WRIA 44/50
WATER STORAGE STUDY

Prepared for

Foster Creek Conservation District
P.O. Box 428
Waterville, Washington 98858

Prepared by

Anchor QEA, LLC
811 Kirkland Ave., Suite 200
Kirkland, Washington 98033

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LIST OF ACRONYMS AND ABBREVIATIONS

ac	acre
AF	acre-feet
BiOp	Biological Opinion
BPA	Bonneville Power Administration
CBP	Columbia Basin Project
cfs	cubic feet per second
CRB	Columbia River Basalt
CRP	Conservation Reserve Program
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
ft	feet
Kcfs	thousand cubic feet per second
M&I	municipal and industrial
MAF	million acre-feet
MW	megawatt
MWhr	megawatt hour
OCR	Office of Columbia River (Ecology)
PHS Program	WDFW's Priority Habitats and Species Program.
PUD	Public Utility District
RCW	Revised Code of Washington
Reclamation	U.S. Bureau of Reclamation
RM	river mile
WAC	Washington Administrative Code
WDFW	Washington Department of Fish & Wildlife
WRIA	Water Resource Inventory Area

1 INTRODUCTION

The Water Resource Inventory Area (WRIA) 44/50 Planning Unit is looking to assess the feasibility of potential surface water storage sites located in WRIAs 44 and 50. The Watershed Management Plan (Foster Creek Conservation District 2004) listed "Pursue potential water storage projects in WRIAs 44 & 50" as Action 19. Specifically, the Planning Unit is looking to assess sites in Rock Island Creek in WRIA 44 and Foster Coulee in WRIA 50 (see Figure 1-1). This Water Storage Study outlines the purpose and description of the projects, hydroelectric potential, geology and environmental resources at the project site, and cost estimates of the projects. Two potential projects on Rock Island Creek were studied and a single project in Foster Coulee was studied.

This study was funded by Washington Department of Ecology (Ecology) through the Columbia River Basin Development Account. In 2006, the Washington State Legislature tasked Ecology to aggressively seek out new water supplies for both instream and out-of-stream uses (Chapter 90-90 of Revised Code of Washington [RCW]). The same legislation established the Columbia River Basin Development Account and authorized $200 million to fund it. The Office of Columbia River (OCR) set aside a significant portion of this money to fund annual competitive grants for local water storage and conservation projects that preserve and enhance the standard of living for the people of Washington by strengthening the state's economy, and restoring and protecting the Columbia Basin's unique natural environment.

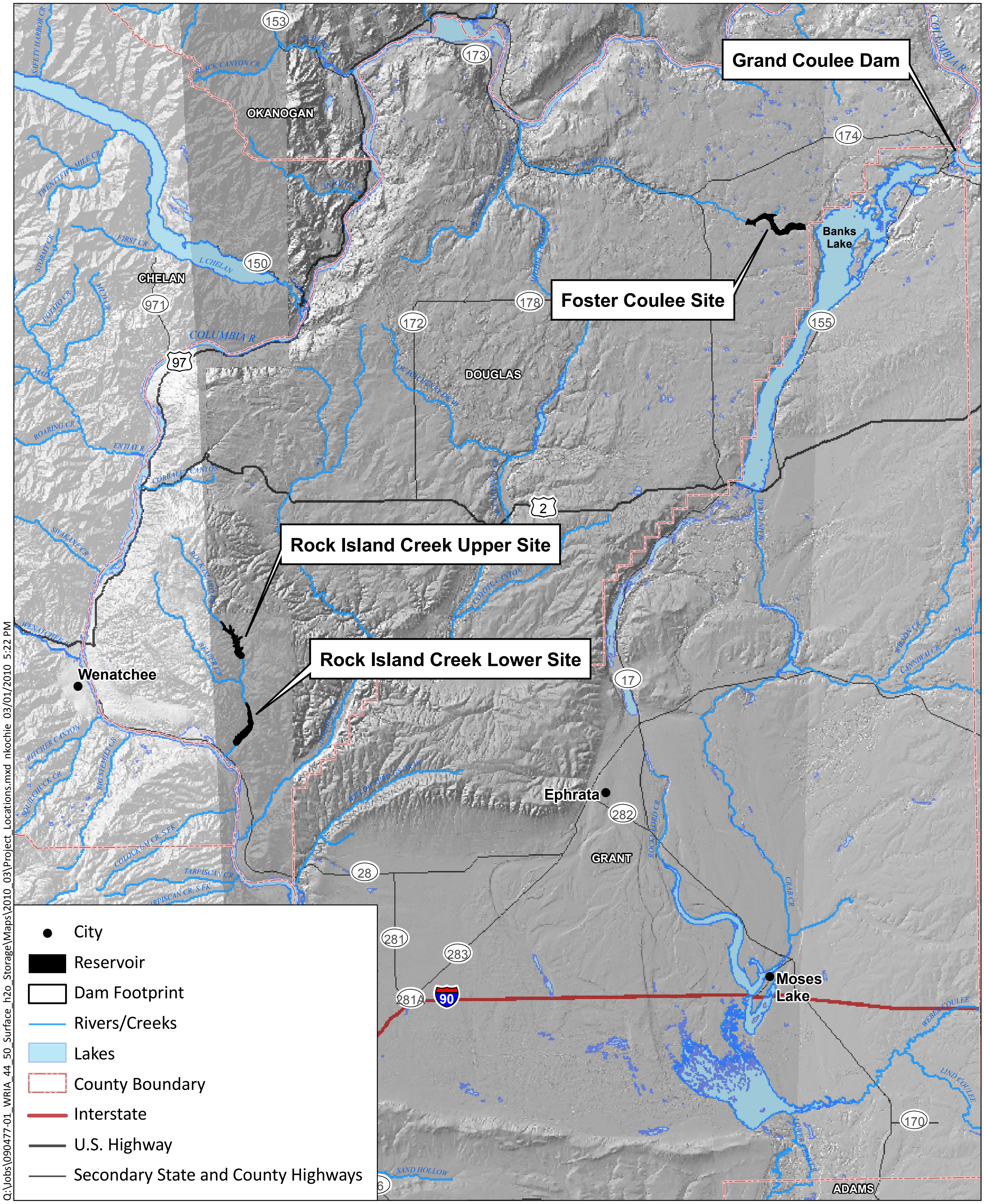

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Figure 1-1
Project Location Map

2 PURPOSE OF WATER STORAGE PROJECTS

The projects described in this study are multi-purpose; that is, the water stored can be used to help satisfy multiple needs along the Columbia River such as water supply for municipal, industrial and agricultural uses, instream flow for fisheries and to generate peaking power as a pumped storage project. A focus of this study was to identify multiple benefits of stored water as the projects would be more desirable to project sponsors and could more easily attract funding as long as the combined benefits of the projects outweigh the costs. The following sections describe the multi-purpose uses of water from the projects.

2.1 Water Supply Uses

Water stored in the projects may be used for a single purpose or multiple purposes. This section presents potential water supply uses for water stored from the projects.

2.1.1 Instream Flow

Minimum instream flows have been set by the State of Washington for the Columbia River for use in protecting instream values and regulating water rights. Those flows are described in WAC 173-563, which was implemented in 1980. Target flows have also been agreed upon by federal agencies as part of the 2004 Biological Opinion (BiOp) for the Federal Columbia River Power System (FCRPS). A comparison of the state minimum instream flow and the target flows is shown in Table 2-1.

Figure 2-1 shows the BiOp target flows along the Columbia River along with average daily flows (1971 to 2000) and flows for drought year 2001. In most years, the Columbia River flows do not meet the BiOp flows from mid-April to mid-May and from mid-July through August. In a drought year such as 2001, the BiOp target flows are not met in the Columbia River from April through August.

The difference between the BiOp flows and the current flows in average conditions is approximately 7.1 million acre-feet from April through August. In a drought year (such as 2001), to the difference is approximately 29.3 million acre-feet from April through August.

Instream Flows Set by WAC 173-563 and the 2004 Biological Opinion

	Chief Joseph		**Wells & Rocky Reach**		**Rock Island & Wanapum**		**Priest Rapids**			**McNary**			**John Day**		**Bonneville**	**The Dalles**	
	WAC 173-563		WAC 173-563		WAC 173-563		WAC 173-563		2004 BiOp	WAC 173-563		2004 BiOp	WAC 173-563		2004 BiOp	WAC 173-563	
Date	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Flow Objective (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Flow Objective (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Flow Objective (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)
Jan	10	30	10	30	10	30	50	70	--	20	60	--	20	60	?[b]	20	60
Feb	10	30	10	30	10	30	50	70	--	20	60	--	20	60	?[b]	20	60
Mar	10	30	10	30	10	30	50	70	--	50	60	--	50	60	?[b]	50	60
Apr 1-2	20	50	20	50	20	60	50	70	--	50	100	--	50	100	?[b]	70	120
3-9	20	50	20	50	20	60	50	70	--	50	100	--	50	100	?[b]	70	120
10-15	20	50	20	50	20	60	50	70	135	50	100	220-260[a]	50	100	?[b]	70	120
16-25	20	60	30	60	30	60	50	70	135	70	150	220-260[a]	70	150	?[b]	70	160
26-30	20	90	50	100	50	110	50	110	135	70	200	220-260[a]	70	200	?[b]	70	200
May	20	100	50	115	50	130	50	130	135	70	220	220-260[a]	70	220	?[b]	70	220
Jun 1-15	20	80	50	110	50	110	50	110	135	70	200	220-260[a]	70	200	?[b]	70	200
16-20	10	60	20	80	20	80	50	80	135	50	120	220-260[a]	50	120	?[b]	50	120
21-30	10	60	20	80	20	80	50	80	135	50	120	220-260[a]	50	120	?[b]	50	120
Jul 1-15	10	60	20	80	20	80	50	80	--	50	120	200	50	120	--	50	120
16-31	10	90	50	100	50	110	50	110	--	50	140	200	50	140	--	50	140
Aug	10	85	50	90	50	95	50	95	--	50	120	200	50	120	--	50	120
Sep	10	40	20	40	20	40	36	40	--	50	60	--	50	85	--	50	90
Oct 1-15	10	30	20	35	20	40	36	40	--	50	60	--	50	85	--	50	90
16-31	10	30	20	35	20	40	50	70	--	50	60	--	50	85	--	50	90
Nov	10	30	10	30	10	30	50	70	--	50	60	--	50	60	125-160[b]	50	60
Dec	10	30	10	30	10	30	50	70	--	20	60	--	20	60	?[b]	20	60

NOTES:

Abbreviations: Min = Minimum; Qi = instantaneous flow; Avg. = Average; WAC = Washington State Administrative Code; kcfs = thousand cubic feet per second

a. Objective varies according to water volume forecasts.

b. Objective varies based on actual and forecasted water conditions. The dates to which this flow objective applies include 11/1 to emergence (spring season) which may vary each year.

c. The 2004 Biological Opinion was issued by NMFS regarding the Federal Columbia River Power System (FCRPS). The data in the table is from Bureau of Reclamation, Bonneville Power Administration, and U.S. Army Corps of Engineers (Action Agencies). 2004. Final Updated Proposed Action for the FCRPS Biological Opinion Remand. November 24, 2004.

Figure 2-1
Flow Objectives from 2004 Biological Opinion Compared to Measured Flows on the Columbia River

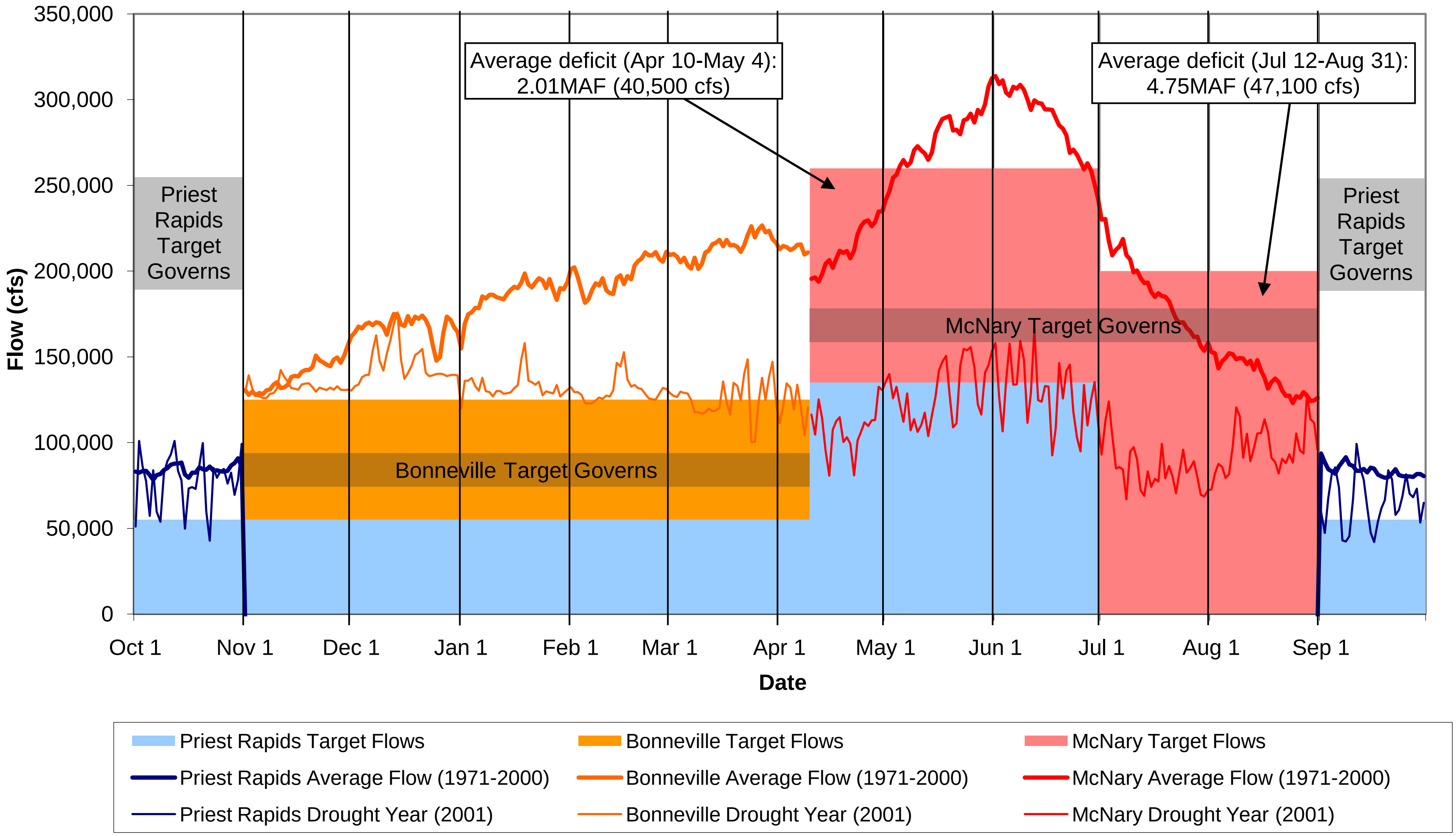

Figure 2-2
State Minimum Flows and Recorded Flows for Columbia River at McNary Dam

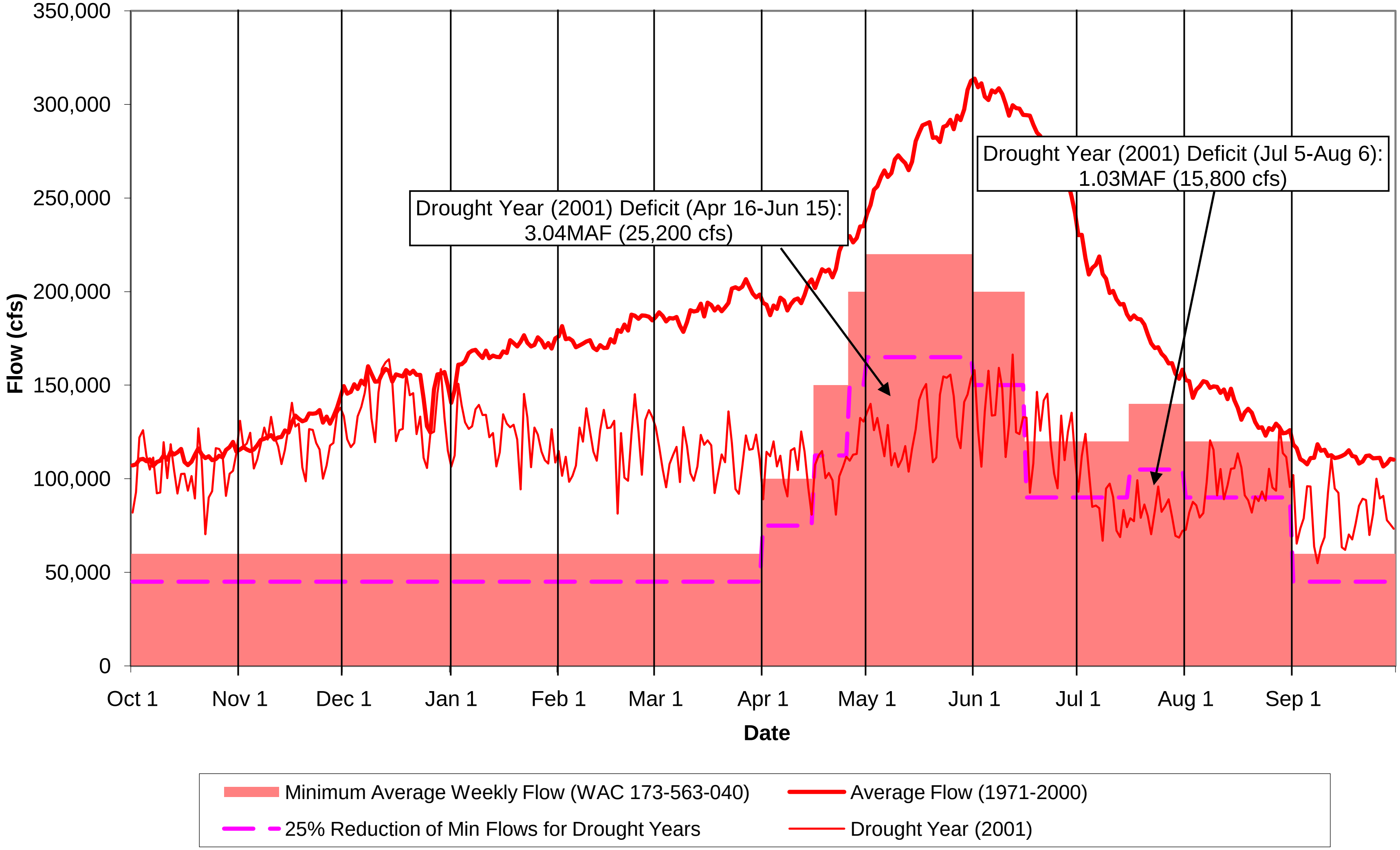

Figure 2-2 shows state minimum instream flows for the Columbia River at McNary Dam along with average flows and flows for the 2001 drought year. For average conditions, State of Washington minimum flows are met year around. In drought conditions (such as 2001), the State of Washington minimum flows are generally not met from mid-April through mid-June and in July through August. The average weekly instream flows in the Columbia River at McNary Dam were approximately 4.1 million acre-feet less than the state instream flow values in 2001, even accounting for an allowable 25 percent reduction in State of Washington minimum flows during drought years.

Water stored in new reservoirs could be used to supplement flow in the Columbia River. Although the volumes provided in the water storage projects would be a small percentage of the additional flow needed to fully make up either the state minimum instream flows or the BiOp target flows, the additional flow is thought to be valuable and Ecology is actively considering projects to provide additional flow. An example is the additional flow to be released from Lake Roosevelt. In the *Final Supplemental Environmental Impact Statement for the Lake Roosevelt Incremental Storage Releases Program* (EIS; Ecology 2008), Ecology proposes to release an additional 27,500 acre-feet during average years and 44,500 acre-feet during drought years from April to August from Lake Roosevelt to increase flow in the Columbia River during salmon and steelhead migration times.

2.1.2 Interruptible Water Users along Columbia River

Water stored in new reservoirs could be used to supply interruptible water users along the Columbia River during drought years.

Interruptible water users may have their water use interrupted when the flow in the river is below the required State of Washington minimum instream flow. As discussed in Section 2.1.1, State of Washington minimum instream flows are typically not met from April to August in drought years such as 2001.

According to the *Lake Roosevelt EIS* (Ecology 2008), there are approximately 379 holders of interruptible water rights within the Columbia River Basin totaling 309,159 acre-feet. It is estimated that 175 of those holders are located on the Columbia River downstream of Rocky Reach Dam with water rights totaling 107,000 acre-feet. Most of the interruptible water rights are for irrigation use where the time of use is from April to August. The Rock Island Creek reservoir sites could release water directly to the Columbia River to meet some of those needs. The Foster Coulee reservoir site could release water to Banks Lake for use in the Columbia Basin Project (CBP). Water could then be released from Lake Roosevelt into the Columbia River in lieu of pumping to Banks Lake.

2.1.3 Future Municipal & Industrial Use

Water stored from this project may potentially be used to supply future municipal and industrial (M&I) use.

From the *Water Supply Inventory and Long-Term Water Supply and Demand Forecast* (Ecology 2006), future water demand was estimated for two tiers. The first tier demand forecast, determined from water rights applications, was estimated to be 183,478 acre-feet for non-agricultural use. The second tier demand forecast, projected from estimated population growth, was estimated to range from 58,000 to 109,400 acre-feet for non-agricultural use.

2.1.4 Future Irrigation Use

Water stored from these projects may potentially be used to supply farms that pump from the Columbia River or close proximity to the Columbia River and in the case of the Foster Coulee project, irrigators in the Odessa subarea.

2.1.4.1 Future Irrigation Demand along the Columbia River

From the *Water Forecast*, demand for future irrigation along the Columbia River was estimated for two tiers (Ecology 2006). The first tier demand forecast, determined from water rights applications, was estimated to be 211,323 acre-feet for agricultural use. The second tier demand forecast, projected from estimated growth, was estimated to range from 0 to 330,000 acre-feet for agricultural use.

2.1.4.2 Irrigation Needs in Odessa Subarea

Groundwater in the Odessa Subarea is currently being depleted to such an extent that water must be pumped from great depths. Pumping depths are 750 feet in some areas, and well depths are as great as 2,100– to 2,400 feet. Well drilling well costs and pumping water from this depth have resulted in expensive power costs and water quality concerns such as high water temperatures and high sodium concentrations. The ability of farmers to irrigate their crops is at risk (Reclamation 2008).

Action is needed to avoid significant economic loss to the region's agricultural sector because of resource conditions associated with continued decline of the aquifers in the Odessa Subarea. In the *Appraisal-Level Investigation Summary of Findings Odessa Subarea Special Study* (Reclamation 2008), actions were proposed to meet this need by replacing the current and increasingly unreliable groundwater supplies with a surface supply from the CBP as part of continued phased development of the CBP. An estimated 170,000 acres within the Odessa Subarea are now being irrigated with groundwater; approximately 140,000 of these acres are within the boundaries of the CBP and can be supplied with water from continued development of the CBP (Reclamation 2008).

The *Odessa Investigation Summary* looked at four water delivery alternatives and six water supply options. Approximately 515,300 acre-feet of water supply was determined to be needed to fully supply the 140,000 acres of the Odessa Subarea within CBP boundaries (Reclamation 2008).

As part of their water supply option recommendations, Reclamation will study Rocky Coulee as a potential new storage site. It was stated that new storage may be required to minimize effects associated with modifying existing facilities (Reclamation 2008).

In the *Odessa Investigation Summary*, Rocky Coulee was proposed to have an active storage of 126,000 acre-feet, which is able to serve 46,900 acres of the Odessa Subarea. The appraisal-level construction costs for Rocky Coulee were estimated to range from $234 to $416 million (Reclamation 2008). The unit costs are approximately $1,860 to $3,300 per acre-foot of storage.

Some issues with Rocky Coulee include 392 acres of shrub-steppe habitat inundation, loss of potential habitat support for 15 wildlife species of concern, and inundation of at least six residences, 5 miles of road, and 1,925 acres of cropland.

Due to its location near the Columbia Basin Project, a reservoir in the Foster Coulee area could be a potential storage alternative or supplement to Rocky Coulee. A Foster Coulee reservoir could tie in with the existing CBP system at Banks Lake and be used to store additional water for continued development of the CBP.

2.2 Power Generation Use

Water stored at these projects can be used for power generation. The most likely scenario would be configuring a reservoir with pump/generation units to both supply water to the reservoir and generate power when water is discharged from the reservoir.

2.2.1 Description of Pumped Storage Projects

A pumped storage project utilizes two reservoirs for water storage. When power demand is low or power availability high, water is pumped from the lower reservoir to the upper reservoir to fill the reservoir. When power demand is high, water stored in the upper reservoir is passed through hydroelectric turbines to generate power and released to the lower reservoir. In the case of the Rock Island projects, the lower reservoir would be the Columbia River upstream of Rock Island Dam. In the case of the Foster Coulee project, the lower reservoir would be Banks Lake. A pumped storage project generates revenue by selling power during high demand (and higher cost) periods while using lower cost power to fill the reservoir.

In the Pacific Northwest, wind generation has substantially increased and is expected to further increase as clean renewable energy resources are in demand and have economic incentives to be developed. Although wind generation increases the power supply, the generation is variable due to rapidly changing weather conditions. For example, Bonneville Power Administration (BPA) tracks wind generation and recorded variations of 1,200 megawatts (MW) in wind generation from one day to the next in January 2009 (Mainzer 2009). The total wind generation peaked at about 1,500 MW in that month. As a comparison, the generating capacity of Rock Island Dam owned by Chelan Public Utility District (PUD) is 624 MW (Chelan PUD 2010) and the peak BPA load is approximately 10,500 MW (McManus 2009). The variable generation creates problems with the hydropower generation facilities located on the Columbia River as they are being used to the extent possible as peaking power generation facilities. However, those hydroelectric facilities have limitations for use as peaking power generation because of their capacity, the required flow releases through the dams and issues with dissolved gas generation below the dams.

The total wind generating capacity in the Pacific Northwest is predicted to increase to between 4,000 and 8,000 MW in the next three years (McManus 2009), which could lead to an even more challenging situation with variable wind generation resources. In the long-term, about 15,000 MW of wind generation is under consideration in the Pacific Northwest. Pumped storage is a viable option to integrate with wind generation for better system reliability and to better meet demands. During times of low demand or surplus energy from high wind generation, water can be pumped to the higher reservoir for storage. During times of high demand or low wind generation, water can be released through hydroelectric turbines for additional power generation.

The interest in creating electrical generation resources such as pumped storage to help balance wind generation is high. BPA has published a Wind Integration Strategy, and a long-term strategy is to evaluate pumped storage projects (Mainzer 2009). Private developers and power companies are also currently studying pump storage projects; currently, 24 preliminary permits with the Federal Energy Regulatory Commission (FERC) exist on pump storage sites in the Pacific Northwest, California, Utah, Nevada, and Montana. Three more developers have recently filed for preliminary permits, which allows a developer to study pump generation facilities at a site without competition. Among the preliminary permits issued by FERC is for a site on Banks Lake similar to the Foster Coulee project. The capacity of that project is proposed to be 1040 MW, and the developer is BPUS Generation Development, LLC.

3 DESCRIPTION OF PROJECTS

This study reviewed three potential reservoir locations within two areas: Rock Island Creek and Foster Coulee. A description of each location is included in this section.

3.1 Rock Island Creek Projects

Rock Island Creek is located in Douglas County in the southwestern portion of WRIA 44 (see Figure 1-1). Rock Island Creek flows south from its headwaters near Badger Mountain for approximately 20 miles before flowing into the Columbia River just upstream of Rock Island Dam. Two sites were chosen within Rock Island Creek for analysis in this study, denoted as Lower Rock Island Creek Project and Upper Rock Island Creek Project.

3.1.1 Lower Rock Island Creek Project

The lower Rock Island site is located on Rock Island Creek with a proposed dam location approximately 1.3 miles upstream of its confluence with the Columbia River (see Figure 3-1). Initially, three dam heights at this site were compared. Table 3-1 compares various properties of the site with varying maximum reservoir elevations.

Table 3-1
Lower Rock Island Creek Project Properties

Reservoir Elevation (ft)	Dam Height (ft)	Approximate Storage Volume (AF)	Head Difference Between Reservoir and Columbia River (ft)	Length of Rock Island Creek Inundated (miles)	Reservoir Area (ac)
1200	365	44,300	235-595	2.5	331
1300	465	85,300	235-695	3.2	505
1400	565	144,400	235-795	3.9	682

A reservoir elevation of 1300 feet was chosen for further investigation. The dam is projected to be 465 feet high with a maximum crest length of 1,940 feet. The storage volume for this reservoir is approximately 85,300 acre-feet with a reservoir area of 505 acres. Drawings 1 through 4 in Appendix A show the reservoir plan, dam plan, dam and reservoir profiles, and dam section for the chosen reservoir elevation.

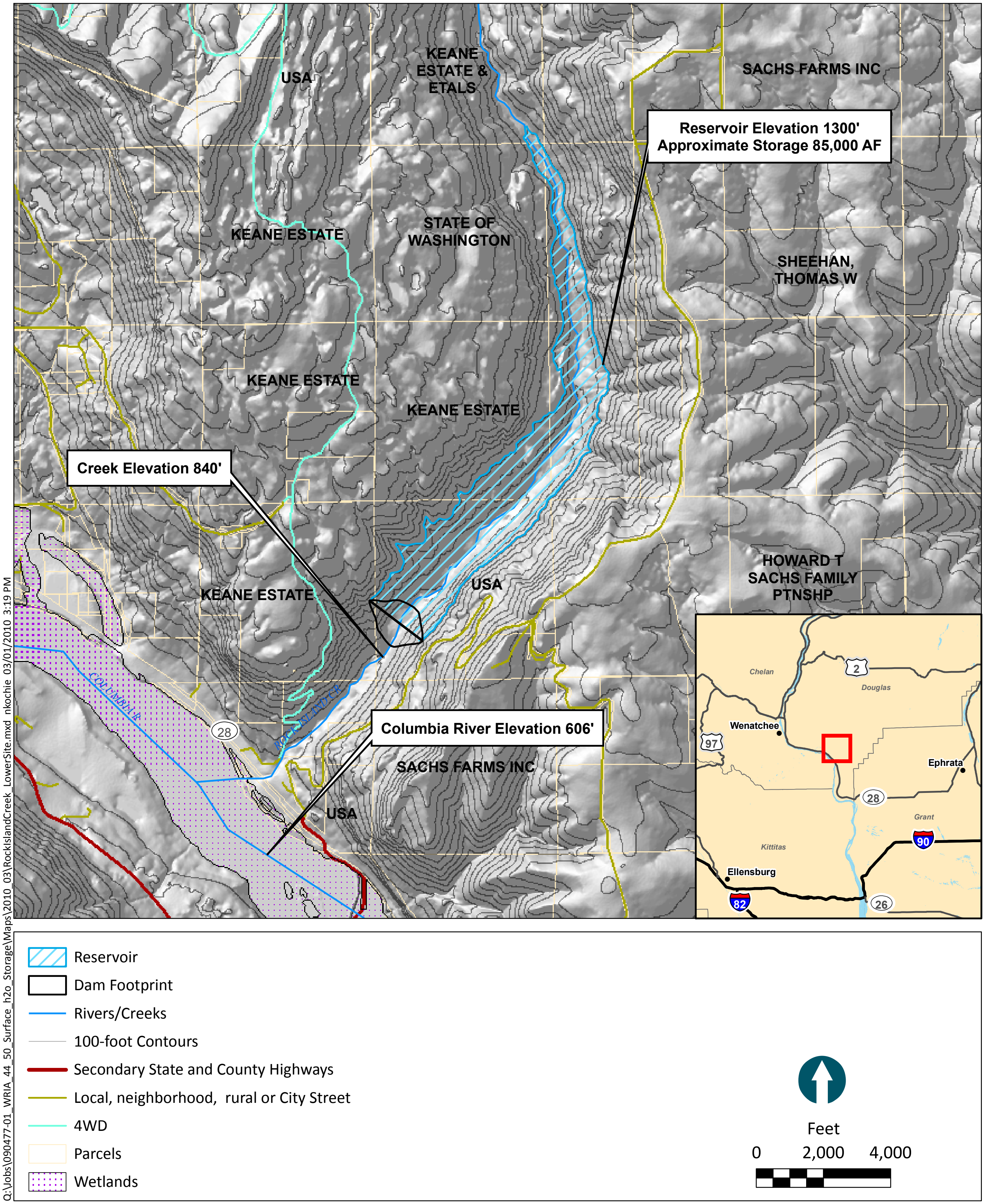

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Figure 3-1
Rock Island Creek Lower Site
Configuration and Land Ownership

Table 3-2 lists the parcels affected by the proposed reservoir at the Lower Rock Island Creek site. Owner information was obtained from Douglas County's GIS data.

Table 3-2
Affected Parcels at Lower Rock Island Creek Site

Parcel Number	Owner	Mailing Address
22220900000	Keane Estate Etals	19 S Garden Avenue Rock Island, Washington 98850
22221520000	Linda Davenport	3052 E Seventh Oakland, California 94601
22221600000	State of Washington	P.O. Box 98 Wenatchee, Washington 98807
22222100000	Keane Estate Etals	19 S Garden Avenue Rock Island, Washington 98850
22222220000	Keane Estate Etals	19 S Garden Avenue Rock Island, Washington 98850
22222810000	USA	
22222910001	Keane Estate Etals	19 S Garden Avenue Rock Island, Washington 98850

3.1.2 Upper Rock Island Creek Project

The Upper Rock Island Creek site is located approximately 7.9 miles east of the Columbia River (see Figure 3-2). Initially, three dam heights at this site were compared. Table 3-3 compares various properties of the site with varying maximum reservoir elevations. The Upper Rock Island Creek Project was included because it is located at a higher elevation and therefore could produce more energy with a pump storage project than one at Lower Rock Island Creek.

Table 3-3
Upper Rock Island Creek Project Properties

Reservoir Elevation (ft)	Dam Height (ft)	Approximate Storage Volume (AF)	Head Difference Between Reservoir and Columbia River (ft)	Length of Rock Island Creek Inundated (miles)	Reservoir Area (ac)
2,200	195	10,700	1405-1595	1.5	104
2300	295	30,200	1405-1695	2.2	229
2400	395	65,900	1405-1795	3.0	412

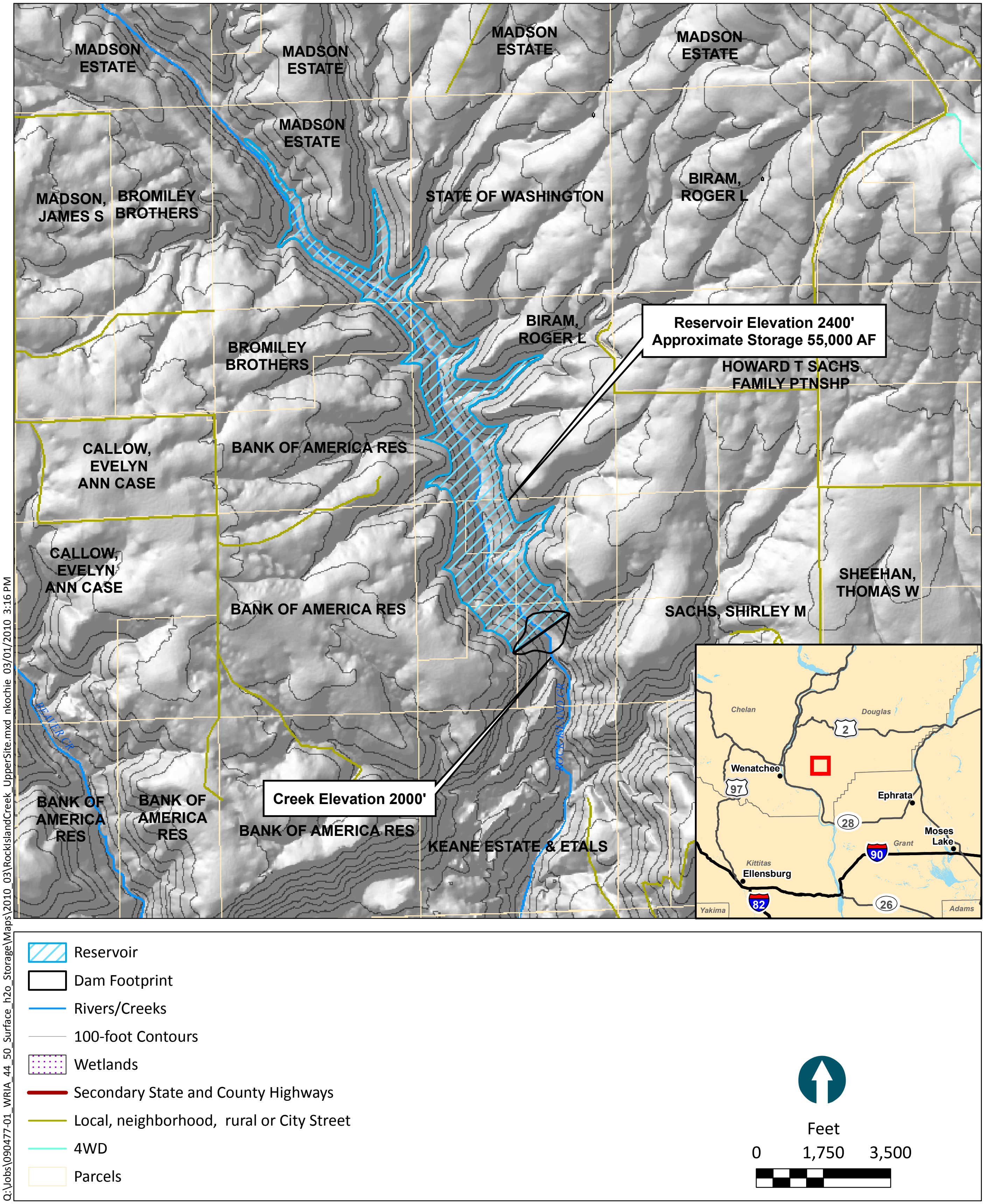

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Figure 3-2
Rock Island Creek Upper Site
Configuration and Land Ownership

A reservoir elevation of 2,400 feet was chosen for further investigation. The dam is projected to be 395 feet high with a maximum crest length of 1,780 feet. The storage volume for this reservoir is approximately 65,900 acre-feet with a reservoir area of 412 acres. This dam location was selected as it could generate more power from a pumped storage project. However, its distance from the river would increase the costs considerably. Drawings 5 through 8 in Appendix A show the reservoir plan, dam plan, dam and reservoir profiles, and dam section for the chosen reservoir elevation.

Table 3-4 lists the parcels affected by the proposed reservoir at the Rock Island 2 site. Owner information was obtained from Douglas County's GIS data.

Table 3-4
Affected Parcels at Upper Rock Island Creek Site

Parcel Number	Owner	Mailing Address
23221600000	State of Washington	P.O .Box 98 Wenatchee, Washington 98807
23221700000	Madson Estate c/o Jim Madson	842 Road S SW East Wenatchee, Washington 98802
23222010001	Bromiley Brothers	783 Road V SW East Wenatchee, Washington 98802
23222010004	Bank of America Res Brett/6500955	P.O. Box 34029 Seattle, Washington 98124
23222100000	Roger Biram	842B Palisades Road Palisades, Washington 98845
23222810002	USA	
23222820001	Roger Biram	842B Palisades Road Palisades, Washington 98845

3.2 Foster Coulee Project

Foster Coulee, in the Foster Creek watershed, originates near the west shoreline of Banks Lake. Foster Coulee is the primary drainage of WRIA 50 in northern Douglas County. Foster Creek flows into the Columbia River at river mile (RM) 554.6, immediately downstream of Chief Joseph Dam at Bridgeport, Washington.

The Foster Coulee Project is located on East Foster Creek with a proposed dam location approximately 0.7 mile west of Banks Lake (see Figure 3-3). Initially, three dam heights at this site were compared. Because of the site topography, a second dam is required at the west end of the reservoir to store water. Table 3-5 compares various properties of the site with varying maximum reservoir elevations.

Table 3-5
Foster Coulee Project Properties Comparison

Reservoir Elevation (ft)	East Dam Height (ft)	West Dam Height (ft)	Approximate Storage Volume (AF)	Approximate Active Storage Volume (AF)	Head Difference Between Reservoir and Banks Lake (ft)	Length of Foster Coulee Inundated (miles)	Reservoir Area (ac)
2120	55	155	93,700	60,100	495-550	6.1	2280
2140	75	115	79,000	69,700	495-570	4.9	1820
2160	95	100	72,000	70,700	495-590	3.9	1330

A reservoir elevation of 2160 feet was chosen for further investigation as it appears to offer the most economical configuration of dam heights and active storage volumes. The east dam is projected to be 95 feet high with a maximum crest length of 1,050 feet. The active storage volume for this reservoir is approximately 70,700 acre-feet with a reservoir area of 1,330 acres. Drawings 9 through 13 in Appendix A show the reservoir plan, dam plan, dam and reservoir profiles, and dam sections for the chosen reservoir elevation.

There are other, larger configurations of reservoirs at this site that have been identified by Ecology. Ecology identified three different reservoir configurations with capacities ranging from 96,000 to 195,000 acre-feet. The configurations studied in this report, although smaller, are thought to be more economical in terms of cost per acre-foot of active storage. Note that the further west a reservoir is extended, less of the reservoir volume can be discharged back to Banks Lake. The western dams in the Ecology reservoir configurations were located further west than the west dam for the configuration studied in this report.

Table 3-6 lists the parcels affected by the proposed reservoir at the Foster Coulee Project site. Owner information was obtained from Douglas County's GIS data.

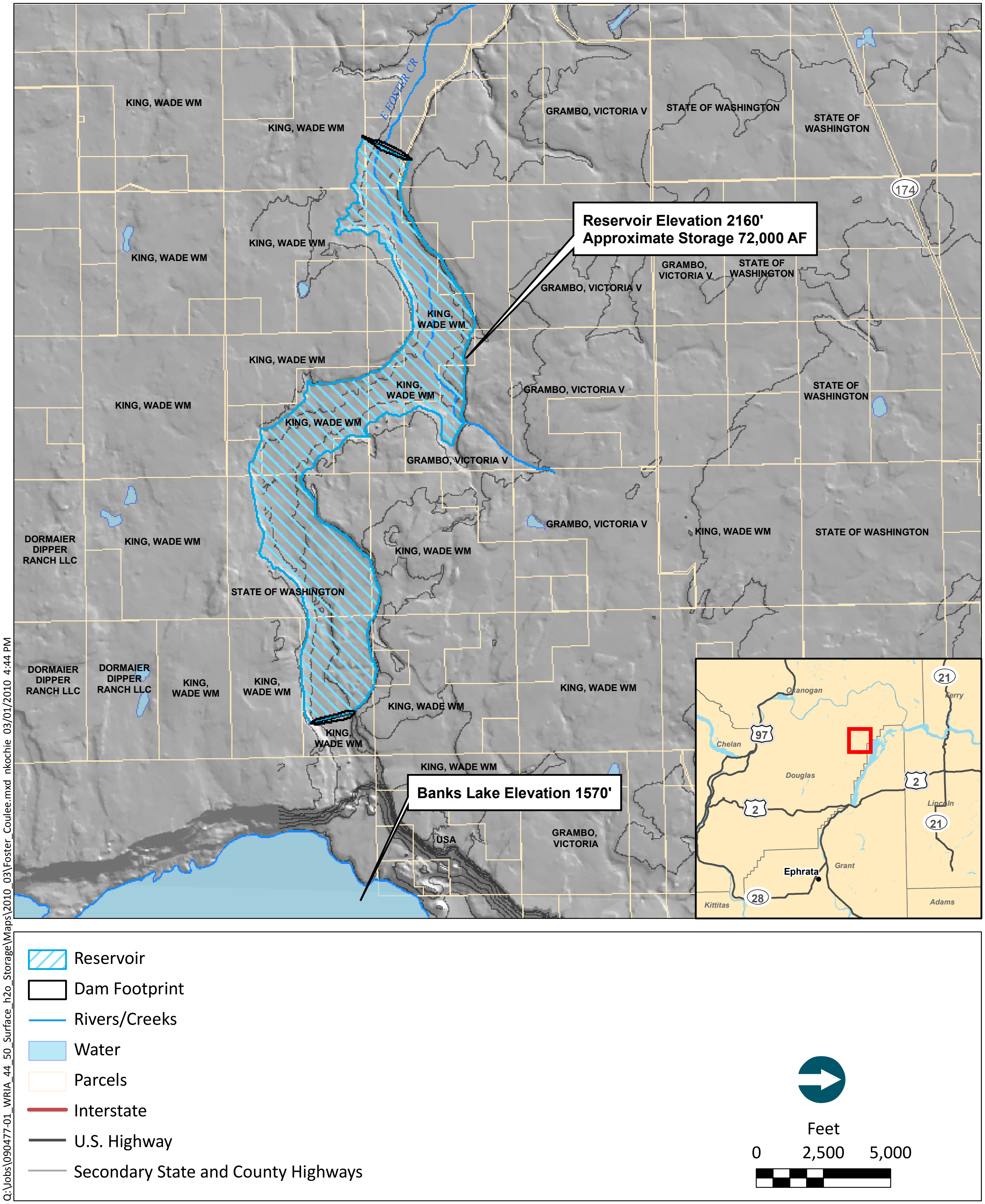

Figure 3-3
Foster Coulee Site
Configuration and Land Ownership

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Table 3-6
Affected Parcels from Foster Coulee Project

Parcel Number	Owner	Mailing Address
28282510000	Wade King	31215 Moore Road NE Coulee City, Washington 99115
28282610000	Victoria Grambo	5707 S Spotted Road Spokane, Washington 99224
28282620001	Wade King	31215 Moore Road NE Coulee City, Washington 99115
28282630001	USA	
28282710001	Victoria Grambo	5707 S Spotted Road Spokane, Washington 99224
28282710002	Wade King	31215 Moore Road NE Coulee City, Washington 99115
28282720001	USA	
28282810000	Dugualla Bay Co LLC	22408 WCR 1 Berthoud, Colorado 80513
28282840001	Wade King	31215 Moore Road NE Coulee City, Washington 99115
28283310000	Wade King	31215 Moore Road NE Coulee City, Washington 99115
28283420000	Wade King	31215 Moore Road NE Coulee City, Washington 99115
28283510001	USA	
28283510002	Wade King	31215 Moore Road NE Coulee City, Washington 99115
28283540001	Douglas County	140 19th St NW East Wenatchee, Washington 98802
28283540002	James & John Seaberg Patricia Seaberg Life Estate	2344 Sherman Creek Road Eau Claire, Wisconsin 54703
28283600000	State of Washington	PO Box 98 Wenatchee, Washington 98807
28293010001	Wade King	31215 Moore Road NE Coulee City, Washington 99115
28293010002	USA	
28293110000	Wade King	31215 Moore Road NE Coulee City, Washington 99115
28293130000	Wade King	31215 Moore Road NE Coulee City, Washington 99115

4 HYDROELECTRIC POTENTIAL

The formula for calculating hydroelectric generating potential is:

$$\text{Power} = (\text{Head}) \times (\text{Flow}) \times (\text{Efficiency}) / 11.8 \qquad (4\text{-}1)$$

where:

Power	=	the electric power (kilowatts)
Head	=	the difference in elevation between the reservoir elevation and the power plant adjusted for pressure losses sustained in the delivery penstock (feet). For this study, the pressure losses were assumed to be 10 percent of the total static pressure head.
Flow	=	the amount of water discharged through the power plant measured in cubic feet per second (cfs).
Efficiency	=	How well the turbine and generator convert the power of falling water into electric power. For this study, an efficiency of 85% was assumed
11.8	=	converts units of feet and seconds into kilowatts

The following sections present estimates of hydroelectric potential at each site. This study does not attempt to determine which configuration of pump storage generating capacity would be preferred by a project developer; we are making assumptions for a configuration only for the purposes of estimating construction costs and comparing the three sites. We are using the largest generating capacity for the sites that may be reasonable based upon penstock sizing and length. A single penstock was assumed for the Rock Island Creek projects because of their length while a dual penstock was assumed for the Foster Coulee project. The Foster Coulee project may also utilize a tunnel if less expensive than steel penstocks.

4.1 Lower Rock Island Creek Project

Figure 4-1 presents the potential capacity of a generating facility for various discharge rates at the Lower Rock Island Creek site, assuming a high operating head of 695 feet, a low operating head of 235 feet, and an operating efficiency of 85 percent.

The potential generating capacity for the Lower Rock Island Creek site could range up to about 290 MW at full reservoir capacity assuming a discharge of 6,500 cfs. A penstock diameter of 24 feet, at a minimum, would be required for that flow rate.

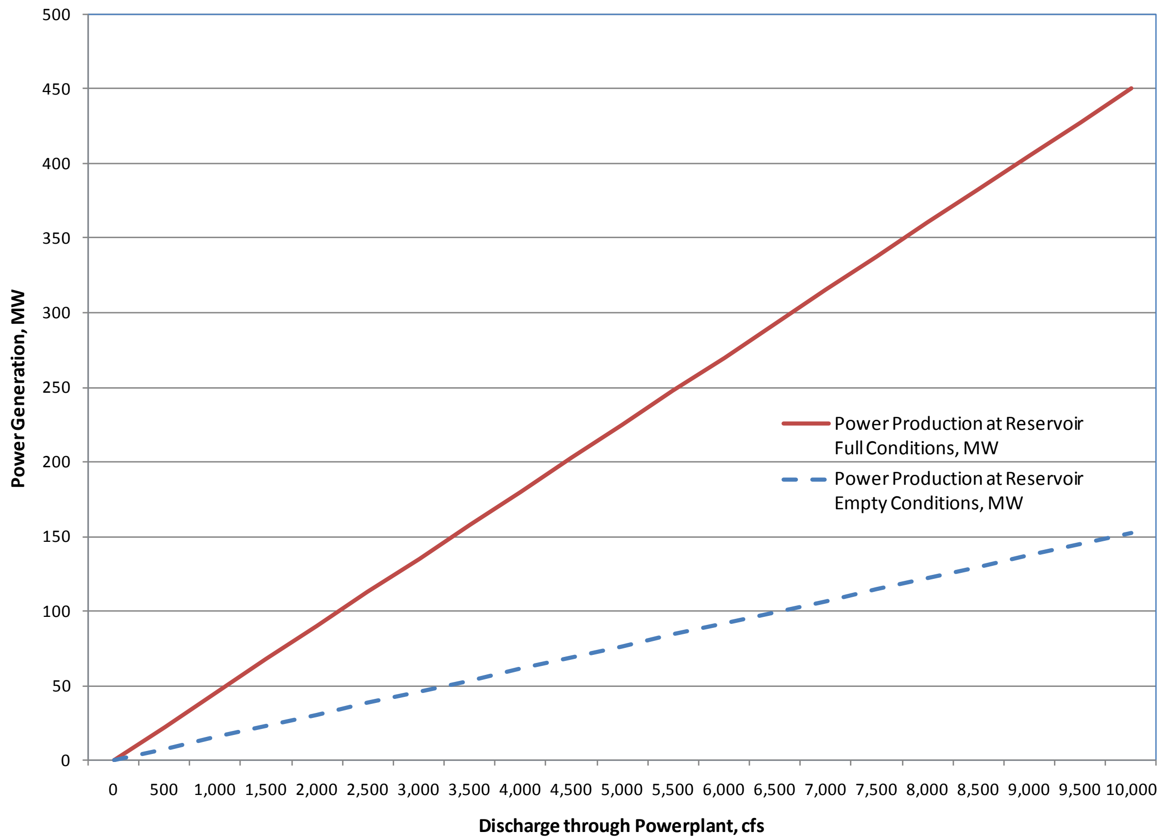


Figure 4-1
Hydroelectric Generating Potential – Lower Rock Island Creek Site

4.2 Upper Rock Island Creek Project

Figure 4-2 presents the potential capacity of a generating facility for various discharge rates at the Upper Rock Island Creek site, assuming a high operating head of 1,795 feet, a low operating head of 1,405 feet, and an operating efficiency of 85 percent.

The potential generating capacity for the Upper Rock Island Creek site could range up to about 695 MW at full reservoir capacity assuming a discharge of 6,000 cfs. A penstock diameter of 24 feet, at a minimum, would be required for that flow rate.

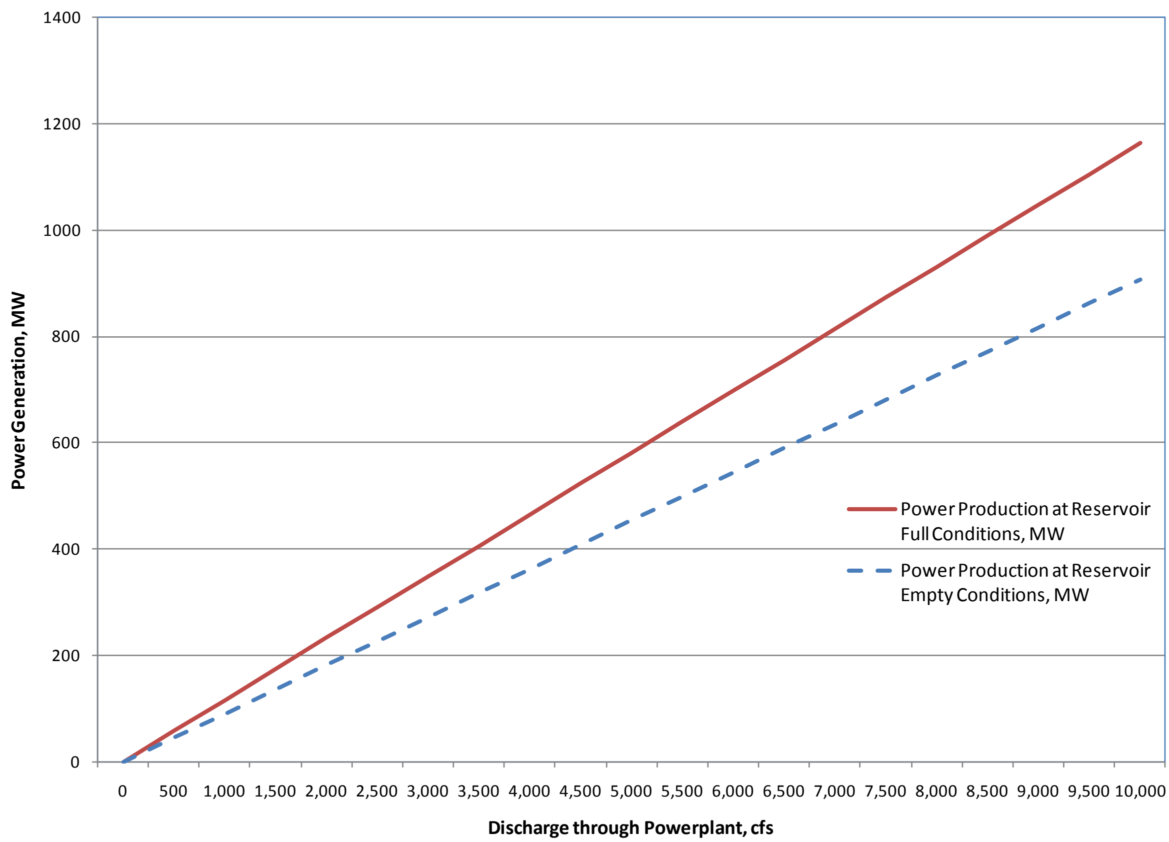


Figure 4-2
Hydroelectric Generating Potential – Upper Rock Island Creek Site

4.3 Foster Coulee Project

Figure 4-3 presents the potential capacity of a generating facility for various discharge rates at the Upper Rock Island Creek site, assuming a high operating head of 590 feet, a low operating head of 495 feet, and an operating efficiency of 85 percent.

The potential generating capacity for the Foster Coulee site could range up to about 515 MW at full reservoir capacity assuming a discharge of 14,000 cfs. Two penstocks with diameters of 24 feet, at a minimum, would be required for that flow rate. A tunnel would also be considered because of the size of the penstock and the geology at the site.

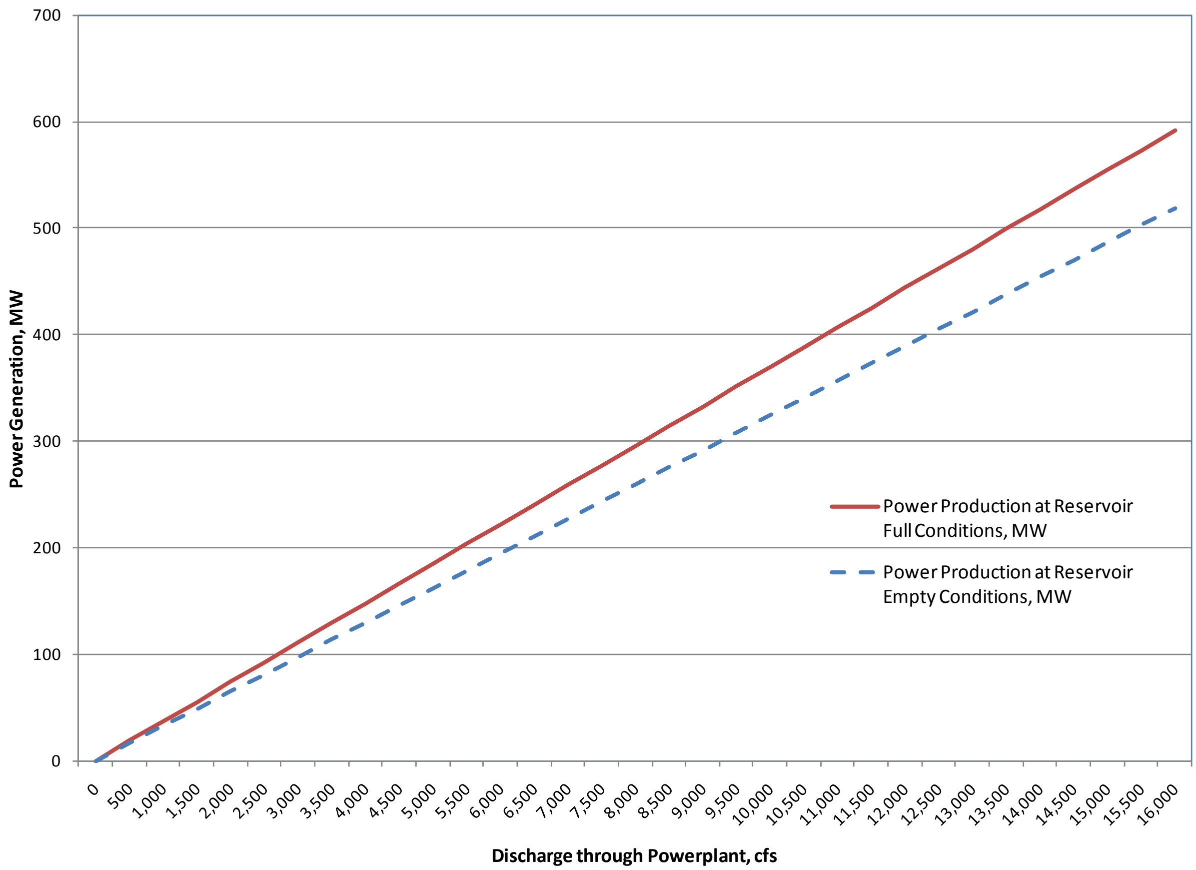


Figure 4-3
Hydroelectric Generation Potential – Foster Coulee Site

4.4 Potential Power Generation

The operation of a pumped storage project capitalizes on the difference in cost of power that can be sold during peaking periods compared to the cost of pumping using off-peak power. If the plant is operated to take advantage of those cost differences on a daily basis, the plant could be operated for a period of 8 to 10 hours per day. Table 4-1 presents estimates of annual power generation in Megawatt hours (MWhr) using operations of 8 hours per day all year.

Table 4-1
Potential Power Production

Project	Estimated Capacity MW	Estimated Annual Generation (MWhr)
Lower Rock Island Creek	290	846,800
Upper Rock Island Creek	695	2,029,400
Foster Coulee	515	1,503,800

The cost difference between peak and off-peak power on a daily basis is forecast to range from approximately $5 to S26 per megawatt hour (MWhr) with an average of approximately $12 per MWhr (NWPCC 2010) over the next 20 years. If the developer of a pumped storage project owned other generation resources the cost difference could be much larger as they presumably could fill the reservoir using low cost power. A mid-Columbia River PUD (Chelan, Douglas, or Grant PUD) is an example of a developer who could operate a pumped storage project at the sites and maximize revenue by using their own low cost power to fill the reservoirs. There is also interest in operating a pumped storage project to supply power when wind power generation falls off because of meteorological conditions. In this case the plant would be operated for more than one day and more power would be produced on an annual basis than listed in Table 4-1. No estimate of the additional power was made as a detailed economic and operational study would be required.

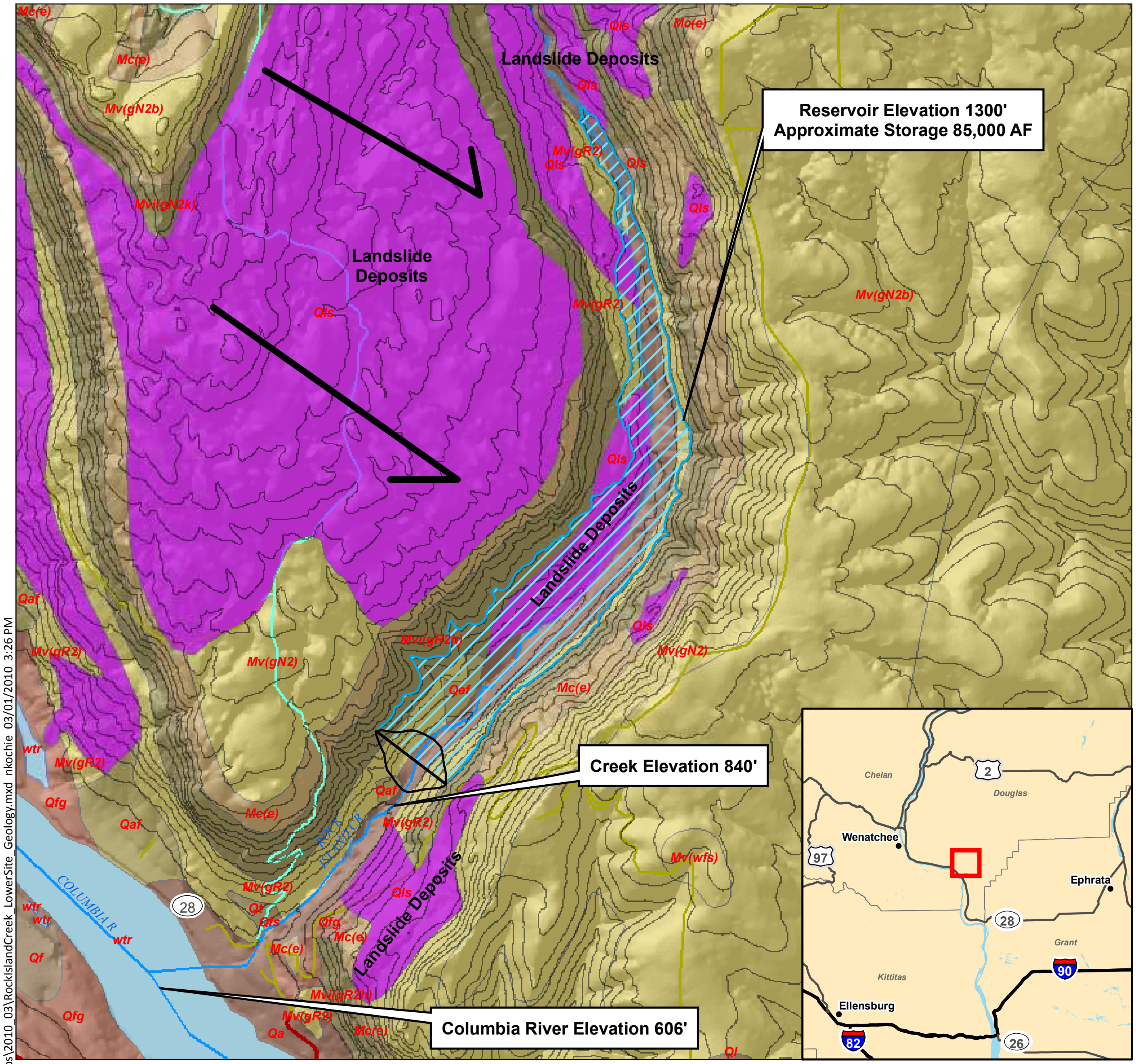
5 GEOLOGY OF SITES

This section summarizes the geology at the proposed dam sites based on observations by Pacific Groundwater Group.

Geologic descriptions focus on the geologic units present, the geologic history of the locations, and selected issues for further consideration if the projects are further explored. The geologic descriptions below are based on review of published and geologic unit descriptions, and review of air photos.

5.1 Rock Island Creek

The geology in the vicinity of the Lower Rock Island Creek and Upper Rock Island Creek sites are shown in Figures 5-1 and 5-2, respectively. Figure 5-3 shows a geologic cross-section of the two proposed Rock Island Creek dam sites.



- Reservoir
- Dam Footprint
- Rivers/Creeks
- 100-foot Contours
- Secondary State and County Highways
- Local, neighborhood, rural or City Street
- 4WD
- Landslide Deposits and Transport Direction Where Known

GEOLOGY

- Mc - continental sedimentary deposits or rocks
- Mv - basalt flows
- Mvi - basalt flows, invasive
- Oc - continental sedimentary deposits or rocks
- Qa - alluvium
- Qaf - alluvial fan deposits
- Qf - artificial fill, including modified land
- Qfg - outburst flood deposits, gravel
- Qfs - outburst flood deposits, sand and silt
- Ql - loess
- Qls - mass wasting deposits
- Qp - peat deposits
- Qt - terraced deposits
- Water

Feet

0 1,750 3,500

ANCHOR QEA

Figure 5-1
Rock Island Creek Lower Site
Geology Map

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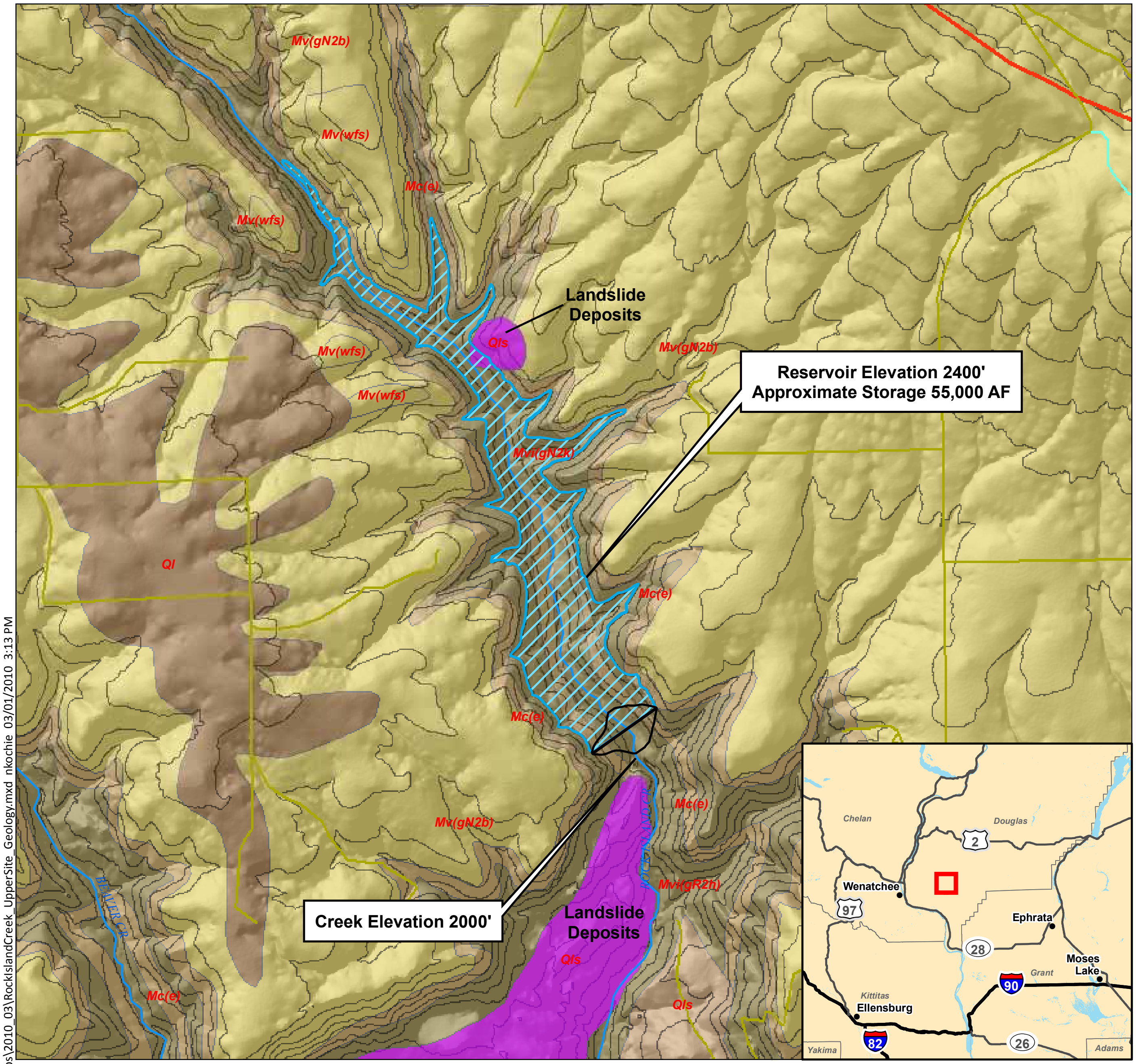

Reservoir	
Dam Footprint	
Rivers/Creeks	
100-foot Contours	
Secondary State and County Highways	
Local, neighborhood, rural or City Street	
4WD	
Landslide Deposits and Transport Direction Where Known	

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- Qt - terraced deposits
- Water

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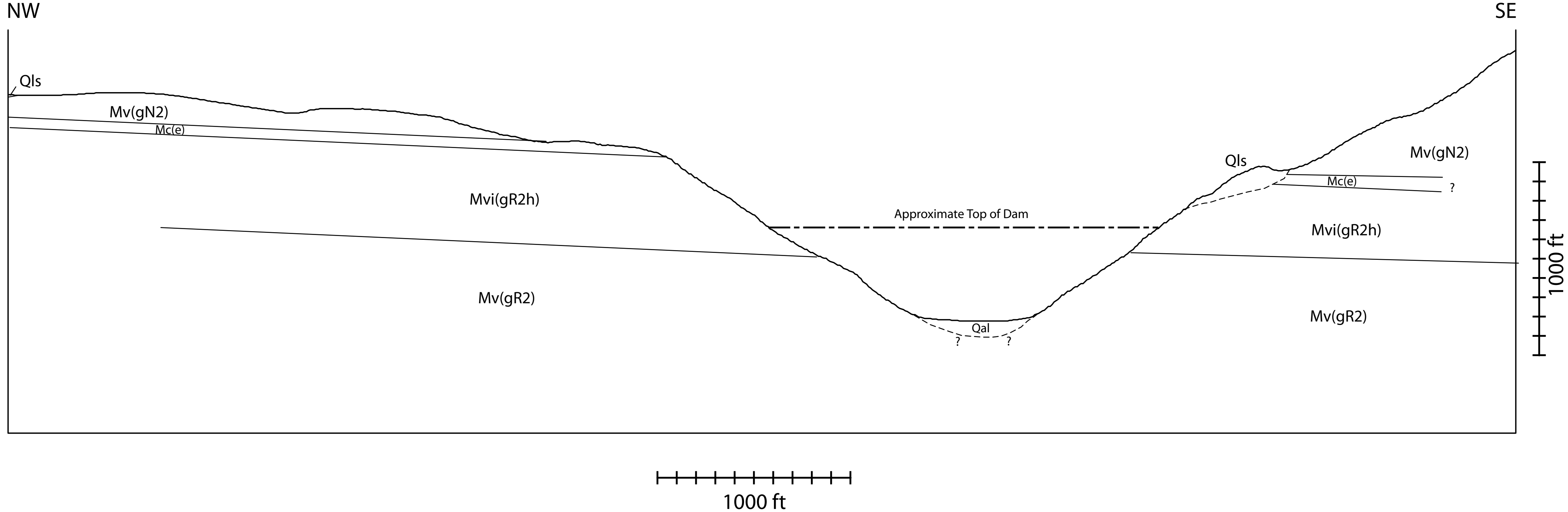
ANCHOR QEA

Feet
0 1,750 3,500

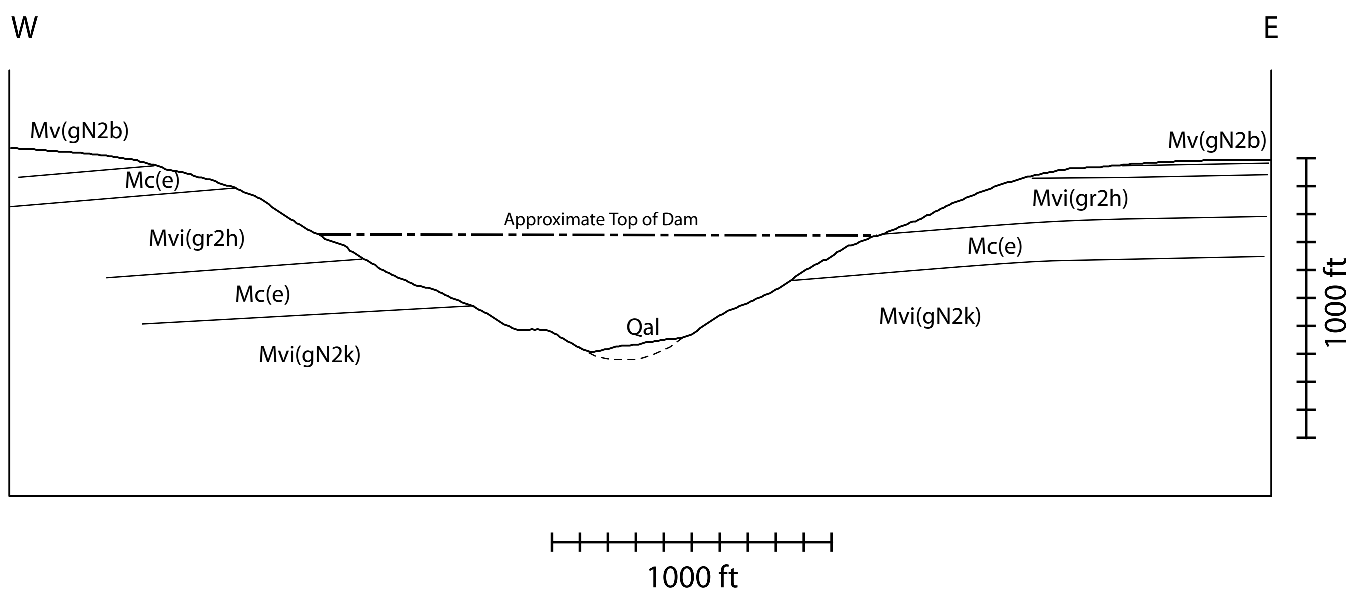
Figure 5-2
Rock Island Creek Upper Site
Geology Map

Site 1 Proposed Dam Location



No Vertical Exaggeration
Note: Dip of units approximate. Units as shown on Figure 3.

Site 2 Proposed Dam Location



No Vertical Exaggeration
Note: Dip of units approximate. Units as shown on Figure 3.

Figure 5-3
Geologic Cross Sections
Rock Island Creek Sites

PgG

5.1.1 Geologic Description

The Rock Island Creek drainage is cut into interbedded Columbia River Basalt (CRB) flows and continental sedimentary units of the Ellensburg Formation. The CRB and Ellensburg formations have been reworked through erosion, deposition and mass wasting processes to form secondary fluvial, talus, and landslide deposits in the project area.

Bedrock in the Rock Island Creek area includes basalt flows of the Grand Ronde Basalt interbedded with sandstone to siltstone members of the Ellensburg formation. The layers are gently folded throughout the area, but no faults are shown on the geologic map.

Landslide deposits occur extensively within both of the proposed Rock Island reservoir areas, and large landslides are common in the region (Tabor et al. 1982). Three types of landslide deposits are mapped in the Rock Island area: undifferentiated landslide deposits (Qls); older landslide deposits (Qlso); and blocky landslide deposits (Qlsb).

The undifferentiated landslide units are the most common within in the areas specifically proposed for dam and reservoir construction. These landslides are of unknown age, and range in size from small, localized releases along the canyon walls to massive slides covering areas greater than a square mile. A large slide west of the canyon has features indicating transport to the southwest. Additional landslide deposits along the north and west sides of the canyon may be material that has dropped into the canyon from the larger slide above. This landslide is adjacent to both of the proposed dam locations. Additional smaller landslides on the east side of the canyon east of the Upper Rock Island Site, at the confluence with Beaver Creek, and at Rock Island State Park immediately downstream from the proposed Lower Rock Island Site dam location.

Older landslide deposits predate the Missoula Flood deposits and are likely about 18,000 years old (Tabor et al. 1982). Blocky landslide deposits appear to be contemporaneous with the older landslide deposits, and are differentiated by the presence of large, intact portions of bedrock which have been rotated during transport. Many of the rotated blocks preserve stratigraphic features such as bedding in sedimentary rocks, or columns in basalt flows. In the vicinity, these two landslide units are principally found near and north of the mouth of the Rock Island Creek canyon.

Alluvial deposits in the area include talus cones along the canyon walls and fluvial (stream) deposits along the canyon bottom.

5.1.2 Identified Lower Rock Island Creek Site Issues

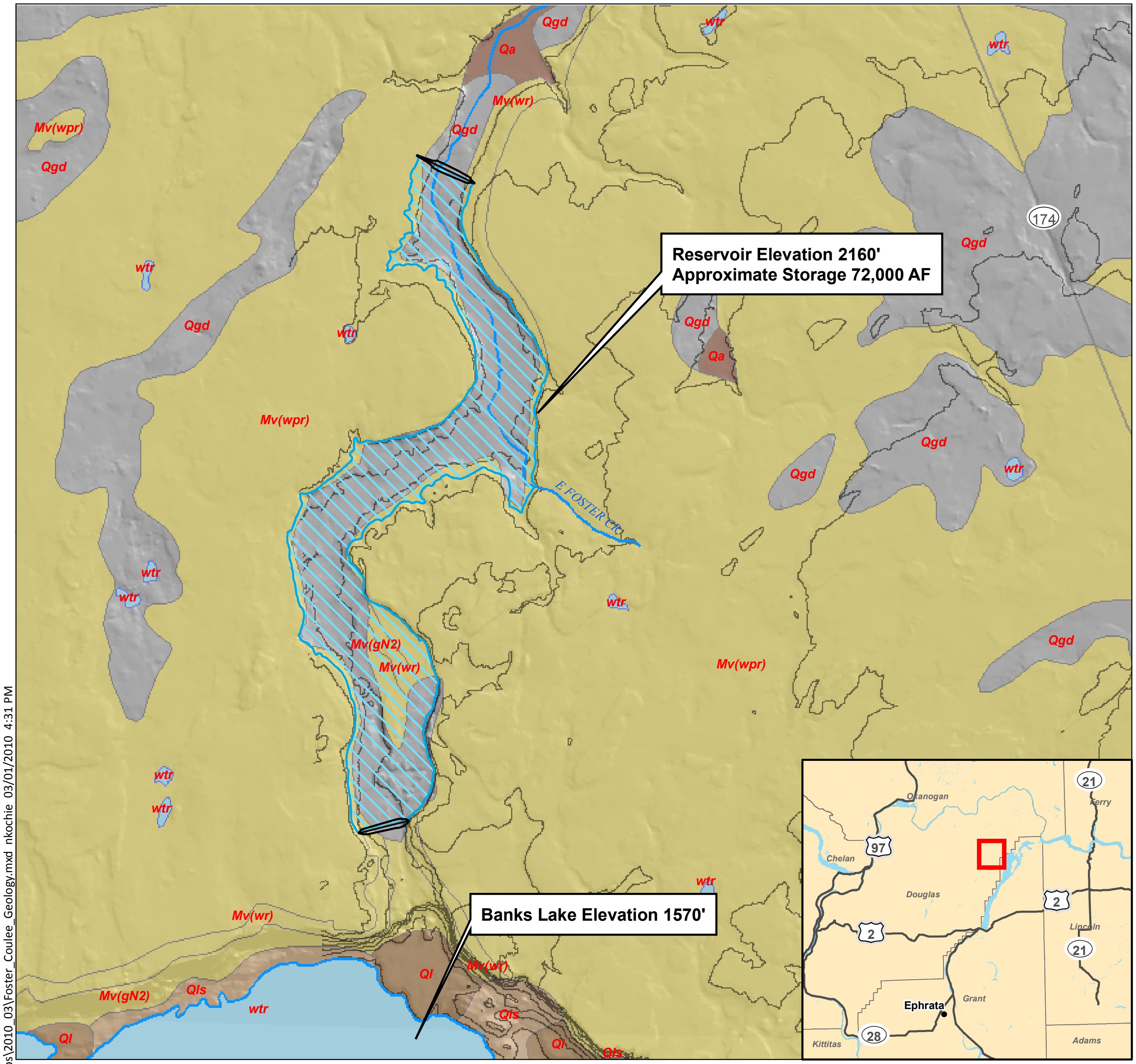
Extensive landslide deposits are present within, downstream of, adjacent to, and above the proposed dam and reservoir areas. Concerns include the potential for reactivating the landslides through reducing the stability of rock masses currently supporting the toe of landslides, impeding drainage of the landslide deposits and increasing seepage through the abutments. Seepage through the abutments could reactivate the landslide mass located downstream of the proposed dam on the south valley wall. A geotechnical evaluation to evaluate the stability of the slopes for dam abutments, the stability of existing landslides and the potential to reactivate currently stable landslide deposits should be performed as part of additional geologic investigation at the site. Alluvium may be up to 100 feet thick at the center of the valley thinning to zero thickness at the edges of the deposit. There is substantial uncertainty in the maximum depth of the alluvium; the 100-feet estimate is derived as 50 percent of the projected depth of the canyon sidewalls.

5.1.3 Identified Upper Rock Island Creek Site Issues

The proposed dam location is located just upstream of a large landslide of unknown age and a landslide is mapped adjacent to the reservoir. A concern includes the potential for reactivating the landslide adjacent to the reservoir through reducing the stability of rock masses currently supporting its toe and impeding drainage of the landslide deposits. Another concern is increasing seepage through the abutments and reactivating the landslide downstream of the proposed dam location. Alluvium in the valley bottom is likely up to 50 feet thick near the middle of the canyon tapering to zero thickness at the canyon edges based on cross-section estimates. The landslide adjacent to the proposed dam location temporarily blocked Rock Island Creek resulting in accumulation of additional sediment near the proposed dam location. This sediment is apparent in air photos, but is not shown on the geologic map. Landslides are common in the area, and should be evaluated as part of additional geologic investigation at the site.

5.2 Foster Coulee

Figure 5-4 shows the overall geology map for the Foster Coulee site.



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Reservoir
Dam Footprint
Rivers/Creeks
100-foot Contours
Interstate
U.S. Highway
Secondary State and County Highways

GEOLOGY

Mc - continental sedimentary deposits or rocks
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Oc - continental sedimentary deposits or rocks
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Ql - loess
Qls - mass wasting deposits
Qp - peat deposits
Qt - terraced deposits
Water

ANCHOR QEA

Feet
0 2,500 5,000

Figure 5-4
Foster Coulee Site
Geology Map

5.2.1 Geologic Description

The coulee is an erosional landform carved into the Columbia River Basalts and later partially filled with glacial deposits.

Bedrock in Foster Coulee is Wanapum Basalt within the study area. Granitic rocks older than the CRB crop out in the surrounding area and related pre-CRB rocks are likely present at an unknown depth beneath Foster Coulee. No substantial interbeds of sedimentary rock are noted in the geologic map in the area, and only minor sediments in interflow zones are seen in the sparse well logs available in the area.

Foster Coulee is partially filled with glacial drift of unknown thickness. The bedrock surface on the floor of the Coulee near Banks Lake where glacial drift is absent has up to 100 feet of local relief suggesting an the range of variability that could be expected in the thickness of the drift elsewhere in the Coulee. The glacial drift mapped in Foster Coulee is undivided and may include materials ranging from high-permeability sands and gravels to lower-permeability glacial units.

Talus has accumulated at the edges of the coulee beneath cliffs. Talus overlies, is younger than the glacial drift, and may be as much as 50 feet thick at the coulee wall based on topographic contours.

Three well logs from the area around, and possibly in, Foster Coulee suggest surface sediments up to 12 feet thick underlain by hard basalt with occasional fractures. Fractured or soft intervals suggesting higher permeability interflows are not described until 50 to 100 feet below ground surface. The depth to groundwater ranges from between 50 to 70 feet in the well logs; however, because the elevation of the wells is not known, it is not clear how this relates to an absolute elevation.

5.2.2 Identified Site Issues

The East Dam site is located on bedrock. Minor accumulations of alluvium on the coulee floor are likely to be relatively thin and less than 10 feet except over possible localized erosional features, such as bedrock potholes, where sediment may be thicker. For the West Dam site, there is considerable uncertainty in the thickness and lithology of the glacial drift in Foster Coulee. The relatively shorter dams at this site will present fewer seepage issues.

6 ENVIRONMENTAL RESOURCES AT SITES

This section describes the environmental resources at the project sites, including topography, ground cover, habitat, fish use, and potential aquatic and terrestrial effects from project implementation.

6.1 Rock Island Creek

6.1.1 Topography and Ground Cover

Rock Island Creek in Douglas County, located in the southwestern portion of WRIA 44, flows south from its headwaters near Badger Mountain for approximately 20 miles before flowing into the Columbia River just upstream of Rock Island Dam. A very small alluvial fan (RM 0.0 to 0.3) exists near the confluence of Rock Island Creek with the Columbia River, but within 1,400 feet Rock Island Creek enters a steep-walled canyon. The longitudinal gradient across the fan is approximately 5 percent.

From RM 0.3 upstream, Rock Island Creek occupies a canyon for most of its length. The lower Canyon segment (RM 0.3 to 7.8) has a gradient of approximately 3.2 percent. Aerial photographs indicate that the 200- to 500-foot wide canyon floor is currently filled with extensive sediment deposits and that the channel pattern throughout the reach is braided. As a result of a series of large floods between 1948 and 1957, the formerly year-round flow of Rock Creek now goes subsurface in the lower canyon most years (Ecology 2000). Landslides and debris flows that occurred during these floods was still evident on the valley walls in aerial photographs dating from 1978.

Near RM 8.0, the creek flows across a very resistant layer of bedrock known as the Hammond sill, and the gradient increases dramatically to over seven percent. Although no direct observations of this area were made, it is likely that the channel bedforms are predominantly cascades formed by boulders and bedrock in this segment (RM 7.8 to 8.0).

Upstream of RM 8 (in the upper canyon segment), the gradient decreases to approximately 3.3 percent. The valley floor is narrow, averaging 100 to 200 feet in width. The upper canyon segment does not appear to have been as dramatically impacted by the historic flood events as the lower canyon segment. The riparian vegetation is still intact and a single thread channel is visible in places. The canyon continues to the headwaters of Rock Island Creek which splits into very small tributaries on the relatively flat surface of Badger Mountain.

6.1.2 Habitat Conditions

Based on information contained in the Washington Department of Fish and Wildlife's (WDFW) databases (2009), both the Lower and Upper Rock Island Creek storage proposals fall within designated mule deer (*Odocoileus hemionus*) habitat under WDFW's Priority Habitats and Species (PHS) Program. During moderate to severe winters, regular concentrations of mule deer use the steep sagebrush and rocky draws of Douglas County for cover while foraging in the winter wheat fields. During spring and summer, mule deer herds use the upper elevations, Conservation Reserve Program (CRP) lands, and riparian draws for fawning areas and summer range. Both Rock Island Creek storage proposals also fall within PHS Program-designated chukar (*Alectoris chukar*) habitat and regular use areas, small and large breeding grounds, and winter use areas that have been documented for sage grouse (*Centrocercus urophasianus*; state Threatened and federal Candidate species) under the PHS Program. Talus slopes and cliff/bluffs habitat in the Rock Island Creek canyon within the proposed Lower storage location are designated PHS Program habitats. Talus slopes combined with the adjacent cliffs and riparian habitats provide habitat for deer, chucker, quail, marmots, bobcats, reptiles, raptors, and nongame bird species.

Downstream of the proposed storage alternatives locations, associated with the Columbia River, there are documented PHS Program waterfowl wintering/fall concentration areas and bald eagle (*Haliaeetus leucochephalus*) habitat comprising winter perches along the shoreline from October to March. Three man-made islands are located in the Columbia River in the vicinity of the confluence, supporting good riparian habitat for nesting waterfowl, furbearers, and raptors. On the eastern plateau above Rock Island Creek and within two miles of the proposed Lower alternative, there is a documented loggerhead shrike possible breeding location.

Sticky Phacelia (*Phacelia lenta Piper*), is a tate Threatened and federal Species of Concern plant species; it is documented to occur within and adjacent to the both proposed storage alternatives. Sagebrush stickweed (*Hackelia hispida*), coyote tobacco (*Nicotiana attenuata*), and dwarf evening-primrose (*Camissonia pygmaea*)—all state Sensitive plant species—are documented as occurring outside of the proposed Lower storage alternative location but within two miles of the Lower alternative.

6.1.3 Fish Use

Spring Chinook, summer/fall Chinook (*Oncorhynchus tshawytscha*), and steelhead (*Oncorhynchus mykiss*) rearing is documented up to approximately RM 0.5 or 0.75 in Rock Island Creek. Steelhead are presumed to spawn in Rock Island Creek up to approximately RM 0.5 or 0.75. A spring wells up about RM 0.5, which is 0.75 mile upstream of the mouth of Rock Island Creek that maintains perennial flow in this lower reach (Bartu and Andonaegui 2001). The Lower Rock Island Creek storage location is located at approximately RM 1.0. Bob Steele of WDFW has also found coho salmon carcasses in this lower reach, although this was in the early 1990s, prior to the start of the Yakama Nation mid-Columbia coho reintroduction program which began in 1997. At that time, Steele assumed the coho found in Rock Island Creek were from planted stocks from the Chelan PUD Turtle Rock Hatchery. Coho salmon were reared and released from this hatchery from 1982 to 1992 (NMFS et al. 1998). Coho salmon were extirpated from the upper Columbia region at the turn of the last century (Bartu and Andonaegui 2001).

Resident rainbow trout are documented to occur starting at approximately RM 5.0 and extending upstream into the upper reaches of Rock Island Creek (WDFW 2009). The lower end of the Upper Rock Island Creek storage location is proposed at approximately RM 8.0. From 1976 to 1979, WDFW surveyed an isolated rainbow trout (*O. mykiss*) population in Rock Island Creek at the top of Badger Mountain. During these surveys, Steele found various size classes of rainbow trout including individuals up to 17 inches long. It is Steele's professional opinion that these rainbow trout are native red-band or "desert-type" rainbow trout that have adjusted to the high water temperatures of the Rock Island Creek drainage. Various size classes of rainbow trout indicate a spawning population but Steele is concerned that the rainbow trout population in the upper Rock Island Creek drainage could have diminished in the past 25 years. During years of high water availability, instream flows may be present to allow access by steelhead trout from the mouth of Rock Island Creek upstream into the upper reaches of the drainage. This would make the isolated rainbow trout population in upper Rock Island Creek accessible to spawning adult steelhead that might be drawn into Rock Island Creek by high spring flows.

6.1.4 Aquatic Effects

6.1.4.1 Lower Rock Island Creek Dam

The storage volumes being considered for this alternative would have limited long-term effects on aquatic resources downstream of the proposed project location. Short-term effects downstream of the project location resulting from project construction can be avoided and minimized using best management practices.

Within the project area, long-term effects would be related to the conversion of a portion of the drainage from a seasonal stream channel carrying spring runoff flows into a reservoir environment. Effects would include loss of seasonally, wetted habitats that likely support amphibian production and limited riparian vegetation. Fish use does not extend upstream into the reach proposed for location of the storage reservoir, being limited by lack of year-round flows and passage barriers associated with hydrogeomorphic conditions (steep slopes and narrow canyon). However, once constructed, reservoir operations can provide permanent, year-round flows downstream in Rock Island Creek. Water pumped from the Columbia River and stored in the reservoir can be released for the benefit of fish resources downstream of the project, providing additional rearing habitat to anadromous salmonids. Additional spawning habitat for steelhead and possibly coho salmon would also be available.

6.1.4.2 Upper Rock Island Creek Dam

The storage volumes being considered for this alternative would have limited long-term effects on aquatic resources downstream of the proposed project location. Short-term effects downstream of the project location resulting from project construction can be avoided and minimized using best management practices.

Within the project area, long-term effects would be related to the conversion of a portion of the drainage from a seasonal stream channel carrying spring runoff flows to a reservoir environment. Effects would include loss of stream habitat that likely support amphibian production and riparian vegetation (although currently sparse). Resident rainbow trout are known to occur in the reach of Rock Island Creek that would be inundated by creation of this reservoir. The total extent of affect is larger or smaller depending on the storage reservoir volume alternative being considered. These rainbow trout are associated with a population isolated except in infrequent, high-water years from downstream anadromous *O. mykiss* populations. However, once constructed, reservoir operations would provide permanent, year-round flows downstream in Rock Island Creek. Water pumped from the Columbia River and stored in the reservoir would be released for the benefit of fish resources downstream of the project. Additional anadromous salmonid habitat would be supported from the existing, uppermost extent at RM 0.75 upstream until passage is precluded by the natural steepness of the slope of the channel.

6.1.5 Terrestrial Effects

The storage volumes being considered for this alternative would have long-term and short-term effects on terrestrial resources. Short-term effects would occur as a result of the construction of a water pipeline to convey water from the Columbia River to the reservoir. Impacts as a result of pipeline construction can be avoided and minimized using best management practices. Unavoidable impacts would be mitigated.

Long-term effects would be related to both the maintenance of the pipeline easement and to inundation of native habitat communities, documented in WDFW's PHS program databases, from project construction and operation. Unavoidable impacts to these habitat types would need to be mitigated. The creation of a reservoir environment and establishment of year-round stream flows in Rock Island Creek downstream of the project would result in an increase in overall aquatic and riparian habitats to support mammal species, waterfowl, game birds, passerine bird species, raptors, reptiles, and amphibians in the vicinity of Rock Island Creek, contributing to the mitigation of project effects.

6.2 Foster Coulee

6.2.1 Topography and Ground Cover

East Foster Creek, in the Foster Creek watershed, originates in the flat shrub-steppe habitat along the west shoreline of Banks Land. Foster Creek is the primary drainage of WRIA 50 (northern Douglas County), flowing into the Columbia River at RM 554.6, immediately downstream of the Chief Joseph Dam at Bridgeport, Washington. East Foster Creek, like most natural drainage corridors in WRIA 50, consists of small copses and short galleries of riparian vegetation where perennial water sources exist. Typical native plant species are waterbirch, aspen, hawthorn, willows, and wild roses (Thomson and Ressler 1998). Non-native species such as reed canary grass, Russian olive, and black locust can be found in these habitats. Depending on the underlying geology and climate, stream reaches of East Foster Creek within the project area may be intermittent and naturally have little or no characteristic riparian vegetation. Instead, the drainage may consist of largely upland plant species, including big sagebrush, bitterbrush, rabbitbrush, and spiny hopsage (Knutson and Neaf 1997).

6.2.2 Habitat Conditions

Based on information contained in the WDFW's databases (WDFW 2009), the Foster Coulee storage alternative falls within designated mule deer habitat under WDFW's PHS Program. The proposed storage site falls within what is considered major mule deer winter range and fawning habitat by WDFW. During moderate to severe winters, regular concentrations of mule deer use the steep sagebrush and rocky draws of Douglas County for cover while foraging in the winter wheat fields. During spring and summer, mule deer herds use the upper elevations, CRP lands, and riparian draws for fawning areas and summer range. Sage grouse regular use areas, small and large breeding grounds, and winter use areas have also been documented within the area proposed for the Foster Coulee alternative. A wetland area associated with East Foster Creek is documented within the project area, extending from the proposed location of the west dam along the East Foster Creek channel about 0.5 to 0.75 mile. The wetland is described as having areas of woody riparian zones with vegetation dominated by patches of rushes (*Juncus spp.*) with waterbirch, aspen, and rose. The wetland provides important habitat for ducks, deer, furbearers, and other nongame species.

Individual occurrences of loggerhead shrike have been documented in pairs and during breeding season (indicating breeding areas) both in the project area and immediately adjacent. One sage thrasher breeding occurrence has also been documented within the project area and two individual occurrences of sage grouse have been documented adjacent to the project area. One occurrence each of a white-tailed jack rabbit and a Washington ground squirrel has been documented in the vicinity of the project area. These species are all native species associated with shrub-steppe plant communities that still maintain a functioning level of habitat diversity.

6.2.3 Fish Use

The only documented occurrence of fish within the East Foster Creek project area is of trout within the stream channel immediately upstream of the proposed location for the west dam (WDFW 2009). Fish distribution in the Foster Creek drainage is naturally limited by the lack of hydrology to support year-round flows in some reaches. In this arid environment, most streams are seasonal, fed by spring runoff or intense summer storm events, or are intermittent, fed by a spring system. Some years, there are perennial flows in some streams, but this hydraulic continuity is unlikely year-round. During a very limited survey effort by Bob Steele of WDFW in East Foster Creek on state land, adult rainbow trout were located associated with a spring system. Steele determined that these trout were not likely the result of natural reproduction but likely planted (Bartu and Andonaegui 2001).

6.2.4 Aquatic Effects

The Foster Coulee storage alternative would have negligible short-term effects within or downstream of the project area. Impacts would be limited to disturbances to project construction which can be avoided and minimized using best management practices. Long-term effects on aquatic resources within the project area would be related to the conversion of a portion of the drainage from an intermittent stream channel carrying spring runoff and intense summer storm event flows, to a reservoir environment. Effects would include loss of seasonally, wetted habitats that likely support amphibian production and limited riparian vegetation. Native fish use has not been documented within the proposed project area or the immediate vicinity; therefore no fishery effects are anticipated. However, once constructed, reservoir operations could provide a permanent, year-round water source in an otherwise arid environment. Water pumped from Banks Lake would be stored in the reservoir for irrigation and hydroelectric power use but also available for aquatic habitat benefits.

6.2.5 Terrestrial Effects

The Foster Coulee storage alternative would have long-term and short-term effects on terrestrial resources. Short-term effects would occur as a result of the construction of a water pipeline to convey water from Banks Lake to the reservoir. Impacts as a result of pipeline construction would be avoided and minimized using best management practices. Unavoidable impacts would be mitigated.

Long-term effects would be related to both the maintenance of the pipeline easement and the inundation of native habitat communities—documented in WDFW's PHS program databases—from project construction and operation. Unavoidable impacts to these habitat types would be mitigated. The creation of a reservoir environment would result in an increase in overall aquatic and riparian habitats to support mammal species, waterfowl, game birds, passerine bird species, raptors, reptiles, and amphibians in the vicinity of East Foster Creek, contributing to the mitigation of project effects.

7 COST ESTIMATES

Cost estimates were assembled using quantities of material derived from the preliminary drawings and unit costs from other similar projects. The costs should be viewed as being reconnaissance level; that is, only major items were estimated and then estimates were rounded up. A contingency of 30 percent is applied to the estimates to account for the level of uncertainty at this stage of the projects. For each of the dams, a concrete-faced rockfill dam configuration was used to estimate costs. The suitability of that type of dam at each site has not yet been examined as geotechnical studies have not been prepared.

7.1 Lower Rock Island Creek Project

Table 7-1 provides estimates of cost for the Lower Rock Island Creek Project assuming a pump storage capacity of 290 MW and a discharge of 6,500 cfs. The total estimated cost is $864 million, of which an estimated $474 million are for the dam and reservoir costs; the remainder is for penstock, pump and generation equipment, river intake, powerhouse and electrical equipment, and transmission costs.

Table 7-1
Lower Rock Island Creek Project Cost Estimate

Item	Estimated Cost
Real Estate	$3,000,000
Dam Structure	$288,000,000
Reservoir Intake and Penstock	$50,000,000
Powerhouse, Generating Equipment and River Intake	$160,000,000
Switchyard, Transformers and Transmission Lines	$20,000,000
Subtotal	**$521,000,000**
Mobilization (5 %)	$26,000,000
Contingencies (30 %)	$156,000,000
Engineering and Administration Costs (20 %)	$104,000,000
Sales Tax on Construction Items (8.1 %)	$57,000,000
Totals	**$864,000,000**

7.2 Upper Rock Island Creek Project

Table 7-2 provides estimates of cost for the Upper Rock Island Creek Project assuming a pump storage capacity of 695 MW and a discharge of 6,000 cfs. The total estimated cost is $1.2 billion of which an estimated $271 million are for the dam and reservoir costs; the remainder is for penstock, pump andgeneration equipment, river intake, powerhouse and electrical equipment and transmission costs.

Table 7-2
Upper Rock Island Creek Project Cost Estimate

Item	Estimated Cost
Real Estate	$1,000,000
Dam Structure	$165,000,000
Reservoir Intake and Penstock	$230,000,000
Powerhouse, Generating Equipment and River Intake	$283,000,000
Switchyard, Transformers and Transmission Lines	$25,000,000
Subtotal	**$704,000,000**
Mobilization (5%)	$35,000,000
Contingencies (30%)	$211,000,000
Engineering and Administration Costs (20%)	$141,000,000
Sales Tax on Construction Items (8.1%)	$77,000,000
Totals	**$1,168,000,000**

7.3 Foster Coulee Project

Table 7-3 provides estimates of cost for the Foster Coulee Project assuming a pump storage capacity of 515 MW and a discharge of 14,000 cfs. The total estimated cost is $705 million, of which an estimated $78 million are for the dam and reservoir costs and the remainder penstock, pump/generation equipment, Banks Lake intake, powerhouse and electrical equipment and transmission costs.

Table 7-3

Foster Coulee Project Cost Estimate

Item	Estimated Cost
Real Estate	$600,000
Dam Structures	$47,000,000
Reservoir Intake and Penstocks	$60,000,000
Powerhouse, Generating Equipment and Banks Lake Intake	$305,000,000
Switchyard, Transformers and Transmission Lines	$12,000,000
Subtotal	**$425,000,000**
Mobilization (5%)	$21,000,000
Contingencies (30%)	$128,000,000
Engineering and Administration Costs (20%)	$85,000,000
Sales Tax on Construction Items (8.1%)	$46,000,000
Totals	**$705,000,000**

7.4 Comparison of Construction Costs and Volumes of Water Supplied

Table 7-4 provides a comparison of the construction costs of the projects in terms of cost per acre-foot of water supplied. The Foster Coulee and the Lower Rock Island Creek projects have similar unit costs of about $10,000 per acre-foot but the Upper Rock Island cost is 75 percent more expensive. The costs include the pump generation costs so they are higher than would be expected for a water storage project without pumped storage capabilities.

Table 7-4

Comparison of Estimated Costs for Complete Project

Project	Estimated Cost ($)	Volume of Water Stored (AF)	Unit Cost of Water ($ per AF)
Lower Rock Island Creek	864,000,000	85,300	10,100
Upper Rock Island Creek	1,168,000,000	65,900	17,700
Foster Coulee	705,000,000	69,700	10,100

The estimated costs for the reservoir only portion of the projects are listed in Table 7-5. This calculation was performed to allow a comparison to other potential water storage projects that do not have expensive pump/generation equipment associated with them. Although pumping equipment and pipelines to deliver water to and from a reservoir are expensive, the facilities would be smaller and less costly than required for pumped storage projects.

Table 7-5

Comparison of Estimated Costs for Reservoirs Only

Water Storage Project Studied	Volume (AF)	Estimated Cost of Reservoir Only($)	Cost per AF ($)
Lower Rock Island Creek	85,300	474,000,000	5,600
Upper Rock Island Creek	65,900	271,000,000	4,100
Foster Coulee	69,700	78,000,000	1,100

7.5 Comparison of Costs to Other Water Storage Projects

Research into other reservoir projects that are proposed or have been reviewed in the Columbia River basin was performed. Table 7-6 provides a list of water storage projects studied, the reservoir volume, estimated cost and cost per acre-foot of water stored. A couple of the potential water storage projects had multiple configurations or reservoir sizes studied and each potential size is listed. Figure 7-1 graphically presents that information and shows where the three water storage projects studied in this report lie in terms of cost per acre-foot of water stored. The costs shown in Table 7-6 are for the dam and reservoir portion of the project only, which allows for a direct comparison to the costs shown in Table 7-5. The projects listed in Table 7-6 do not have pump and generation equipment.

The costs for dams and reservoirs for the three water storage projects studied in this report are not the least expensive on a cost per acre-foot basis, but they are generally reasonable compared to other projects studied in the Columbia River basin. The least expensive project in the same size range as these three water storage projects is the proposed Wanapum Dam Pool Raise, at a cost of $457 per acre-foot. That project also would operate by gravity and not need pumps and therefore would be much less expensive to operate than the projects studied here.

Table 7-6

Costs of Other Water Storage Projects in Columbia River Basin

Water Storage Project Studied	Volume (AF)	Estimated Cost of Reservoir Only($)	Cost per AF ($)
Hawk Creek	3,000,000	5,705,200,000	1,902
Hawk Creek	2,000,000	4,340,800,000	2,170
Foster Creek	1,340,000	2,922,100,000	2,181
Hawk Creek	1,000,000	2,829,000,000	2,829
Goose Lake	3,720,000	2,812,200,000	756
Dry Coulee	481,000	1,919,000,000	3,990
Moses Coulee	4,130,000	1,593,200,000	386
Mission Creek	470,000	1,112,800,000	2,368
Ninemile Flat	1,030,000	1,061,700,000	1,031
Rock Creek East	1,000,000	961,900,000	962
Similkameen River (Shanker's Bend)	1,,300,000	910,000,000	700
Kalama River	1,185,000	799,000,000	674
Pine Creek Reservoir	65,000	361,500,000	5,562
Rocky Coulee	126,000	343,000,000	2,722
Similkameen River (Shanker's Bend)	138,000	316,000,000	2,290
Alder Creek	330,000	301,500,000	914
Similkameen River (Shanker's Bend)	20,000	252,000,000	12,600
Wanapum Dam Pool Raise	70,000	32,000,000	457
SVID MP 59.29 Rereg Reservoir	300	6,500,000	21,667
SVID MP 23.7 Rereg Reservoir	500	5,180,000	10,360

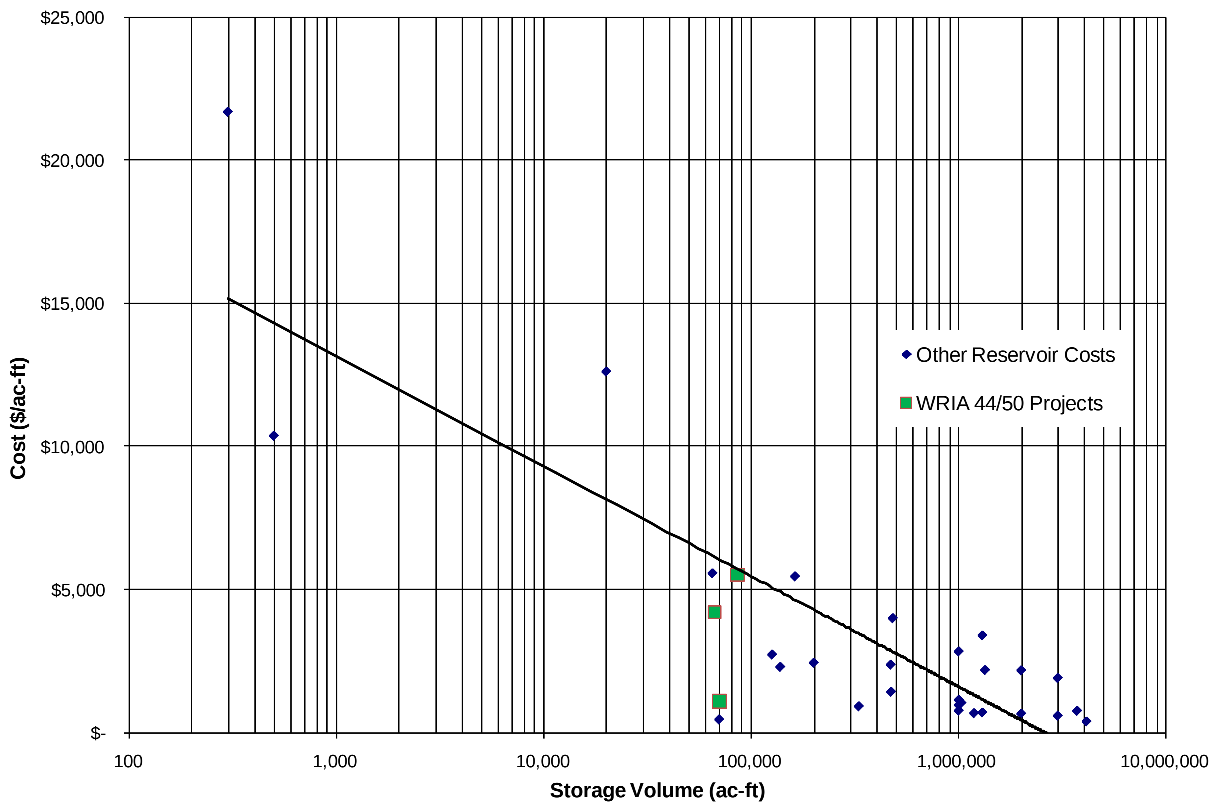

Figure 7-1

Comparison of Reservoir Costs to Other Reservoir Costs in Columbia River Basin

8 FATAL FLAW DISCUSSION

A fatal flaw in a water storage project may be due to property owners not willing to sell, geotechnical issues preventing the safe construction or operation of a reservoir, water not being available for storage, environmental or permitting issues that would prevent or make very difficult the construction of a reservoir, and funding issues such high costs making the project infeasible.

Issues with acquiring property have not been identified at this stage of study, but the ownership of the reservoir areas are held by a small group of people at each site, which leads us to believe that property acquisition could be accomplished. Geotechnical issues are present at the Rock Island Creek sites and would require additional geotechnical exploration to determine if the landslides present would be reactivated by a reservoir. At this point, however, they are not fatal flaw issues. Water could be obtained from the Columbia River for the Rock Island Creek sites during periods when flows in the river are greater than State minimum flows and BiOp flows. At the Foster Coulee site, the water would need to be supplied by CBP facilities through the Grand Coulee Pumping Plant which pumps to the Main Canal and Banks Lake. Obtaining water through the CBP will be problematic unless the reservoir becomes a source of storage and supply for the CBP. The reservoir would need to either supply additional water to CBP lands (such as Odessa Subarea) or be operated to release water to Banks Lake and supplant pumping from Lake Roosevelt when water is desired in the Columbia River. In discussions with Ecology, it was their opinion that this would not be a fatal flaw for the project. No unusual environmental or permitting issues appear to be present for any of the sites. For funding, the Upper Rock Island Creek site is very expensive when including the conveyance system between the Columbia River and the site, and we doubt it would attract funding solely because of its cost to develop as a pumped storage project.

The primary fatal flaw will be the cost of the Upper Rock Island Creek project. Additional investigation of the Lower Rock Island Creek and Foster Coulee site would be warranted if a project sponsor is found. Additional fatal flaws may be found upon further investigation.

9 SUMMARY AND RECOMMENDATIONS

Three potential water storage sites were reviewed in this study. Table 9-1 summarizes the reservoir volumes, their cost for water storage and pumped storage, their potential peak generating capacity and the potential use of water from each reservoir.

Table 9-1
Summary of Water Storage Sites

Project	Estimated Cost ($)	Volume of Water Stored (AF)	Unit Cost of Water ($ per AF)	Pumped Storage Generation Capacity (MW)	Potential Use of Water From Reservoir
Lower Rock Island Creek	864,000,000	85,300	10,100	290	Instream flow in Columbia River, supply interruptible water users along Columbia River, provide water for future municipal or irrigation use, pumped storage to generate peaking power to offset variations in wind energy production
Upper Rock Island Creek	1,168,000,000	65,900	17,700	695	Instream flow in Columbia River, supply interruptible water users along Columbia River, provide water for future municipal or irrigation use, pumped storage to generate peaking power to offset variations in wind energy production
Foster Coulee	705,000,000	69,700	10,100	515	Supply water to Odessa Subarea, pumped storage to generate peaking power to offset variations in wind energy production

The most feasible of the sites is likely the Foster Coulee Project. Although Reclamation does not appear interested in this reservoir now, Ecology is interested as the unit cost of water is low ($1,100 per acre-foot for reservoir costs only) compared to other potential reservoir sites in the Columbia River Basin.

Of the Rock Island Creek sites, the Lower Rock Island Creek site is the only site worthy of any future review for water storage. If the site is desirable for a pump storage project the cost allocated to just water storage ($5,500 per acre-foot) although high, may be reasonable as the project could be more easily implemented than other water storage projects as environmental permitting of the project would be more straight-forward.

9.1 Recommendations

We recommend that the WRIA 44/50 Planning Unit provide this report to groups potentially interested in water storage and pumped storage projects, such as Ecology and the mid-Columbia PUDs. If there is sufficient interest in the projects, we recommend further geotechnical and engineering studies be performed of the Foster Coulee and Lower Rock Island sites to better determine their feasibility. No further study of the Upper Rock Island site is warranted, in our opinion.

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APPENDIX A
DRAWINGS