and Sampling Design

Goals

The goals of this 2009-12 project are to:

- Establish a baseline for surface water and groundwater quality.
- Monitor surface water and groundwater to assess impacts of additional water transport.

Sampling Design

Figure 2 shows the sampling site locations, and Table 1 presents a summary of all sampling sites.

Table 1. Sampling summary, 2009-12.

Year	Surface Water		Groundwater	
	Sites	Visits	Sites	Visits
2009	7	19	5	12
2010	7	12	5	12
2011	7	12	5	12
2012	7	12	5	12

Surface water sites

Ecology will monitor six surface water sites. During the first two years of the study, surface water sites will be sampled twice a month during the irrigation season (April-October) and once a month the rest of the year. For the remaining two years, all sites will be sampled monthly.

Parameters monitored for surface water sites will be flow, pH, conductivity, dissolved oxygen, temperature, total suspended sediments, alkalinity, turbidity, and nutrients.

Table 2 describes the surface water sampling locations.

Table 2. Surface water sampling locations.

Station Name	Latitude	Longitude	Description
43A170	47.4279	-119.2721	Crab Creek at Brook Lake outlet
42A070	47.3829	-119.3848	Crab Creek at Adrian
41A150	47.3223	-119.3551	Crab Creek at Rd 16
41A130	47.2255	-119.2765	Crab Creek at Stratford Rd
41A110	47.1898	-119.2647	Crab Creek near Moses Lake
41A105	47.1459	-119.2640	Crab Creek at mouth
41H050	47.0806	-119.3324	Moses Lake at south outlet

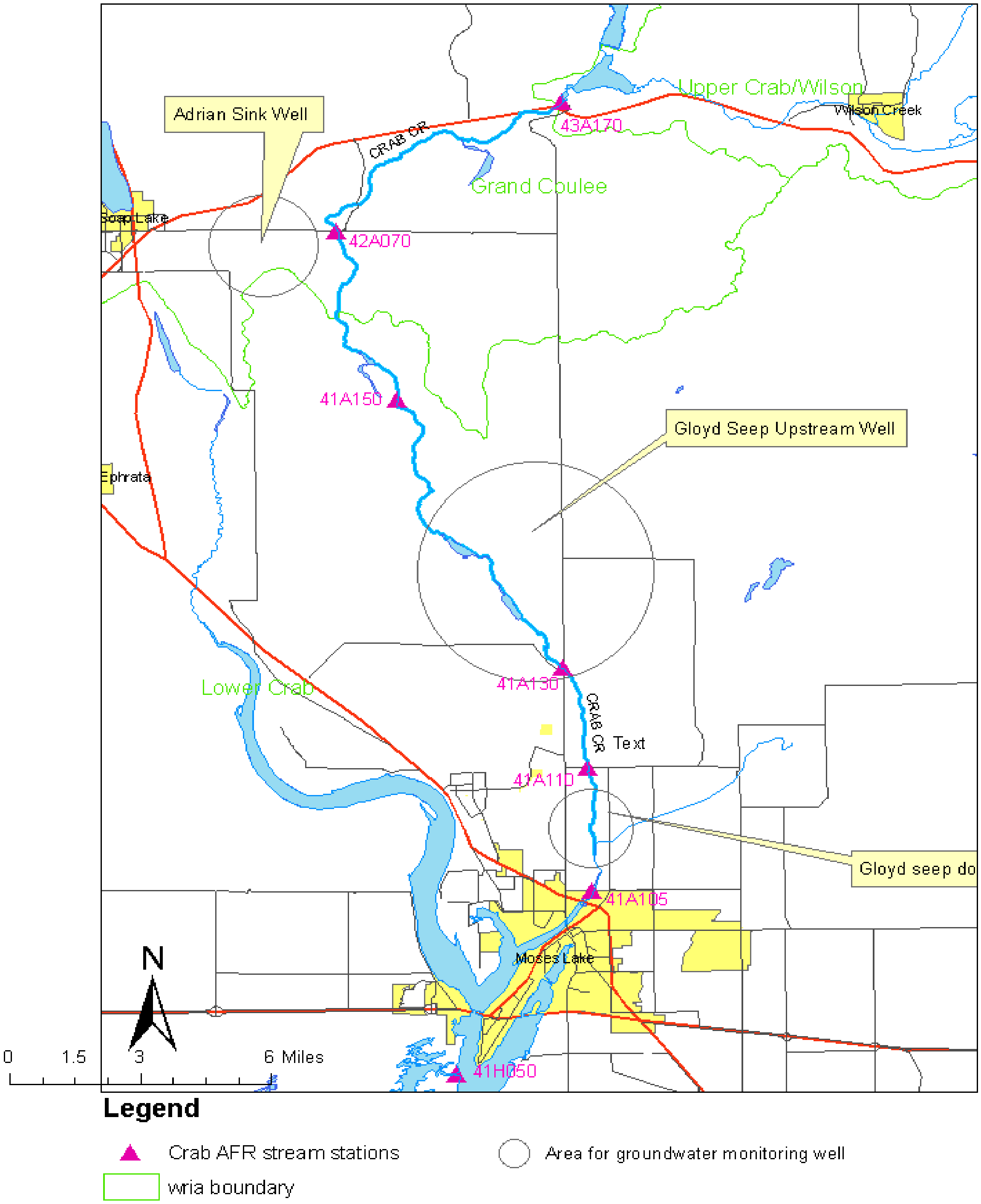

Figure 2. Crab Creek Alternate Feed Route Sampling Locations.

AFR = Alternate Feed Route; wria = Water Resource Inventory Area.

Groundwater sites

Up to five wells will be sampled. The wells will be sampled monthly for the duration of the project.

Parameters monitored will be water level, pH, conductivity, temperature, alkalinity, and nutrients.

Existing groundwater well sites are still being selected. Since there is not a suitable existing well near our desired locations, they will be drilled if permissions are obtained. One or two wells will be located in the Adrian Sink area, one in the Gloyd Seep area upstream of the hatcheries, one in the Gloyd Seep area downstream of the hatcheries, and possibly one east of the Potholes Reservoir.

Well locations are listed in Table 3 and indicated by gray circles in Figure 2.

Table 3. Groundwater sampling locations.

Well Name	Latitude	Longitude	Description
TBD	TBD	TBD	Adrian Sink 1
TBD	TBD	TBD	Adrian Sink 2
TBD	TBD	TBD	Gloyd Seep upstream
TBD	TBD	TBD	Gloyd Seep downstream
TBD	TBD	TBD	East of Potholes Reservoir

Organization, Schedule, and Laboratory Costs

The following people are involved in this project. All are employees of the Washington State Department of Ecology.

Table 4. Organization of project staff and responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
James Ross Eastern Operations Section Eastern Regional Office (509) 329-3425	Project Manager	Writes the QAPP, conducts QA review of data, analyzes and interprets data, and writes the data memo.
Tighe Stewart Eastern Operations Section Eastern Regional Office (509) 329-3476	Principal Investigator	Conducts field sampling and transportation of samples to the laboratory, conducts QA review of data, analyzes and interprets data, enters data into EIM.
Gary Arnold Eastern Operations Section Eastern Regional Office/ Central Regional Office (509) 454-4244	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Wayne Peterson Water Quality Program Eastern Regional Office (509)329-3518	Hydrogeologist	Selects sites for the monitoring wells and reviews the draft QAPP.
David Knight Water Quality Program Eastern Regional Office (509) 329-3500	EAP Client	Clarifies scopes of the project, provides internal review of the QAPP, and approves the final QAPP.
Stuart Magoon Manchester Environmental Laboratory (360) 871-8801	Director	Approves the final QAPP.
William R. Kammin (360) 407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

EAP – Environmental Assessment Program
QAPP – Quality Assurance Project Plan
EIM – Environmental Information Management system

Table 5. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	
Field work commences	March 23, 2009
Field work completed	October 31, 2012
Laboratory analyses completed	December 31, 2012
Environmental Information System (EIM) system	
EIM data engineer	Dan Sherratt
EIM user study ID	jros011
EIM study name	Crab Creek AFR
Data due in EIM	June 30, 2013
Final report (memo only)	
Author lead	James Ross
Schedule	
Draft due to supervisor	March 31, 2013
Draft due to client/peer reviewer	May 31, 2013
Draft due to external reviewer(s)	NA
Final memo due on web	June 30, 2013

Table 6. Laboratory cost estimate.

Sample type	Parameter	Sites	Visits	Analytical Cost ($)	Subtotal ($)
Surface Water	TSS/Alk/Turb	7	66	39	18,018
	Nutrients	7	66	76	35,112
Well Water	Alkalinity	6	53	17	5,406
	Nutrients	6	53	76	24,168
				Total	82,704

Costs include 50% discount for Manchester Laboratory.

Quality Objectives

Following is a table describing quality objectives for both field and laboratory analysis performed during this project.

Table 7. Measurement quality objectives.

Analysis	Method	Accuracy	Precision RSD	Bias	Reporting Limits
Field Measurements					
Flow					
pH	SM 4500-H^+	0.05 S.U.*	0.05 S.U.	0.10 S.U.	1-14 S.U.
Temperature	SM 2550B	0.1°C	0.025°C	0.05°C	1°C to 40°C
Dissolved Oxygen	SM 4500-O C	15%	<5%	±5%	0.1 to 15 mg/L
Specific Conductivity	SM 2510B	10%	<10%	±5%	1 umhos/cm
Laboratory Analyses					
Total Suspended Solids	SM 2540D	20%	<20%	N/A	1 mg/L
Turbidity	SM 2130B	20%	<20%	N/A	1 NTU
Alkalinity	SM 2320B	20%	<20%	±20%	1 mg/L
Total Persulfate Nitrogen	SM 4500-NO3 B	20%	<20%	±20%	25 ug/L
Ammonia Nitrogen	SM 4500-NH3 H	20%	<20%	±20%	10 ug/L
Nitrate & Nitrite Nitrogen	SM 4500-NO3 I	20%	<20%	±20%	10 ug/L
Orthophosphate P	SM 4500-P G	20%	<20%	±20%	3 ug/L
Total Phosphorus	SM 4500-P F	20%	<20%	±20%	5 ug/L

* S.U. - Standard Units

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Sampling Procedures

Table 8 lists the sample size, containers, preservation, and holding time for each parameter in this study. Sample containers will be provided by Ecology's Manchester Laboratory. Surface water sampling procedures will follow the guidance in Ecology's stream sample collection standard operating procedure (SOP) (Ward, 2007).

Well sampling will follow protocols being developed by Ecology's groundwater monitoring staff (Pitz et al., in progress). A portable peristaltic pump and pre-cleaned tubing will be used to purge the well until readings of pH and conductivity stabilize. Sample containers will then be filled, tagged and put on ice.

A Global Positioning System (GPS) will be used to record the coordinates of the sampling locations.

Table 8. Sample containers, preservation, and holding times.

Parameter	Container	Preservative	Holding time
Total suspended solids	1 L poly	Cool to 4°C	7 days
Turbidity	500 mL poly		48 hours
Alkalinity			14 days
Total Persulfate Nitrogen	125 poly	H_2SO_4 to pH < 2, 4°C	28 days
Ammonia Nitrogen			
Nitrate & Nitrite Nitrogen			
Orthophosphate P	125 poly	Filter, Cool to 4°C	48 hours
Total Phosphorus		HCL to pH < 2, 4°C	28 days

H_2SO_4 –Sulfuric acid.
HCL –Hydrochloric acid.

Measurement Procedures

Temperature, pH, conductivity, and dissolved oxygen will be analyzed in the field. All other parameters will be analyzed by Manchester Laboratory according to their current SOPs.

Methods selected will meet reporting limits in Table 7.

Quality Control Procedures

Field

Table 9 lists the field quality control (QC) samples for this project. Field QC will consist of replicate samples and field blanks. Replicates will consist of two samples taken at the same location and at nearly the same time. Field blanks will consist of deionized water that is processed as a sample (filtered, preserved, cooled) and returned to Manchester Laboratory for analysis.

Laboratory

Manchester Laboratory will follow their SOPs as described in their quality assurance manual (Manchester Laboratory, 2006). Laboratory QC will consist of using (1) laboratory control samples, method blanks, analytical duplicates, and matrix spikes, where appropriate, and (2) their standard practice. (See Table 9.)

Table 9. Quality control samples.

Parameter	Field		Laboratory			
	Replicates	Blanks	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes
pH/Conductivity	1/trip	N/A	In field	N/A	N/A	N/A
Nutrients	1/trip	1/year	1/batch	1/batch	1/batch	1/batch
TSS/Alk/Turb	1/trip	1/year	1/batch	1/batch	1/batch	N/A

Data Management Procedures

Case narratives included with the data package from Manchester Laboratory will discuss any problems encountered with the analysis, corrective action taken, changes to the requested analytical method, and a glossary for data qualifiers.

Laboratory data and quality control results, with any qualifiers noted, will be included in the data package. This information will be used to evaluate data quality and will act as acceptance criteria for the project data.

Field and laboratory data will be entered into Ecology's EIM system. Laboratory data will be downloaded directly into EIM from Manchester's Laboratory Information Management System (LIMS). Field data will be reviewed then entered into EIM by the project manager on a quarterly basis.

Data Verification

Verification of laboratory data is usually performed by a Manchester Laboratory unit supervisor or an analyst experienced with the particular method. It involves a detailed examination of the data package to determine whether method data quality objectives have been met. Manchester Laboratory's SOPs and EPA's functional guidelines will be used in the data assessment. Manchester Laboratory staff will provide a written report of their data review. This report will include a discussion verifying if: (1) measurement quality objectives were met, (2) proper analytical methods and protocols were followed, (3) calibrations and control were within limits, and (4) data were consistent, correct, and complete.

The project manager is responsible for final acceptance of the project data. The project manager will assess the complete data package for completeness and reasonableness. Based on these assessments, the data will be accepted, accepted with qualifications, or rejected.

Data Quality (Usability) Assessment

After the project data have been reviewed and verified, the project lead will determine if the data are of sufficient quality to make decisions for which the study was conducted. The project memo will discuss data quality and whether project objectives were met. It will also note any limitations in the data.

Audits and Reports

Manchester laboratory participates in performance and system of their routine procedures. Results of these audits are available upon request.

An annual memo summarizing the current year's data will be prepared and submitted to the client and cooperating agencies. At the end of the study, a final memo will be prepared that contains at a minimum:

- Map and photos of sampling locations
- Summary table of chemical and physical data, as well as pertinent field notes.
- Discussion of data quality and the significance of problems encountered
- Comparison of sample results with water quality standards
- Evaluation of significant findings and recommendations for further action

The final report (memo) will be prepared by June 30, 2013.

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Appendices

Appendix A. Crab Creek Alternate Feed Route Environmental Assessment

Technical Memorandum
Alternative A—Crab Creek

(Note: This document supports Alternatives 2A and 2B in the Draft Environmental Assessment)

Potholes Reservoir Supplemental Feed Route Draft Environmental Assessment

Columbia Basin Project
Grant County, Washington

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region April 2007

T E C H N I C A L M E M O R A N D U M

Bureau of Reclamation—Supplemental Feed Route for Potholes Reservoir

Alternative A—Crab Creek

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Joe Young/BOI
REVIEWED BY: Stan Schweissing/KEN
DATE: April 16, 2007
PROJECT NUMBER: 348226
TASK ORDER: 03C610150B Task Order 29

Executive Summary

The Bureau of Reclamation (Reclamation) is evaluating three alternatives for supplementing water supply to the Potholes Reservoir in central Washington. This memorandum is focused on Alternative C, which provides supplemental flows (released from the outlet works of Pinto Dam) to the Potholes Reservoir through the existing channel of Crab Creek.

The Crab Creek work includes initial scoping and evaluation of alternatives, surveying, and conceptual design and development of estimated costs for each element of this alternative. The work includes an evaluation of feasibility of construction, impacts to property, capital costs, and operations and maintenance requirements to identify the most beneficial configuration of this alternative to design, fund, and construct.

The memorandum presents the Crab Creek findings in three primary sections:

- Sediment Transport Analysis
- Structural Modifications
- Dieringer Dairy Wastewater Improvements

Each of the three sections includes a description of the associated field work, data analysis/modeling, conceptual design, and cost estimates. To support this work, Reclamation performed a test release from the Pinto Dam outlet during summer and fall 2006, including a 1,000 cfs release for a short time (which is approximately the maximum possible release from the outlet). The test releases presented an opportunity to observe water flowing throughout the entire 23-mile reach as well as at specific locations of interest including the Pinto Dam outlet, Brook Lake and its outlet, Crab Creek between Brook Lake and the East Low Siphon, and around the Dieringer Dairy. The test releases also provide an opportunity to measure discharge and suspended sediment as well as providing calibration data for the hydraulic and sediment transport modeling.

The first section, Sediment Transport Analysis, examines how an increase to the flows in Crab Creek could potentially influence the way water and sediment are transported in Crab Creek. The first section specifically addresses the following potential issues:

- Immediate and long-term rates of sediment delivery to Moses Lake
- Extent of inundation relative to land ownership
- Bank erosion

Work on the Sediment Transport Analysis included meetings with Reclamation and Washington Department of Fish and Wildlife (WDFW) staff, field reconnaissance, sediment sampling, hydraulic and sediment transport modeling, evaluation of Reclamation-provided inundation maps, identification of erosion-prone reaches, and descriptions of potential bank stabilization treatments.

Two scenarios for the release of water from Pinto Dam are being considered by Reclamation and are expected to deliver the following amounts of sediment to Moses Lake:

• A continuous release of 150 cfs would contribute approximately 2,013 tons (895 cubic yards), and an additional release of 500 cfs (resulting in an estimated flow of 433 cfs at Road 7) for approximately 2 months would contribute approximately 2,157 tons (959 cubic yards). Under this scenario, an estimated annual total of 4,171 tons (1,854 cubic yards) would be delivered annually to Moses Lake.

• A second scenario that releases 650 cfs (resulting in an estimated flow of 580 cfs at Road 7) for approximately 3 months would contribute approximately 5,432 tons (2,414 cubic yards) annually to Moses Lake.

The extent of inundation, along Crab Creek when supplemental flows are being released, is dependent upon the discharge. At a release of 2,400 cfs, approximately 2,612 acres are inundated. Of this acreage, 54 percent (1,422 acres) occurs on federal, state, or county land. Private land ownership within the inundated area encompasses the remaining 1,190 acres. Between Brook Lake and Road 7, data were collected at 27 locations along Crab Creek, including 3 structures and 7 road crossings. Based on field observations, 9 of the 27 sites are classified as moderate, high, or very high erodibility.

The second section, Structural Modifications, examines what modifications required to the channel and existing structures or facilities if flows were increased in Crab Creek. The second section specifically addresses the following potential issues:
• Channel modifications to Crab Creek between Brook Lake and the East Low Siphon to convey a maximum flow of 1,000 cfs
• Fish passage barrier to isolate Loan Springs at flows up to 850 cfs for the protection of a specific population of trout from other predatory species in Crab Creek
• Crossings at Road 10 NE, Walker Road, Lower Stratford, and Barren Road to convey 500 cfs
• Modifications to the Pinto Dam outlet spillway
• Modifications to the Brook Lake outlet

Work included meetings with Reclamation and Grant County staff, field reconnaissance and surveying assistance, hydraulic modeling, and development of conceptual-level drawings and associated cost estimates. Results of the structural modifications assessment identified several key constraints including the following:
• To convey 1,000 cfs in Crab Creek from Brook Lake to the East Low Siphon, excavation of the channel alone could cost as much as $12,000,000. Additional modifications to ensure long-term stability of the newly excavated channel could push the costs significantly higher. Based on these costs, Reclamation terminated the effort to consider channel modifications in this section of Crab Creek.
• To reduce the potential for carp accessing Loan Springs, a fish passage barrier would be constructed at the south end of Willow Lake at an estimated cost of $75,000.
• A total of six crossings would need to be built or improved to convey the expected flows along Crab Creek at an estimated cost of $832,000.
• The 1,000 cfs test release from the Pinto Dam outlet eroded a large scour pool in the silty soils adjacent to the existing plunge pool. In addition, the Brook Lake elevation eventually rose above the invert of the Pinto Dam outlet pipe and inundated the Pinto Dam toe drain weirs.

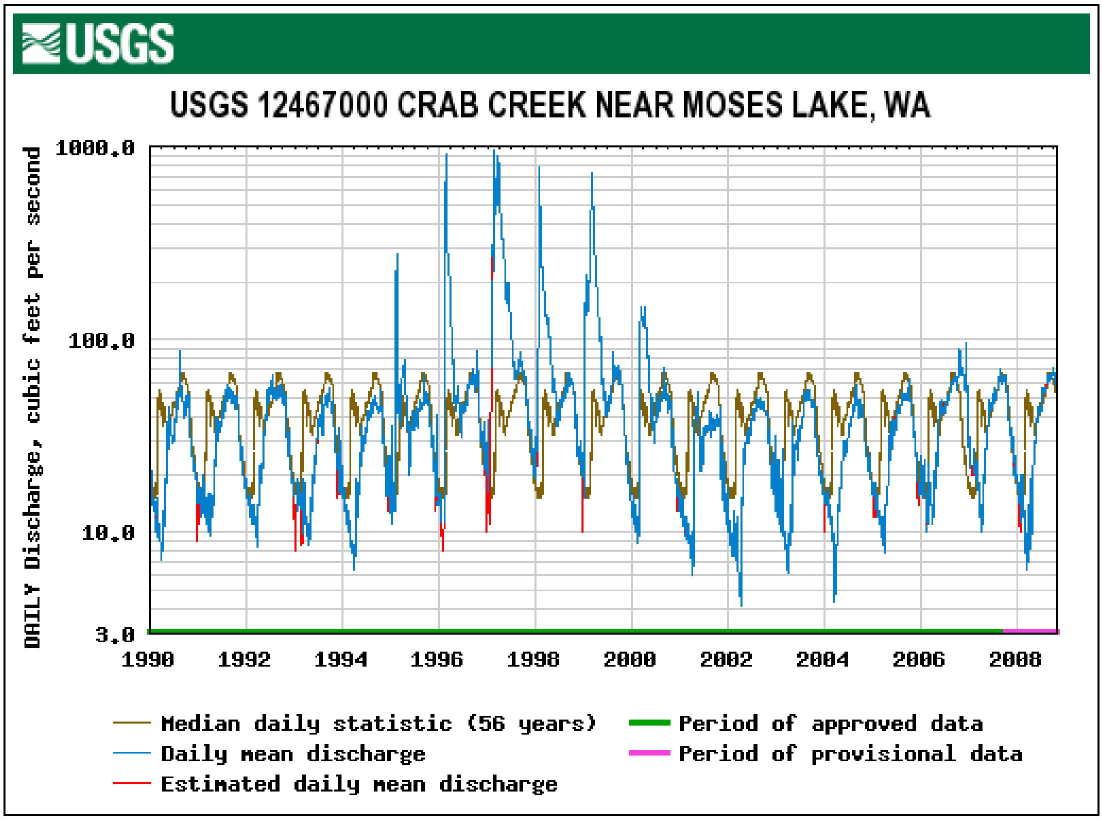
• The erosion and significant impacts from backwater below Pinto Dam in Brook Lake observed during the test release must be addressed for Crab Creek to be a viable supplemental feed route option. Spillway improvements (including a concrete discharge structure and placement of additional riprap) to minimize erosion at the Pinto Dam outlet are estimated to cost approximately $651,000.
• A flow measurement structure at the outlet of Brook Lake is required to allow Reclamation to properly manage supplemental flows released from Pinto Dam into Crab Creek. The estimated cost for a flow measurement weir at the Brook Lake outlet is $248,000.

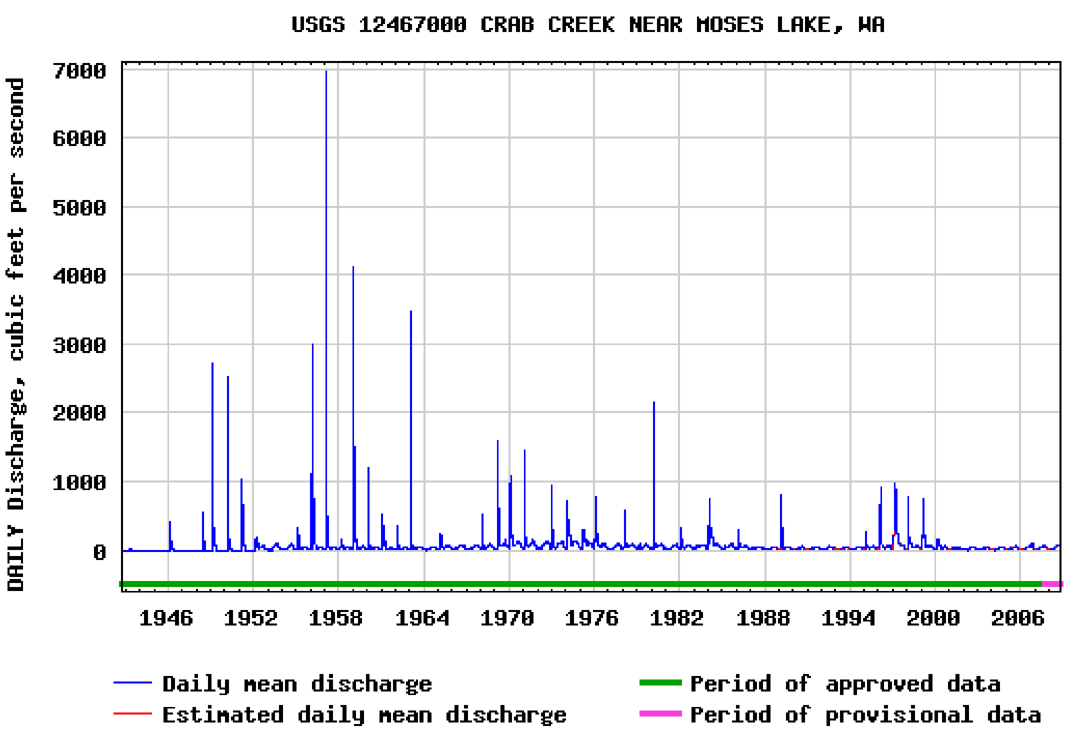
The third section, Dieringer Dairy Wastewater Improvements, examines the modifications required to allow dairy operations to continue at their present location when flows are increased in Crab Creek. The following improvements would be required if standing or flowing water were present in the Crab Creek channel south of the dairy barns (as occurred during the test releases):

• Construct two lined, 4,000,000-gallon lagoons to replace the existing lagoons.
• Construct a protective earth berm to isolate the dairy and irrigated land from the adjacent future water body.
• Construct two pump stations and a pipeline to convey wastewater from the dairy to and from the storage lagoons.
• Construct a stormwater collection and pumping system to convey water to the lagoons.

The estimated cost for these improvements is $2.6 million.

Appendix B. Crab Creek Historic Flows





Appendix C. Data from Crab Creek near Moses Lake (Ecology site 41A110)

Source file: www.ecy.wa.gov/apps/watersheds/riv/allstationdata_14params.asp?sta=41A110&sta_id=278

Table C-1. Historic water quality data collected by Ecology.

date	time	CO (u	FC (#/100ml)		FLOW (CFS)		NH3_N (mg/L)		NO2_ (mg/L	OP_DIS (mg/L)		OXYG (mg/L	PH (pH)		PRESS (mm/Hg	SUSSOL (mg/L)		TEMP (deg C)		TP_P (mg/L	TP_PI (mg/L	TPN (mg/L	TU (NT	Turb-JTU (JTU)	
7/24/1980	9:45	505	140		74		0.04			0.02		11.5	8.3		739	35		18.2		0.05			8		
8/21/1980	8:45	392	140		81		0.03			0.01	U	9.2	8.3		738	33		15.1		0.04			5		
9/18/1980	8:30	540	2	J	86		0.01	U				8.5	8		730	2		14.5		0.07			1		
10/23/1980	10:00	535	26		66		0.01	U		0.01	U	13.3	8.5		749	4		7.5		0.03			3		
11/13/1980	9:30	575	29		42		0.02			0.01			8.9		752	4		5.8		0.03			2		
12/11/1980	10:30	580	670	J	27		0.08			0.01	U	13.1	8.6		740	4		1.8		0.05			3		
1/15/1981	10:30	612	25		18		0.03			0.03		12.6	8.5		742	3		2.3		0.06			6		
2/5/1981	10:45	630	58		16		0.04			0.04		12.9	7.9		741	22		3		0.1			14		
3/19/1981	9:40	625	300		10		0.08			0.02		12.2	8.2		731	28		6		0.08			18		
4/16/1981	9:45	540	65		10		0.03			0.01	U	12.2	8.3		741	24		10.8		0.04			11		
5/7/1981	9:25	475	120		19		0.07			0.01	U	10.6	8.4		735	46		12.6		0.05			23		
6/4/1981	9:10	480	380	J	44		0.02			0.01	U	10.2	8.4		736	29		15.3		0.04			11		
7/9/1981	9:40	498	120		61		0.04			0.01	U	12.8	8.4		735	15		16.8		0.02			3		
8/6/1981	8:30	520	160		69		0.02			0.01	U	9.3	8.1		741	8		18.2		0.02			2		
9/10/1981	9:50	520	210		74		0.04			0.01	U	11.4	8.1		738	9		15.8		0.01			2		
10/8/1981	9:25	480	160		87		0.02			0.01		10.3	8		729	6		10.3		0.04			2		
11/5/1981	9:25	540	12	J	48		0.13			0.01	U	13.5	8.2		744	5		5.8		0.02			2		
12/10/1981	11:00	600			26		0.3			0.01		15.1	8.3		734	8		4.8		0.1			8		
3/4/1982	10:00	275	31		139		0.1			0.09		11	7.6		734	98		6		0.17			140		
4/8/1982	9:25	418	21		41		0.13			0.01		13.9	7.7		737	30		7.8		0.09			30		
5/6/1982	10:10	440			32		0.06			0.01	U	13.6	8		735	33		14.4		0.05			18		
6/10/1982	10:00	460			54		0.04			0.01			8.6		729	16		17.4		0.03			8		
7/12/1982	16:35	425	18	J	75		0.28			0.01	U	18.8	8.7		739	10		25					2		
8/5/1982	10:15	480	64		80		0.02			0.01	U	12.8	8.4		743	12		16.4		0.03			2		
9/9/1982	8:35	500	340		78		0.02			0.01	U	8.7	8.1		722	7		15.1		0.04			2		
10/6/1982	14:30	525	270		66		0.01			0.01	U	13.2	8.4		732	5		11.9		0.02			3		
11/4/1982	9:30	545	48		48		0.02			0.01	U	11.8	8.1		733	4		8.6		0.03			2		
12/9/1982	10:15	585	12	J	26		0.07			0.02		14.4	8.4		745	1	U	1.5		0.05			1		
1/6/1983	10:25	590	8	J	17		0.06			0.04		12.6	8		740	18		2.7		0.06			5		
2/17/1983	10:15	660	88		21		0.03			0.02		11	8.3		732	23		7.2		0.07			11		
3/10/1983	10:10	478	100	J	66		0.03			0.01	U	12.4	8.3		737	62		10.8		0.02			34		
4/14/1983	9:15	440	68	J	79		0.04			0.01	U	13.6	8.5		744	25		10		0.05			14		
5/5/1983	11:05	485	170		54		0.02			0.01	U	13.6	8.4		731	30		16.5		0.05			13		
6/9/1983	10:10	490	65		56		0.03			0.01	U	14.1	8.4		735	14		18.6		0.02			4		
7/14/1983	8:55	520	150		76		0.02			0.01	U	12	7.9		739	4		14.7		0.02			2		
8/4/1983	9:45	530	88		70		0.02			0.01	U		8.1		739	9		17.7		0.03			3		
9/15/1983	9:35	520	220		76		0.01			0.01	U	11.7	7.9		731	9		13.8		0.02			2		
10/4/1993	10:50	492	52		44		0.011		0.977	0.014		11.8	8.2		734.3	12		12.8		0.034		1.39	2.1		
11/1/1993	10:40	543	22		32		0.011		1.42	0.021		13.9	8.3		742.7	2		6.8		0.031		1.54	0.8		
12/6/1993	10:40	622	17		17		0.037		1.35	0.053		12.2	7.8		732	2		1.4		0.075		1.79	1.4		
1/3/1994	10:45	625	18		18		0.068		1.13	0.062		11.4	8.2		739.9	4		2.8		0.078		1.45	1		
2/7/1994	10:55	696	34		11		0.052		1.45	0.064		12.2	8.4		729.7	9		1.3		0.083		1.75	4		
3/7/1994	10:40	614	6		8		0.02		0.86	0.037		12.9	8.3		745.5	8		2.6	J	0.057		1.11	2.6		
4/4/1994	10:35	589	23		7		0.017		0.28	0.011		10.2	8.3		738.1	3		8.2*		0.03		0.63	1.4		
5/2/1994	10:20	424	57		18		0.014		0.306	0.01		12.3	8.4		734.1	14		10.9		0.047		0.537	4		
6/6/1994	11:05	431	61		29		0.01	U	0.546	0.01	U	11.1	8.1		729.7	44		14.8		0.045		0.838	9.1		
7/5/1994	11:15	454	35		41		0.01		0.872	0.01	U	11.9	8.2		732.8	14		18.1		0.022		0.931	4.1		
8/1/1994	10:35	387	190		44		0.01	U	0.781	0.01	U	11.3	8.1		732.5	17		19		0.025		0.907	4.9		
9/5/1994	10:20	500	48		49		0.014		0.958	0.011		11.1	8.1		740.4	13		15		0.017		1.1	4.9		
10/8/1997	8:50		89		61		0.01	U	1.25	0.021		9.2	8		729.5	5		8.2		0.167		1.48	3.6		
11/5/1997	7:05		14		41		0.01	U	1.75	0.021		9.2	8.1		736.6	4		6.1		0.039		1.88	3.1		
12/10/1997	10:35		150		24		0.059		1.97	0.042		11.9	7.8		748.8	8		1.5		0.09		2.21	3.9		
1/7/1998	9:10		19		31		0.033		1.9	0.015		11.6	8.3		733	10		1.5		0.111		2.26	4.9		
2/4/1998	8:45		31		569		0.065		0.919	0.151		11.1	8		716.3	37		1.8		0.174		1.9	190		
3/4/1998	9:00		190		182		0.114		1.22	0.098		10.3	8.2		732	37		3.3		0.159		2.06	75		
4/16/1998	8:15		26		107		0.01	U	0.047	0.005	U	10.1	8.8		733.6	45		8.7		0.113		0.866	31		
5/6/1998	9:05		190		67		0.026		0.388	0.02		7.5	8.2		724.9	42		17.7		0.083		0.79	26		
6/10/1998	10:55		63		50		0.017		0.72	0.006		12.9	8.5		725.2	20		18.3		0.056		1.03	11		
7/8/1998	8:10		180		48		0.01	U	1.04	0.013		6.5	8		730.3	13		18.2		0.063		1.3	6.4		
8/5/1998	10:50		170	J	52		0.01	U	0.985	0.018		10.7	8.4		722.6	11		19.8		0.039		1.34	4.1		
9/16/1998	9:40		95		60		0.01	U	1.13	0.01		8.8	8		722.6	10		17.3		0.073		1.45	4.9		
10/8/2000	12:15		27		49		0.01	U	0.99	0.016		15.47	8.44		733.806	6		8.8			0.058*	1.08	3.1		
11/12/2000	12:30		7		24		0.01	U	1.41	0.034		15	8.19		738.378	1		3.1			0.081*	1.69	0.9		
12/10/2000	12:00		9		17	J	0.01	U	1.45	0.049		13.43	8.04		732.536	2		2.8			0.107*	1.61	1.4		
1/7/2001	11:50		4		13		0.024		1.46	0.051		13.4	7.99		736.6	2		0.2			0.09*	1.62	1.2		
2/11/2001	11:30		230		9.9		0.179		1.45	0.061		14.32	7.97		727.456	45		2.4			0.159*	1.85	22		
3/11/2001	12:10		9		9.1		0.017		0.628	0.019		14.09	8.2		732.536	6		7			0.074*	0.869	3.5		
4/8/2001	12:10		27		6.4		0.01	U	0.253	0.012		13.23	8.51	J	728.472	8*	J	9.1			0.053*	0.489	3.2		
5/13/2001	12:10		180	J	47		0.022		0.498	0.012		10.98	8.48		725.424	20		19			0.06*	0.749	11		
6/10/2001	11:30		200		27		0.017		0.568	0.011		12.46	8.68		728.726	45		17.3			0.067*	0.819	12		
7/8/2001	12:25		43		34		0.021		0.58	0.016		12.3	8.62		725.932	21		23.5			0.038*	0.78	8.5		
8/5/2001	12:40		56		37		0.013		0.471	0.014		11.71	8.41		726.186	12		21.1			0.038*	0.716	4.8		
9/9/2001	12:15		53	J	38		0.01	U	0.692	0.013		13.33	8.35		725.17	7		15.5			0.042*	0.898	4.4		

Parameters in top row of Table C-1. www.ecy.wa.gov/apps/watersheds/riv/parameters_ref.html.

Code	Parameter	Description	Method *	Storet Code	Unit	Detect Limit
COND	Conductivity	Daily instrument calibrations (Former method SM2510-B).	SM2510B	P95	umhos/cm	0
FC	Fecal Coliform Bacteria		SM16-909C	P31616	#/100ml	1
FLOW	Flow	Estimated by outside agency.	EST_GageF	P60	CFS	0
NO2_NO3	Nitrate+Nitrite-Nitrogen	Collected in acid-washed passenger, acid-preserved, shipped on ice. EIM Method was EPA353.2 prior to 09/00.	SM4500NO3I	P630	mg/L	0.01
OP_DIS	Phosphorus, Sol Reactive	Collected in acid-washed passenger, acid-preserved, shipped on ice. EIM Method was EPA365.3M prior to 05/01.	SM4500PG	P671	mg/L	0
OXYGEN	Oxygen	Winkler with bi-iodate correction for thiosulfate. (after Feb 89).	EPA360.2	P300	mg/L	0
PH	pH	Liquid probe (most dates low ionic strength), calib. 3x daily.	PHMETERF	P400	pH	1
PRESS	Barometric Pressure		BAROF	P25	mm/Hg	0
SUSSOL	Suspended Solids		SM2540D	P530	mg/L	1
TEMP	Temperature	Thermistor (in river).	TEMPTHERMF	P10	deg C	0
TP_P	Phosphorus, Total	Collected in acid-washed passenger, acid-preserved, shipped on ice. Sometimes from MEL as SM4500PI, sometimes as EPA365.1.	EPA365.1	P665	mg/L	0.01
TP_PInLine	Phosphorus, Total (In-Line digestion)	Latchet In-line digestion. Probable high bias in TP, though not in OP or TPLL with this method. Collected in acid-washed passenger, acid-preserved, shipped on ice. Sometimes from MEL as SM4500PI, sometimes as EPA365.1.	SM4500PI		mg/L	0.01
TP_P_ICP	Phosphorus, Total (by ICP-MS)	ICP-MS, no digestion. When turbidity was >4 to 10 NTUs, there was a probable low bias in TP with this method. Collected in acid-washed passenger, acid-preserved, shipped on ice.	EPA200.8M		mg/L	0.001
TP_PLL	Phosphorus, Total LL	Latchet manual digestion. Low Level analysis; Collected in acid-washed passenger, acid-preserved, shipped on ice.	SM4500PH		mg/L	0.003
TP_PLL	Phosphorus, Total	ICP-MS analysis; Collected in acid-washed passenger, acid-preserved, shipped on ice.	EPA200.8M		mg/L	0.001
TPN	Total Persulfate Nitrogen	Collected in acid-washed passenger, acid-preserved, shipped on ice. Manchester/reg10 VAX call this P100021. (Former method: "valderama")	SM4500NB	P600	mg/L	0.01
TURB	Turbidity		SM2130	P82079	NTU	1

* SM=Standard Methods for the Examination of Water and Wastewater; EPA=Methods fo Chemical Analysis of Water and Wastes.

Units in top row of Table C-1.

Abbreviation	Description
#/100ml	number per hundred milliliters
%	percent
deg C	degrees Celsius (Centigrade)
mg/L	milligrams per liter
pH	pH units
ug/L	micrograms per liter
umhos/cm	micro mhos (mho = 1/ohm = 1 Siemen) per centimeter
CFS	cubic feet per second
NTU	nephelometric turbidity units
mm/Hg	millimeters Mercury
std. Units	standard units

Data qualifiers in parameter columns of Table C-1.

Code	Description
E	Reported result is an estimate.
G	Value is greater than result reported.
J	The analyte was positively identified. The associated numerical result is an estimate.
J?	Converted from older remark codes with various definitions. Result should be considered an estimate.
U	The analyte was not detected at or above the reported result.
UJ	The analyte was not detected at or above the reported estimated result.

Appendix D. Glossary, Acronyms, and Abbreviations

Alkalinity: The capacity of water for neutralizing an acid solution.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Dissolved oxygen: A measure of the amount of oxygen dissolved in water.

Eutrophic: Nutrient rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems.

Feed route: Water supply route.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Total Maximum Daily Load (TMDL): Water cleanup plan.

Total suspended solids: Portion of solids retained by a filter.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Acronyms and Abbreviations

AFR	Alternate Feed Route
Alk	Alkalinity
EAP	Environmental Assessment Program (Department of Ecology)
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
QA	Quality assurance
QC	Quality control
SOP	Standard operating procedure
TSS	Total suspended solids
Turb	Turbidity
USGS	U.S. Geological Survey