RECLAMATION

Managing Water in the West

Initial Alternative Development and Evaluation

Odessa Subarea Special Study

Columbia Basin Project, Washington

U.S. Department of the Interior
Bureau of Reclamation

Technical Service Center
Denver, Colorado

Pacific Northwest Regional Office
Boise, Idaho

Upper Columbia Area Office
Yakima, Washington

September 2006

U.S. Department of the Interior

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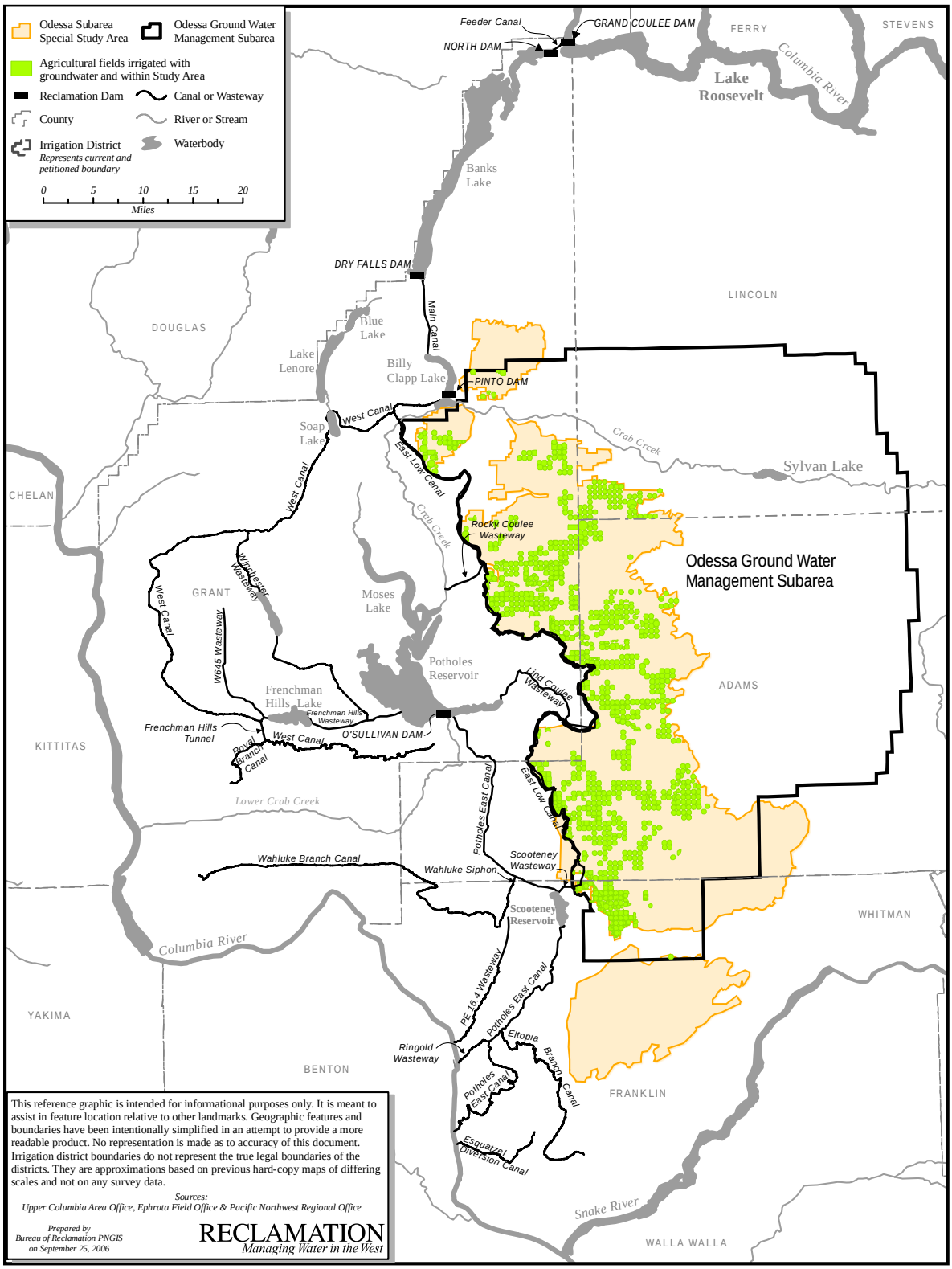
Mission of the Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.



This reference graphic is intended for informational purposes only. It is meant to assist in feature location relative to other landmarks. Geographic features and boundaries have been intentionally simplified in an attempt to provide a more readable product. No representation is made as to accuracy of this document. Irrigation district boundaries do not represent the true legal boundaries of the districts. They are approximations based on previous hard-copy maps of differing scales and not on any survey data.

Sources:
Upper Columbia Area Office, Ephrata Field Office & Pacific Northwest Regional Office

Prepared by
Bureau of Reclamation PNGIS
on September 25, 2006

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ACRONYMS AND ABBREVIATIONS

BiOp	biological opinion
BPA	Bonneville Power Administration
CBP	Columbia Basin Project
cfs	cubic feet per second
CRI MOU	Columbia River Initiative Memorandum of Understanding
DEIS	draft environmental impact statement
ECBID	East Columbia Basin Irrigation District
Ecology	Washington Department of Ecology
EHC	East High Canal
ELC	East Low Canal
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
FEIS	final environmental impact statement
GIS	Geographic Information System
GWMA	Ground Water Management Area
Hyd-Sim	BPA hydrologic model
I-90	Interstate 90
Kaf	thousands of acre-feet
NAIP	National Agricultural Imagery Program
NEPA	National Environmental Policy Act
NOAA Fisheries	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
PASS	Project Alternative Solutions Study
Project	Columbia Basin Project
Q-CBID	Quincy-Columbia Basin Irrigation District
Reclamation	Bureau of Reclamation
SCBID	South Columbia Basin Irrigation District
Secretary	Secretary of the Interior
State	State of Washington
Study	Odessa Subarea Special Study

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Conducted in Cooperation with
Washington Department of Ecology and
Columbia Basin Project Irrigation Districts

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INTRODUCTION

The Bureau of Reclamation (Reclamation) is investigating continued phased development of the Columbia Basin Project (CBP or Project). The investigation, known as the Odessa Subarea Special Study (Study), will focus on Project development for the purpose of replacing groundwater currently used for irrigation in the Odessa Ground Water Management Subarea with surface water. This Study will not address full completion of the CBP, but does not preclude Reclamation from considering this in the future. Reclamation anticipates the Study will take five years, beginning in 2006, and will conclude with a planning report and the appropriate National Environmental Policy Act (NEPA) documents.

Reclamation conducted a Project Alternative Solutions Study (PASS), which relies on an Objectives Team and Technical Team, to quickly and objectively identify engineering concepts, and develop and evaluate alternative solutions. This report documents the PASS and work products developed by the two teams. Alternatives recommended in this report will be examined further during appraisal-level analysis.

STUDY BACKGROUND

The Odessa Subarea Special Study is conducted under the authority of the Columbia Basin Project Act of March 10, 1943, as amended, and the Reclamation Project Act of 1939. The CBP was authorized for the irrigation of 1,029,000 acres. Reclamation submitted a feasibility report (House Document No. 172, 79th Congress, 1st Session, *Joint Report on Allocation & Repayment of the Costs of the Columbia Basin Project*, Reclamation Report of Oct. 30, 1944) to authorize construction of the CBP which was approved by the Secretary of the Interior (Secretary) in 1945. This report anticipated a 71-year development period. Reclamation has developed the CBP incrementally in phases since its authorization. Most development occurred primarily in the 1950s and 1960s, with some acreage added sporadically until 1985. Reclamation is authorized to continue phased CBP development as long as the Secretary makes a finding of economic and financial feasibility.

The Odessa Ground Water Management Subarea, a boundary designation made by the Washington Department of Ecology (Ecology), comprises a region of deep groundwater, a portion of which underlies the eastern most part of the authorized CBP, east of the East Low Canal (ELC) (Frontispiece). Ecology issued groundwater permits for irrigation in the Odessa Ground Water Management Subarea in the mid-1960s and 1970s as a temporary measure until Reclamation provided CBP water to these lands.

The aquifer is now declining to such an extent that the ability of farmers to irrigate their crops is at risk. Domestic, commercial, municipal and industrial uses, and water quality are also affected. The State of Washington (State), Project irrigation districts, and local constituents concerned about the declining aquifer and resulting economic effects advocate providing CBP water to these groundwater irrigated lands to help reduce demands on the aquifer. In 2005, Congress funded Reclamation to investigate the problem. The State has agreed to partner with Reclamation, providing funding and collaborating on various technical studies.

A Columbia River Initiative, developed under former Governor Gary Locke, was intended to promote a cooperative process for implementing activities to improve Columbia River water management and within the CBP. The State, Reclamation, and CBP irrigation districts signed a Memorandum of Understanding (CRI MOU) in December 2004 which describes studies and activities. The Odessa Subarea Special Study is consistent with Section 15 of the CRI MOU which states in part that "The parties will cooperate to explore opportunities for delivery of water to additional existing agricultural lands within the Odessa Subarea." Additional background information about the Study can be found at: www.usbr.gov/pn.

Study Area

The Study area is defined by those lands authorized to receive CBP water (Reclamation 1976) and that coincide with the Odessa Ground Water Management Subarea boundary defined by Ecology (Frontispiece). These lands are located in Adams, Grant, and a small portion of Franklin and Lincoln Counties. The Study area is generally defined by the area bounded on the west by the Project's ELC, on the east by the City of Lind, and extending north to Wilson Creek and south to the Connell area.

Purpose and Need

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 Ground Water Management Subarea. The purpose of the action proposed in this report is 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 as authorized.

The aquifers underlying the Odessa Ground Water Management Subarea are part of the larger Columbia Plateau Regional Aquifer System. Groundwater is currently being depleted to such an extent that water must be pumped from great depths; in some areas the pumping depth is as deep as 2,100–2,400 feet. Pumping water from this depth has resulted in expensive power costs and water quality concerns such as high water temperatures and high sodium concentrations. Those irrigating with wells of lesser depth live with the uncertainty about future well production. Municipalities rely on the groundwater as well. A study conducted by Washington State University determined that continued aquifer declines will result in a reduction to current potato production and processing. The resulting economic losses to the potato processing sector are estimated at $630 million dollars annually and a loss of 3,600 jobs in the area (Washington State University 2005).

COLUMBIA BASIN PROJECT

The Project is located in central Washington and currently serves a total of about 671,000 acres in Grant, Adams, Walla Walla, and Franklin Counties. These total acres include 557,530 acres of platted farm units, 73,227 acres of water service contracts, and 40,323 acres of Quincy Subarea groundwater licenses. The Project is authorized for the irrigation of 1,029,000 acres, including a portion of Lincoln County. The Project is multi-purpose, providing irrigation, power production, flood control, municipal water supply, recreation, and fish and wildlife benefits.

Three irrigation districts receive Project water, including Quincy-Columbia Basin Irrigation District (Q-CBID), East Columbia Basin Irrigation District (ECBID), and South Columbia Basin Irrigation District (SCBID), serving approximately 247,000 acres, 152,000 acres, and 232,000 acres, respectively. In addition, Reclamation serves about 43,000 acres under an artificially stored groundwater program located within the Quincy Ground Water Management Subarea.

The existing Project consists of several major facilities and features including about 330 miles of main canals, 1,990 miles of laterals, and over 3,500 miles of drains and wasteways (Figure 1). Grand Coulee Dam, the Project's key structure, forms Lake Roosevelt which is located on the main stem of the Columbia River about 90 miles west of Spokane, Washington. The Grand Coulee Pump-Generating Plant lifts irrigation water approximately 280 feet from Lake Roosevelt to Banks Lake, which serves as an equalizing reservoir for the irrigation system. The Main Canal transports flow southward from Banks Lake at Dry Falls Dam to the northern end of the irrigable area via Billy Clapp Lake, which is an equalizing reservoir within the Main Canal. The Main Canal splits into the ELC and West Canal which carry water to serve a large portion of the north and east portions of the Project area.

In the central part of the Project, O'Sullivan Dam forms Potholes Reservoir, which receives return flows from the northern part of the Project. The Potholes East Canal begins at O'Sullivan Dam and runs south to serve the southern part of the Project area. Potholes Reservoir stores natural runoff from the Crab Creek watershed which flows through Moses Lake. During most years, runoff from Crab Creek is low and irrigation return flows and runoff flows into Potholes Reservoir are not sufficient to meet the annual irrigation demand that is supplied from the Potholes East Canal, requiring water to be diverted from Banks Lake to Potholes Reservoir. This water is called feed. The primary feed route is via the ELC to Rocky Coulee Wasteway which discharges into Crab Creek.

See Appendix A for further details on Project water supply and operations.

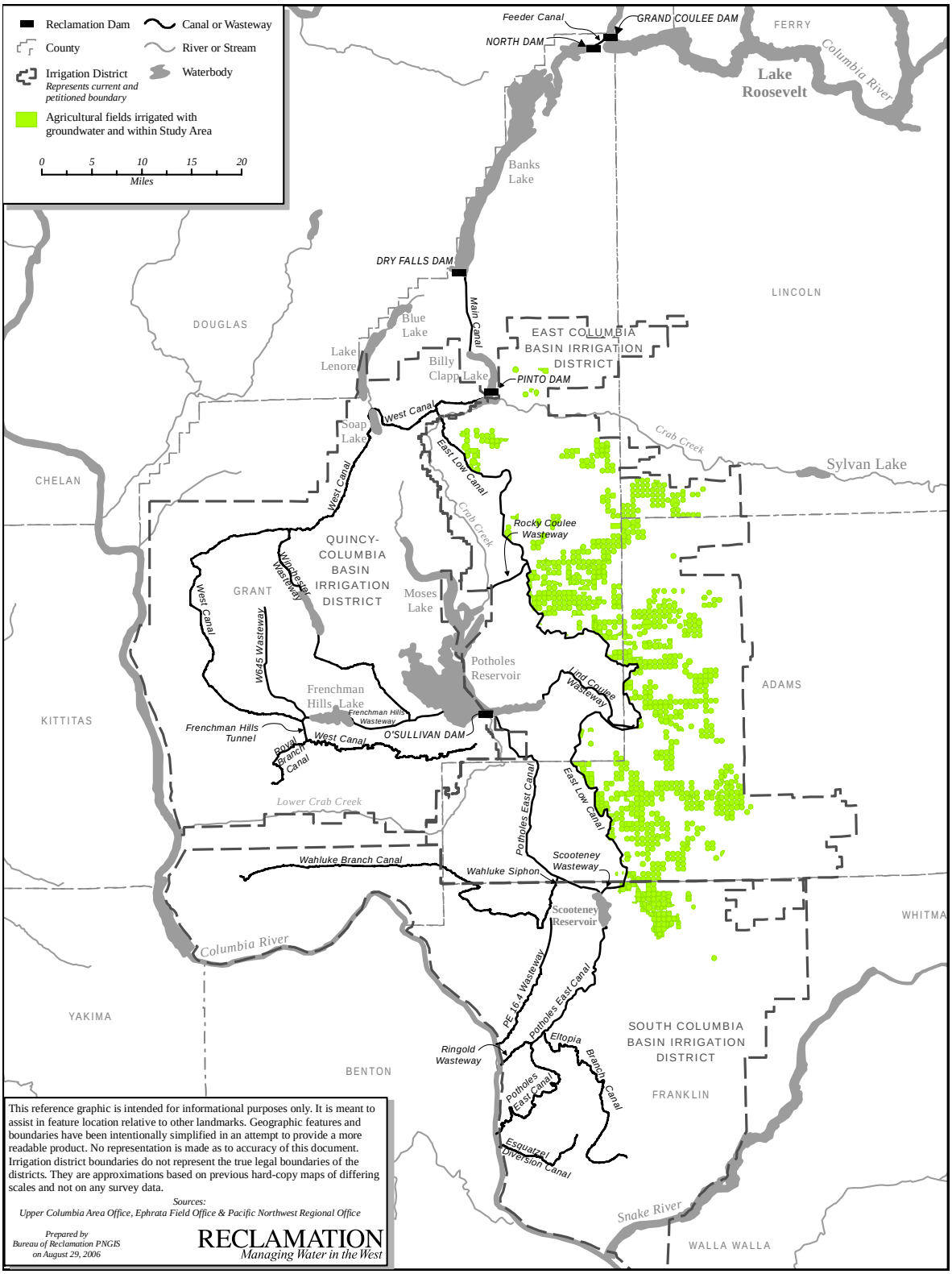

Figure 1 - Columbia Basin Project and Facilities

OPERATIONAL AND WATER SUPPLY CONSTRAINTS

The PASS Technical Team identified several operational and water supply constraints that guided the development of alternatives and water supply options.

Columbia River Water Availability

The National Oceanic and Atmospheric Administration, National Marine Fisheries Service's (NOAA Fisheries) November 2004 biological opinion (BiOp) for the Federal Columbia River Power System (FCRPS) identifies seasonal flow objectives for the Columbia River downstream from Priest Rapids, McNary, and Bonneville Dams. Flow objectives were identified primarily to facilitate downstream passage of juveniles, and to accommodate chum spawning and returning adult salmon and steelhead listed under the Endangered Species Act (ESA). The current flow objectives have been in place since the 1995 FCRPS BiOp. The PASS process assumed water from the Columbia River could not be diverted unless flows exceeded these flow objectives. In addition, the State has recently enacted a law that does not allow new Columbia River diversions in July and August without replacement water supply.

Output data from the Bonneville Power Administration's (BPA) Hyd-Sim (Version FRIII_03SN6704) hydrologic model of the FCRPS was used to determine the amount of Columbia River water available for diversion in excess of flow objectives. The BPA model includes all significant United States Federal and non-Federal dams and the major Canadian projects on the main stem Columbia River and its major tributaries. It is widely accepted as an accurate simulation of current Columbia River system operation.

Reclamation compared the Hyd-Sim model output to the seasonal flow objectives on the Columbia River at each control point. The average monthly flow in excess of the flow objectives was calculated as the amount of water in the Columbia River available for diversion to the CBP for this Study.

Reclamation's analysis of the Hyd-Sim model output concluded that there is no water available for diversion during August of any year. In drier years, there is no water available for diversion during the months of April through August. However, even in drier years there is significant water available for diversion during September, October, December, and January. Appendix B provides more information about this analysis and contains a table indicating the monthly volume of water available above Columbia River flow objectives as compared to current operations.

Potholes Reservoir Feed and Evacuation Route

Some of the alternatives considered during the PASS process may require increased use of the ELC to supply irrigation water to lands presently irrigated with groundwater in the Study area. The increased demand on the ELC may reduce the amount of feed available to Potholes Reservoir

and may require a change to the reservoir operations. An additional feed route may be needed to ensure that adequate water supply for all lands served from the Potholes Reservoir will be met. Reclamation is currently conducting a study to identify an alternative feed route for existing operations (Potholes Supplemental Feed Study).

Changes in Potholes Reservoir operations also may require an adequate evacuation route. Currently, evacuation of Potholes Reservoir cannot exceed passage of Upper Crab Creek drainage floodwater in excess of flows that might naturally occur without the CBP. Project return flows and natural inflows stored in Potholes Reservoir are not considered floodwater. Stored water can only be released down lower Crab Creek within the "normal bank." Normal bank flows are estimated to be 50 to 100 cubic feet per second (cfs). Return flows from additional development within the CBP and changes in reservoir operations to accommodate more fall feed, thus carrying the elevation of the reservoir higher through the winter, will require the ability to pass winter return flows and natural inflows down Lower Crab Creek in volumes greater and more frequent than present operational constraints allow.

Groundwater Irrigated Acreage in Study Area

There are an estimated 170,000 acres within the Odessa Ground Water Management Subarea presently being irrigated with groundwater. An estimated 121,000 of these acres are within the boundaries of the authorized CBP. These acre quantities were derived from area calculations using Geographic Information System (GIS) techniques and data supplied by the Franklin County Conservation District from the Ground Water Management Area (GWMA) dataset. Appendix C provides a more detailed description of the process used to derive the number and distribution of groundwater irrigated acres.

Of the 121,000 acres, approximately 2,400 groundwater irrigated acres east of the ELC may begin receiving CBP water as a replacement supply in 2006 and 2007. The water supply for these acres is a result of the conveyance system conservation projects within the ECBID and is therefore included within the current CBP water right certificate for Columbia River diversions at Grand Coulee Dam.

Of the 121,000 acres, 10,000 groundwater irrigated acres east of the ELC may receive a replacement irrigation water supply (30,000 acre-feet) as a result of the CRI MOU (Section 14). By agreement, the water supply for these acres may require a new water right permit using the 1938 withdrawal and the CBP's storage certificate at Grand Coulee Dam.

Interruptible water service contracts to utilize CBP water for 14,000 acres east of the ELC have been in place since the mid-1980s. These acres are not part of the 121,000 acres described above. This water supply and these acres are included within the CBP's existing water right certificate and permit for Columbia River diversions at Grand Coulee Dam.

The PASS Technical Team assumed the maximum acreage that could receive a replacement water supply, consistent with the Study purpose, is 121,000 groundwater irrigated acres. If during the term of the Study the conditions regarding the referenced 2,400 acres and 10,000 acres change, the Study assumptions would be adjusted accordingly.

PASS PROCESS

PASS activities, input data, and evaluations were the result of a combined effort by a number of participants and agencies. The PASS consists of two sequential team activities. The first team activity involves an "Objectives Team" which focuses a variety of stakeholder perspectives to develop objectives, guidance measures used in the development and evaluation of alternatives. This information is collected and documented for use during the remainder of the PASS. In the second activity, the "Technical Team" uses the Objectives Team output to develop and evaluate alternatives. The Technical Team reviews, combines, and evaluates existing and new alternatives. This series of activities results in identification of alternatives that meet the defined objectives and the study purpose and need.

The Objectives Team was comprised of various stakeholders in the Study area representing Federal and State agencies, local governments, Tribes, Project irrigation districts, groundwater irrigators, and other local interest groups (Appendix D). They met in February 2006 and established the objectives described in the next section.

The Technical Team was comprised of technical experts from Reclamation, Ecology, and the CBP irrigation districts (Appendix E). They met in a series of meetings during July and August 2006. Significant preparatory work was conducted by a "Support Team," comprised of technical experts from Reclamation and Ecology, prior to the Technical Team meetings. The Support Team was also consulted by the Technical Team during development of potential alternatives. Reclamation's Technical Service Center personnel facilitated the PASS process under a service agreement with Reclamation's Pacific Northwest Region.

Team member participation should not imply specific sponsorship of any alternative within this report.

Objectives

The Objectives Team identified seven objectives and suggested ways to measure each (see list that follows). During the evaluation process, alternatives were rated based on their ability to accomplish these objectives. Specifically: "How do the alternatives differ in the ability to…?"

Objective	Suggested Measures
1) Replace all or a portion of current* groundwater withdrawals within the CBP area of the Odessa Ground Water Management Subarea with Project water. (** Current equals about 121,000 acres within the CBP area and within the Odessa Ground Water Management Subarea that are currently irrigated with groundwater.)*	Acre-feet of groundwater irrigation replaced by Project water and by resulting secondary benefits: • Slow depletion or • Stabilize aquifer or • Recover aquifer Measured as: – Rate of recharge – Area of recharge – Decline rate
2) Maximize use of existing infrastructure.	No or minimum impact to current existing users (e.g., irrigators, recreation, fish and wildlife, power, and other beneficiaries), realizing that some new infrastructure will be needed.
3) Retain the possibility of full CBP development in the future.	Does the alternative preclude full development in the future?
4) Address ESA issues:	
- NOAA Fisheries seasonal flow objectives. (*Consideration: Storage or operational changes within the Project need to be considered as diversion offsets in this Study. Off-channel storage as permitted by House Bill 2860 (Columbia River Basin Water Resource Management) will be considered in a later phase.*)	No net loss to existing NOAA Fisheries seasonal flow objectives: • Spring targets • Summer targets • Winter chum flows
- Potential impact to shrub-steppe habitat for ESA-listed species	Acres of shrub-steppe habitat affected
5) Provide environmental and recreational enhancements.	i.e., acres of additional wetland or upland habitat

Objective	Suggested Measures
6) Minimize potential delay in the Study schedule. - *(Considerations: Complete study as fast as possible without compromising study quality (thorough, covers all issues adequately). Technical Team needs to be aware of other studies that affect ability to implement alternatives considered.)*	Environmental Impact Statement and selection of a preferred alternative completed by end of 2010.
7) Be developed in phases based on: - Funding expectations - Physical/operational constraints - Rate of groundwater decline	Weighting might be used for this objective.

Development and Screening of Alternatives

Reclamation compiled a list of initial concepts from public input received during a February 2006 public meeting, written correspondence from the public, and a review of previous related investigations. This list served as a starting point for the Technical Team to develop alternatives for later evaluation. Table 1 lists the concepts and identifies how the Technical Team utilized each concept. The Technical Team's review of the concepts resulted in the development of the ten alternatives evaluated in Table 2 and eleven water supply options shown in Table 4.

Table 2 documents the Technical Team ratings for the seven objectives. A scale of 1 to 4 was used for some objectives to indicate the level of challenge or difficulty associated with the alternative. The higher the number, the better the alternative performed for that particular objective. Generally, a '1' indicates significant challenges or difficulties associated with the alternative and a rating of '4' indicates the alternative has less challenges or is the least difficult to implement.

The Technical Team evaluated all alternatives using the seven objectives defined by the Objectives Team described earlier. Information was not available to rank some of the objectives using the measures suggested by the Objectives Team. When this was the case, the Technical Team used other appropriate information, if available. Each of the six numbered alternatives in Table 2 were determined to not merit further study at this time because the alternative:

- Went beyond the Study purpose of replacing groundwater irrigation with CBP surface water.
- Was outside of the CBP authorization.
- Was outside Reclamation's authority to implement.

Alternatives A through D evolved from Table 1 concepts. The Technical Team determined that Alternatives A through D represented the best range of solutions for further study, based on the defined objectives and technical and engineering considerations. The section following the tables provides a more detailed description of Alternatives A through D.

Table 1 - Concepts List

No.	Concept	Outcome of Concept Evaluations and Comments
1	Full development of CBP as described in Reclamation's 1989 Draft Environmental Impact Statement (DEIS) for continued development of the CBP (Alternative 1). • Take water from Main Canal above Summer Falls to supply East High area • Construct Black Rock Branch Canal system (can be used to recharge groundwater) • Expansions to Main, West, and East Low Canals • Irrigate 350,000 + acres	Alternative 1 in Table 2.
2	Partial development of East High Canal (EHC) – develop only those portions of Concept 1 above that deliver water to areas currently served by groundwater wells (about 128,000 acres maximum). • Construct EHC • Expansion of ELC	Incorporated into Alternative A in Table 2.
3	Construct pipelines with associated pump stations, to carry water from Banks Lake about 28 miles uphill to the east (about a 300-foot lift). Discharge the water to the upper part of Wilson Creek with potential storage sites. Lift water from Wilson Creek to supply proposed EHC and Black Rock Canal systems.	Alternative 3 in Table 2. Full CBP development.
4	Construct pipeline portion of EHC with pump-generation capability.	Does not address Study objectives. Not a stand alone alternative. Future concept to consider.
Concepts 5a through 5g are variations of utilizing ELC to provide irrigation service to groundwater users.		
5a	Develop ELC to provide service to 87,000 acres of land in East Columbia Basin and South Columbia Basin Irrigation Districts as contained in the 1989 DEIS (Alternative 2).	Incorporated into Alternatives B and C in Table 2.
5b	Enlarge ELC south of Interstate 90 (I-90) and construct pumping plants and pipelines to serve from 90,000 to 135,000 acres within 3 to 5 miles east of ELC (there is a second siphon barrel already installed under I-90).	Incorporated into Alternatives B and C in Table 2.
5c	Construct pumped laterals to the east from ELC up coulees to serve EHC lands.	Incorporated into Alternatives B, C, and D in Table 2.
5d-g	d. Construct pipeline (two 48-inch-diameter pipes) from ELC and/or Crab Creek above Moses Lake to serve 13,000 acres of deep well irrigated land between Crab Creek and Rocky Coulee. e. Construct pipeline east from ELC near Warden to serve groundwater irrigators. f. Construct 6-foot-diameter pipeline east from ELC near Moses Lake. Run 4-foot-diameter pipeline north to serve lands above Rocky Coulee. g. Bring ELC water to high density well irrigators located below Warden and above Scooteney Reservoir.	Identifies potential delivery areas considered in Alternatives B, C, and D in Table 2.
5h	Consider providing an interruptible canal water supply. Supply supplemental water to well irrigators during April, May, and September; well water would be used in June, July, and August.	Alternative 5h in Table 2.
6	Take water from Lake Roosevelt at Hawk Creek. Lift it about 300 feet and convey it south under Highway 2, through the Lake Creek (and chain of lakes) to a storage reservoir at Crab Creek.	Alternative 6 in Table 2.
7	Consider two-phased approach for north and south. Use aquifers to convey water to deep well irrigators in north. Create reservoir in Lind Coulee and pump south to top of hill and gravity feed to south towards Connell.	Partially incorporated into Alternatives B and C in Table 2. Enlargement of ELC is required. Other options provide similar or greater benefit with enlarged canal.
8	Pump water from Billy Clapp Lake to well irrigators near Rocky Coulee.	Incorporated into Alternatives A and B in Table 2.
9	Supply Potholes Reservoir feed water from West Canal via pipeline to Rocky Ford Creek. This will allow more water to be conveyed in the first 23 miles of ELC to supply reregulation reservoirs with water during early season for high demand times.	Potholes Supplemental Feed Study is being conducted concurrently and will determine supplemental feed route to consider in the Odessa Subarea Special Study.
10	Take water from Davenport Creek/Mill Canyon (tributary to Spokane River) and bring to reservoirs in Crab Creek.	Alternative 10 in Table 2.

No.	Concept	Outcome of Concept Evaluations and Comments
11	Construct reregulation reservoirs in coulees along ELC to capture existing wastewater for reuse and/or pump water from ELC in off season for use in irrigation season. a. Black Rock Coulee – Site about 8 miles south of the town of Wilson Creek b. Batum Moody Draw - Build dam at Ruff to create reservoir (North of I-90, mile 23 of ELC) c. Rocky Coulee – Feed from Rocky Coulee Check and Siphon Inlet d. Lind Coulee – Stored water pumped out by pipe south to T16 area; excess water to Scooteney Reservoir e. Warden Coulee f. Providence Coulee (just north of Scooteney Wasteway) – Store water from ELC in winter and pump back into canal system g. Washtucna Coulee (near Connell below Scooteney Wasteway) – Pump water south to area proposed to be served by ELC extension h. Crab Creek	Storage concepts initially considered for all alternatives – see Table 4 for Black Rock Coulee, Rocky Coulee, Lind Coulee, and Lower Crab Creek. Batum Moody Coulee, Warden Coulee, Providence Coulee, Washtucna Coulee, and Upper Crab Creek are limited operationally by location and size.
12	Operate Banks Lake to maximize its ability to supply water to the Study area.	Considered for all alternatives, see Table 4.
13	Improve water utilization/reduce waste in the system - use conserved water to replace groundwater irrigation. • To help capacity issues, consider lining canals • Capture/reuse Project water runoff from irrigated lands/reregulating reservoirs	Additional opportunities being studied, but are small in scale. Could provide minor enhancements to conveyance or storage needs. Item is included in Table 4 for that reason. Past 18 years of conservation projects = 2,400 additional acres irrigated from savings; annual reuse of return flows already designed into project.
14	Aquifer storage and recovery.	Alternative 14 in Table 2.

Table 2 - Alternative Development and Evaluation Matrix

Alternative [1]	OBJECTIVES							Comments
	Replace All or a Portion of Current Groundwater Withdrawals Within CBP Area of the Odessa Ground Water Management Subarea **(Groundwater acres replaced)**	**Maximize Use of Existing Infrastructure** **(1-4 scale) [2]**	**Retain the Possibility of Full CBP Development in the Future** **(Yes or No)**	**Address ESA Issues (Columbia River Flow Objectives, Shrub-steppe Habitat Impacts)** **(1-4 scale) [2]**	**Provide Environmental and Recreational Enhancements**	**Minimize Study Schedule Delays (NEPA/ Feasibility Analysis Completed in 2010)** **(1-4 scale) [2]**	**Develop in Phases Based on Funding, Physical /Operational Constraints, and Rate of Groundwater Decline** **(1-4 scale) [2]**	
1	121,000 plus 230,000 dry land acres	2- Significant new infrastructure	Yes	1 - Significant challenge	See note [3]	1 – Significant challenge	1 - Most difficult to implement	Full CBP development which is outside Study scope and purpose.
3	121,000 plus 230,000 dry land acres	2- Significant new infrastructure	Yes	1 - Significant challenge	See note [3]	1– Significant challenge	1 – Most difficult to implement	Full CBP development which is outside Study scope and purpose. Appears not to be competitive when compared to other alternatives -- requires pumping all water and/or tunnel, longer intake distance, and a 300-foot lift. Other alternatives have shorter intake, gravity, and/or less pumping.
5h	0 groundwater acres at times (still pumping from aquifer)	4 - Least new infrastructure	Yes	4 - Least challenging	See note [3]	2 – Some challenge	2 – Difficult to implement	Still pumping from aquifer some of the time so does not fulfill Study purpose to replace groundwater with CBP water 100 percent of time. Difficult to manage water rights.
6	Uncertain	1 - All new infrastructure	Yes	1 - Significant challenge	See note [3]	1 – Significant challenge	1 – Most difficult to implement	Outside of CBP authority, and therefore, may require additional Congressional authorization for Reclamation. May be inconsistent with the January 4, 2005, Agreement-in-Principle between the State and Confederated Tribes of the Colville Reservation (see page 33). Long distance, infiltration losses, physical constraints (300-foot lift). Potentially long environmental review. Environmental impacts to chain of lakes. Does not use existing infrastructure.
10	Uncertain	1 - All new infrastructure	Yes	1 - Significant challenge	See note [3]	1 - Significant challenge	1 – Most difficult to implement	Outside of CBP authority, and therefore, may require additional Congressional authorization for Reclamation. May be inconsistent with the January 4, 2005 Agreement-in-Principle between the State and Confederated Tribes of the Colville Reservation. Long distance – 50 miles, infiltration losses, physical constraints (300-foot lift), right-of-way issues likely. Potentially long environmental review.
14	0 groundwater acres (still pumping from aquifer)	2- Significant new infrastructure	Yes	1 - Significant challenge	See note [3]	1 - Significant challenge	3 – Some challenge to implement	Does not fulfill the Study purpose to replace groundwater pumping with CBP surface water. Outside of Reclamation authority - State manages aquifer. Would require water treatment.
A	121,000	2 - Significant new infrastructure	Yes	1 - Significant challenge	See note [3]	2 – Some challenge	1 – Most difficult to implement	Recommend for appraisal analysis.
B	121,000	2 - Significant new infrastructure	Yes	1 - Significant challenge	See note [3]	2 – Some challenge	2 – Difficult to implement	Recommend for appraisal analysis.
C	73,000	3 - Some new infrastructure	Yes	2 - Challenging	See note [3]	3 – Slight challenge	3 – Some challenge to implement	Recommend for appraisal analysis.
D	48,000	4 - Least new infrastructure	Yes	3 - Less challenging	See note [3]	4 – Least challenging	4 – Easier to implement	Recommend for appraisal analysis.

1 - Numbered alternatives are described in Table 1. Alternatives A through D are described on pages 17–25.
2 – 1 to 4 scale: A rating of '1' indicates significant challenges or difficulties associated with the alternative and a rating of '4' indicates the least challenging or lesser difficulties.
3 – Was not rated due to lack of data. Will be evaluated during NEPA analyses.

ALTERNATIVE DESCRIPTIONS

The Technical Team recommended four alternatives for appraisal-level analysis. These alternatives represent different water delivery configurations and infrastructure to deliver surface water to lands presently irrigated with groundwater in the Study area.

A. Construction of an EHC system sized to serve the current groundwater irrigated lands.

B. Development of the northern portion of EHC system and enlargement and partial extension of ELC.

C. Enlargement and partial extension of ELC.

D. Construction of distribution facilities to serve lands north of I-90 from existing ELC.

Assumptions common to all alternatives are provided in Appendix F.

Figures 2 through 5 are conceptual representations of Alternatives A through D, identifying major components and approximate locations and alignments. In later Study phases, as more information is developed, alternatives will be refined to identify all necessary infrastructure components and locations and alignments.

Alternative A: Construction of an EHC System Sized to Serve the Current Groundwater Irrigated Lands

This alternative involves development of the EHC system sized to deliver water to those lands currently irrigated by groundwater (Figure 2). Major components include:

- Construction of outlet from Main Canal above Summer Falls to the proposed EHC division (bifurcation).
- Construction of an EHC system to divert Project water from the Main Canal, construction of a reregulation reservoir in Black Rock Coulee, and installation of two major and a few smaller pumping plants, in order to irrigate higher-elevation lands in the eastern part of the Project.

The estimated number of groundwater acres to be served is 121,000, which is 100 percent of the total acres currently irrigated with groundwater in the Study area.

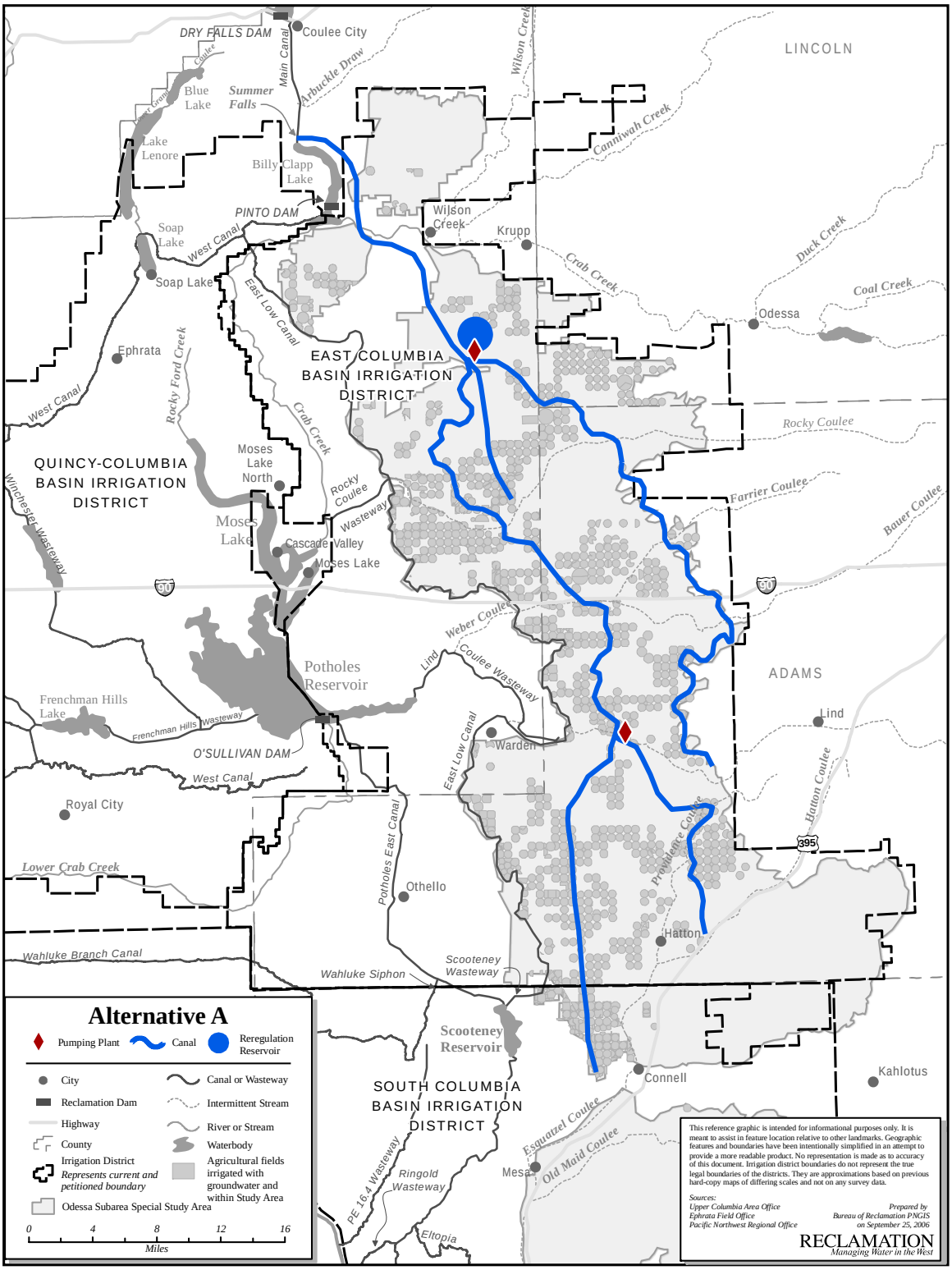

Figure 2 - Alternative A

Alternative B: Development of the Northern Portion of EHC System and Enlargement and Partial Extension of ELC

Construct the upper end of the EHC system to approximately Rocky Coulee to supply approximately 48,000 northern acres (Figure 3). Enlarge the existing ELC south from Weber Branch Siphon (near I-90) and extend to near Connell, Washington. Construct a series of canal side pumping plants and associated conveyance systems (pipelines, laterals, etc.) to deliver water from the ELC to the groundwater irrigated lands. This alternative may require replacement of the abandoned Weber Wasteway at a new location near where ELC crosses I-90. The ELC enlargement and extension would serve an additional 73,000 acres. Major components include:

- Construction of outlet from Main Canal above Summer Falls to the proposed EHC division (bifurcation).
- Construction of an EHC system to divert Project water from the Main Canal, construction of a reregulation reservoir in Black Rock Coulee, and installation of a few pumping plants, in order to irrigate higher-elevation lands in the eastern part of the Project.
- Enlargement of two sections of the ELC south from Weber Branch Siphon to Scooteney Wasteway.
- Extension of ELC east to near Connell, Washington.

The estimated number of groundwater acres to be served is 121,000, which is 100 percent of the total acres currently irrigated with groundwater in the Study area.

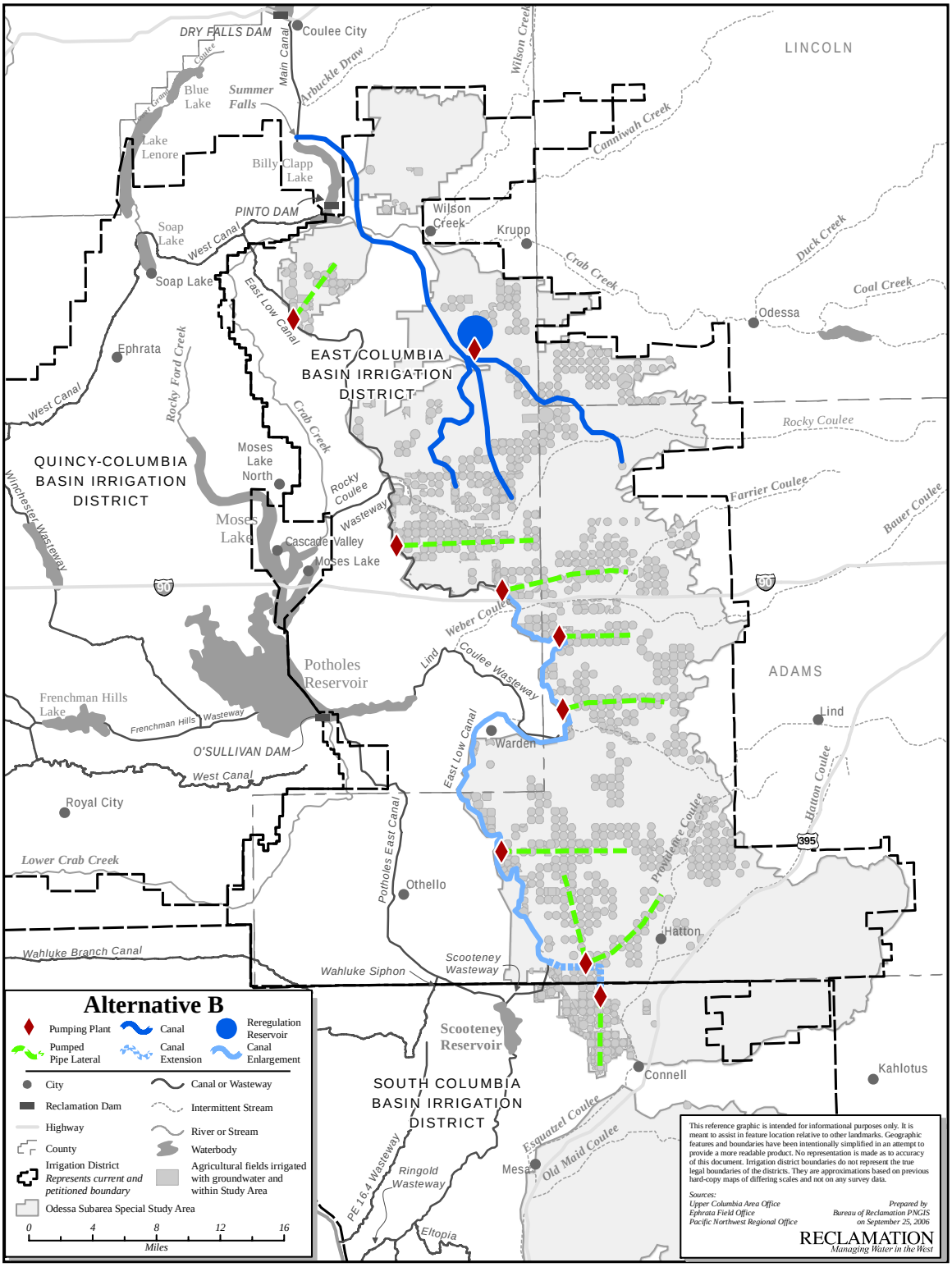

Figure 3 - Alternative B

Alternative C: Enlargement and Partial Extension of ELC

Enlarge the existing ELC south from Weber Branch Siphon (near I-90) and extend to near Connell, Washington (Figure 4). Construct a series of canal side pumping plants and associated conveyance systems (pipelines, laterals, etc.) to deliver water from the ELC to the groundwater irrigated lands. This alternative may require replacement of the abandoned Weber Wasteway at a new location near where ELC crosses I-90. The lands to be served would be near or adjacent to the existing ELC. Major components include:

- Enlargement of two sections of the ELC south from Weber Branch Siphon to Scooteney Wasteway.
- Extension of ELC east to near Connell, Washington.

The estimated number of groundwater acres to be served is 73,000, which is 60 percent of the total acres currently irrigated with groundwater in the Study area.

Alternative C includes concentrated areas of groundwater irrigated lands that are close enough to the ELC to make construction of distribution facilities economically viable. Specific lands to be served have not been identified.

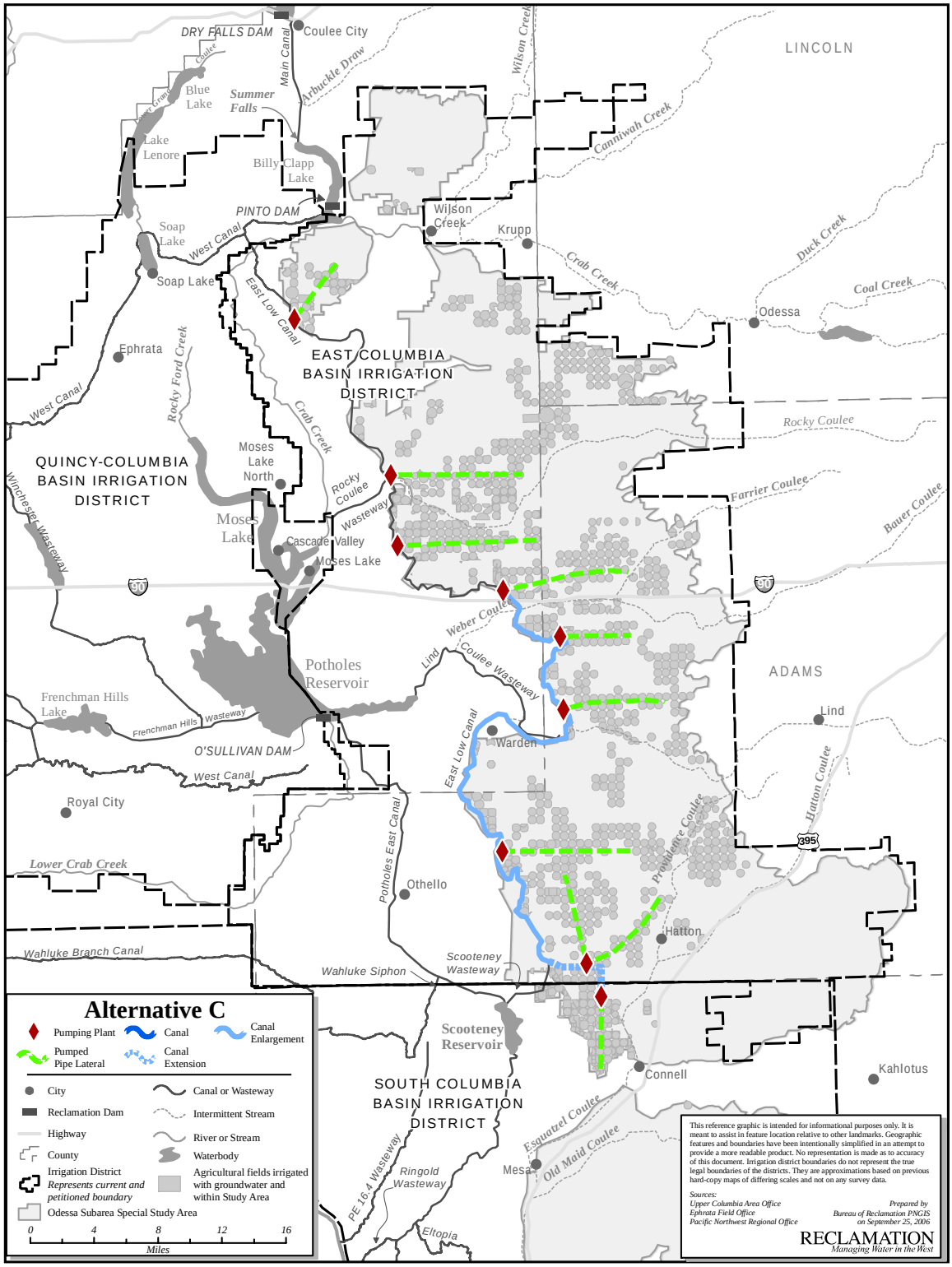

Figure 4 - Alternative C

Alternative D: Construction of Distribution Facilities to Serve Lands North of I-90 from Existing ELC

Using the existing ELC infrastructure, construct a series of pumping plants and associated conveyance systems (pipelines, laterals, etc.) to deliver water from the ELC to those lands north of I-90 irrigated by groundwater (Figure 5). This alternative may require replacement of the abandoned Weber Wasteway at a new location near where ELC crosses I-90.

The estimated number of groundwater acres to be served is 48,000, which is 40 percent of the total acres currently irrigated with groundwater in the Study area.

Alternative D includes concentrated areas of groundwater irrigated lands that are close enough to the ELC to make construction of distribution facilities economically viable. Specific lands to be served have not been identified.

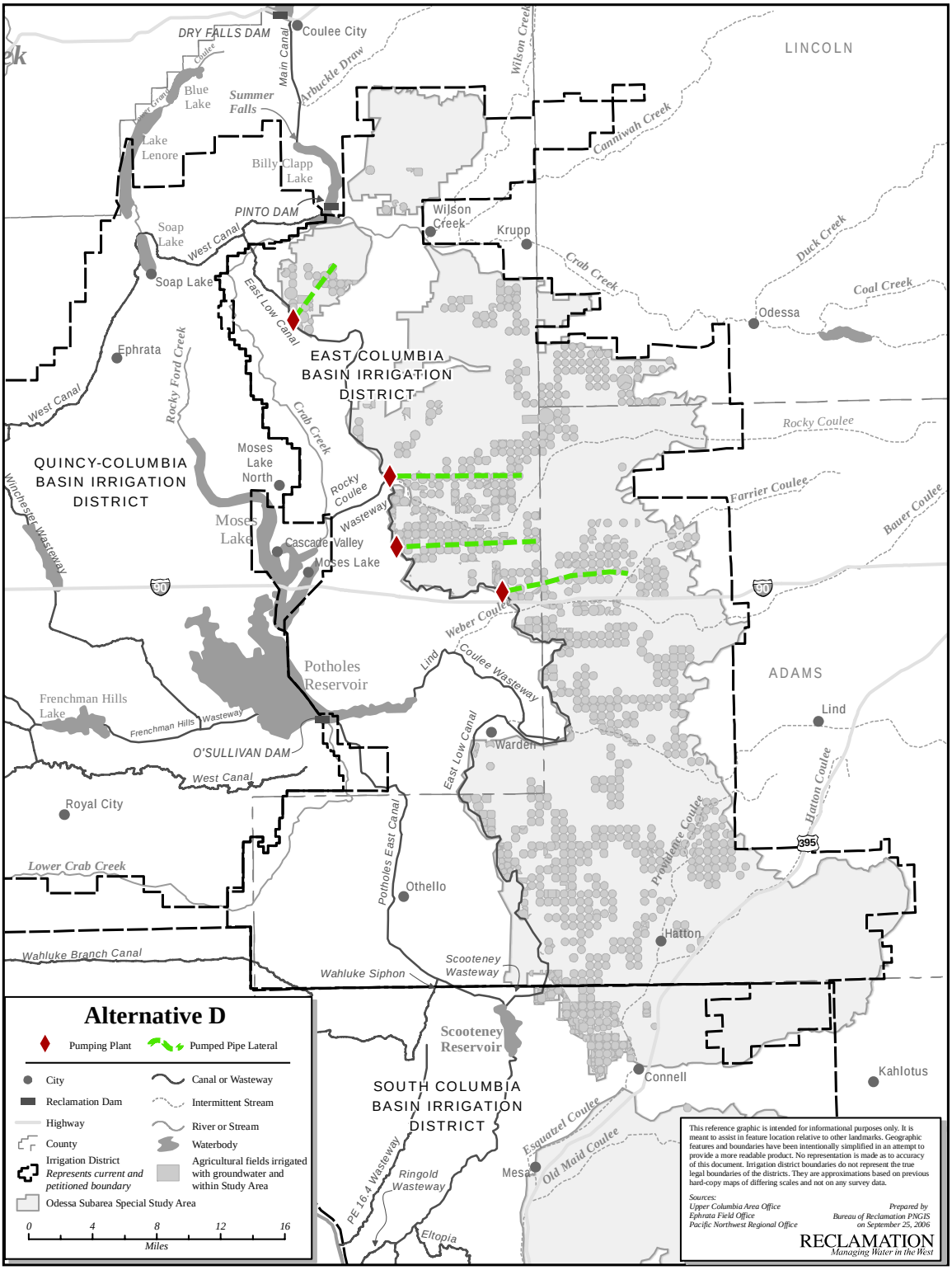

Figure 5 - Alternative D

WATER SUPPLY OPTIONS

Alternatives A through D identify possible water delivery alternatives to convey water to groundwater irrigated lands in the Study area. Each alternative requires CBP water beyond current Project diversions. An estimated water supply requirement for each alternative is shown in Table 3.

Reclamation has a senior water withdrawal in place to irrigate the remaining authorized acres of the Project; however, it will need to comply with NEPA regulations, consult under the ESA, and address other issues before it can divert additional water from the Columbia River. Reclamation may also need to apply for an additional water right permit to cover the lands in the Study area.

Despite having appropriated or reserved water for a fully-developed CBP, it will be a challenge to provide water during the summer months, and during spring and summer months in drier years, when Columbia River diversions may be restricted because of fish flow objectives for species listed under the ESA. The Technical Team considered a variety of water supply options to enable replacement of the groundwater currently pumped with a surface supply from the CBP for Alternatives A through D. Water supply options identified include relying on existing reservoirs within the CBP (Lake Roosevelt and Banks Lake), adjusting current Project operations, and/or constructing new storage. These options are listed in Table 4 and depicted in Figure 6. The quantity of groundwater acreage that could be supplied by each water supply option was estimated using various methods ranging from hydrologic modeling to approximations from preliminary storage capacity curves. These estimates will need to be reexamined during the appraisal-level analysis.

Table 3 - Appraisal-level Alternatives and Estimated Water Supply Needs

Alternatives	Estimated Water Supply Needs * (acre-feet)	Potential Groundwater Acreage to be Supplied (acres)	Percent of Total Groundwater Irrigated Acres in Study Area Supplied
A – Construction of an EHC system sized to serve the current groundwater irrigated lands.	520,000	121,000	100
B - Development of the northern portion of EHC system and enlargement and partial extension of ELC.	470,000	121,000	100
C - Enlargement and partial extension of ELC.	260,000	73,000	60
D – Construction of distribution facilities to serve lands north of I-90 from ELC.	160,000	48,000	40

* Alternative A utilizes entirely new conveyance infrastructure and will introduce new conveyance system losses. Alternative B utilizes less new conveyance infrastructure and relies more on existing conveyance infrastructure thus introducing less new conveyance system loss. See Appendix F for planning assumptions regarding diversions and conveyance efficiencies for all alternatives.

The Technical Team determined that additional information and study is required during the appraisal-level analysis to narrow down the possible water supply options. The PASS process concluded that although technically feasible, further drawdown of Lake Roosevelt is not a viable option at this time because of a signed Agreement-in-Principle between the State and Confederated Tribes of the Colville Reservation (signed January 4, 2005, extended November 9, 2005). This Agreement-in-Principle outlines the basis for Tribal support of new drawdowns from Lake Roosevelt. This document also commits the State to not seek further drawdowns beyond those described in the agreement.

Banks Lake Operation

Changes in the operation of Banks Lake are among the mix of possible methods to supply all or part of the Study area groundwater acres without adversely impacting the Columbia River flow objectives established by NOAA Fisheries for the protection of ESA listed salmon and steelhead.

Drawdown Scenarios

The Banks Lake drawdown options attempt to utilize Banks Lake storage during the months that additional diversions at Grand Coulee Dam are not available. For drier years that means April through August, with refill in September and October.

Hydrologic simulations of CBP operations estimate an April through August drawdown to elevation 1563 feet can supply 39,000 Study area groundwater acres (Reclamation 2006a). A drawdown to elevation 1559 feet can supply an estimated 73,000 acres. It would take a drawdown to elevation 1553 feet to supply the entire 121,000 Study area groundwater acres. These simulations incorporate the 5-foot drawdown that currently occurs in August. Full pool for Banks Lake is elevation 1570 feet. In all scenarios, refill to 1570 feet occurs during September-October, assuming normal pumping capacity is available at Grand Coulee Dam.

Reclamation's *Banks Lake Drawdown Final Environmental Impact Statement* (FEIS) (2004a) evaluated the effects of drawing Banks Lake down an additional five feet to elevation 1560 (for a total of 10 feet below full pool) in August to enhance the probability of meeting Columbia River flow objectives for ESA listed salmonid stocks. Reclamation determined that the resulting benefits to fish were insignificant and did not outweigh potential adverse effects to other resources; therefore, Reclamation decided not to implement additional drawdowns at Banks Lake at that time. The action considered in the FEIS had a different purpose and the timing of the proposed drawdown differed from what the Technical Team has considered. However, based on the analyses contained in the FEIS, a drawdown to elevation 1563 feet may be achievable with minimal adverse impacts to the existing multiple purpose benefits of Banks Lake, or have impacts that are reasonable to mitigate. Drawdowns to elevations below 1560 were not studied in the FEIS and may have more significant impacts and may be unpopular with a range of user groups. Additional analysis of foot-by-foot effects will be needed.

Table 4 - Water Supply Options

Option	Potential Water Supply Options	Estimated Groundwater Acreage to be Supplied				Comments
		Alternative A	Alternative B	Alternative C	Alternative D	
1	Lake Roosevelt reoperation – exercise 1938 water withdrawal	Up to 121,000	Up to 121,000	Up to 73,000	Up to 48,000	Although technically feasible, this alternative is inconsistent with the January 4, 2005, Agreement-in-Principle between the State and Confederated Tribes of the Colville Reservation. Has potential to change the timing of exposure of cultural resources to looters and collectors.
2	Banks Lake – drawdown to approx. elevation 1563'	Up to 39,000	Up to 39,000	Up to 39,000	Up to 39,000	Elevation 1563' may be an elevation that causes minimal impact.
3	Banks Lake – drawdown to below elevation 1563'	Up to 121,000	Up to 121,000	Up to 73,000	Up to 48,000	It is possible to irrigate an additional estimated 8,000 acres for each foot of drawdown below elevation 1563.' Adverse environmental, social, and cultural resource effects possible.
4	Banks Lake –- raise operational level above elevation 1570'	Up to 16,000	Up to 16,000	Up to 16,000	Up to 16,000	Estimated acres assume a 2-foot raise above current maximum Banks Lake water surface elevation to 1572.' It is possible to irrigate an additional estimated 8,000 acres for each foot of increase above elevation 1570.' Potential safety of dams issues. Additional Infrastructure changes will be necessary. Adverse environmental, social, and cultural resource effects are also possible.
5	Dry Coulee Reservoir	Up to 121,000	Up to 121,000	Up to 73,000	Up to 48,000	It appears that it can be gravity inflow from Main Canal and gravity outflow to ELC or West Canal. Assumes gravity operation and storage capacity could be increased by pumping. Potential for excessive seepage and/or could adversely impact downgradient lands. Possible ESA issues and impact to other species; shrub-steppe acreage disturbed.
6	Rocky Coulee Reservoir	Up to 42,000	Up to 42,000	Up to 42,000	Up to 42,000	Water surface limited to elevation 1290' to allow gravity inflow from ELC then gravity outflow to Potholes Reservoir. Assumes gravity operation and storage capacity could be increased by pumping. Alternatives A and B would allow inflow via EHC. Alternatives B, C, and D may not have sufficient ELC capacity to fill reservoir. Possible ESA issues; shrub-steppe habitat affected.
7	Lind Coulee Reservoir	Up to 25,000	Up to 25,000	Up to 25,000	Up to 25,000	Water surface limited to elevation 1250' to allow gravity inflow from ELC then gravity outflow to Potholes Reservoir. Assumes gravity operation and storage capacity could be increased by pumping. Alternative A would allow feed via EHC. Alternatives B and C may not have sufficient ELC capacity to fill reservoir. Possible ESA issues, shrub-steppe habitat affected.
8	Lower Crab Creek Reservoir	Up to 121,000	Up to 121,000	Up to 73,000	Up to 48,000	Could be used to offset Grand Coulee diversions during fish critical periods, however, flows will be affected on the Columbia River from Grand Coulee Dam to the confluence of Crab Creek. Possible ESA issues; shrub-steppe habitat affected.
9	Black Rock Coulee Reregulation Reservoir	Up to 9,500	Up to 9,500	n/a	n/a	Feasible only as a reregulation reservoir for Alternatives A and B.
10	Reoperation of Potholes Reservoir	Up to 16,000	Up to 16,000	Up to 16,000	Up to 16,000	Shift spring feed to fall when Columbia River water in excess of flow objectives is available. This change in operation will require an evacuation route from Potholes Reservoir.
11	Canal system efficiency improvements	To be determined by irrigation districts at a later date.				

NOTES:
Alternatives A through D may require a supplemental feed route and/or evacuation route from Potholes Reservoir. The need for these will be evaluated during appraisal-level analysis.
Quantity of groundwater acreage to be supplied was estimated using various methods. These estimates will need to be reexamined during the appraisal-level analysis.
Combining water supply options could provide more benefits with reduced impacts and should be examined during the appraisal-level analysis.

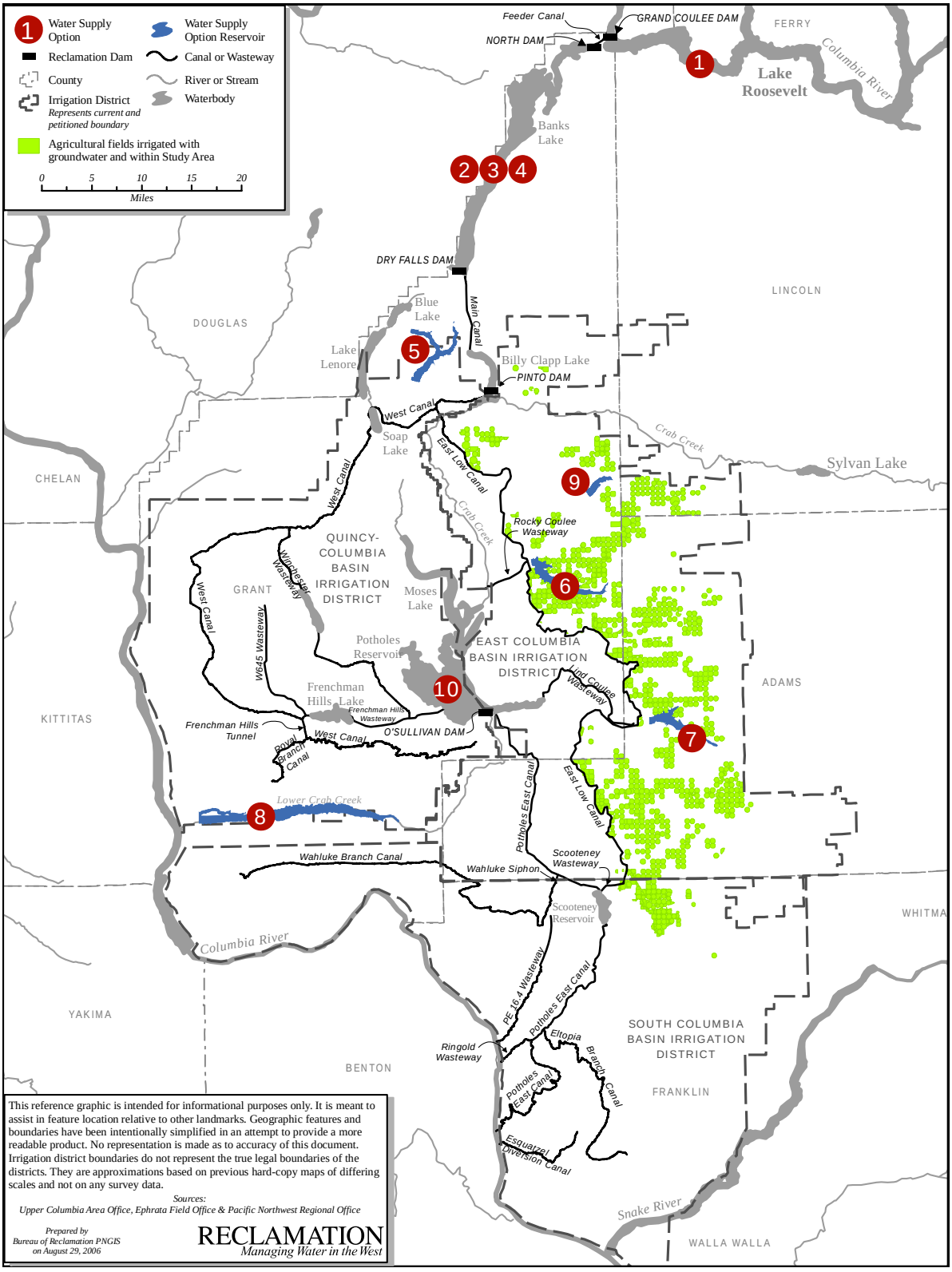

Figure 6 - Water Supply Options

Raising Banks Lake

Filling Banks Lake to above elevation 1570 feet (the current full pool) could also provide additional water supply while meeting Columbia River flow objectives, especially if done in conjunction with Banks Lake drawdown or other water supply options. Each additional foot of elevation equates to about 25,000 acre-feet of additional storage, enough to supply about 8,000 acres. Available technical information indicates that Dry Falls Dam and North Dam each have approximately 10 feet of potentially useable freeboard above elevation 1570 feet. Operating the reservoir within this potentially useable freeboard will require a Reclamation safety of dams review. Impacts to highways, parks, other shoreline features, other infrastructure, the riparian environment, and the communities of Coulee City and Electric City will also need detailed review. For the purposes of this report, the Technical Team assumed a raise of 2 feet to a new operational level of elevation 1572 feet.

If it is decided to include Banks Lake drawdowns and/or a raise as possible water supply options in the appraisal-level analysis, foot-by-foot hydrologic, environmental, and economic studies will be needed.

Potential Water Storage Sites

An additional water supply is needed during the summer months when pumping from the Columbia River is restricted due to the necessity of meeting flow objectives in the lower river. To offset potential impacts to flow objectives from additional Columbia River withdrawals, water could be pumped when available and stored in a new off-stream reservoir site. Five potential reservoir sites were identified within the Project boundaries (Table 5 and Figure 6). These sites were primarily chosen based on location, minimum size criteria, and potential for gravity inflow and outflow. Preliminary evaluation indicates Black Rock Coulee has insufficient volume to be practical as a storage reservoir but could be useful as a reregulation reservoir for infrastructure alternatives that include the EHC. The Dry Coulee, Rocky Coulee, Lind Coulee, and Lower Crab Creek sites appear to have sufficient potential storage volume to warrant further study. Each has its advantages and disadvantages.

Table 5 summarizes existing information about these potential water storage sites. Additional information is provided in Appendix G. Preliminary area-volume calculations and existing land use and environmental information were developed using GIS analysis. Preliminary review of existing geologic reports and maps also occurred. Additional engineering, geologic, cultural, and environmental study is needed to obtain more precise quantification and better understanding of issues associated with each site.

Table 5 - Potential Water Storage Sites

Site	Estimated Active Volume (acre feet)	Estimated Surface Acres	Elevations (feet)	Estimated Irrigated Acreage	Landcover (acres)	Infrastructure	Land Ownership (acres)	Geological Summary	Other
Black Rock Coulee (Reregulation only for Alternatives A and B)	28,599	859	Top = 1,500 Bottom = 1,365	9,500	655 - shrub-steppe 29 - wetland/water 1- forest 1 - barren 173 - crop	1 - residence 0.3 mi. county rd.	All private	203 acres - alluvium 650 acres - basalt flows No well logs available in this reservoir site. Estimate that the coulee would have silt, sand, and gravel fill on the order of 50 feet thick. The reservoir sides would be basalt flows, which would be very similar in nature to all of the reservoir sites in the area.	Potential habitat for ferruginous hawk and north leopard frog.
Dry Coulee	313,690	3,236	Top = 1,480 Bottom = 1,165	103,000	2,711 - shrub-steppe 32 - wetland/water 6 - forest 208 - barren 246 - crop	6 - residences 6.0 mi. Dry Coulee Rd.	542 - Public 2,694 - Private	1,807 acres - basalt flows 1,416 acres - flood deposits Well logs available in the Dry Coulee area Depth to basalt varies from 25 to 218 feet; south end of coulee and near West Canal depths to basalt range mostly from 150 to 218 feet. Overburden materials are mostly sand, gravel, cobbles, and boulders. Material would likely be very permeable and would require some sort of cutoff to prevent seepage. Fault intersects basalt flows in west side of site, in the southern arm. Concern that broken basalt in and near the fault would provide conduit for seepage and impact groundwater conditions in the Soap Lake area.	Potential habitat for north leopard frog.
Lind Coulee	75,907	2,471	Top = 1,250 Bottom = 1,185	25,000	511 - shrub-steppe 7 - wetland/water 25 - barren 361 - range 1,567 - crop	3 - residences 9.6 mi. Lind-Warden Rd.	Not Available	1,141 acres - alluvium 172 acres - basalt flows 1,144 acres - flood deposits 17 acres - sedimentary deposits Located close to the Lind Coulee Siphon. Siphon explorations found sandy silt with varying amounts of gravel, cobbles, and boulders. Basalt bedrock was encountered near the middle of the coulee at a depth of 26 feet. Bedrock is likely at a depth of 60 to 70 feet. About 1 mile east of siphon, a well encountered gravel to 28 feet, clay from 28 to 71 feet, and basalt bedrock at 71 feet. If clay located at dam site, it should provide a tight foundation; clay was not encountered in the siphon investigations.	Significant archaeological site-ancient bison kill site. Potential habitat for north leopard frog.
Rocky Coulee	126,085	3,028	Top = 1,290 Bottom = 1,195	42,000	378 - shrub-steppe 649 - range 2,001 - crop	6 - residences 5.0 mi. county rds.	80 - Public 2,948 - Private	1,515 acres - alluvium 331 acres - basalt flows 1,177 acres - flood deposits 6 acres – wind-blown silt At Rocky Coulee Siphon, less than 1/2 mile west of proposed dam site, several test holes were drilled. In coulee bottom basalt bedrock was not hit before they stopped drilling. About 50 feet of compact sandy silt was encountered. Depth to basalt is likely at about 80 feet. Compact sandy silt should provide a fairly tight foundation.	Potential habitat for ferruginous hawk and north leopard frog.
Lower Crab Creek	313,166	9,674	Top = 570 Bottom = 495	101,000	4,383 - shrub-steppe 1,793 - wetland/water 506 - forest 475 - barren 2,506 - crop	20 - residences 23.0 mi. county rds.	5,649 - Public 3,916 - Private	7,734 acres - alluvium 849 acres - basalt flows 186 acres - flood deposits 489 acres - talus deposits 175 acres - dune sand	Potential habitat for ferruginous hawk.
Acreages and volumes are estimates derived from multiple databases from different sources and varying scales.									

Potholes Reservoir Reoperation

By reoperating Potholes Reservoir, an estimated 50,000 acre-feet of water can be made available to replace groundwater use in the Study area by shifting that volume of feed from spring to fall. This option will require an evacuation route from Potholes Reservoir.

Canal System Efficiency Improvements

Canal system conservation improvements could reduce both the amount of additional water supply needed to replace groundwater irrigation and increase the acreage that the existing or future system can dependably support. However, such measures will likely only make a modest water supply available for the alternatives. Forty-nine conveyance system conservation projects over 18 years by the ECBID yielded enough net savings to supply replacement water, on an interruptible basis, to approximately 2,400 acres in the Odessa Ground Water Management Subarea, only about 2 percent of the acres needing a replacement supply from the CBP.

Water efficiency improvements within the CBP do not necessarily result in additional water available for the Study area or the Project as a whole because operational losses in the ELC and West Canal systems contribute to the supply for the Potholes Reservoir and the Potholes Canal. As efficiencies improve, the need to direct feed Columbia River water to Potholes Reservoir increases which diminishes both the water supply and ELC conveyance space improvements being sought. To maximize the net savings, both in terms of water supply and conveyance space, ECBID and SCBID conveyance system conservation activities should be coordinated.

Conveyance system conservation and space improvement actions that are possible within the ECBID could include replacing areas of aging lining in the upper 27 miles of the ELC, adding new lining in other reaches of the ELC, additional lining and piping of laterals, and pumping from drains and wasteways to supply selected laterals.

FUTURE CONSIDERATIONS

Reclamation will use the PASS recommendations to define tasks comprising the appraisal-level analysis which will begin in October 2006. The appraisal analysis will further develop and evaluate Alternatives A through D and the water supply options listed in Table 4.

The Technical Team lacked sufficient information to definitively rank four storage sites (Dry Coulee, Rocky Coulee, Lind Coulee, and Lower Crab Creek). The Technical Team recommends that the appraisal analysis evaluate these four sites to a level of detail sufficient to rank them and determine which, if any, warrant detailed engineering, economic, and environmental study. This ranking should include elements such as geology, environmental advantages and disadvantages, infrastructure replacement (highways, residences, etc.), and water supply benefits. The level of effort and expense of this ranking should be kept to the minimum necessary to identify sites for further analysis.

Additional tasks for the appraisal analysis include:

- Identify general groundwater irrigated land areas to be served to facilitate hydrologic simulations.
- Develop estimates of potential return flow from Study area to support hydrologic modeling.
- Conduct hydrologic simulations to verify water supply options are operationally feasible with current Project operation and able to meet Study area demands.
- Develop engineering design and cost estimates as appropriate for an appraisal-level analysis.
- Determine if drainage infrastructure will be required.
- Analyze local geology and determine suitability.
- Collect additional information about specific environmental concerns, including ESA-listed and state sensitive species potentially impacted, shrub-steppe habitat and other fish and wildlife concerns, water quality, etc., as appropriate for an appraisal-level analysis.
- Identify significant cultural and historical resources potentially affected.
- Begin to determine recreation benefits and effects.

This list is not meant to be comprehensive.

The following issues are outside of the scope of the appraisal-level analysis, but are important for implementation of any alternative, and therefore, require consideration and action sometime during the Study period:

- The type and terms of contracts for new water delivery will need to be coordinated with existing interruptible water service contracts east of the ELC before any alternative is implemented.
- Reclamation may need to obtain a water right permit to implement any of the alternatives. Appendix H details the water right background and application process.

REFERENCES

Adams County. 2006. *TaxSifter Parcel Search Website*. Retrieved August 3, 2006 from http://adamswa.taxsifter.com/taxsifter/disclaimer.asp.

Columbia Basin Development League. 2006. *Columbia Basin Water Initiative, Proposed Options for the Odessa Sub-area Special Study*.

East Columbia Basin Irrigation District. 1989. *Pre-Feasibility Report for Rocky Coulee Reservoir*. Othello, Washington.

Franklin County Conservation District. 2005. *Columbia Basin Ground Water Management Area Geographic Information Systems Data Sets*.

Grant County. 2004. *Tax parcel layer compiled from county data on October 13, 2004*.

Grant County. 2006. *Tax parcel layer compiled from county data on July 27, 2006*.

Hansen, A.J., Jr., Vaccaro, J.J., and Bauer, H.H. 1994. *Ground Water Flow Simulation of the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho.* Water Resources Investigations Report 91-4187. U.S. Geological Survey.

MWH. 2005. *Columbia River Mainstem Storage Options, Off-Channel Storage Assessment Pre-Appraisal Report*. Prepared for Washington Department of Ecology and Reclamation. December 2005.

Montgomery Water Group, Inc. 2003. *Columbia Basin Project, Water Supply, Use and Efficiency Report*. Prepared for East Columbia Basin Irrigation District, Quincy-Columbia Basin Irrigation District, South Columbia Basin Irrigation District, Grand Coulee Electric Authority, and Reclamation. Kirkland, Washington.

Mundorff, M.J., Reis, D.J., and Strand, J.R. *Progress Report on Ground Water in the Columbia Basin Project Washington.* Ground Water Report No. 3. December 1952. U. S. Department of the Interior, U. S. Geological Survey, Water Resources Division, Ground Water Branch, State of Washington.

National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 2004. *Biological Opinion, Consultation on Remand for Operation of the Columbia River Power System and 19 Bureau of Reclamation Projects in the Columbia Basin*. F/NWR/2004/00727. Northwest Region, Portland, Oregon.

Natural Resources Conservation Service. 2005. *Soil Survey Geographic Version 2.2 Databases for Adams and Grant Counties*.

Pitz, Charles F. 2003. M*oses Lake Total Maximum Daily Load Ground Water Study*. Publication No. 03-03-005. February 2003. Washington State Department of Ecology.

State of Washington and Confederated Tribes of the Colville Reservation. 2005. Government-to-Government Agreement in Principle for Developing a Formal Memorandum of Agreement between the State of Washington and the Confederated Tribes of the Colville Reservation for the Lake Roosevelt Component of the Columbia River Initiative. January 4, 2005, extended November 9, 2005.

State of Washington, U. S. Bureau of Reclamation, East Columbia Basin Irrigation District, Quincy-Columbia Basin Irrigation District, and South Columbia Basin Irrigation District. 2004. Memorandum of Understanding Concerning the State of Washington's Columbia River Initiative. December 17, 2004.

U. S. Bureau of Reclamation. 1958. *Columbia Basin Project, Alternate Plans for Providing Irrigation Water to East High Canal Areas, Study No. 1*. Ephrata, Washington.

U. S. Bureau of Reclamation. 1960a. *Columbia Basin Project, Alternate Plans for Providing Irrigation Water to East High Canal Areas, Study No. 2*. Ephrata, Washington.

U. S. Bureau of Reclamation. 1960b. *Columbia Basin Project, Alternate Plans for Providing Irrigation Water to East High Canal Areas, Study No. 2, Supporting Materials*. Ephrata, Washington.

U. S. Bureau of Reclamation. 1966. *Columbia Basin Project Completion of Irrigation Facilities, Feasibility Grade Study Preliminary Draft.* Ephrata, Washington.

U. S. Bureau of Reclamation. 1968a. *Columbia Basin Project, East High Investigations, Washington*. Boise, Idaho.

U. S. Bureau of Reclamation. 1968b. *Columbia Basin Project, Completion of Irrigation Facilities, Revisions to Plans and Estimates Appendixes, Volume VI B.* Ephrata, Washington.

U. S. Bureau of Reclamation. 1970. *East High Plan Selection, Summary Report, Plans and Estimates Supporting Data*. Upper Columbia Development Office, Spokane, Washington.

U. S. Bureau of Reclamation. 1972. *Columbia Basin Project, East High-East Low Extension, Supporting Data for Development of Costs for Initial Plan Formulation Studies*. Upper Columbia Planning Office, Spokane, Washington.

U. S. Bureau of Reclamation. 1976. *Lands Report for Completion of the Columbia Basin Project.* February 1976.

U. S. Bureau of Reclamation. 1980. *Environmental Assessment of the Proposed Potholes Reservoir Feed Route, Columbia Basin Project, Washington.* July 1980.

U. S. Bureau of Reclamation. 1984. *Briefing Information on Continued Development of the Columbia Basin Project, Washington.* Boise, Idaho.

U. S. Bureau of Reclamation. 1989. *Continued Development of the Columbia Basin Project, Washington, Draft Environmental Impact Statement*. Pacific Northwest Region, Boise, Idaho

U. S. Bureau of Reclamation. 1993. *Continued Development of the Columbia Basin Project, Washington, Supplement to the Draft Environmental Impact Statement*. Pacific Northwest Region, Boise, Idaho

U. S. Bureau of Reclamation. 2003. *Appraisal Design Study, Columbia Small M&I Storage Reservoirs*. Pacific Northwest Region, Boise, Idaho.

U. S. Bureau of Reclamation. 2004a. *Banks Lake Drawdown, Final Environmental Impact Statement*. Upper Columbia Area, Ephrata Field Office, Ephrata, Washington.

U. S. Bureau of Reclamation. 2004b. *Warden Coulee Reregulating Reservoir, Interim Report*. Prepared for East Columbia Basin Irrigation District. Pacific Northwest Region, Boise, Idaho.

U. S. Bureau of Reclamation. 2005a. *Standing Operating Procedures Dry Falls Dam and Banks Lake, Columbia Basin Project, Washington*. Pacific Northwest Region, Ephrata, Washington. Revised 2005.

U. S. Bureau of Reclamation. 2005b. *Standing Operating Procedures O'Sullivan Dam, Potholes Reservoir, Columbia Basin Project, Washington*. Pacific Northwest Region, Ephrata, Washington. Revised 2005.

U. S. Bureau of Reclamation. 2005c. *Standing Operating Procedures Pinto Dam, Columbia Basin Project, Washington*. Pacific Northwest Region, Ephrata, Washington. Revised 2005.

U. S. Bureau of Reclamation. 2006a. *Odessa Subarea Special Study, Columbia Basin Irrigation Project RiverWare Model Runs*. Draft report. Upper Columbia Area, Ephrata, Washington.

U. S. Bureau of Reclamation. 2006b. *Summary of Geologic Conditions within the Odessa Subarea, Odessa Subarea Special Study, Columbia Basin Project, Washington*. June 2006. Boise, Idaho.

U. S. Bureau of Reclamation. 2006c. *Standing Operating Procedures North Dam, Columbia Basin Project, Washington*. Pacific Northwest Region, Grand Coulee, Washington. Revised 2006.

U. S. Geological Survey. 2006. *Sagemap Website*. Retrieved August 14, 2006 from http://sagemap.wr.usgs.gov/form_result.asp.

Washington Department of Fish and Wildlife. 2004. *Shrub Steppe Mapping of East Washington Using Landstat Satellite Thematic Mapping Data*. August 2000.

Washington Department of Fish and Wildlife. 2005. *Priority Habitats and Species Data – Geographic Information Systems*. April 25, 2005.

Washington Department of Fish and Wildlife. 2006. *Washington GAP Data Products Website*. Retrieved August 14, 2006 from http://www.wdfw.wa.gov/wlm/gap/vdm.htm.

Washington Department of Natural Resources. 2005. *Digital 1:100,000 Scale Geology of Washington State, Version 1.0*.

Washington State University. 2005. *The Economic Impact of Possible Irrigation – Water Shortage in Odessa Sub-basin: Potato Production and Processing.* Prepared for Washington State Potato Commission. June 2005.

APPENDICES

APPENDIX A
CURRENT COLUMBIA BASIN PROJECT
WATER SUPPLY AND OPERATION

The Columbia River is the primary source of water for the Project. Columbia River water is impounded by Grand Coulee Dam to form Lake Roosevelt. Lake Roosevelt has a capacity of 9,692,000 acre-feet. Water is pumped from Lake Roosevelt to the Feeder Canal, which leads to Banks Lake, using six pumps and six pump-generator units.

Banks Lake is 27-miles-long with a total volume of 1,053,100 acre-feet and an active capacity of 715,000 acre-feet. The elevation of Banks Lake is normally maintained between elevation 1565 and 1570 feet throughout the year. Water is delivered to Project lands via the Main Canal from Dry Falls Dam at the south end of Banks Lake. Full delivery to the Main Canal from Banks Lake is possible down to elevation 1540 feet.

The Main Canal is sized to handle a flow of 19,300 cfs from the outlet through the Second Bacon Siphon and Tunnel. The Main Canal is operated from about March 18th to October 31st each year. Dates given are approximate, with the specific date being set annually. Water passes through the Main Canal Powerplant located on Dry Falls Dam and Summer Falls Powerplant located at the north end of Billy Clapp Lake.

Billy Clapp Lake formed by Pinto Dam on the Main Canal, is used to regulate flow into the West Canal and ELC systems. The reservoir also raises the water level up to the elevation needed to put water into the Main Canal. Billy Clapp Lake level during the irrigation season is between elevation 1326 feet and 1336 feet, with the level being dropped near the end of the irrigation season (October 31st) to elevation 1320 feet to provide space to intercept possible winter flows from Arbuckle Draw.

Water is released from Billy Clapp Lake by one of three methods: 1) through the Main Canal and into the irrigation system, which is the headworks structure located on the right side of Pinto Dam; 2) through a gate located at the left toe of Pinto Dam, which releases water into Brook Lake and Upper Crab Creek; or 3) through the passive spillway, which spills at elevation 1336 feet.

The Main Canal continues from Billy Clapp Lake, with a design capacity of 10,000 cfs, to the bifurcation with the ELC and West Canal. The upper sections of the ELC and West Canal have actual capacities of 4,200 cfs and 4,800 cfs, respectively.

Potholes Reservoir is located within the center of the Project area and serves to capture return flows from major portions of the ELC and West Canal areas for reuse into the Potholes East Canal. Potholes Reservoir is created by O'Sullivan Dam and has an active storage of 407,000 acre-feet. Potholes Reservoir also collects a large amount of natural runoff from the 3,805-square-

mile drainage area of the reservoir, which includes the Crab Creek drainage basin. Flow from Crab Creek, Rocky Ford Creek, and several Project wasteways pass through Moses Lake before entering Potholes Reservoir. Moses Lake is operated by the Moses Lake Irrigation and Rehabilitation District and is that district's water supply for irrigation. The Moses Lake Irrigation and Rehabilitation District is not affiliated with the CBP.

At present, the Potholes Canal System serves approximately 227,000 acres, requiring up to 940,000 acre-feet annually from Potholes Reservoir. The annual average natural runoff and irrigation return flows average 610,000 acre-feet per year. To meet Potholes East Canal demand, Potholes Reservoir requires 330,000 acre-feet of feed annually in average years. Currently there are three feed routes. The primary route is through the ELC to Rocky Coulee Wasteway then into Upper Crab Creek, then Moses Lake, and finally into Potholes Reservoir. The Crab Creek portion of this route has a right-of-way capacity limitation of 2,100 cfs. The two secondary routes are through Lind Coulee Wasteway from the ELC and through Frenchman Hills Wasteway from the West Canal. These two routes have capacity limitations of 400 cfs and 150 cfs, respectively. All of these feed routes have zero feed capacity during the peak summer irrigation demand months.

The operation of Potholes Reservoir is guided by a seasonal rule curve to assure Potholes East Canal deliveries can be met throughout the summer. With Potholes Reservoir full, at elevation 1046.5 feet, near the first of June, the reservoir is above the rule curve during the summer when no feed flow is possible during the peak irrigation demand months of June, July, and mid-August. The low elevation on the rule curve is 1027.5 feet at the end of August. Fall feed is provided so Potholes Reservoir is near elevation 1033.5 feet by October. During the winter and spring, natural runoff from Crab Creek and Rocky Ford Creek and irrigation return flows enter the reservoir. Beginning in April, feed water is used as needed to have Potholes Reservoir full near the first of June.

Provisions for assuring the water supply delivery to the Potholes Canal system were included in the Master Water Service Contracts between ECBID, Q-CBID, and the United States (dated August 27, 1976), requiring the construction of a feed route for transporting irrigation water from Banks Lake to Potholes Reservoir which would not adversely affect the operation of the existing canal system. These provisions were included due to the irrigation districts' concern about the existing canal systems having the capacity to transport the required water to Potholes Reservoir and still supply the needs of their own water users. They were also concerned that operating the canals and wasteways at flows necessary to feed Potholes Reservoir would increase the operating and maintenance costs of the system, seepage losses, and the risk of a canal or wasteway failure.

The existing canal system has feed capacity during spring and fall, but no feed capacity during the summer. Current spring feed is limited by the existing canal system capacity and the capacity of Upper Crab Creek in the reach immediately upstream of Moses Lake. Because of the limitation on feed during the high demand months—mid-June through mid-August—Potholes Reservoir must have enough storage to carry through until fall feed can begin.

During low runoff years, the spring feed capacity is not sufficient to fill Potholes Reservoir without a fall feed program the previous year. Fall feed is limited by the reservoir space in Potholes Reservoir needed for winter return flows and spring runoff to minimize spill into Lower Crab Creek. The ability to predict winter runoff from the Upper Crab Creek basin does not exist with any degree of accuracy. Historic winter runoff volume ranges from 30,400 acre-feet to 157,000 acre-feet. Historically, Potholes Reservoir has been left with as much storage space as is practical. Fall feed, which leaves Potholes Reservoir at high elevations, increases the risk of a spring spill.

Spring spill, if needed, is passed down Lower Crab Creek. Reclamation has rights to pass floodwaters down Lower Crab Creek to the extent that the flood releases made into Lower Crab Creek do not exceed flows that would have naturally occurred if there were no Project facilities in place. Project return flows and natural inflows stored in Potholes Reservoir are not considered floodwater and can be released down Lower Crab Creek only to the extent that these flows remain within the "normal bank." The return flow that could be spilled from Potholes Reservoir down Lower Crab Creek within the normal banks has been judged to be 50 to 100 cfs, depending on the time of year and other flows in the channel. Other return flows in Lower Crab Creek are from the lands irrigated in Block 49 and on the Royal Slope.

Areas that are licensed to use artificially stored groundwater are located within the Quincy Ground Water Management Subarea and are primarily northwest of Potholes Reservoir. These pumping wells intercept return flows from the West Canal system that would have entered Potholes Reservoir. The acreage served by groundwater was developed after the Project was in operation. Reclamation under an "artificially stored groundwater program" has licensed the groundwater pumping since 1975.

The average annual withdrawal from Banks Lake as measured in the Main Canal at mile 0.2 is 2,650,000 acre-feet. The average annual split of flows at the Main Canal Bifurcation is 1,378,000 acre-feet to the West Canal and 1,272,000 acre-feet to the ELC. These volumes include 330,000 acre-feet of feed water diverted to Potholes Reservoir. Approximately 280,000 acre-feet of this feed is via the ELC. Return flows from the southern end of the ELC also enter the Potholes East Canal. The majority of this flow enters via the EL68D Wasteway upstream of Scooteney Reservoir. This annual return averages 160,000 acre-feet. The releases from Potholes Reservoir and direct return flows to Potholes East Canal combine to provide an average annual supply of 1,100,000 acre-feet. The three canal systems, West Canal, ELC and Potholes East Canal, deliver approximately 2,200,000 acre-feet annually to water users, serving approximately 631,000 acres.

In the 1980s, the three irrigation districts developed seven small hydroelectric generating plants on Project facilities. The total generating capacity of these seven plants is 144.6 megawatts. The Grand Coulee Project Hydroelectric Authority, which is a separate entity formed by the three irrigation districts, operates five of the hydroelectric plants. Two plants are operated by Grant County Public Utilities District.

APPENDIX B
COLUMBIA RIVER WATER AVAILABILITY ANALYSIS

Reclamation used output data from BPA's Hyd-Sim model for the FCRPS to determine the quantity of water available for diversion from the Columbia River for the CBP. The BPA model includes all significant United States Federal and non-Federal dams and the major Canadian projects on the main stem Columbia River and its major tributaries. It is widely accepted as accurately simulating current operation of the Columbia River system.

Hyd-Sim uses the current FCRPS system operating requirements for each project and historic hydrologic flow conditions. It contains a data set of runoff from 1929 through 1978 to determine impacts to various resources and obligations (such as irrigation, flood control, power, instream flow, other contract obligations, project authorizations, and biological opinions). Data beyond 1978 has not yet been regulated through the BPA Hyd-Sim model. The 1930s and 1940s are the controlling "dry years" of the Columbia River water supply. Reclamation is currently working with BPA to extend the historic hydrologic analysis on the Columbia River through the most current water year possible, which would include the 3-year dry period of 1992-1994. Adding these historic years are not anticipated to change these results appreciably. The model does not yet project changes to future water conditions due to climatic change.

Hyd-Sim model output includes information such as inflow, outflow, end-of-month reservoir elevations, power generation at each project, and monthly average flows at different target points on the Columbia River. The Hyd-Sim model splits the average monthly flows for the months of April and August so the first 15 days are separate from the remaining days of those two months. This is because April and August are dynamic months in which flows can change dramatically.

The Hyd-Sim model includes the Columbia River seasonal flow objectives established by NOAA Fisheries, beginning with the 1995 FCRPS BiOp, at Priest Rapids, McNary, and Bonneville Dams. Flow objectives were identified primarily to facilitate downstream passage of juveniles, and to accommodate chum spawning and returning adult salmon and steelhead listed under the ESA. For the PASS, Reclamation assumed water from the Columbia River could not be diverted unless water exceeded these flow objectives.

The Hyd-Sim model output was compared to the biological flow objectives on the Columbia River at each control point; average monthly flow in excess of flow objectives was calculated as Columbia River water available for diversion to the CBP. When the monthly model output indicated that Columbia River flow objectives were not being met, water was not available for diversion during that month. Table B-1 simulates the average monthly Columbia River water volumes in excess of downstream flow objectives under current operations. These volumes may be available for diversion from the Columbia River to the CBP under water supply conditions similar to those of the 1929 through 1978 period.

Table B-1 Monthly volume of Columbia River water above current operations and NOAA Fisheries flow objectives – in thousands of acre-feet (Kaf). (Source: BPA Hyd-Sim model results, version FRIII_03SN6704)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Ap1	Ap2	May	Jun	Jul	Au1	Au2	Sep
28-29	1387	0	0	1286	0	0	0	0	0	0	0	0	0	640
29-30	1844	0	0	0	362	0	153	0	0	0	0	0	0	834
30-31	1587	0	0	0	0	0	298	0	0	0	0	0	0	1095
31-32	1666	0	0	0	0	615	1780	971	2552	234	216	0	0	800
32-33	1451	0	1537	5222	3198	0	795	0	0	5587	5137	0	0	1353
33-34	2858	2591	7443	10999	7327	4400	4028	927	823	0	0	0	0	729
34-35	1543	0	963	4610	4697	0	623	0	0	0	26	0	0	879
35-36	1667	0	0	0	0	123	262	0	4174	0	0	0	0	440
36-37	1662	0	0	0	0	0	84	0	0	0	0	0	0	530
37-38	1828	0	829	5977	895	2519	1190	0	3774	0	0	0	0	860
38-39	1489	0	0	1902	0	347	298	0	159	0	0	0	0	509
39-40	1811	0	324	1009	179	2476	733	0	0	0	0	0	0	380
40-41	1470	0	1013	2094	0	0	11	0	0	0	0	0	0	637
41-42	1314	0	3706	5673	253	0	80	0	0	2049	463	0	0	585
42-43	1632	0	1387	4318	2178	2121	2826	593	3646	1462	2075	0	0	512
43-44	1458	0	89	1731	0	0	0	0	0	0	0	0	0	734
44-45	1462	0	0	0	0	0	52	0	0	1323	0	0	0	315
45-46	1690	0	231	2869	2088	2868	1613	39	4587	0	857	0	0	904
46-47	1060	0	3937	5674	3158	4252	982	0	2430	0	236	0	0	737
47-48	3993	1699	2887	5379	1229	2015	1301	0	4441	15620	2691	0	0	1927
48-49	1814	0	955	2297	1497	3462	494	695	3845	0	0	0	0	205
49-50	1490	0	156	3091	4423	4935	1890	281	1920	7856	3747	0	0	1160
50-51	2294	2627	5332	7953	6321	3344	2042	1050	6477	0	1613	0	0	1416
51-52	3124	412	3340	4990	2673	2978	1625	220	5346	0	0	0	0	513
52-53	1422	0	0	2093	3594	190	298	0	1877	3934	1955	0	0	885
53-54	1747	81	2368	4107	4192	2541	1816	0	3299	6281	3923	952	3	4452
54-55	2454	1170	2056	1044	0	0	446	0	0	8682	6263	0	0	1037
55-56	2271	1976	4676	8003	2812	3760	2451	2216	8134	7434	2711	0	0	875
56-57	1724	0	2704	3532	0	919	2296	0	3918	5691	0	0	0	514
57-58	1372	0	398	3136	2625	2876	569	0	3261	2619	0	0	0	657
58-59	1394	1019	3747	7579	4872	2461	2217	0	1540	5052	3306	0	0	3983
59-60	4693	3082	4817	4475	1370	1872	3908	438	0	956	372	0	0	839
60-61	1623	553	964	3981	3484	3073	2499	0	502	8336	0	0	0	384
61-62	1401	0	59	3733	0	0	2566	626	0	0	0	0	0	517
62-63	1587	1047	3703	3899	1114	1340	565	0	1034	272	41	0	0	1006
63-64	1240	0	375	3640	665	0	298	0	0	5978	4743	0	0	1657
64-65	2742	159	4194	7821	4269	3464	1547	626	3902	1899	243	0	0	667
65-66	1579	223	1993	4767	0	153	1909	0	0	0	698	0	0	589
66-67	1344	0	1184	5768	5729	643	1972	0	0	7189	3661	0	0	1208
67-68	1593	220	2042	4925	3010	2513	0	0	0	2511	2700	0	0	2291
68-69	2484	1528	2892	6828	4322	1967	3454	1085	6553	629	185	0	0	619
69-70	1453	0	530	4042	2436	497	280	0	0	1986	0	0	0	0
70-71	1185	0	452	5101	6073	2486	1516	455	7258	4962	3308	0	0	792
71-72	1158	103	2025	5336	6007	5846	4269	0	6591	10615	4977	528	0	1421
72-73	1545	0	2564	5397	0	0	0	0	0	0	0	0	0	0
73-74	1300	0	3694	9959	7484	3970	2795	1477	6382	8111	7671	129	0	1513
74-75	1149	0	800	5034	2409	3166	902	0	2225	2737	5096	0	0	801
75-76	1888	2160	5986	7108	5041	1848	2678	335	5064	106	3843	1453	1062	5103
76-77	1753	0	313	1936	0	0	0	0	0	0	0	0	0	431
77-78	938	0	860	3575	698	3889	1514	0	1714	0	1131	0	0	1040
avg	1773	413	1791	4078	2254	1719	1318	241	2149	2602	1478	61	21	1040
min	938	0	0	0	0	0	0	0	0	0	0	0	0	0
max	4693	3082	7443	10999	7484	5846	4269	2216	8134	15620	7671	1453	1062	5103
Driest 10-yr Avg (37-46)	1582	0	758	2557	559	1033	689	63	1217	483	339	0	0	597
Wettest10-yr Avg (67-76)	1510	401	2217	5950	4251	2294	1787	335	3407	3885	3144	211	106	1375

APPENDIX C
GROUNDWATER IRRIGATED AREA CALCULATION
GEOSPATIAL DATA PROCESS STEPS

Source Data
File Names

afgl_flds	Cultivated fields for Adams, Franklin, and Grant Counties, and a portion of the cultivated fields for Lincoln County. From the GWMA dataset. Provided to Reclamation Study Manager by Mark Nielson, District Manager for Franklin County Conservation District.
WSC_E_ELow	Estimate of all the irrigated land east of the ELC that currently receives water from the Columbia Basin Project through water service contracts. (The rest of the irrigated fields east of the canal are assumed to use groundwater.) From the GWMA dataset. Provided to Reclamation Study Manager by Mark Nielson, District Manager for Franklin County Conservation District.
afgl_flds_03	A version of the original GWMA dataset. Provided to Pacific Northwest Regional Office GIS from Upper Columbia Area Office GIS.
Odessa Subarea	Odessa Ground Water Management Subarea Boundary as defined by Ecology.
OSA	Odessa Subarea Special Study Boundary (Reclamation). Provided to Pacific Northwest Regional Office GIS from Upper Columbia Area Office GIS.
gw_irrig_fields	Estimated groundwater irrigated fields. Represents **afgl_flds** clipped to **OSA** and **Odessa Subarea** and subtracting **WSC_E_ELow**. Additional photo interpretation was done so that the file agreed with the 2003 National Agricultural Imagery Program (NAIP) data. Provided to Pacific Northwest Regional Office GIS from Reclamation Hydrogeologist. Renamed **gw_irrig_fields_20060616** to note most recent version received on June 16, 2006.
WA_NAIP.sid	NAIP aerial image. Provided to Pacific Northwest Regional Office by Ephrata Field Office GIS.

Groundwater Irrigated Area Calculation within Odessa Subarea Special Study Boundary

1. Remove/Replace slivers from previous clip operation.

   To refine area calculation to more accurately represent lands within the Odessa Subarea Special Study boundary (**OSA**), we removed features from **gw_irrig_fields_20060616** where less than 50 percent of their original area (from **afgl_flds_03**) fell within **OSA**. Where greater than 50 percent of their original area (from **afgl_flds_03**) fell within OSA, we replaced the 'sliver' features with the original geometry from the source dataset **afgl_flds_03**.

2. Calculate GIS acres

   Add field (GIS_ACRES) to calculate area in acres. Sum of GIS_ACRES equals 121, 032.1306 acres. Compared sum of GIS_ACRES to attribute field ACRES from source data. Sum of ACRES equals 121,032.9000 acres. Resulting dataset is **gw_irrig_fields_acres**.

Groundwater Irrigated Area Calculation within Odessa Ground Water Management Subarea Boundary (Ecology)

1. Select from **afgl_flds_03** that have their centers in **Odessa Subarea.**
2. Remove from **afgl_flds_03** that have their centers in **WSC_E_ELow**.
3. Select from **afgl_flds_03** where IRR_METHOD = "I".

The following steps were performed in order to take advantage of the additional processing steps conducted previously (including aerial imagery photo interpretation) to create **gw_irrig_fields_acres**:

4. Select from **afgl_flds_03** that have their centers in **gw_irrig_fields_acres.**
5. Select from currently selected set from **afgl_flds_03** that have their centers in **OSA.**
6. Switch selection.
7. Deleted selected features.

Resulting dataset is **gw_irrig_fields_State Odessa_Subarea_Boundary**. Sum of ACRES field equals 169,483.5 acres, which approximates the 170,000 acres commonly cited.

APPENDIX D
OBJECTIVES TEAM

Name	Representing	Location
LeRoy Allison	Grant County	Ephrata, WA
Dennis Beich	Washington Department of Fish and Wildlife	Ephrata, WA
Richard Erickson	East Columbia Basin Irrigation District	Othello, WA
William Gray	Bureau of Reclamation, Upper Columbia Area	Ephrata, WA
Jim Harris	Washington State Parks and Recreation Commission	Wenatchee, WA
Clark Kagele	Groundwater Pumpers	Odessa, WA
Dave Kaumheimer	Bureau of Reclamation, Upper Columbia Area	Yakima, WA
Mark Miller	U.S. Fish and Wildlife Service	Wenatchee, WA
Gerry O'Keefe	Washington Department of Ecology, Water Resources	Olympia, WA
Gary Passmore	Confederated Tribes of the Colville Reservation	Nespelem, WA
Rudy Plager	Adams County	Ritzville, WA
Keith Stoffel	Washington Department of Ecology, Water Resources	Spokane, WA
Art Tackett	Municipalities	Connell, WA
Paul Wagner	NOAA Fisheries	Portland, OR

Invited, but unable to attend February 2006 meeting		
James Clark	Central Basin Audubon Society	Moses Lake, WA
Rob Masonis	American Rivers	Seattle, WA
Shannon McDaniel	South Columbia Basin Irrigation District	Pasco, WA

APPENDIX E
TECHNICAL TEAM

Name/Title/Discipline	Representing	Location
Roger Sonnichsen, Agriculture Engineer	Bureau of Reclamation	Ephrata, WA
Kayti Didricksen, Hydrogeologist	Bureau of Reclamation	Grand Coulee, WA
Steve Robertson, Civil Engineer	Bureau of Reclamation	Denver, CO
Paul Ruchti, Structural Engineer	Bureau of Reclamation	Denver, CO
Lynn Maser, Watermaster	Washington Department of Ecology	Ephrata, WA
Richard Erickson, Manager	East Columbia Basin Irrigation District	Othello, WA
Shannon McDaniel, Manager	South Columbia Basin Irrigation District	Pasco, WA

Tom Cook, Study Facilitator	Bureau of Reclamation	Denver, CO
Ellen Berggren, Study Manager	Bureau of Reclamation	Boise, ID

APPENDIX F
PRELIMINARY PLANNING ASSUMPTIONS

The Technical Team relied on the following assumptions when developing and evaluating alternatives. The major conveyance system will be via canals distributed by open laterals and/or low pressure pipelines. The alternatives would provide water to groundwater irrigated lands scattered within the Study area. Development of a minor amount of dry agricultural lands may incidentally be included. None of the proposed alternatives preclude the eventual completion of the entire Project.

The Technical Team used the following diversion and efficiency assumptions:

- New infrastructure – 4.3 acre-feet per acre with 70 percent system-wide efficiency
- Expansion of existing infrastructure – 3.7 acre-feet per acre with 82 percent system-wide efficiency
- Pumping from existing infrastructure – 3.3 acre-feet per acre with 90 percent system-wide efficiency

Evaporation, seepage, and other losses were assumed to range from 0.30 to 1.3 acre-feet per acre between the Columbia River diversion and the farm delivery. Return flows from current groundwater irrigated lands are unknown at this time.

Water would be delivered to the farms primarily through a series of pumping stations when required and gravity pressure pipe distribution systems. Water allotment is to be based on 3.0 acre-feet per acre per year for on-farm use. Each turnout would include a valve controlled by the irrigation district to isolate the turnout from the main lateral pipeline. A flowmeter in a buried vault would be provided for use by the ditchrider and grower to measure water delivery. Sublateral pipelines running along farm unit borders would convey water to turnout facilities to deliver water to each farm unit boundary (not necessarily the high point) at a low pressure. However, topographic conditions may produce significantly higher pressures at some delivery points. The farmer would be responsible for on-farm pressurization and application.

An on-farm drainage program may be necessary for the long-term productivity of many of the irrigated lands in the Project area. The program would help sustain the land's productive capability by maintaining the water table below the root zone of crops and by preventing salt accumulation, which is often associated with poorly drained lands. Reclamation has conducted and funded drainage construction to protect irrigable land in the presently developed Project. Future contract negotiations would need to address drainage responsibilities, including funding, related to this development.

APPENDIX G
POTENTIAL WATER STORAGE SITE DESCRIPTIONS

Dry Coulee Dams and Reservoir Site

Site Location The Dry Coulee site is located approximately 10 miles south of Coulee City. Two dams and a reservoir would be located in Grant County, as shown on Figure 6.

Reservoir Volume Total potential storage volume is estimated at approximately 374,000 acre-feet. Usable storage volume, assuming an inactive and dead storage of 60,000 acre-feet, would be approximately 314,000 acre-feet.

Inundated Area The inundated surface area at full-pool elevation would be approximately 3,200 acres in a reservoir approximately 7.5 miles long.

Dam Size Two dams would form this reservoir. The south dam would be approximately 6,400 feet long and the north dam would be approximately 3,390 feet long. The reservoir would have an approximate depth of 315 feet.

Water Sources Water would be diverted from the Columbia River at Grand Coulee through the Main Canal to fill this reservoir. This is a gravity inflow. Water would then be released back to the West Canal. This is a gravity outflow.

Regional and Local Geology Exposed bedrock at this site are basalts of the Columbia River Basalt Group. Approximately 25 to 218 feet of sedimentary overburden, composed of fine to coarse grained materials, overlies the valley floor. A fault intersects basalt flows in the west side of this site, in the southern arm.

Issues of Concern Construction and operation of the dams and reservoir and related features at the Dry Coulee site may involve the following environmental and institutional issues of concern:

Landcover	Approximately 32 acres of wetlands; 2,711 acres of shrub-steppe, and 246 acres of cropland would be impacted.
Archaeological	Unknown
Infrastructure	• Approximately 6 miles of the Dry Coulee Road would be inundated by the reservoir. • An abandoned railroad may be inundated by the reservoir. • Power transmission line facilities would be inundated by the reservoir. • 6 farm residences would be inundated by the reservoir.
Hydrogeologic Issues	A fault may have adverse impact on seepage from the reservoir. Excessive depth to top of bedrock in permeable overburden materials may require additional seepage control.
ESA Issues	Federal candidate species and State-listed candidate species have suitable habitat within the reservoir area. More detailed survey of ESA species will be required. A large quantity of shrub-steppe acreage is within this site.

Lind Coulee Dam and Reservoir Site

Site Location	The Lind Coulee site is located approximately 6 miles east of Warden. The dam and reservoir would be located in Adams County, as shown on Figure 6.
Reservoir Volume	Total potential usable storage volume is estimated at approximately 75,000 acre-feet.
Inundated Area	The inundated surface area at full-pool elevation would be approximately 2,500 acres in a reservoir approximately 6 miles long.
Dam Size	The dam would be approximately 4,000 feet long. The reservoir would have an approximate depth of 65 feet.
Water Sources	Water would be diverted from the Columbia River at Grand Coulee through the Main Canal to ELC at Mile 54.9 to fill this reservoir. This is a gravity inflow. Water would then be released back to Lind Coulee Wasteway into Potholes Reservoir. This is a gravity outflow.
Regional and Local Geology	Exposed bedrock at this site are basalts of the Columbia River Basalt Group. Approximately 60 to 70 feet of sedimentary overburden, composed of fine to coarse grained materials, overlies the valley floor.
Issues of Concern	Construction and operation of a dam and reservoir and related features at the Lind Coulee site may involve the following environmental and institutional issues of concern:
Landcover	Approximately 7 acres of wetlands, 511 acres of shrub-steppe, and 1,567 acres of cropland would be impacted.
Archaeological	Known ancient bison kill site occurs in Coulee.
Infrastructure	• 9.6 miles of the Lind-Warren Road would be inundated by the reservoir. • Power transmission line facilities would be inundated by the reservoir. • 3 farm residences would be inundated by the reservoir.
Hydrogeologic Issues	Unknown
ESA Issues	Federal candidate species and State-listed candidate species have suitable habitat within the reservoir area. More detailed survey of ESA species will be required. A lesser amount of shrub-steppe acreage is within this site.

Rocky Coulee Dam and Reservoir Site

Site Location	The Rocky Coulee site is located approximately 8 miles northeast of Moses Lake. The dam and reservoir would be located in Grant County, as shown on Figure 6.
Reservoir Volume	Total potential usable storage volume is estimated at approximately 126,000 acre-feet.
Inundated Area	The inundated surface area at full-pool elevation would be approximately 3,000 acres in a reservoir approximately 8 miles long.
Dam Size	The dam would be approximately 3,850 feet long. The reservoir would have an approximate depth of 95 feet.
Water Sources	Water would be diverted from the Columbia River at Grand Coulee through the Main Canal to ELC at Mile 23 to fill this reservoir. This is a gravity inflow. Water would then be released back to Rocky Coulee Wasteway into Potholes Reservoir. This is a gravity outflow.
Regional and Local Geology	Exposed bedrock at this site are basalts of the Columbia River Basalt Group. Approximately 80 to 100 feet of sedimentary overburden, composed of fine to coarse grained materials, overlies the valley floor.
Issues of Concern	Construction and operation of a dam and reservoir and related features at the Rocky Coulee site may involve the following environmental and institutional issues of concern:
Landcover	Approximately 378 acres of shrub-steppe, 2,000 acres of cropland, and 650 acres of rangeland would be impacted.
Archaeological	Unknown
Infrastructure	• 6 miles of county roads would be inundated by the reservoir. • Power transmission line facilities would be inundated by the reservoir. • 6 farm residences would be inundated by the reservoir.
Hydrogeologic Issues	Unknown
ESA Issues	Federal candidate species and State-listed candidate species have suitable habitat within the reservoir area. More detailed survey of ESA species will be required.

Black Rock Coulee Dam and Reregulation Reservoir Site

Site Location The Black Rock Coulee site is located approximately 17 miles northeast of Moses Lake. The dam and reservoir would be located in Grant County, as shown on Figure 6.

Reservoir Volume Total potential usable storage volume is estimated at approximately 29,000 acre-feet.

Inundated Area The inundated surface area at full-pool elevation would be approximately 860 acres in a reservoir approximately 3.5 miles long.

Dam Size The dam would be approximately 4,090 feet long. The reservoir would have an approximate depth of 135 feet.

Water Sources Water would be diverted from the Columbia River at Grand Coulee through the Main Canal to a proposed EHC to fill this reservoir. This is a gravity inflow. Water would then be released back to Black Rock Coulee into Upper Crab Creek through Moses Lake to Potholes Reservoir. This is a gravity outflow.

Regional and Local Geology Exposed bedrock at this site are basalts of the Columbia River Basalt Group. No well logs exist. It is estimated that approximately 50 feet of alluvium overlies the valley floor.

Issues of Concern Construction and operation of a dam and reservoir and related features at the Black Rock Coulee site may involve the following environmental and institutional issues of concern:

Landcover — Approximately 29 acres of wetlands, 655 acres of shrub-steppe, and 173 acres of cropland would be impacted.

Infrastructure
- 1 mile of county road would be inundated by the reservoir.
- Power transmission line facilities would be inundated by the reservoir.
- 1 residence would be inundated by the reservoir.

Archaeological — Unknown

Infrastructure — Unknown

Hydrogeologic Issues — Unknown

ESA Issues — Federal candidate species and State-listed candidate species have suitable habitat within the reservoir area. More detailed survey of ESA species will be required.

Lower Crab Creek Dam and Reservoir Site

Site Location

The Crab Creek site is located east of the Columbia River, approximately four miles south of Wanapum Dam. The dam and reservoir would be located in southwest Grant County, as shown on Figure 6.

Reservoir Volume

Total potential storage volume is estimated at approximately 313,166 acre-feet. Usable storage volume, assuming a 10 percent reduction of total volume for inactive and dead storage, would be approximately 281,849 acre-feet.

Inundated Area

The inundated surface area at full-pool elevation would be approximately 9,674 acres in a shallow narrow reservoir approximately 20.5 miles long.

Dam Size

The dam would be approximately 8,050 feet long by 75 feet high.

Water Sources

Water would be diverted from the Columbia River at Grand Coulee through the Main Canal to the East Low to Rocky Coulee Wasteway to Potholes Reservoir and into Lower Crab Creek to fill this reservoir. This is a gravity inflow. Water would then be released back to the Columbia River to offset diversion from Grand Coulee used to serve new acreage in the Study area. This is a gravity outflow.

Regional and Local Geology

The Crab Creek site is located in the western part of the Columbia Plateau, a structural and topographic basin that encompasses most of the Columbia River drainage. Exposed bedrock at this site are basalts of the Columbia River Basalt Group. Approximately 50 to 100 feet of sedimentary overburden, mostly fine sand but also including silt, coarse sand, and gravel, overlies the valley floor. The site overlies the Saddle Mountains Anticline, a major east-west trending feature of the Yakima Fold Belt. A thrust fault associated with the anticline runs parallel to Crab Creek.

Issues of Concern

Construction and operation of a dam and reservoir and related features at the Crab Creek site may involve the following environmental and institutional issues of concern:

Landcover

Approximately 1,793 acres of wetlands, 4,383 acres of shrub-steppe, 506 acres of forest, and 2,506 acres of cropland would be impacted. The area is a breeding and migration resource for large numbers of waterfowl and shorebirds.

- Portions of the Columbia National Wildlife Refuge and the Lower Crab Creek State Wildlife Area would be inundated by the reservoir.

Archaeological

Unknown

Infrastructure

- 23 miles of local roads would be inundated by the reservoir.
- An abandoned Chicago, Milwaukee, St. Paul, and Pacific Railroad track would be inundated by the reservoir.
- Power transmission line facilities would be inundated by the reservoir.
- 20 residences would be inundated by the reservoir.

Lower Crab Creek Dam and Reservoir Site (continued)

Hydrogeologic Issues	Unknown
ESA Issues	Crab Creek is critical habitat for anadromous fish species, including steelhead trout. The dam would be a barrier to anadromous fish passage and the reservoir would inundate anadromous and resident fish habitat in the creek. • Washington ground squirrel, a federal candidate species, has suitable habitat within the reservoir area. • Northern leopard frog, a State-listed endangered species, has been observed in the reservoir area and suitable habitat would be inundated by the reservoir. • Ferruginous hawk, a State threatened species, has been observed in the area and suitable habitat may inundated by the reservoir. • Burrowing owl, loggerhead shrike, sage sparrow, sage thrasher, and black-tailed jack rabbit, all State candidate species, have been observed in the area and suitable habitat may be inundated by the reservoir. • Northern wormwood, Columbia milkvetch, and Hoover's desert-parsley are federal candidate plant species that occur in the Crab Creek area. The State lists Northern wormwood as an endangered plant species. The State lists Dwarf evening primrose, White eatonella, Wanapum crazyweed, Columbia milkvetch, and Hoover's desert parsley as threatened species.

APPENDIX H
WATER RIGHT CONSIDERATIONS

Reclamation may need to apply for a water right permit for any additional Columbia River diversions to supply groundwater irrigated lands. The Federal government has a 1938 "withdrawal" in effect, which has set aside water for the entire CBP. This set-aside essentially instructed the State to keep in reserve specific amounts of water: 6,400,000 acre-feet total Project storage; 75,000 cfs for hydropower generation; and 25,000 cfs for other secondary uses, mainly irrigation. Over the years, Reclamation has obtained a series of water rights from the State to make use of that "withdrawn" water. They have also obtained a series of other water rights with later priority dates for additional waters for the Project.

Half of the irrigation withdrawal has been put to use, but about 3.3 million acre-feet remains. That water is usually referred to as the "second half" water, because only the "first half" of the originally envisioned irrigation project has been built to date. The lands included in the Study area are located in the second half area, which is east of the ELC; therefore, the water needed to supply these lands will come from the remaining "second half water" or withdrawal water.

The process to obtain a water right for these lands is the same that has been in use for the duration of the Project. Reclamation will submit an application for another secondary use permit to take additional water out of Lake Roosevelt. The choice of the final alternative will determine the parameters requested on the application, including number of acres, the appropriate rate of withdrawal in cfs, and the appropriate volume in acre-feet needed.

Prior to issuing the new permit, Ecology considers environmental impacts, water availability, and possible water rights impairments. The permit, if granted, will carry the 1938 priority date of the withdrawal.

The permit will be structured to have a development schedule to accommodate the options included in the selected alternative. The eventual resulting State water right certificate will reflect the extent to which the water has been put to "beneficial use," and will be the sixteenth water right associated with the CBP. Whatever quantities are authorized by the permit will leave ample water in reserve to complete development of the CBP in the future.