Lower Yakima River Water Quality Model and Evaluation of the USBR Columbia River Pump Exchange Project

Quality Assurance Project Plan

By
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Project Description

Background Information

The U.S. Bureau of Reclamation (USBR) is proposing several changes in water management in the lower Yakima River to meet the needs of irrigators and fisheries in a more effective way. The Columbia River Pump Exchange Project is one of these changes that may be beneficial to fisheries habitat and water quality in the lower Yakima River while improving service to irrigators.

Figure 1 shows the portion of the lower Yakima River that pertains to the project proposal. The focus of the proposed project is to move, wholly or partially, the Kennewick Irrigation District (KID) diversion. The diversion would be moved from the main stem Yakima River near Prosser to a pump station installed in the Columbia River near Kennewick. The basic water right for KID would not change, just the point of diversion. The exchange of water taken from the Columbia River and left in the Yakima River would be equivalent.

The current diversion for KID begins at Prosser Dam located at river mile (RM) 47.0, near the city of Prosser. Prosser Dam diverts water into the Chandler Canal. Normally the canal's capacity is about 1300 cfs. This can vary from 1100 to 1500 cfs, depending on the condition of the canal. The canal water travels 11 miles downstream, paralleling the main stem Yakima, to the Chandler Power and Pumping Plant (RM 35.8). At this point, about 375 cfs from the canal turns hydraulic pumps. The pumps move approximately 300 cfs of canal water under the river, up the opposite bank, and into the KID irrigation canal. The 375 cfs that was used to turn the hydraulic pumps is returned to the river below the power plant. The balance of the water in Chandler Canal is used to turn electrical turbines at the power plant, and is returned to the river below the plant.

By Public Law (PL) 103-434, flow over Prosser Dam must be maintained at a minimum target of 300 cfs. In high water years, this amount is increased (e.g., 1999 had a target of about 600 cfs). By moving the KID irrigation diversion to the Columbia River pump station at Kennewick, up to 300 cfs usually diverted from the Yakima River to the canal will be allowed to flow over the dam. The 375 cfs that turns the hydraulic pumps could also be spilled over the dam, for a maximum net increase of 675 cfs into the 11 mile main stem reach. A partial exchange condition is also being considered that would still use pumps to deliver some water to KID through the Chandler system. Another option being examined is eliminating the electrical generation at the Chandler Power and Pumping Plant, closing the diversion, and sending all the water over the Prosser Dam. Additional scenarios could fall somewhere between these.

Another part of the proposed project is for the Columbia Irrigation District's (CID) diversion to be included in the KID pump station routing. CID's current diversion of approximately 160 cfs is at Wanawish Dam (formerly Horn Rapids Dam), at river mile 18.0 and 29 miles below

Prosser. Wanawish Dam would continue to be used and maintained, diverting approximately 30 cfs to local irrigators. The remainder would be supplied by the KID project. This change in diversion could add approximately 130 cfs to the last 18 miles of the river. A final possibility is to maintain minimum flows and keep the additional water in reservoir storage in the upper Yakima to be used as needed in a biologically-based flow regime.

Project Goals

The USBR is interested in comparing water quality effects of the proposed operational changes in the lower Yakima River through mathematical modeling. The Department of Ecology Environmental Assessment Program has been contracted by the USBR to develop a model to evaluate the possible water quality changes in the lower Yakima. This project plan describes a technical study to provide USBR with the water quality information it needs to select the best operational options for the Columbia River Pump Exchange Project.

The purpose of this modeling project is to assess the possible effects of water management operational changes on water quality in the lower Yakima River. The Columbia River Pump Exchange Project offers one or more water management options on water routing from Prosser Dam to the mouth of the Yakima, especially at Chandler Canal and Wanawish Dam. The water quality modeling project is a part of a larger effort by USBR to assess the effect of the Columbia River Pump Exchange Project on aquatic habitat and fish populations in the lower Yakima River.

The modeling project will include the following major tasks:

- Construct a water quality model with flexible and accurate hydrological routing, and with a large number of water quality parameters
- Collect water quality data from the literature to determine critical river periods and critical locations, and for model verification
- Collect additional field data for model calibration and verification
- Compare results from the calibrated model to current conditions and to various combinations of water management activities
- Compare results from the water quality model to previous SNTEMP temperature modeling results (Payne and Monk, 1999).

The water quality parameters of concern include: total suspended solids, turbidity, dissolved oxygen, temperature, pH, nutrients, biochemical oxygen demand, and selected pesticides. Several of these parameters have direct interactions, or have complex biological components that require simulation, (e.g. nutrient and periphyton or phytoplankton interaction).

The water quality assessment will use a mathematical model that has been calibrated to hydrologic and water quality conditions in the lower Yakima River. Using independent data sets, the model will be verified over a range of critical conditions. Once the model has been calibrated and its range of accuracy known, several water management scenarios will be simulated.

Study Design

Data Review

Physical channel and water quality data will be necessary to construct a mathematical model that accurately simulates hydrology and water quality characteristics. These data may be available from several government agencies or technical literature, but they are not currently available from one source. A quick but in-depth search from several agencies and sources will be conducted. The goal is to have enough water quality and physical data at several sites in each of the following three reaches during critical periods to calibrate and verify a water quality model:

1. Prosser Dam to Chandler Power Return
2. Chandler Power Return to Wanawish (formerly Horn Rapids) Dam, and
3. Wanawish Dam to the Columbia River.

Channel cross sections, rating curves, and other physical data are available through US Geological Survey, Corps of Army Engineers, USBR, and from past instream flow incremental method (IFIM) assessments. Physical data will be estimated from maps and discharge data, and by using mathematical formulae, as a last resort.

Water quality monitoring has been conducted at sites within the three reaches by several agencies. Initial inquiries indicate that data are more numerous at a few sites in the upper two reaches than for the lowest reach. The most extensive water quality data have been collected by several agencies at Benton City/Kiona (RM 29.9). Data from periodic sampling of tributary and main stem sites in the Prosser to Chandler reach, and at West Richland in the Wanawish to Columbia Reach have already been located from sources within the Department of Ecology.

Climate data is available through the Washington State University PAWs network, or from local sources. Agencies will be contacted to obtain suitable data for temperature, chemical reaction rates, and biological growth functions in the model.

One water temperature modeling effort has been recently completed, and may be expanded. The SNTEMP model of the Prosser Dam to Chandler Return reach was constructed in 1998 (Payne and Monk, 1999). Water temperature data were collected in 1995 and 1997 at points within the reach and used for model calibration. The model was used to simulate some of the same diversion changes proposed by USBR. The results of the simulation indicated only a 1°C decrease in temperature at Chandler Power return, regardless of how much water was allowed over Prosser Dam (Payne and Monk, 1999). The researchers would like to expand the geographic scope of the model (Monk, 1999).

Field Studies

Historical data will not provide complete data sets for model calibration and verification. Therefore, some field data collection is necessary. The Environmental Assessment Program staff are experienced in collecting all types of water quality data. The program has access to advanced instrumentation, boats, and a qualified, accredited laboratory.

Two water quality sampling events will be conducted: one in late September 1999, the other in mid-summer, late July 2000. Each sampling event will include two days of sampling at 10 stations along the main stem dispersed between the three reaches. Samples will be collected by boat, or from bridges and bank-sides, depending on access. The following point sources and tributaries also will be sampled: Prosser, Benton City, and West Richland wastewater treatment plants, Twin City Foods, Snipes/Spring Creek, Chandler Return, and Corral Creek.

USBR has identified two seasons of critical concern. The first is the spring out-migration of salmon that occurs from February through June. The second is the late summer aquatic food chain production period that occurs from July through September. The latter period also coincides with the summer low-flow period when PL 103-434 usually comes into play. Changes in parameters relative to aquatic life toxicity or habitat limitations are of greatest interest and the greatest water quality changes are expected during the summer low flows. Figure 2 shows box plots of the average daily flows by month for the Yakima River below the Prosser diversion. Because the lowest assimilative capacity occurs in the summer months of July, August, and September, the surveys are scheduled during that season. One data set will be used to calibrate the water quality model and the other survey data collection will be used to verify or confirm the water quality model performance.

Data Collection Requirements:

Reconnaissance Survey:

A reconnaissance survey will be conducted in September 1999 in order to identify specific sampling locations and evaluate the logistical requirements of the survey.

Stream Geometry and Hydraulic Data:

Channel cross-section measurements may be required as another field task if adequate data are not found. Accurate channel configurations are required to simulate various model functions, e.g., reaeration, sedimentation, and light extinction. Ecology has the boat, cables, and measuring equipment needed for the work. If river access and stage levels are favorable, several representative cross-sectional measurements will be made in each reach over a three or four day period. Time of travel dye studies may be performed in some reaches in order to validate velocity and dispersion estimates for the model. The dye studies would be performed with

Rhodamine WT in accordance with protocols outlined in Wilson (1968) and Hubbard et al. (1982).

Water Quality Data and Sample Collection:

Water quality data and literature data will be used to parameterize (set rates and constants for water column processes) and calibrate the water quality model. The sampling sites and a schedule for field measurements and sample collection for laboratory analysis are presented in Tables 1 and 2, respectively.

During each field measurement survey, water column data will be collected at each of the river stations using a Hydrolab® Surveyor 2. At 5 stations (RM 47.1, 36.0, 30.0, 18.4, and 8.4) *in situ* data loggers (Datasonde 3) will be placed for 48 hours to record temperature, pH, conductivity, and dissolved oxygen. These data will be used to assess diel changes in the parameters measured. During the synoptic surveys, grab samples will be collected once a day for two days from the river and tributary stations. Effluent grab and composite samples will also be collected during the synoptic surveys. Because of their expense and the extended laboratory analysis time needed, pesticide and metals analyses will not be collected for this project. Organochlorine pesticide data may be inferred from historical sample collections and established correlations to total suspended solids (Joy and Patterson, 1997).

Phytoplankton samples will be collected at selected stations to provide data on species composition. Phytoplankton data will be used to select plankton growth rates from literature values based on species composition for modeling productivity.

Vertical profiles of light extinction will be measured at two stations (RM 29.6 and 14.4). Photosynthetic production and respiration will be measured using light and dark bottle tests of dissolved oxygen production and consumption (APHA et al., 1985). Light and dark bottles will be incubated at 1 and 3-meter depths for approximately six hours at RM 14.4. Algal photosynthesis and respiration rates would be calculated by methods of APHA et al., (1985) and Thomann and Mueller (1987).

Ecology is willing to coordinate field data collection with other USBR contractors working in the area. Channel profile and water quality data collected by Ecology will be made available to contractors or USBR staff as soon as quality assurance tasks are completed.

Data Quality Objectives and Analytical Procedures

The Manchester Laboratory's (MEL, 1994) published lower reporting limits for the analytical methods to be used have been deemed satisfactory to meet the data quality objectives for this project and so the lower reporting limits have been adopted as the data quality objectives. Field measurements and laboratory analyses are listed in Table 3, including the methods, corresponding lower reporting limits, target precision and target bias acceptable range.

Sampling and Quality Control Procedures

Collecting replicate samples will assess total variation for field sampling and laboratory analysis and thereby provide an estimate of total precision. At least 10% of the total number of laboratory samples and field measurements per parameter will be replicated. In addition, field blanks will be collected to determine the presence of bias in the analytical method.

All water samples for laboratory analysis will be collected in pre-cleaned containers supplied by the Manchester Environmental Laboratory (MEL), except dissolved organic carbon and ortho-phosphorus, which will be collected in a syringe and filtered into a pre-cleaned container. The syringe will be rinsed with ambient water at each sampling site three times before filtering. All samples for laboratory analysis will be preserved as specified by Manchester Environmental Laboratory (MEL 1994) and delivered to MEL within 24 hours of collection. Laboratory analyses listed in Table 3 will be performed in accordance with MEL (1994).

Field sampling and measurement protocols will follow those specified in WAS (1993) for temperature (alcohol thermometer), pH (Orion Model 250A meter and Triode™ pH electrode), conductivity (Beckman Model RB-5 and YSI 33), dissolved oxygen (Winkler titration), streamflow (Marsh-McBirney 201 & 2000), and *in situ* temperature, dissolved oxygen, pH, and specific conductance (Hydrolab® multi-parameter meters). All meters will be calibrated and post-calibrated per manufacturer's instructions.

Effluent samples from the point sources listed in Table 1 will be collected in pre-cleaned ISCO 24-hour composite samplers. Effluent sampling will be conducted according to standard operating procedures for Class II inspections by Ecology as documented in Glenn (1994).

Data Assessment Procedures

Laboratory data reduction, review, and reporting will follow procedures outlined in MEL's Users Manual (MEL 1994). All water quality data will be entered into Ecology's Environmental Information Management (EIM) system. Data will be verified, and 100% of data entry will be reviewed for errors.

Data analysis will include evaluation of data distribution characteristics and, if necessary, appropriate distribution transformations. Estimation of univariate statistical parameters and graphical presentation of the data (box plots, time series, regressions) will be made using SYSTAT/SYGRAPH8, EXCEL, or WQHYDRO (Aroner, 1994) computer software.

Water Quality Modeling

The project requires a model capable of simulating the transport and fate of several water quality constituents. In addition, the model needs to be flexible enough to easily change hydrologic routing. A steady-state model appears to be adequate at this time to simulate the scenarios of interest to USBR. The entire project area could be included in one model, or each reach could be simulated individually. The QUAL2E model (USEPA, 1987) is a strong candidate to fulfill all the needs required in the project.

QUAL2E is a one-dimensional, steady-state numerical model capable of simulating a variety of conservative and non-conservative water quality parameters (Brown and Barnwell, 1987). The model has been supported and expanded by the US Environmental Protection Agency (USEPA) through its Center for Exposure Assessment Modeling. QUAL2E can provide estimates of daily ranges for specific parameters like temperature and dissolved oxygen at individual sites in a dynamic simulation mode. The inherent variability in simulation results from variability in the input data and coefficients can be determined using the model enhancement, QUAL2EU.

The model has been widely used to assess multiple point source impacts on well-mixed river systems, and its usefulness is well documented. Ecology has used QUAL2E for total maximum daily load (TMDL) assessments in several large and complex basins including the Snoqualmie River (Joy, 1993), the Puyallup River (Pelletier, 1993), and the Colville River (Pelletier, 1997).

Ecology staff also used QUAL2E in the Timber, Fish and Wildlife temperature model assessment (Sullivan, *et al.*, 1990).

As mentioned earlier, the list of water quality parameters of concern include: total suspended solids, turbidity, dissolved oxygen, temperature, pH, nutrients, biochemical oxygen demand, and selected pesticides. Daily average concentrations or values for most of these parameters can be resolved with QUAL2E. Turbidity cannot be modeled, but Ecology has developed a regression relationship between total suspended solids, a model parameter, and turbidity for the lower Yakima (Joy and Patterson, 1997).

The following is a list of scenarios USBR wishes to have simulated. Both specific water quality changes within a reach, and the residual downstream effects are of interest.

— In the Prosser Dam to Chandler Power Return, and downstream through the project area:
- Current conditions
- Chandler partial diversion of KID with powerhouse in operation
- Chandler full diversion of KID with powerhouse in operation
- Chandler without diversion or powerhouse operation (Chandler off)

— In the Wanawish Dam to Columbia River Reach:
- no exchange at Columbia Canal
- exchange at Columbia Canal

Changes in parameters relative to aquatic life toxicity or habitat limitations are of greatest interest. Washington State water quality standards, USEPA guidelines, and literature research recommendations for the parameters of interest will be compared to simulation results.

Project Schedule and Budget

The modeling project will commence on 15 September 1999, or as soon as contractual arrangements are completed. The schedule for the proposed study, at this time, is as follows:

Submit draft QAPP for internal review:	April 30, 2000
Finalize QAPP:	June 30, 2000
Sampling Surveys begin	September 1999
Sampling Surveys end	July 31, 2000
Draft Report	November 30, 2000
Final Report	January 31, 2001

The original completion date of the project was September 30, 2000. This was anticipating that the second synoptic survey would take place during the spring of 2000. However, as discussed above, there is little anticipated water quality degradation during the spring period compared to the low summer flow. Therefore, the second Spring 2000 sampling period will be delayed until July 2000 and, accordingly, the completion date will be amended and adjusted to January 31, 2001. An additional month is budgeted into the timeline to respond to comments on the draft report. Tables 4 and 5 present the laboratory budget and the overall project budget, respectively.

Project Responsibilities

The following individuals and organizations will be involved in the project:

Joe Joy (Ecology): Project Manager responsible for overall project supervision, contractual arrangements and communication with USBR. (360-407-6486)

Jim Carroll (Ecology): Principal Investigator responsible for preparation of Quality Assurance Project Plan (QAPP), project design, collecting and analyzing data, modeling, developing graphs and figures, writing and editing draft and final reports. (360-407-6196)

Will Kendra (Ecology): Section Supervisor of the Watershed Ecology Section of the Environmental Assessment Program. Responsible for approving the project QAPP, project budget, and project reports. (360-407-6698)

Karol Erickson (Ecology): Unit Lead of the Watershed Studies Unit of the Environmental Assessment Program. Responsible for internal review of the project QAPP and draft data summary reports. (360-407-6694)

Stuart Magoon, and Pam Covey (Ecology). Manchester Environmental Laboratory (MEL) staff responsible for analysis and reporting of chemical data. (360-871-8860)

Stew Lombard (Ecology). Quality Assurance Section staff responsible for review of the project QAPP. (360-895-4649)

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Figures

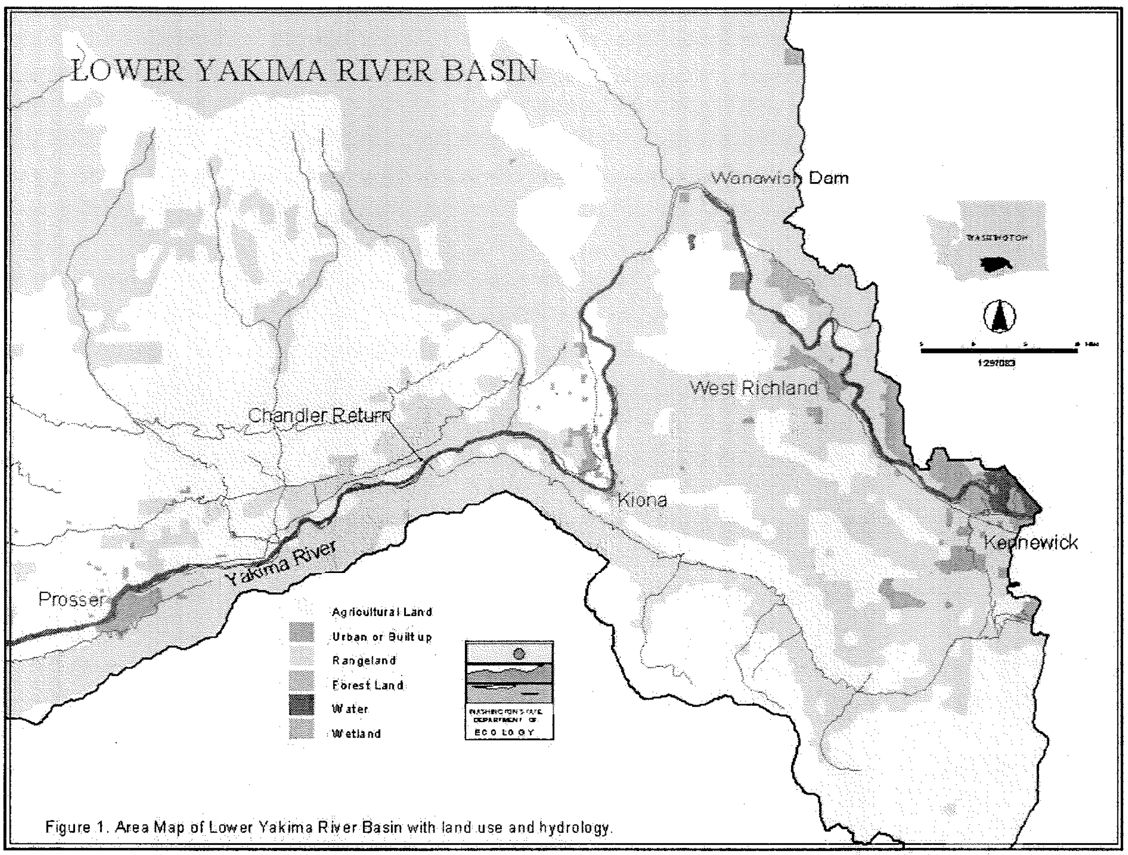


Figure 1. Area Map of Lower Yakima River Basin with land use and hydrology.

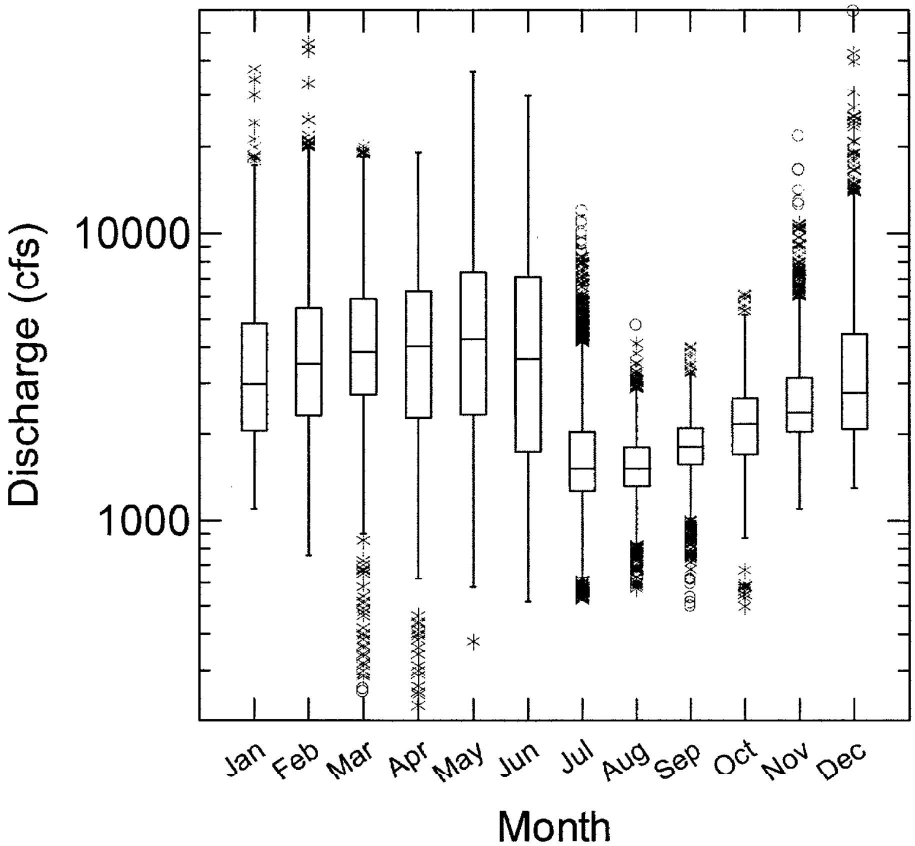
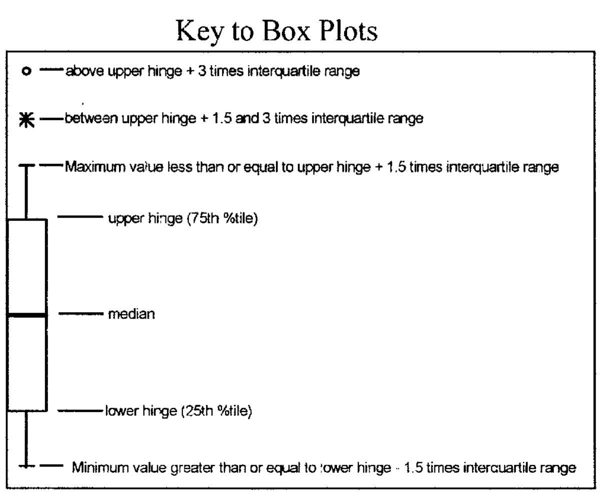


Figure 2. Box plots of average daily flows by month from 1933-1999 for Yakima River at Kiona (RM 29.6).



Tables

Table 1. River, tributary, and point source sampling sites for the USBR modeling project.

River Mile	Site Name	#	Location
47.1	BRCHANUP	1	Above Prosser Dam
46.6	BRPROSWW	2	Prosser WWTP
45.8	BRBLPROS	3	Below Prosser WWTP
45.2	BRTREETO	4	Twin City Foods IWTP
41.8	YAK-17	5	Spring Creek
41.8	YAK-19	6	Snipes Creek
36.0	BRABCHAN	7	Above Chandler Return
35.8	BRCHANRE	8	Chandler Return
34.0	BRBLCHAN	9	Below Chandler Return
33.5	BRCORRAL	10	Corral Creek
29.6	YAK-6	12	Kiona bridge
27.0	BRBLBENT	13	Below Kiona
18.8	BRABWANA	14	Above Wanawish Dam
16.2	BRBLWANA	16	Below Wanawish Dam
12.8	BRTWINBR	17	Twin Bridges
9.8	BRWRICHW	19	West Richland WWTP
8.4	YAK-7	15	Van Geisen bridge
5.6	BRHWY182	20	Above Hwy 182

Table 2. Site Locations and Parameters for the USBR Modeling Project

Site Location	RM	Type	Field	Turbidity	TSS	Alkalinity	Hardness	Chloride	Chlorophyll	TOC	OPO4	TPN	Nut. 5	BOD	FC
Pool above Prosser	47.1	Mainstem	2	2	2	2	2	2	2	2	2	2	2	2	2
Prosser WWTP	46.6	Effluent	1	1	1			1					1		1
Yakima below Prosser WWTP	45.8	Mainstem	1	1	1	1	1	1	1	1			1		1
Twin City Foods IWTP	45.2	Effluent	1	1	1			1					1		1
Spring Creek	41.8	Tributary	1	1	1			1			1	1	1		1
Snipes Creek	41.8	Tributary	1	1	1			1			1	1	1		1
Yakima above Chandler Return	36.0	Mainstem	1	1	1	1	1	1	1	1	1	1	1		1
Chandler Return	35.8	Tributary	2	2	2	2	2	2	2	2	2	2	2	1	2
Below Chandler Return	34.0	Mainstem	1	1	1	1	1	1	1	1	1	1	1		1
Corral Creek	33.5	Tributary	1	1	1			1					1		1
West Richland WWTP	9.8	Effluent	1	1	1			1					1		1
Yakima at Kiona	29.6	Mainstem	1	1	1	1	1	1	1	1	1	1	1	1	1
Below Kiona	27.0	Mainstem	1	1	1	1	1	1	1	1			1		1
Above Wanawish Dam	18.8	Mainstem	1	1	1	1	1	1	1	1	1	1	1	1	1
QA				2	2	1	1	2	1	1	1	1	2		3
Day 1 Totals			16	18	18	11	11	18	11	11	11	11	18	5	19
Above Wanawish Dam	18.8	Mainstem	1	1	1	1	1	1	1	1	1	1	1		1
Prosser WWTP	45.8	Effluent	1	2	2			2				1	2	1	1
Twin City Foods	45.2	Effluent	1	2	2			2				1	2	1	1
Below Wanawish Dam	16.2	Mainstem	1	1	1	1	1	1	1	1	1	1	1		1
Twin Bridges	12.8	Mainstem	1	1	1	1	1	1	1	1			1		1
West Richland WWTP	9.8	Effluent	2	2	2			2				1	2	1	1
Van Geisen Bridge	8.4	Mainstem	1	1	1	1	1	1	1	1	1	1	1		1
Hwy 182 Bridge	5.6	Mainstem	1	1	1	1	1	1	1	1			1	1	1
QA				2	2	1	1	2	1	1	1	1	2	1	3
Day 2 Totals			9	13	13	6	6	13	6	6	4	7	13	5	11
Two Day Total			25	31	31	17	17	31	17	17	15	18	31	10	30

Field Parameters: pH, DO, temperature, conductivity

Lab Parameters: Total organic carbon (TOC), total suspended solids (TSS), biochemical oxygen demand (BOD), fecal coliform (FC)
Ortho-phosphate (OPO4), total persulfate nitrogen (TPN), total phosphorus, ammonia, nitrate, nitrite (Nut. 5)

Effluent samples will be collected from an ISCO 24-hour composite sampler

Table 3. Summary of parameters, methods, reporting limits and targets for precision and bias.

Parameter	Lower Reporting Limit	Target Precision RSD- (relative std. deviation) or acceptable range	Target Bias	Method[a]
Field Measurements				
Velocity	NA	± 0.05 f/s	NA	Current Meter
Temperature (Temp)	NA	± 0.2 /C	NA	Alcohol Thermometer
pH	NA	± 0.1 pH units	NA	Field Meter/Electrode
Dissolved Oxygen (DO)	NA	± 0.06 mg/L	NA	Winkler Titration
Specific Conductivity (Cond)	NA	± 20 µmhos/cm	NA	Conductivity Bridge
Secchi Disc Depth	NA	± 0.5 m	NA	Secchi Disc
Light Attenuation	0.0014 $\mu W/cm^2$	<15 % RSD	<10%	Irradiameter
General Chemistry				
Specific Conductance	1 µmhos/cm	<10 % RSD	<10%	SM16 2510
Ammonia nitrogen (NH3)	0.01 mg/L	<10 % RSD	<20%	EPA 350.1
Nitrate + nitrite nitrogen (NO2-3)	0.01 mg/L	<10 % RSD	<10%	EPA 353.2
Total persulfate nitrogen (TPN)	0.01 mg/L	<10 % RSD	<10%	SM 4500 NO3-F (Mod)
Total Kjeldahl Nitrogen (TKN)	0.01 mg/L	<10 % RSD	<25%	SM 4500
Orthophosphate (Ortho-P)	0.005 mg/L	<10 % RSD	<20%	EPA 365.3
Total phosphorus[b] (TP)	0.003 mg/L	<10 % RSD	<15%	EPA 365.3
Chloride (Cl)	0.1 mg/L	<10 % RSD	<10%	EPA 300.0
Total Organic Carbon (TOC)	1.0 mg/L	<10 % RSD	<15%	EPA 415.1
Dissolved Organic Carbon[c] (DOC)	1.0 mg/L	<10 % RSD	<15%	EPA 415.1
5-day BOD[d] (BOD5)	2 mg/L	<15 % RSD	NA	EPA 405.1
Ultimate Carbonaceous BOD	2 mg/L	<15 % RSD	NA	NCASI (1987)[e]
Phytoplankton ID/Biovolume	NA	NA	NA	SM18 10200F; Sweet,1987
Fecal Coliforms (Membrane Filter)	1 col./100 ml	<25 % RSD	< 10%	SM16-909C
Chlorophyll *a* (Chloro-a)	0.05 µg/L	<10 % RSD	<10%	Fluorometer, SM10200H(3)

[a] SM = Standard methods for the examination of water and wastewater. 20th edition (1998). American Public Health Association, American Water Works Association, and Water Environmental Federation. Washington, D.C.

[b] Low level phosphorus analysis.

[c] Filter in field with Whatman PURADISC™ 0.45 µm pore size syringe filter.

[d] Use uncensored data for readings below 2 mg/L.

[e] A procedure for estimation of ultimate oxygen demand. National Council of the Paper Industry for Air and Stream Improvement. Inc. Special Report No. 87-06. May 6, 1987.

Table 4. Lab estimate for the Columbia River Pump Exchange Project Summer 1999 & 2000

Parameter	Cost/Analysis (water only)	# Samples (incl. field QA)	Cost	Number of Surveys	Cost
Turbidity	7	31	217	2	434
Total Suspended (TSS)	10	31	310	2	620
Alkalinity	14	17	238	2	476
Hardness	12	17	204	2	408
Chloride	12	31	372	2	744
Chlorophyll	53	17	901	2	1802
Ortho Phosphate PO4	34	15	510	2	1020
Total Persulfate Nitrogen (TPN)	16	18	288	2	576
Nutrients 5 (NH3, NO3, NO2, O-P, T-P)	53	31	1643	2	3286
BOD 5	46	10	460	2	920
Total Organic Carbon	33	17	561	2	1122
Fecal Coliform	20	30	600	2	1200
Additional samples (for unknown souces, etc)					1232
	Total:				$13,840

Table 5. Proposed budget for the lower Yakima model of the Columbia River pump exchange project, 1999-200

Costs:

Staff	Total Days	Cost
Project Manager, Joe Joy	56	12,569
Project Lead, Jim Carroll	226	43,742
Field Assistant	10	1,936
Lab		13,840
Travel and Expenses		1,066
Total		**$ 73,152**