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The Integrated Basin-Scale Opportunity Assessment Initiative, FY 2011 Year-End Report: Deschutes Basin Preliminary Hydropower Opportunity Assessment

Draft Report

S Geerlofs, N Voisin, K Ham, J Tagestad, T Hanrahan, A Coleman
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September 2011

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Abstract

This document reports on first-year progress of the Integrated Basin-Scale Opportunity Assessment Initiative, an action item of the March 24, 2010 Sustainable Hydropower Memorandum of Understanding (MOU) between the U.S. Department of Energy (DOE), U.S. Army Corps of Engineers, and the Bureau of Reclamation. As envisioned in the MOU, an integrated basin-scale opportunity assessment would take a system-scale approach to identifying opportunities and actions to both increase hydropower and enhance environmental conditions within the context of existing water uses in river basins of the United States. Assessments are intended to be collaborative processes that work with stakeholders at the basin scale to identify hydropower and environmental opportunity scenarios. Opportunity scenarios are analyzed, again in collaboration with stakeholders, through modeling and visualization software to assess tradeoffs and system-scale effects. Opportunity assessments are not intended to produce decisional documents or substitute for basin planning processes; assessments are instead intended to provide tools, information, and a forum for catalyzing conversation about scenarios where environmental and hydropower gains can both be realized within a given basin. In fiscal year 2011, DOE's Energy Efficiency and Renewable Energy Water Power Team provided funding to Pacific Northwest National Laboratory, Oak Ridge National Laboratory, and Argonne National Laboratory to develop an assessment approach and toolbox, and carry out an initial pilot opportunity assessment. In February 2011, the Upper Deschutes/Crooked River Basin in central Oregon was selected as the pilot basin. Through establishment of stakeholder working groups, a technical site visit, a series of interviews, a stakeholder workshop, and identification of existing tools and data sets, initial opportunities have been identified and analytical tools selected to explore opportunity scenarios. This report documents project progress to date, describes the opportunity assessment approach, and establishes an agenda for analysis of stakeholder-identified opportunities in fiscal year 2012. Findings presented here are preliminary; the final Deschutes Basin pilot study report will be submitted at the end of fiscal year 2012.

Acknowledgments

The central idea of the Integrated Basin-Scale Opportunity Assessment Initiative is that by working together towards mutual goals we can accomplish more collectively than each of us could working alone. While that sounds simple, in the world of water, “hydropower" and "environment” are just two of many valuable uses, whose advocates, generally speaking, have not always seen eye to eye. That seems to be changing, and this project represents one of many ongoing efforts to build respect, trust, and common purpose among stakeholders who have a stake in healthy rivers, clean energy, and adequate water supply now and into the future. It is both humbling and exciting to play a small part in this shift and we acknowledge the hard work that has come before by agencies, industry, nongovernmental organizations, universities, national laboratories, and others to create the foundation and context for our current effort.

This project would not be possible without financial support from the U.S. Department of Energy’s (DOE’s) Water Power Team, as well as the vision, support, and participation by members of the hydropower industry, environmental community, agencies, irrigators, cities, and individuals willing to roll up their sleeves and think creatively about new options and opportunities. We acknowledge the tremendous support and guidance from the following groups and individuals who have participated on Steering Committees and advisory groups for this project at the national and basin scale:

- Alejandro Moreno, Hoyt Battey, T.J. Heibel, Brennan Smith, Mike Sale, and Gary Johnson of the DOE Water Power Team
- Kerry McCalman, C.J. McKeral, Mike Pulskamp, Cathy Cunningham, Dawn Wiedmeier, Scott Boelman, and Jennifer Johnson of the Bureau of Reclamation
- Kamau Sadiki and Lisa Morales of the U.S. Army Corps of Engineers
- Lori Caramanian and Tanya Trujillo, of the Department of the Interior
- Richard Roos-Collins and John Seebach of the Hydropower Reform Coalition
- Linda Church Ciocci and Jeff Leahey of the National Hydropower Association
- Jeff Opperman and Leslie Bach of the Nature Conservancy
- Fred Ayer of the Low Impact Hydropower Institute
- Julie Keil of Portland General Electric
- Steve Johnson of the Central Oregon Irrigation District
- Kate Miller of Trout Unlimited
- Tod Heisler of the Deschutes River Conservancy
- Kyle Gorman of the Oregon Water Resources Department
- Brett Swift of American Rivers.

Finally, we acknowledge the more than 100 stakeholders who participated in two workshops, the first in Denver, Colorado, in 2010, and the second in Bend, Oregon, in 2011. Input from these workshops was essential in defining the tools, approach, scope, opportunity scenarios, and necessary analyses for this effort. Workshops would not have been nearly as productive without the help of our facilitation team:

- Erik Swanson of the American Public Lands Exchange facilitated the Denver Methodology Workshop.
- Kearns and West (Anna West, Deb Nudelman, Megan Vinett, and Emily McGrath) carried out stakeholder interviews, facilitated the Deschutes Basin Workshop, and drafted the workshop report.

Workshop attendees continue to stay involved in this Initiative by reviewing project documents, receiving project updates, and providing technical guidance and support, and we appreciate their continued participation.

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Acronyms and Abbreviations

AID	Arnold Irrigation District
ANL	Argonne National Laboratory
BOR	Bureau of Reclamation
BSOA	Basin-Scale Opportunity Assessment
CADSWES	Center for Advanced Decision Support for Water and Environmental Systems
cfs	cubic foot(feet) per second
COID	Central Oregon Irrigation District
Corps	U.S. Army Corps of Engineers
CTWS	Confederated Tribes of the Warm Springs
DBBC	Deschutes Basin Board of Control
DOE	U.S. Department of Energy
DVWD	Deschutes Valley Water District
DWA	Deschutes Water Alliance
ESA	Endangered Species Act
ETO	Energy Trust of Oregon
FERC	Federal Energy Regulatory Commission
FPC	Federal Power Commission
FY	fiscal year
GWh	gigawatt-hour(s)
HRC	Hydropower Reform Coalition
ILP	Integrated Licensing Process
IWRM	Integrated Water Resource Management
kW	kilowatt(s)
LIHI	Low Impact Hydropower Institute
MW	megawatt(s)
MWh	megawatt-hour(s)
NGO	non-governmental organization
NHA	National Hydropower Association
NHAAP	National Hydropower Asset Assessment Program
NRCE	Natural Resources Consulting Engineers, Inc.
NUID	North Unit Irrigation District
OID	Ochoco Irrigation District
ORNL	Oak Ridge National Laboratory
OWRD	Oregon Water Resources Department
PGE	Portland General Electric
PNNL	Pacific Northwest National Laboratory

RM	river mile
SID	Swalley Irrigation District
TID	Tumalo Irrigation District
TSID	Three Sisters Irrigation District
TNC	The Nature Conservancy
USGS	United States Geological Survey
VIC	Variable Infiltration Capacity (model)
WSPE	Warm Springs Power Enterprises

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1.0 Introduction

Assessing hydropower and environmental performance at the scale of an entire river basin is intended to identify opportunities that rely upon integration across facilities and among management efforts. The benefits to energy and basin-wide environmental conditions that are possible from such a basin-level approach are almost certain to exceed those available from a location-specific approach. Shared resources reduce costs, and shared benefits encourage strong partnerships.

The U.S. Department of Energy's (DOE's) Wind and Water Power Program provided funding to Pacific Northwest National Laboratory (PNNL), Oak Ridge National Laboratory (ORNL), and Argonne National Laboratory (ANL) (collectively referred to as the "project team") to develop an approach to basin-scale hydropower and environmental assessment that emphasizes sustainable, low-impact or small hydropower and related renewable energies within the context of basin-wide environmental protection/restoration. Called the Integrated Basin-Scale Opportunity Assessment Initiative (BSOA Initiative or "Initiative"), the assessment is one of seven action items of the March 24, 2010 Memorandum of Understanding (MOU) for Sustainable Hydropower between the U.S. Department of Energy (DOE), the Department of the Interior (through the Bureau of Reclamation), and the Department of the Army (through the U.S. Army Corps of Engineers).

The report describes Initiative activities from March 2010 through September 2011, reports on the first year of a 2-year pilot opportunity assessment in the Upper Deschutes/Crooked River Basin in central Oregon, and establishes a research agenda for completing analysis of opportunities in the pilot basin in fiscal year (FY) 2012. As a mid-project report, findings presented here are preliminary and subject to revision through stakeholder review. The ensuing sections of this Introduction provide background and describe first-year Initiative activities, the development of its vision, and the FY 2011 work plan and objectives.

1.1 Background and Fiscal Year 2010 Initiative Activities

Fundamentally, the BSOA Initiative asks one key question: Within a given river basin, is it possible to increase hydropower generation and associated ancillary benefits, while at the same time improving environmental quality and protecting other important water uses?

There is clear recognition that environmental protection and development of renewable energy are linked and that hydropower will continue to provide significant generation of renewable electricity to the nation. There are opportunities for safe, sustainable development of new hydropower resources, and many existing facilities can be upgraded to improve generation, grid services, and environmental performance. In addition, hydropower can play a key role in integrating other renewable resources within a basin or region to better meet the nation's renewable energy needs.

However, dams and diversions can have adverse environmental effects by blocking access to fish habitat, altering water quality, and affecting downstream flow regimes and habitats. River basins are complex ecosystems where upstream changes potentially affect multiple variables elsewhere in the basin.

In FY 2010, the DOE Water Power Team, in collaboration with the U.S. Army Corps of Engineers (Corps), the Bureau of Reclamation (BOR), the hydropower industry, and the environmental community, initiated scoping of an initiative to identify and assess environmentally sustainable hydropower opportunities in river basins in the United States. These assessments would integrate environmental protection/restoration and hydropower generation/optimization opportunity analyses at the system scale to identify specific actions to achieve both hydropower and environmental protection goals across a given river basin. Opportunity assessments would provide information that industry, environmental stakeholders, the Federal Energy Regulatory Commission (FERC), and resource agencies could use to inform hydropower planning processes and potentially expedite licensing for new sustainable hydropower generation or ancillary services. Examination of river basins as integrated systems is possible through the use of advanced modeling and information management tools, as well as through collaborative partnerships between industry, the environmental community, and agencies.

On March 24, 2010, DOE, BOR, and the Corps signed an MOU for sustainable hydropower development; "Integrated Basin-Scale Opportunity Assessments" is identified as one of seven initial action items for interagency collaboration. As envisioned in the MOU, opportunity assessments would involve MOU signatory agencies as well as other federal partners, the hydropower industry, the environmental community, affected Indian Tribes, and other stakeholders to emphasize sustainable, low-impact or small hydropower and "identify ecosystems or river basins where hydropower generation could be increased while simultaneously improving biodiversity, and taking into account impacts on stream flows, water quality, fish, and other aquatic resources."

After signing the Sustainable Hydropower MOU, agency partners formed a Steering Committee consisting of MOU agencies, the hydropower industry members, and environmental nongovernmental organizations (NGOs) to develop the vision and goals of the Initiative.[1] The Steering Committee met by phone and in person six times in FY 2010. National laboratory staff supported the Steering Committee by conducting literature reviews and research, and two workshops: an internal workshop to identify basins where opportunity assessments would be most appropriate, and a national expert's workshop to refine assessment methodologies for stakeholder interaction and system-scale analysis.

The internal workshop was held at the National Hydropower Association conference on April 28, 2010, in Washington D.C. It was attended by Steering Committee members and staff from MOU agencies. The purpose of the internal workshop was to identify basins suitable for a BSOA Initiative pilot study and finalize outreach materials needed to present goals and activities to an audience outside of the Steering Committee.

The national workshop, held in Denver, Colorado, in September 2010, completed FY 2010 activities and was attended by nearly 60 representatives from agencies, national laboratories, the hydropower industry, environmental NGOs, and other interested parties (see Appendix A for the workshop agenda and summary). The workshop identified preferred methodologies for stakeholder engagement, discussed existing and needed analytical tools, opportunity assessment process barriers, and data gaps. Workshop

[1] Steering Committee participation has evolved throughout the course of this initiative; core members of this group are Jeff Leahey and Linda Church-Ciocci (National Hydropower Association); Richard Roos-Collins (Hydropower Reform Coalition); Julie Keil (Portland General Electric); Jeff Opperman (The Nature Conservancy); Fred Ayer (Low Impact Hydropower Institute); Dave Sabo, Kerry McCalman, CJ McKeral, and Mike Pulskamp (Reclamation); Kamau Sadiki and Lisa Morales (Corps); and Alejandro Moreno and Hoyt Battey (DOE). The Steering Committee was supported by National Laboratory staff, including Mike Sale, Brennan Smith, and Bo Saulsbury (ORNL), and Simon Geerlofs (PNNL).

participants developed a three-step process for carrying out opportunity assessments and identified basins appropriate for initial case studies (described further in Chapter 2.0).

By the end FY 2010, the Steering Committee and MOU agencies had defined high-level participation in Initiative activities (Table 1.1), articulated goals, solicited input from hydropower experts through presentations at conferences and workshops, identified priority basins for an initial pilot opportunity assessment, and defined an approach for carrying out opportunity assessments. Through these activities the Steering Committee agreed on a vision and goals for the Integrated Basin-Scale Opportunity Assessments Initiative and defined potential benefits of assessment activities, which were used to draft the FY 2011 DOE work plan for Initiative activities.

Table 1.1. List of Fiscal Year 2010 Activities

Activity and Participants	Date	Outcome
Initial Visioning Meeting—DOE, TNC, HRC	December 1, 2009	Discuss the benefits of a basin-scale approach to hydropower planning and assessment. Lay the groundwork for MOU language.
First Steering Committee Meeting—NHA, TNC, HRC, LIHI, DOE	February 2, 2010	Draft statement of purpose, organizational roles of Steering Committee members.
Sustainable Hydropower MOU Signing—DOE/Corps/BOR	March 24, 2010	Basin-scale opportunity assessments an action item.
Steering Committee Meeting—Steering Committee and MOU Agencies	April 6, 2010	Develop pilot study selection criteria; solicit basins of interest for pilot.
Basin-Scale Workshop at NHA Conference—Steering Committee and MOU Agencies	April 28, 2010	Review initial ranking on pilot basins of interest and revise communications document and approach.
Steering Committee Meeting—Steering Committee and MOU Agencies	May 13, 2010	Begin planning for the national workshop in Denver; vet additional potential pilot basins.
National "Methodologies" Workshop Planning Meeting— Steering Committee and MOU Agencies	June 4, 2010	Confirm space for workshop, identify speakers, set goals and outcomes for workshop, agenda.
Hydrovision Panel	July 27–30, 2010	Panel presentation on basin-scale opportunity assessments, instream flow, and Green Hydro Certification
Basin Scale Literature Review—Oak Ridge National Laboratory	August, 2010	Identify previous analogous efforts, roles and missions of participants; collect literature to inform workshop planning and initiative activities.
Methodology Workshop in Denver, Colorado—Agency, National Laboratory, and Private Sector Hydropower Experts	September 8 and 9, 2010	National workshop to develop approach and methodologies for stakeholder outreach and technical analysis of environmental and hydropower opportunities

1.2 Defining a Vision and Goals for the Initiative

The goal of the BSOA Initiative is to develop an approach to hydropower and environmental assessment that emphasizes sustainable, low-impact or small hydropower and related renewable energies within the context of basin-wide environmental protection/restoration. Looking at the basin as an integrated system, assessments will identify specific opportunities where hydropower value/generation could be increased while simultaneously enhancing environmental conditions. Opportunity assessments focus on two water uses in the basin: hydropower and environment. However, stakeholders from irrigation, recreational, and other water user groups must also be involved to ensure that assessments are feasible within the context of existing water rights and uses. Identification of hydropower and environmental opportunities may also benefit other water user groups, whose interests often intersect with hydropower and environmental issues.

As articulated in the FY 2011 work plan for this initiative, Integrated Basin-Scale Opportunity Assessments, will:

1. Take a proactive and collaborative approach to identifying opportunities for new low-impact[1] hydropower development, improvements at existing projects, and ecosystem restoration and protection.
2. Be carried out in basins with significant potential for both new generation and environmental improvements.
3. Be carried out in basins where opportunity assessments are desired by basin stakeholders and where an assessment would provide clear value to the hydropower industry and environmental stakeholders.
4. Leverage existing and new information tools, evaluate alternative futures, and identify specific actions that agencies, developers, and stakeholders can take to achieve sustainable hydropower development.
5. Build consensus around priority activities to simultaneously increase electricity generation and improve environmental outcomes in river basins of the United States.
6. Inform existing and future regulatory and planning processes, rather than create new layers or affect existing agreements or settlements.

Assessments will consider multiple scenarios to address the needs of basin stakeholders and identify actions that could be taken for basin-wide improvements in hydropower generation/services and environmental conditions, while protecting other uses of water. Opportunity assessments do not substitute for basin-scale planning or relicensing processes—rather by taking an integrated, systems approach to analysis, opportunity assessments could inform the planning process to accelerate sustainable hydropower development while improving environmental quality.

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[1] Such as powering non-powered dams, new small hydropower in irrigation canals and conduits, and other opportunities identified in the 2012 Sustainable Hydropower MOU.

Opportunity assessment activities are intended to benefit multiple stakeholders, including hydropower producers, the environmental community, federal and state agencies, and power consumers. The approach to evaluating benefits would vary by basin to meet the needs of stakeholders, and include the following:

Hydropower Industry

- Collaborative evaluation of opportunities could remove constraints on development and operation in areas of the basin where environmental risks are low.
- Shared information products and common goals could reduce the time, cost, and conflict associated with new licenses, amendments, and relicensing.
- Third-party environmental research could partially remove cost burdens associated with environmental review and permitting (this is also a potential benefit to the environmental community).
- Support for opportunities to test and demonstrate new technologies that could increase generation potential or increase effectiveness and decrease the costs of environmental mitigation.

Environmental Community

- Identification of key areas within river basins where adjustments to hydropower operations could support major ecosystem improvements.
- Identification of areas within a basin where further development of hydropower poses the lowest and highest risks for the basin's ecosystem could focus efforts where they are most likely to produce benefits.
- Support for studies to increase comprehensive understanding of key drivers of river basin ecosystem health.
- Support for tools, technologies, and restoration activities to improve river basin ecosystem health.

Agencies

- Collaborative identification of hydropower and environmental restoration/protection activities could build consensus and reduce conflict during the hydropower licensing process.
- Information products and new data on key environmental risks would aid decision-making.
- Collaborative assessment of opportunities could help inform license applications, reducing the time required of agency staff to review permits with insufficient information.
- The basin scale is ideal for consideration of the effects of climate change on water resources. Emerging information products that model effects and forecast changes to the basin system could allow agency staff to more effectively incorporate longer-term trends into their decision-making process.

1.3 Fiscal Year 2011 Work Plan and Objectives

During FY 2011, we focused on moving from policy and Initiative design at the national level (through MOU and Steering Committee activities) to outreach and application of an assessment approach through a pilot study at the basin scale. It was the first year of a 2-year pilot study process (Figure 1.1).

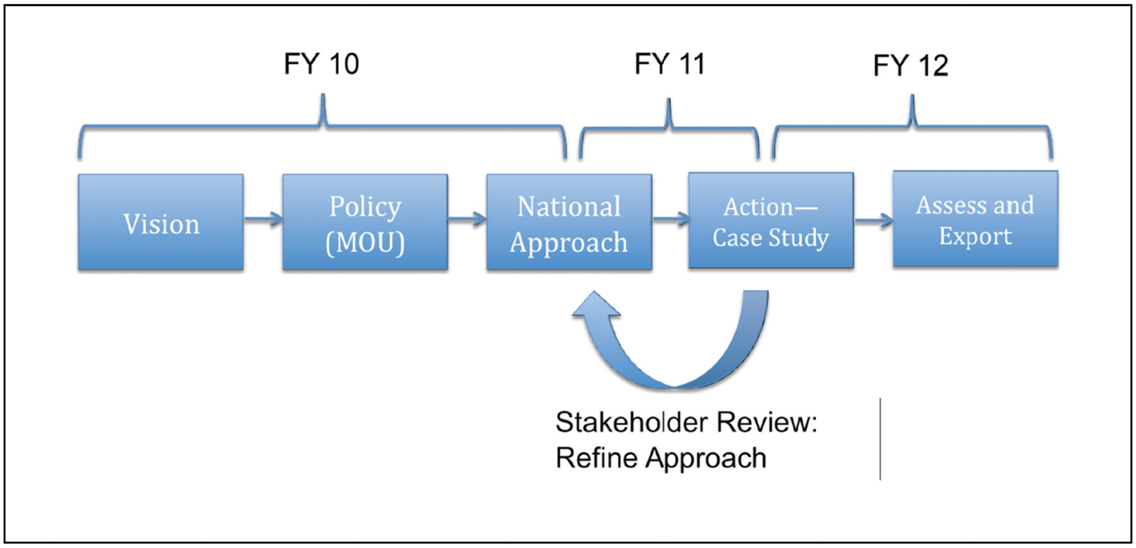

Figure 1.1. Overarching Process for First Two Years of the Integrated Basin-Scale Opportunity Assessment Initiative

The overarching goal for FY 2011 was to work within a pilot basin to develop an approach for integrated hydropower and environmental opportunity assessment at the basin scale. This approach is intended to achieve national goals as described in the hydropower MOU, as well as provide value to local stakeholders to identify and explore promising opportunities. The approach is to identify and apply appropriate analytical tools as well as enable stakeholder participation, feedback, and review of assessment documents. Collaborative application of analytical assessment tools is intended to initiate dialog about specific actions within basins that are achievable and how to best meet the goals of the initiative—to increase both hydropower generation and environmental health within the river basin, within the context of existing uses.

The following set of objectives was identified at the beginning of FY 2011 to allow for development of the opportunity assessment approach:

- **Select Pilot Basin**. Identify one basin as a pilot for initial BSOA in consultation with MOU partners and Steering Committee members. The pilot basin will have significant opportunities for new hydropower generation as well as significant opportunities for environmental improvement. Ideally, the pilot basin will be selected where stakeholder support for integrated opportunity assessments is strong.
- **Develop Opportunity Assessment Toolbox**. Identify data, information, and analytical tools that exist among MOU agencies, non-federal partners, and stakeholders that can be leveraged for opportunity assessments, including the following: environmental analyses; water-resources analyses; systems modeling; GIS expertise; new technology development; and data management capabilities to

support rapid, transparent, science-driven identification of hydropower and environmental protection/ restoration opportunities. Tailor the application of existing tools to the needs of a selected pilot basin.

- **Initiate Basin-Scale Pilot Assessment**. Perform preliminary opportunity assessment in the identified basin through outreach to stakeholders and aggregation of existing data. This high-level assessment will be produced for consideration by basin stakeholders, who will be engaged to provide feedback on its usefulness, make requests for further information or modification of the assessment, and help determine appropriate next steps and a research agenda within the basin to analyze identified opportunities in FY 2012.

1.4 Report Contents and Organization

The balance of this document reports on FY 2011 activities and serves the following primary purposes related to the objectives stated above:

1. Document the Opportunity Assessment Approach as developed at the national scale and refined through actions in the case study basin (Chapters 1.0 and 2.0).
2. Describe development of the opportunity assessment toolbox (Chapter 3.0).
3. Present findings from the preliminary opportunity assessment for the Initiative's first pilot basin, the Upper Deschutes/Crooked River Basin in central Oregon (Chapter 4.0).
4. Based on the preliminary opportunity assessment in the Deschutes Basin and the Opportunity Assessment Toolbox, present a research plan for FY 2012 to analyze identified hydropower and environmental opportunity scenarios (Chapter 5.0).

Appendixes A and B contain the agendas and summaries of the Basin-Scale Opportunity Assessment Initiative Goals, Process, Methodologies, and Products Workshop (Denver Methodology Workshop) and the Deschutes River Basin-Scale Opportunity Assessment Community Stakeholder Workshop (Deschutes Basin Workshop), respectively. Appendix C contains a table of existing non-powered dams and large diversions in the Deschutes Basin from the ORNL National Hydropower Asset Assessment Project.

2.0 Basin-Scale Opportunity Assessment Approach

The basin is a natural scale of integration among human activities and water-resource values. By adopting this scale in the approach for assessing opportunities to improve hydropower and environmental conditions, several benefits accrue. One benefit is that some opportunities can be realized only through collaborative management of the resource. Another benefit is that considering the entire basin allows a more efficient process of collecting information and evaluating alternatives. This chapter describes the coordination, stakeholder engagement, pilot study, and technical analysis elements of the BSOA approach. It begins by providing context and describing previous efforts that have informed integrated assessment activities at the river basin scale.

2.1 Context for the Opportunity Assessment Approach

There are many existing examples of assessments of hydropower or environmental resources in river basins and watersheds of the United States (see DOI, Corps, and DOE 2007; Flynn 1982; GAO 1981; The National Academies 2004; BOR 2005, 2011b; TVA 2004; and Corps 2010), and the Integrated Water Resource Management (IWRM) literature provides approaches to integrating analysis and management of multiple water-use objectives (see GWP 2000, 2003a, 2003b, 2009; GWP/INBO 2009; Lenton and Muller 2009; Rahaman and Varis 2005). The BSOA Initiative was informed by these efforts, as well as recent basin-scale planning activities and collaborative agreements that have used FERC's Integrated Licensing Process (ILP). Three projects in particular have served as touchstones, informing case studies at the Denver Methodology Workshop as well as goals and objectives for the Initiative:

- Clark Fork Settlement Agreement, Clark Fork River, Montana and Idaho (FERC No. 2058) – The Clark Fork Settlement Agreement includes both the Noxon Rapids and Cabinet Gorge hydroelectric developments. It is an example of a multi-stakeholder collaborative agreement that allowed for a single license joining both facilities, reflecting their integrated operations. Environmental improvements were also considered on the system scale, with 26 protection, mitigation, and enhancement measures agreed on to improve ecosystem health in the river. The Clark Fork Settlement Agreement also adopts the concept of a "living license," which promotes ongoing problem solving through adaptive management (Avista Utilities 2011).
- Penobscot River Restoration Project, Penobscot River, Maine – The Penobscot Project set out to consider relicensing of existing hydropower facilities within the context of two goals: 1) restoration of 11 species of sea-run fish to the Penobscot River and 2) maintaining energy production the basin. Meeting these goals at the basin scale required great flexibility on the part of the hydropower operator, PPL Corporation, and creativity on the part of all parties. The agreement resulted in the planned purchase and removal of two dams lower in the basin and decommissioning of a third, while increasing power production at upper dams and resulting in improved access to nearly 1,000 miles of historic habitat while maintaining power production in the basin. The Penobscot River Restoration Trust is the non-profit entity charged with implementing the agreement (Penobscot River Restoration Trust 2011).
- Pelton-Round Butte relicensing, Deschutes River, Oregon – The Pelton-Round Butte Hydroelectric Project is described in Chapter 4.0 of this report. Portland General Electric (PGE) and the Confederated Tribes of the Warm Springs (CTWS) are co-licensees for the project, and in 2005 they signed a comprehensive Settlement Agreement for a 50-year project license with more than 20 other

parties. The agreement included innovative fish passage and restoration measures designed for basin-wide environmental improvements, including reintroduction of Endangered Species Act-listed steelhead above Pelton Dam. The success of these measures requires coordination across the basin on habitat, flow, and water quality restoration and protection.

These examples have several things in common:

- They all considered options for environmental and hydropower operational improvements beyond the scale of a single project—multiple hydropower facilities were considered in the license, and environmental improvements went beyond project-by-project fixes to focus on the system as a whole.
- Planning processes were collaborative and sought feasible outcomes to meet the needs of both power customers and environmental stakeholders.
- Maintaining power generation and improving river environmental conditions were key parameters for decision-making.
- Processes resulted in outcomes that would not have been achieved otherwise using project-by-project, site-by-site approaches.

These commonalities provide context for the goals and objectives of the BSOA Initiative, but it is important to recognize that the Initiative is also different in several ways, including the following:

- BSOAs are **not** intended to serve as planning or management activities, but rather as a way to identify opportunities and options for hydropower and environmental improvements.
- Opportunity assessments set out to identify ways to *improve* or *increase* (rather than maintain) environmental and hydropower objectives, within the context of protecting other important water uses. Protecting other uses serves to bound assessments, but the primary focus is on hydropower and environmental opportunities, rather than opportunities directed toward other uses in the basin.
- Opportunity assessments have limited resources that need to be applied strategically to identify and analyze key opportunities.
- The BSOA Initiative is a national effort as part of the Sustainable Hydropower MOU. Because of this, individual assessments of opportunities in basins are to be carried out relatively rapidly to *initiate* dialog about feasible opportunities. Assessments are not intended to last more than 2 years in any one basin, which contrasts to planning and relicensing activities that may last for many years.

This context provides the building blocks for an approach to opportunity assessment that meets the goals and objectives of the BSOA Initiative, as well as respects its constraints (time, funding, meeting both national and local needs, etc.). A primary goal in FY 2011 was to define an approach to guide BSOAs in the pilot basin and in future basins. The following sections describe the approach by addressing these four topic areas:

1. Coordination
2. Stakeholder Interaction
3. Pilot Study
4. Opportunity Analysis.

2.2 Coordination

The BSOA Initiative is a collaborative activity with core involvement from the hydropower industry, environmental NGOs, MOU agencies, and national laboratory technical staff. Other agencies and stakeholders with an interest in hydropower and environmental protection participate in Initiative planning and activities through workshops, the Federal Inland Hydropower Working Group, and basin assessment activities. Coordination of Initiative collaborative activities is carried out at both the national and basin scale.

Coordination is identified as its own task in the FY 2011 work plan and is called out as a key element of the Initiative's approach in recognition of the need to ensure that the collaborative process is managed and channeled towards achieving the Initiative's goals and objectives. The number of agencies and stakeholders involved in both hydropower and environmental issues in river basins, as well as those affected by hydropower and environmental decisions, necessitates an inclusive approach. Coordinating bodies were designed to be inclusive, representative of many different groups and interests, and consensus based; in addition, they were designed to encourage efficiency and allow for participation at a number of levels to suit stakeholders needs and interests. Coordinating bodies fall into two major bins at both the national and basin scale: "action oriented" and "information oriented." Table 2.1 describes the Initiative's coordinating bodies and roles and the activities of each.

"Action-oriented" bodies, such as the Basin-Scale Steering Committee and the In-Basin Logistics Committee, are small working groups that meet *regularly* to provide *active* guidance on Initiative tasks, such as planning workshops and other events. Trust, camaraderie among members, and a relatively informal structure are critical to allow for an honest exchange of ideas and timely pursuit of Initiative goals and objectives.

"Information-oriented" bodies, such as the National and In-Basin Interest Groups are intended to reach a broad base of interested parties. Input from these groups is typically sought *periodically* through facilitated workshops, review of Initiative documents, and as requests for information arise. The primary goals of these coordinating bodies are to keep stakeholders informed of Initiative activities, to solicit guidance at Initiative "stage gates" (such as review of this report), and to identify opportunities for more focused or one-on-one interaction.

It is important to note that there is overlap between coordinating bodies and that collaborative activities do not always fall neatly into the bins described above. Stakeholders and interested parties are encouraged to contact the national laboratory-led project team with questions or to provide input, and ad hoc working groups are formed to address technical needs and answer specific questions.

Table 2.1. National and In-Basin Coordinating Bodies and Activities for the Basin-Scale Opportunity Assessment Initiative

Coordinating Body	Scale and Roles	Coordination Activities
Basin-Scale Steering Committee	National-Scale Action Oriented—Overarching guidance on Initiative goals, objectives, and activities.	Quarterly phone meetings, yearly meetings at the National Hydropower Association Conference in Washington D.C. Review and input on work plans, products, and assessment activities. Participate in in-basin activities.
MOU Agencies Working Group	National-Scale Action Oriented—Guidance and management of Initiative activities within the context of the Sustainable Hydropower MOU. Ensuring Initiative activities are aligned with MOU goals and agency policies.	Monthly phone meetings, review, and input on work plans, products, and assessment activities.
Federal Inland Hydropower Working Group	National-Scale Information Oriented—Guidance for and coordination of Initiative activities with activities of federal agencies outside of the MOU who have a role in hydropower and environmental protection.	Quarterly meetings alternating in-person or on the phone. Briefed on Initiative activities in order to inform appropriate representatives from within their agencies.
National Interest Group	National-Scale Information Oriented—Agency, private sector hydropower experts, environmental NGOs and others that participated in the national methodology workshop and continue to provide input and guidance into Initiative activities.	Participants at the Denver Methodology Workshop; contributed to methodological approach and identified appropriate tools for opportunity assessment activities. Group is informed of Initiative activities via email periodically.
In-Basin Logistics Committee	Basin-Scale Action Oriented—Similar to National Steering Committee, but populated with regional and local representatives who know basin stakeholders and issues and can assist the project team in outreach to basin stakeholders and identification of resources for opportunity assessment activities.	Monthly planning calls, or as needed, to facilitate execution of assessment activities within the pilot basin (similar group will be established in future basins). Identify key stakeholders, outreach opportunities; plan site visit, and plan logistics for Deschutes Basin Workshop.
In-Basin Interest Group	Basin-Scale Information Oriented—Regional and local representatives from agencies, hydropower industry, irrigation districts, environmental NGOs, local governments and other stakeholders who participated in the Deschutes Basin Workshop. Group provides review and feedback to project team on assessment activities and products.	Participate in basin workshops, correspond with project team via email to provide review of draft documents.
Inter-Lab Project Team	National and Basin Action Oriented—technical experts from PNNL, ORNL, and ANL who carry out opportunity assessment activities. This group may also subcontract activities to other qualified experts.	Bi-weekly coordination calls with labs to manage work plan activities. Establish appropriate working groups to carry out assessment tasks; meet in person and on the phone as needed. Project team plans and participates in site visits and in-basin workshops.

2.3 Stakeholder Interaction Activities

Stakeholder interaction and Initiative coordination activities relate to one another, with stakeholder interaction activities, such as workshops and site visits, providing the catalyst for creation of coordination bodies described above in Section 2.2. Stakeholder interaction activities can be defined as specific and strategic events such as workshops, site visits, and interviews, while coordination activities are designed to leverage and maintain the human capital generated by stakeholder interactions through continued participation. ORNL has primary responsibilities for stakeholder interaction activities, while PNNL has responsibility for coordination activities, requiring close inter-lab collaboration.

As described in Section 2.2, the BSOA Initiative is a collaborative activity that depends on input from stakeholders across the spectrum of water interests, at both the national and basin scale. Water use, hydropower, and environmental protection/restoration are sensitive issues in the river basins of the United States. Because of this sensitivity, working towards positive stakeholder interaction through strategic activities is a primary goal of BSOA Initiative activities. Specific objectives are listed below (with activities designed to achieve each objective provided in *italic* font):

1. Identify stakeholder needs and interests in participation in opportunity assessment activities. Stakeholder mapping.
2. Inform project design, methodologies, and approach. National- and basin-scale workshops.
3. Identify sensitivities and analytical constraints. Site visits, interviews, workshops.
4. Initial identification of opportunities within a particular basin; develop opportunity scenarios for technical analysis. Site visits, interviews, workshops.
5. Conduct collaborative analysis of opportunity scenarios; review of project documents to ensure relevance and feasibility of identified opportunities. Workshops.
6. Build community around opportunity assessment activities to encourage honest analysis and explore pathways towards implementation. Site visits, workshops overlap into coordination activities.

Specific stakeholder interaction activities carried out in FY 2011 within the context of the Deschutes Basin pilot study are discussed in Section 4.2.3.

2.4 Pilot Study

Because of local differences in stakeholder dynamics, hydropower opportunities, environmental issues, and other water uses, BSOAs are place-based activities. In designing an opportunity assessment approach, the project team, Steering Committee, and participants at the Denver Methodology Workshop recognized the need for a pilot study to develop and apply assessment tools and approaches in response to stakeholder needs within a specific basin. The pilot study is intended to serve as a stage-gate for the Initiative and concludes at the end of FY 2012.

The Basin-Scale Steering Committee developed criteria (Table 2.2) for pilot basin selection and evaluated a number of potential basins in 2010 and early 2011 during Steering Committee meetings and workshops. The criteria were intended to facilitate dialog about potential pilot basins among Steering Committee members and serve as a screening, rather than selection tool. ORNL provided input to the screening process (existing dams, potential for new hydropower, basic environmental information) through the DOE Water Power Team's National Hydropower Asset Assessment Project. Steering Committee members drafted memoranda for each potential basin that addressed the selection criteria and catalyzed discussion.

Table 2.2. Selection Criteria for Pilot Basin

Primary Pilot Basin Selection Criteria
An existing mix of hydropower projects that includes private and public facilities
Significant opportunities for new hydropower generation
Significant opportunities for ecosystem restoration and protection
Existing potential for effective basin-scale coordination or leadership
Opportunity for learning or knowledge transfer to other basins
Additional Evaluation Criteria
Opportunities to explore integration of other renewable resources
Competing water uses exist that could be addressed through BSOAs

Pilot-basin selection was a discussion topic at the Denver Methodology Workshop (Appendix A). A key challenge in selecting a pilot basin is ensuring that in-basin stakeholders welcome opportunity assessment activities and foresee a benefit from the project. At the very least, it is essential to ensure that assessment activities do not run counter to or increase the complexity of existing planning or research processes. If benefits are not communicated or if stakeholders are suspicious of motivations and assessment outcome, buy-in is unlikely and the success of outreach and analytical activities is at risk. Furthermore, without stakeholder buy-in, the opportunity assessment results may not be trusted, reducing the chance of future implementation.

Denver Methodology Workshop participants recommended a four-part approach to evaluating stakeholder interest and ensuring a transparent process in potential case study basins:

1. Identify ambassador(s) or key stakeholder(s) in the basin who are familiar with issues in the basin as well as the structure of the BSOA Initiative.
2. Project team works through ambassador(s) to initiate informal outreach calls to key stakeholder groups within the basin, including all hydropower operators, local and national environmental groups, other water users of central importance to basin water issues (irrigators, for example), and regional agency staff. Gauge interest and assess whether an opportunity assessment will be welcomed in the basin—essentially give stakeholders a chance to say "yes" or "no."
3. If stakeholders say "yes," return to Steering Committee and MOU agencies for final approval of basin selection.
4. Begin formal outreach activities.

While this process takes time and effort, it is necessary to initiate a collaborative assessment that aims to integrate analysis of opportunities across water uses. As described previously, stakeholder interaction and coordination are central to the goals of this Initiative; starting with positive engagement within the basin saves time during the analysis and reduces risk of project failure. Creating a community, or forum, around the assessment activity enhances the likelihood that identified opportunities will be realized; the best way to do this is to seek stakeholder buy-in through effective communication of project benefits at the outset. Finally, because this is a national initiative that aims to move from a pilot basin to future basins, it is important to establish a good reputation in the relatively small hydropower and river basin environmental community. It is the expectation of the project team that careful upfront work during the pilot basin selection will lead to a more efficient selection process in future basins as stakeholders begin to see benefits from the opportunity assessment approach.

2.5 Opportunity Identification and Analysis

Once the collaborative structure is in place, the process of identifying and assessing opportunities can begin. A preliminary set of opportunity statements will be solicited from regional stakeholders. These opportunity statements describe a modification to the configuration or operation of the system that is expected to provide a benefit to the interests of one or more stakeholder groups. From a practical standpoint, it is useful to begin with opportunities that result in a revenue stream, such as hydropower generation, or activities such as water conservation that may qualify for funding support if conserved water is dedicated to environmental purposes. These funded activities form the backbones for the formulation of more complete scenarios by adding compatible opportunities benefits. A scenario incorporates multiple opportunities to realize benefits at the basin scale. Analysis tools allow the performance of scenarios to be estimated and evaluated relative to stakeholder values. Scenarios represent a fully realized, basin-scale opportunity for increasing the benefits delivered by the available resource. To the extent possible, analysis of opportunity scenarios will rely on existing data and application of tools that are in use or trusted within the basin of interest and can also be applied in future opportunity assessments (described in Chapter 3.0). The basin-scale opportunity assessment helps stakeholders identify and evaluate alternative scenarios, but it is up to the stakeholders to choose whether to implement the actions identified as part of the scenario.

3.0 Opportunity Assessment Toolbox

As basins across the country attempt to optimize their water use, a number of common needs arise. A survey of available tools was undertaken to identify where those needs were covered by existing tools or data and where technology gaps may exist. The following sections describe the Basin-Scale Opportunity Assessment Toolbox that was compiled to support selection of tools for assessment activities.

3.1 Basin-Scale Assessment Toolbox Methods

As a foundational resource for the BSOA Initiative, the project team developed a database of tools and approaches that can be applied in a basin-scale assessment approach. The purpose of the toolbox is to aggregate existing, appropriate tools in a format that can be easily communicated to interested parties. By identifying tools and resources upfront, tools can be vetted and compared among stakeholders to determine which best meet analytical needs in a given basin.

Information for the database was solicited from and submitted by experts in the fields of river ecology, biology, hydrology, hydraulic engineering, fish passage, modeling and decision support. The submissions were organized in an online database with a description of the tools, tool developer, inputs, outputs, and where the tool has been previously applied.

3.2 Survey Methods

A survey template was developed to solicit input from technical leaders in hydropower and environmental system analysis. The survey template specified the type of input that was being requested with example tools as a guide. The purpose was to solicit information on commonly used or highly relevant tools, methodologies, and approaches that could be leveraged in an integrated basin-scale hydropower/environmental opportunity assessment. The template and instructions were sent out via email to more than 60 potential contributors. To offer further guidance the following definitions were provided to the contributors:

- ***Assessment Indicators***. Opportunity assessments will establish baseline descriptions of key indicators of hydropower and environmental value. Examples of hydropower and environmental indicators vary from basin to basin and include the following:

Hydropower	Environment
Generation	Habitat
Capacity	Passage
Storage	Biology
Scheduling/Integration	Flow
Peaking	Water quality

- ***Metrics***. Once indicators have been selected in consultation with stakeholders, metrics can be defined as the basis for measuring how baseline indicators change under different scenarios or over time. As an example, “capacity” is an indicator of hydropower value; the metric you might use to track opportunities for new capacity could be “additional megawatts above the current baseline.” For an environmental example, “passage” is an indicator of value; “additional river miles available above the current baseline” could be a metric useful for tracking opportunities to improve this value.

- ***Opportunities***. Opportunities are instances where it is feasible to realize measurable gains in a hydropower or environmental value while protecting other uses. Systems modeling, trade-off analysis, geospatial analysis, and scenarios are useful tools for examining hydropower and environmental opportunities. An example of a potential opportunity could be adding devices to irrigation canals or conduits to increase electricity generation without exposing fish to the devices, while also improving efficiency of irrigation canals so that conserved water could be left in the river to improve instream flow.
- ***Tool***. A tool is a model, technology, analytical process, or other methodological approach that can be used to better understand and measure hydropower and environmental values, or aggregate analyses for identification of opportunities.

3.3 Toolbox Results

Submissions were received for more than 40 tools and approaches that can be used for opportunity assessment. The tools organized by assessment indicator are listed in Table 3.1 (many tools provide information for several indicators).

Table 3.1. Entries in Basin-Scale Opportunity Assessment Toolbox as of September 2011

Indicator	Tool Name
Biology (11)	Comprehensive Passage Model (COMPASS)
	Criterium Decision Plus
	Habitat availability models
	Index of Hydrologic Alteration (IHA)
	Individual Based Modeling
	Instream Flow Incremental Methodology (IFIM)
	Major System Improvements Analysis (MSIA)
	Physical Habitat Simulation (PHABSIM)
	River Habitat Simulation (RHABSIM)
	River Habitat Model (RHM)
	Population Dynamics Models
Capacity (7)	Soil-Water Assessment Tool (SWAT)
	Climate Change Impacts On Rivers (CIOR) tools
	MODSIM-DSS (MODSIM)
	Water Evaluation and Planning system (WEAP)
	Electricity Infrastructure Operations Center (EIOC)
	National Hydropower Asset Assessment Program (NHAAP)

Table 3.1. (contd)

Indicator	Tool Name
Flow (10)	ADYN
	ANSYS Fluent
	Climate Change Impacts On Rivers (CIOR) tools
	Distributed Hydrology Soil Vegetation Model (DHSVM)
	Habitat availability models
	Index of Hydrologic Alteration (IHA)
	Instream Flow Incremental Methodology (IFIM)
	RiverWare
	River Habitat Simulation (RHABSIM)
	Variable Infiltration Capacity model (VIC)
Generation (8)	Criterium Decision Plus
	Instream Flow Incremental Methodology (IFIM)
	Major System Improvements Analysis (MSIA)
	MODSIM-DSS (MODSIM)
	RiverWare
	Water Evaluation and Planning system (WEAP)
	Electricity Infrastructure Operations Center (EIOC)
	National Hydropower Asset Assessment Program (NHAAP)
Habitat (5)	Modular Aquatic Simulation System 1D and 2D (MASS1 and MASS2)
	Physical Habitat Simulation (PHABSIM)
	Rapid geomorphic assessment tool
	Water Evaluation and Planning system (WEAP)
	River Habitat Model (RHM)
Hydrology (14)	ADYN
	CEQUALW2
	Climate Change Impacts On Rivers (CIOR) tools
	Comprehensive Passage Model (COMPASS)
	Distributed Hydrology Soil Vegetation Model (DHSVM)
	Instream Flow Incremental Methodology (IFIM)
	Modular Aquatic Simulation System 1D and 2D (MASS1 and MASS2)
	RIVER2D
	RiverWare
	Virtual Hydropower Prospector
	Better Assessment Science Integrating point & Non-point Sources (BASINS)
	Soil-Water Assessment Tool (SWAT)
	Variable Infiltration Capacity model (VIC)
	Transient Energy Transport HYdrodynamics Simulator (TETHYS)

Table 3.1. (contd)

Indicator	Tool Name
Passage (3)	Comprehensive Passage Model (COMPASS)
	Barrier Assessment Tool (BAT)
	River Habitat Model (RHM)
Scheduling (5)	Soil-Water Assessment Tool (SWAT)
	MODSIM-DSS (MODSIM)
	Distributed Hydrology Soil Vegetation Model (DHSVM)
	Electricity Infrastructure Operations Center (EIOC)
	Variable Infiltration Capacity model (VIC)
Water quality (10)	ADYN
	CEQUALW3
	HeatSource
	Instream Flow Incremental Methodology (IFIM)
	Modular Aquatic Simulation System 1D and 2D (MASS1 and MASS2)
	Qual2Kw
	RQUAL
	TTools
	Water Evaluation and Planning system (WEAP)
	Better Assessment Science Integrating point & Non-point Sources (BASINS)

In addition, we created a public website (Figure 3.1) to organize the tools in a user-controlled list based on the tools' relevance to indicators of hydrology, biology, capacity, compliance, flow, generation, scheduling, and water quality.

3.4 Conclusion

The tools identified in the Basin-Scale Opportunity Assessment Toolbox cover the broad scope of capabilities that are required for basin-scale opportunity assessments. All tools will not apply to all basins, and it may be necessary to expend considerable effort to enable specific tools to function in basins where they have not previously been applied. Where possible, it will be most efficient to build solutions around existing models and tools that have been applied in a basin, supplementing those efforts with additional tools as needed.

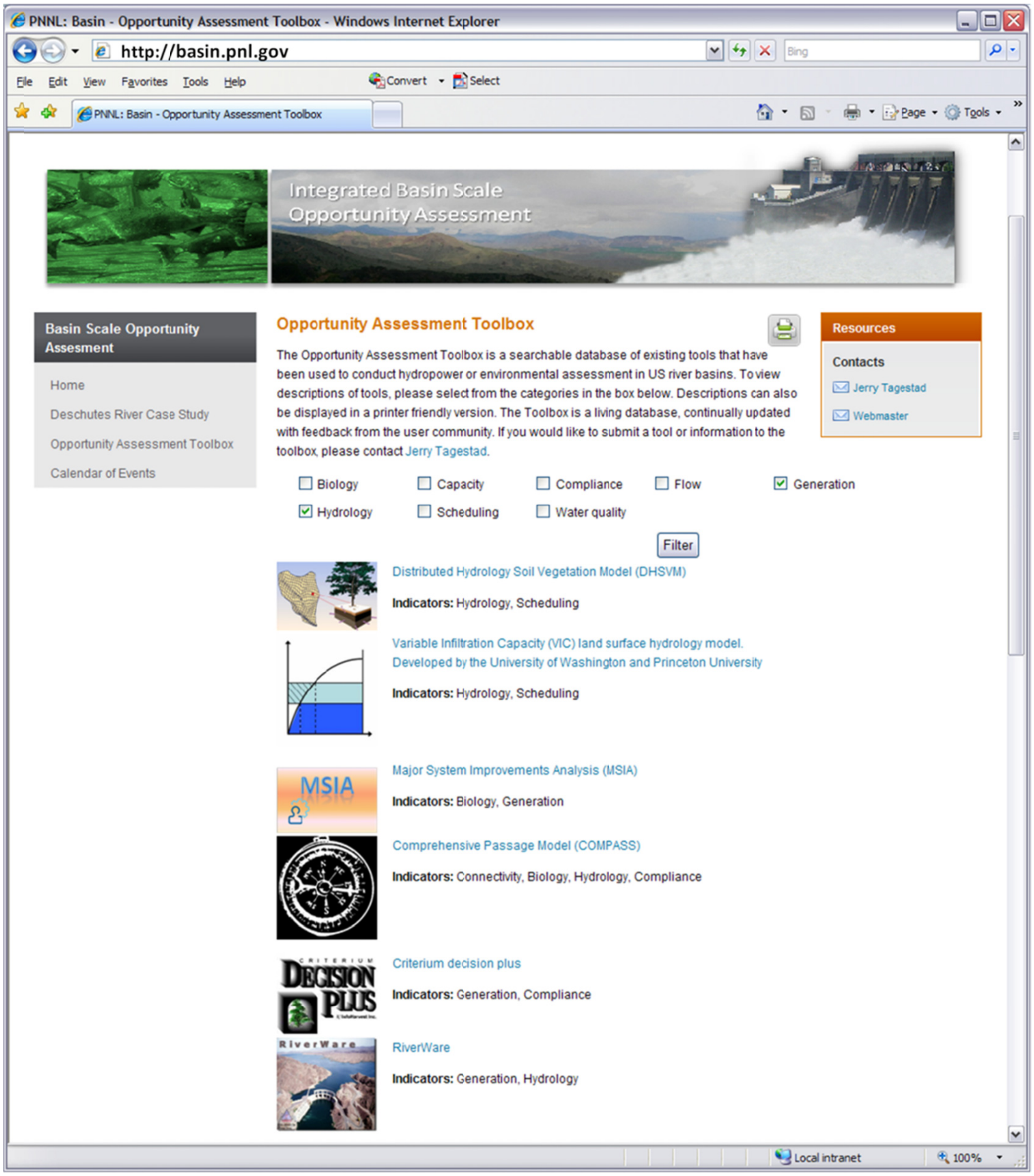

Figure 3.1. Screenshot of the Opportunity Assessment Toolbox on the basin.pnl.gov website

4.0 Deschutes Basin Pilot Study

This chapter describes FY 2011 assessment activities in the selected pilot study basin, the Deschutes River Basin. We present background on the process for pilot basin selection, a detailed physical and historic description of the project area, brief descriptions of previously identified hydropower and environmental opportunities, and a summary of the processes aimed at identifying initial opportunities in the pilot basin to be analyzed in more detail during FY 2012.

4.1 Pilot Basin Selection

The Steering Committee identified the Upper Deschutes/Crooked River Basin (Figure 4.1) as an excellent candidate pilot basin, meeting all of the selection criteria described in Section 2.4. The basin is a manageable size for an initial pilot, complex enough to test assessment tools and methodologies, but not so geographically and jurisdictionally challenging as to pose unacceptable project risks. PGE is the major power producer in the basin and co-licensee of the Pelton-Round Butte Hydroelectric Project (located in the Middle Deschutes River) with CTWS. A factor supporting the Deschutes River Basin as the pilot basin was PGE's willing participation in assessment activities and assistance with outreach to other basin stakeholders.

After conducting conversations with Steering Committee members and basin stakeholders, the project team set assessment boundaries to include the Upper and Middle Deschutes and Crooked River subbasins down to and including the Pelton-Round Butte Hydroelectric Project. The Lower Deschutes Basin was not included in the assessment because it is designated as a Federal Wild and Scenic River and thus offers fewer new opportunities for hydropower and environmental improvements. Upper and lower subbasin issues are also quite different; limiting the assessment to upper basin issues was appropriate to achieve the goals of the pilot study while making for a manageable initial effort.

While the Steering Committee and MOU agencies agreed that the Upper Deschutes/Crooked River Basin would be ideal for pilot basin assessment, final selection was contingent on the desire of basin stakeholders to participate in assessment activities. After Steering Committee selection, the project team began informal outreach with basin stakeholders using the process described in Section 2.4. Working through the Steering Committee contacts in the basin, the project team held a series of conference calls with environmental NGOs and irrigation districts to evaluate their interest in participating in assessment activities. Through these conversations, the project team identified political sensitivities and worked to understand how the assessment could best be crafted to avoid negative interference with existing processes; the goal was to understand how BSOA activities could best benefit the stakeholders in the Deschutes Basin.

It became apparent that an assessment focused narrowly upon hydropower and environmental opportunities would not be appropriate in the Deschutes Basin. To be successful, a three-pronged assessment approach was required: Hydropower + Environment + Irrigation and Water Supply. The irrigation community is tremendously important to the culture and economy of the Deschutes Basin; in fact, nearly all of the potential hydropower and environmental opportunities in the basin are associated with irrigation infrastructure, facilities, or practices. A commitment to work with the irrigation community to identify hydropower and environmental opportunities that protect water supply and provide benefits to their patrons was a critical part of obtaining stakeholder buy-in.

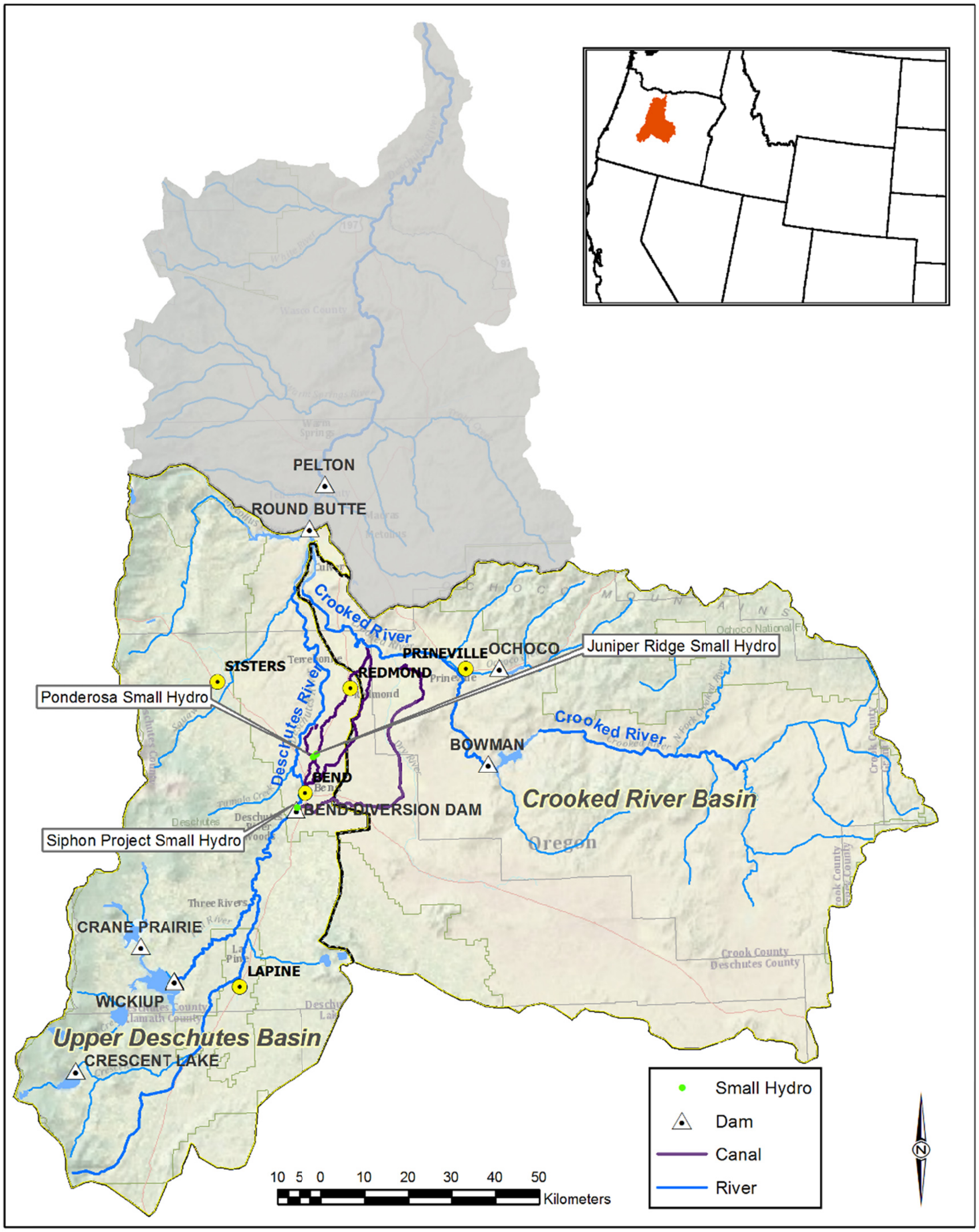

Figure 4.1. Deschutes River Basin Showing Opportunity Assessment Study Area: Upper Deschutes/Crooked River Subbasins

4.2 Deschutes River Basin Description

The Deschutes River Basin shares many characteristics with other western river basins, such as the high importance of irrigation and available storage in river management. The interplay of storage, water rights, and environmental needs provides a complex context within which small hydropower development and adding power to non-powered dams must be integrated. The following sections describe that context.

4.2.1 Physical Description and Historical Context

The Deschutes River Basin is characterized by a permeable geology, which results in easy transfer between surface water and groundwater, and a human history that has resulted in the allocation of a large proportion of surface water to uses such as irrigation or water supply. These factors result in unique challenges and opportunities that are described in the following sections.

4.2.1.1 Deschutes River Basin

Named “River of the Falls” (“Riviere des Chutes” in French), the Deschutes River originates in the Cascade Mountains of Central Oregon, is joined by the Metolius and Crooked rivers near Madras, Oregon, and runs 252 miles to join the Columbia River near Moody, Oregon. The Deschutes River Basin covers 10,700 square miles and is the second largest river basin in Oregon (the Willamette River Basin is the largest) (DWA 2006).

Most of the Deschutes Basin is located in Crook, Deschutes, Jefferson, Sherman, and Wasco counties in Oregon. Central Oregon, which is composed of Crook, Deschutes, and Jefferson counties, constitutes 73 percent of the basin (DWA 2006). Agriculture accounts for 90 percent of the water use in the Deschutes Basin, with municipal and industrial use accounting for 5 percent, instream use 4 percent, and resort use 1 percent (DWA 2011).

For this assessment, the Deschutes Basin is divided into three subbasins (Figure 4.2). The Upper Deschutes extends from the river’s headwaters in the Cascade Mountains downstream to the North Diversion Dam at Bend, Oregon. The Middle Deschutes extends from the North Diversion Dam at Bend downstream to the Pelton-Round Butte Hydroelectric Project’s reregulating dam, and includes Lake Billy Chinook. The Lower Deschutes extends from the Pelton-Round Butte project’s reregulating dam downstream to the river’s terminus at the Columbia River.

As discussed in Section 4.1, this assessment focuses on the Upper and Middle Deschutes and Crooked River subbasins (Figure 4.2) because they offer more opportunities for increasing hydropower generation while improving environmental conditions than does the Lower Deschutes. The assessment specifically includes the Pelton-Round Butte Hydroelectric Project in the Middle Deschutes because of its importance for energy and the environment throughout the Deschutes and Crooked basins. The following subsections provide background information about the Upper and Middle Deschutes basins.

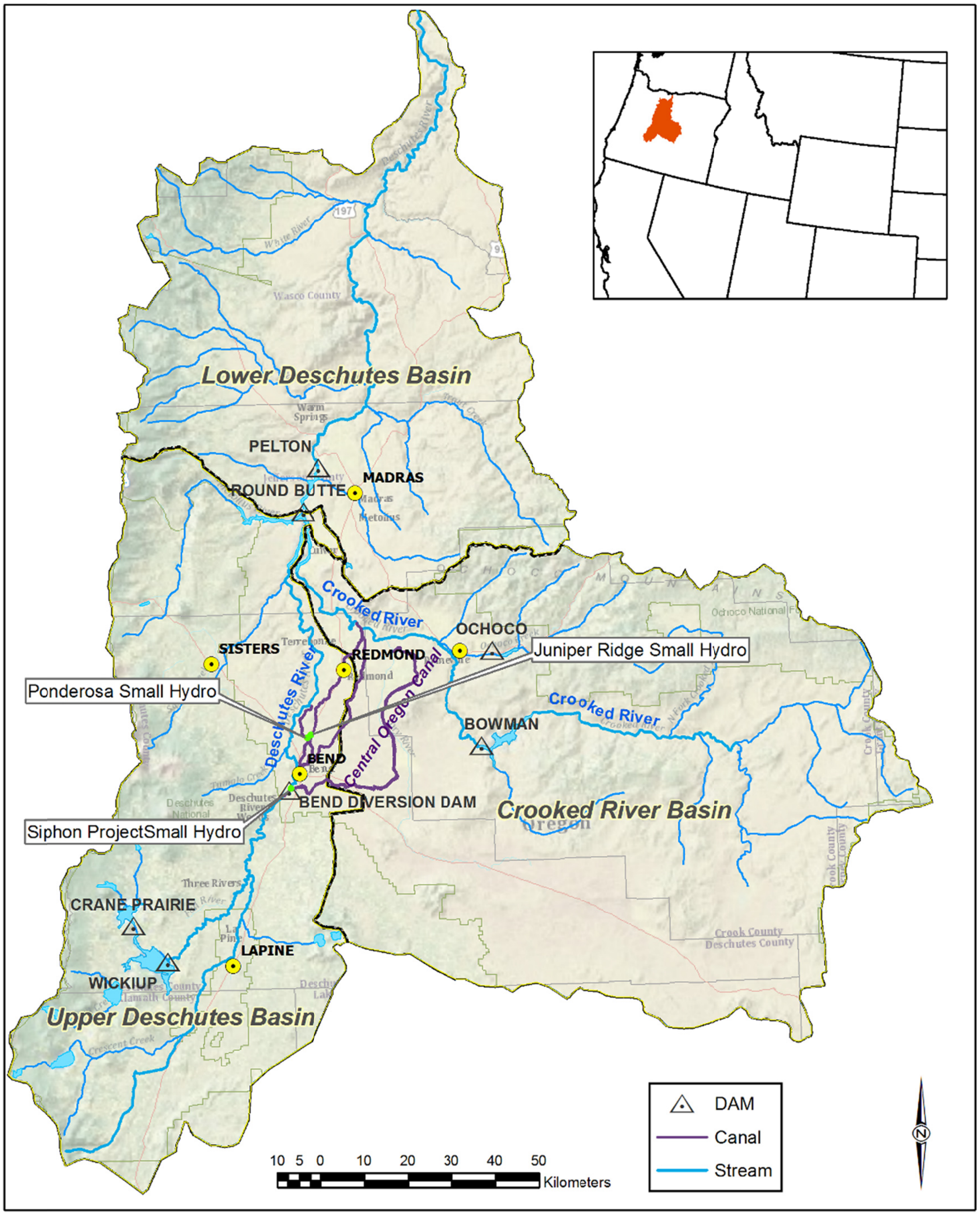

Figure 4.2. Deschutes River Basin Showing Three Major Subbasins, Existing Dams, and Small Hydropower Facilities

4.2.1.2 Upper Deschutes Basin

The Deschutes River begins at Little Lava Lake at elevation 4,739 feet (Figure 4.3 and Figure 4.4). Little Lava Lake is filled via groundwater inflow from the snowfields of Mt. Bachelor and the Three Sisters mountains. In low water years, "Blue Lagoon" or "Blue Hole"—a massive spring located at river

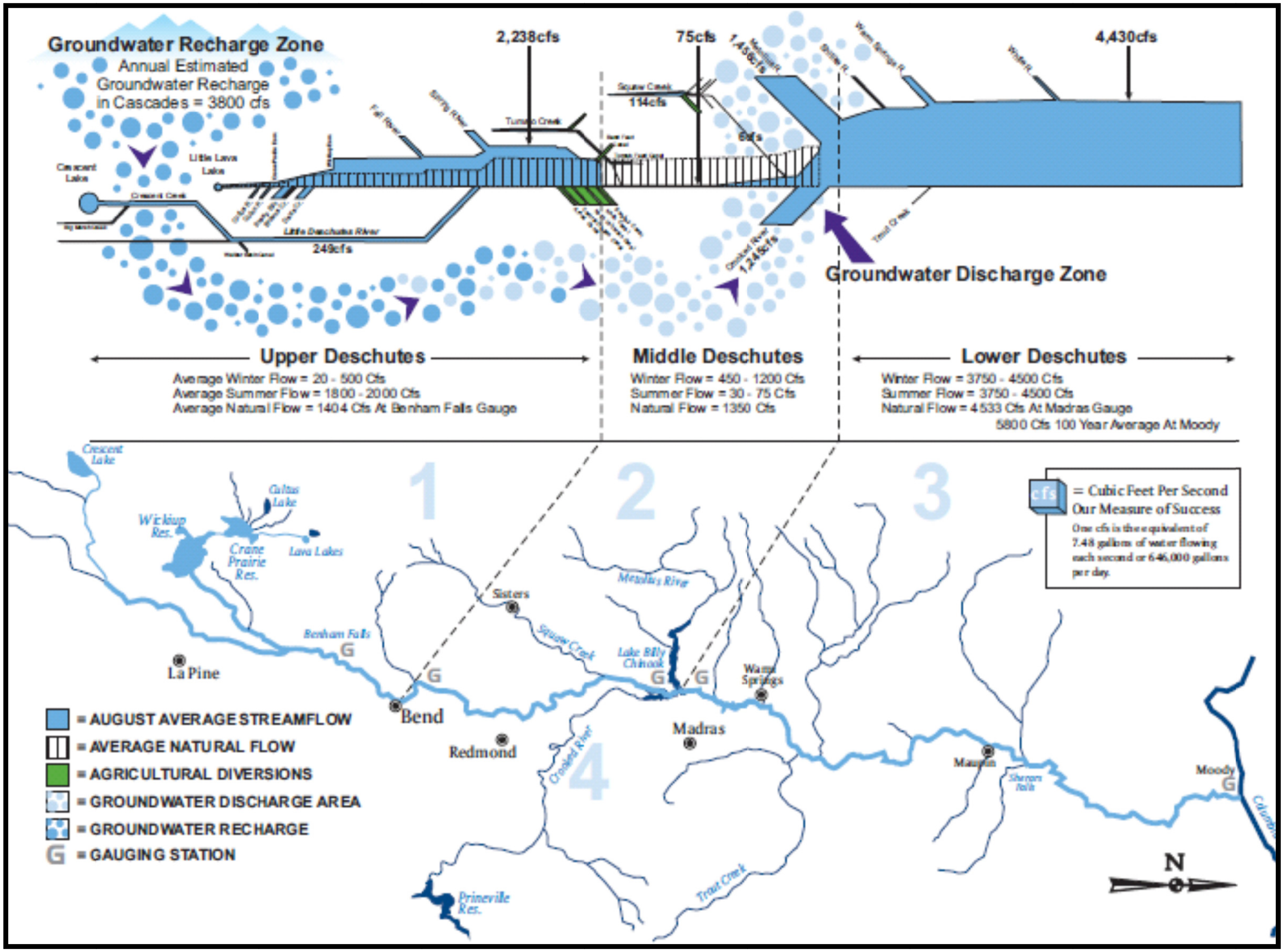

Figure 4.3. The Subbasins of the Deschutes River Basin (Source: DRC 2011 based on OWRD 2002)

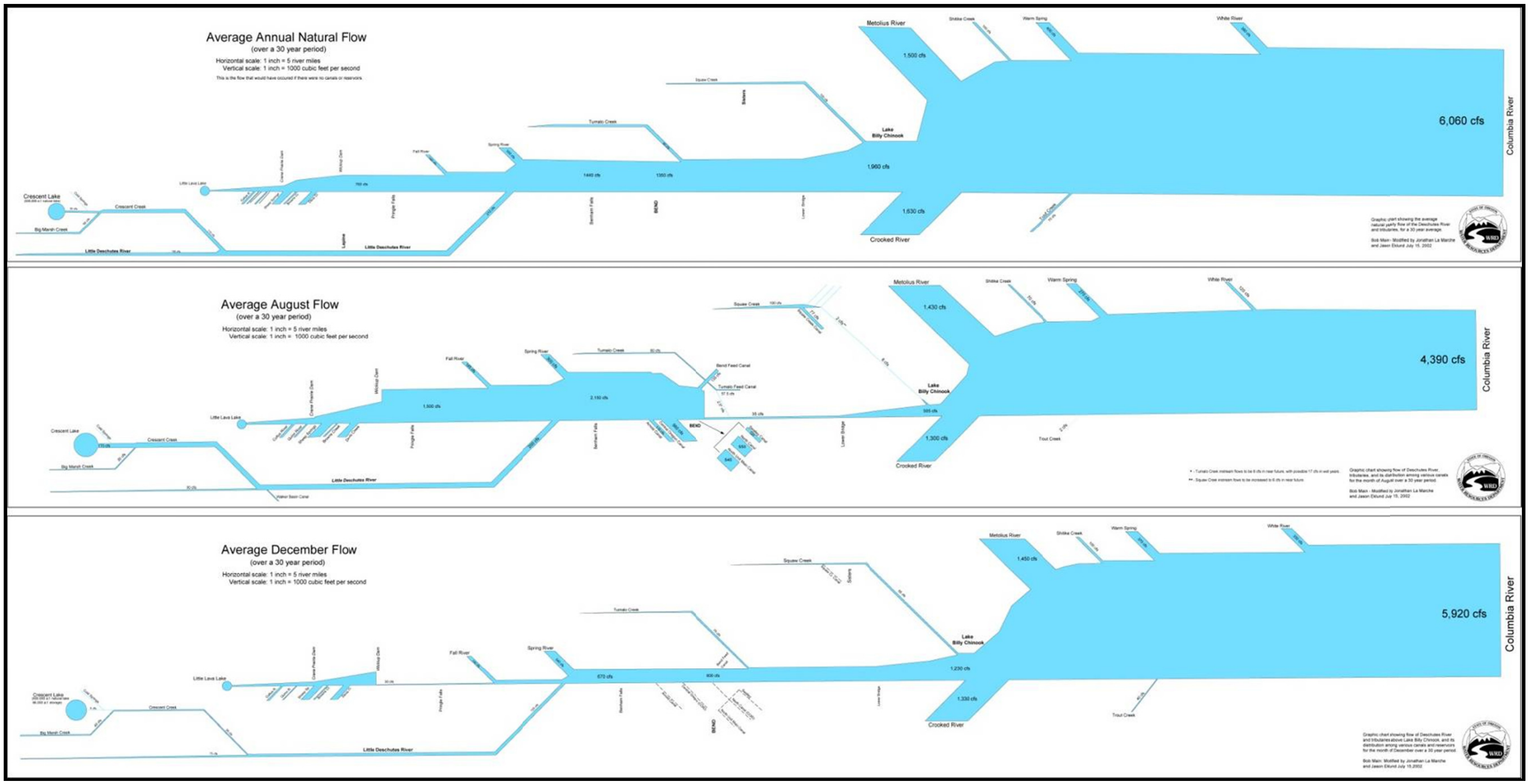

Figure 4.4. Deschutes River "Blue Whale" Diagram Showing River Average River Flows for Natural, August, and December Periods (Source: OWRD 2002)

mile (RM) 251—appears to be the head of the Deschutes, but there are subterranean water flows moving south in the basin upstream from this spring area (UDWC 2003; NPPC 2004).

From Little Lava Lake, the Deschutes River flows 8.4 miles south to Crane Prairie Reservoir. This segment of the Deschutes River above Crane Prairie Reservoir is the only reach of the 252-mile river where the flow regime remains unaltered by dams (NPPC 2004). Crane Prairie Dam, completed in 1940, is the uppermost dam in BOR's Deschutes Project. The project provides irrigation water to the Central Oregon Irrigation District, Arnold Irrigation District, and Lone Pine Irrigation District—aka Crook County Municipal Improvement District. Crane Prairie Dam is 36 feet tall and 285 feet long, and Crane Prairie Reservoir has a capacity of 55,300 acre-feet of storage with water rights totaling only 50,000 acre-feet.

After Crane Prairie Dam, the river runs east through Wickiup Reservoir. Wickiup Dam, completed in 1949, is also part of the BOR's Deschutes Project and provides irrigation water to the NUID. Wickiup Dam is 100 feet tall and 13,860 feet long, and Wickiup Reservoir provides 200,000 acre-feet of storage.

Above Crane Prairie Dam, the main tributaries to the Deschutes River are Snow Creek, Cultus River, Cultus Creek, Quinn River, and Deer Creek. Between Crane Prairie and Wickiup Reservoir, Brown's Creek contributes water to the Deschutes River and Davis Creek drains into Wickiup Reservoir. In addition, Sheep Springs contributes water to Wickiup Reservoir. The main tributaries between Wickiup Dam and Bend are the Little Deschutes River, Fall River, and Spring River (UDWC 2003).

The Little Deschutes River begins near Mule Peak in Klamath County and drains approximately 1,020 square miles, flowing 97 miles to its confluence with the Deschutes River at RM 192.5. Fall River originates from a spring and flows 8 miles to meet the Deschutes River at RM 204.5. Spring River originates from a spring and is approximately 1 mile long, joining the Deschutes River at RM 191 (NPPC 2004).

The Deschutes River is a spring-fed system that has a stable natural hydrologic regime in which daily, monthly, and even annual fluctuations in water flows are minimal (UDWC 2003). Unlike most streams in Oregon, natural flow in the Deschutes River is lowest in the winter and peaks in June near Sunriver below the mouth of Spring Creek. As indicated in Figure 4.3 and Figure 4.4, the average natural flow at the Benham Falls gauge upstream of Bend is 1,404 cubic feet per second (cfs) (DRC 2011). Because it has a very stable flow regime, the Deschutes and its tributaries have not been greatly affected by floods throughout history. Also, the volcanic geology of the basin has a high level of permeability, allowing rain and melting snow to quickly infiltrate the soil and recharge the water table. Therefore, flooding is much less common in the Upper Deschutes than in other less stable, less permeable systems (UDWC 2003).

The Deschutes River's naturally stable flow regime has been greatly altered by the creation of reservoirs and irrigation canals (UDWC 2003; NPPC 2004). In the Upper Deschutes, Crane Prairie Dam regulated flows as early as 1922, and Wickiup Dam began influencing flows in 1945. Water stored at Crane Prairie and Wickiup reservoirs during the winter is used for irrigation downstream in the summer. Consequently, water storage creates very low flows in the Upper Deschutes during the winter (average winter flow varies from 20 cfs to 500 cfs), and water releases create very high flows during the summer irrigation season (average summer flow varies from 1,800 cfs to 2,000 cfs, with an August average flow of 2,238 cfs) (Figure 4.3 and Figure 4.4) (DRC 2011; UDWC 2003; NPCC 2004).

Some segments of the Upper Deschutes and its tributaries have been designated as scenic or recreational under the Federal Wild and Scenic Rivers Act. These segments include a 40.5-mile recreational river from Wickiup Dam to the northern border of Sunriver, an 11.2-mile scenic river between the northern border of Sunriver and Lava Island, and a 3-mile recreational river from Lava Island to the Bend Urban Growth Boundary (UDWC 2003).

Segments of the Upper Deschutes have also been designated as scenic waterways under the State of Oregon's Scenic Waterway Act. The scenic waterway area includes the river and its shoreline and all tributaries within a quarter mile. The program is intended to protect the free-flowing character of designated rivers for fish, wildlife, and recreation. The segments of the Upper Deschutes that have been designated as scenic waterways are from Little Lava Lake downstream to Crane Prairie Reservoir, from the gauging station below Wickiup Dam to General Patch Bridge, and from Harper Bridge to the Central Oregon Irrigation District (COID) diversion in Bend (UDWC 2003; NPPC 2004)

4.2.1.3 Middle Deschutes Basin

The Middle Deschutes extends from the North Canal Diversion Dam at Bend downstream to the Pelton-Round Butte project's reregulating dam, and includes Lake Billy Chinook (Figure 4.1). The Deschutes River's average natural flow at Bend is 1,350 cfs (Figure 4.3 and Figure 4.4) (DRC 2011). However, water storage in the Upper Deschutes reduces flows in the Middle Deschutes during the winter (average winter flow varies from 450 cfs to 1,200 cfs), and water withdrawals at the six irrigation canals at Bend reduce flows in the Middle Deschutes during the summer (average summer flow varies from 30 cfs to 75 cfs, with an August average of 75 cfs). Thus, nearly all the water in the Middle Deschutes upstream of Lake Billy Chinook is diverted for irrigation during the high withdrawal months of June through September (DRC 2011; UDWC 2003; NPCC 2004). However, most recently, the summer flows have averaged nearly 150 cfs and above due to conservation work by the Deschutes Basin stakeholders.

With the porous, volcanic soil characteristic of the region, as much as 50 percent of the water diverted from the Deschutes River in irrigation canals seeps into the ground before it reaches farms. As a result, the seven irrigation districts that serve the region (Figure 4.5) must divert twice the amount of water needed to serve their patrons (DRC 2011).

The major tributaries to the Deschutes between Bend and Lake Billy Chinook are Tumalo Creek and Whychus Creek (formerly Squaw Creek). Tumalo Creek flows about 20 miles from its headwaters in the Cascades to enter the Deschutes River at RM 160.4. Flow in lower Tumalo Creek is substantially reduced by withdrawals for irrigation (NPPC 2004).

Whychus Creek flows 35 miles to enter the Deschutes River at RM 123.1, a few miles above Lake Billy Chinook. Stream flow in Whychus Creek is notoriously "flashy," fluctuating from extremely high flows to low flows that at times go subsurface (NPPC 2004). The creek is also heavily used for irrigation and stream flows are over-allocated. The average August flow in Whychus Creek is 114 cfs (DRC 2011) above all diversions and is reduced to approximately 20 cfs by the time the Creek flows through the town of Sisters. Downstream near the confluence with the Deschutes River, Whychus Creek gains a minimum of nearly 100 cfs discharges to the Deschutes River from Whychus Creek because of groundwater springs (Figure 4.6) (NPPC 2004).

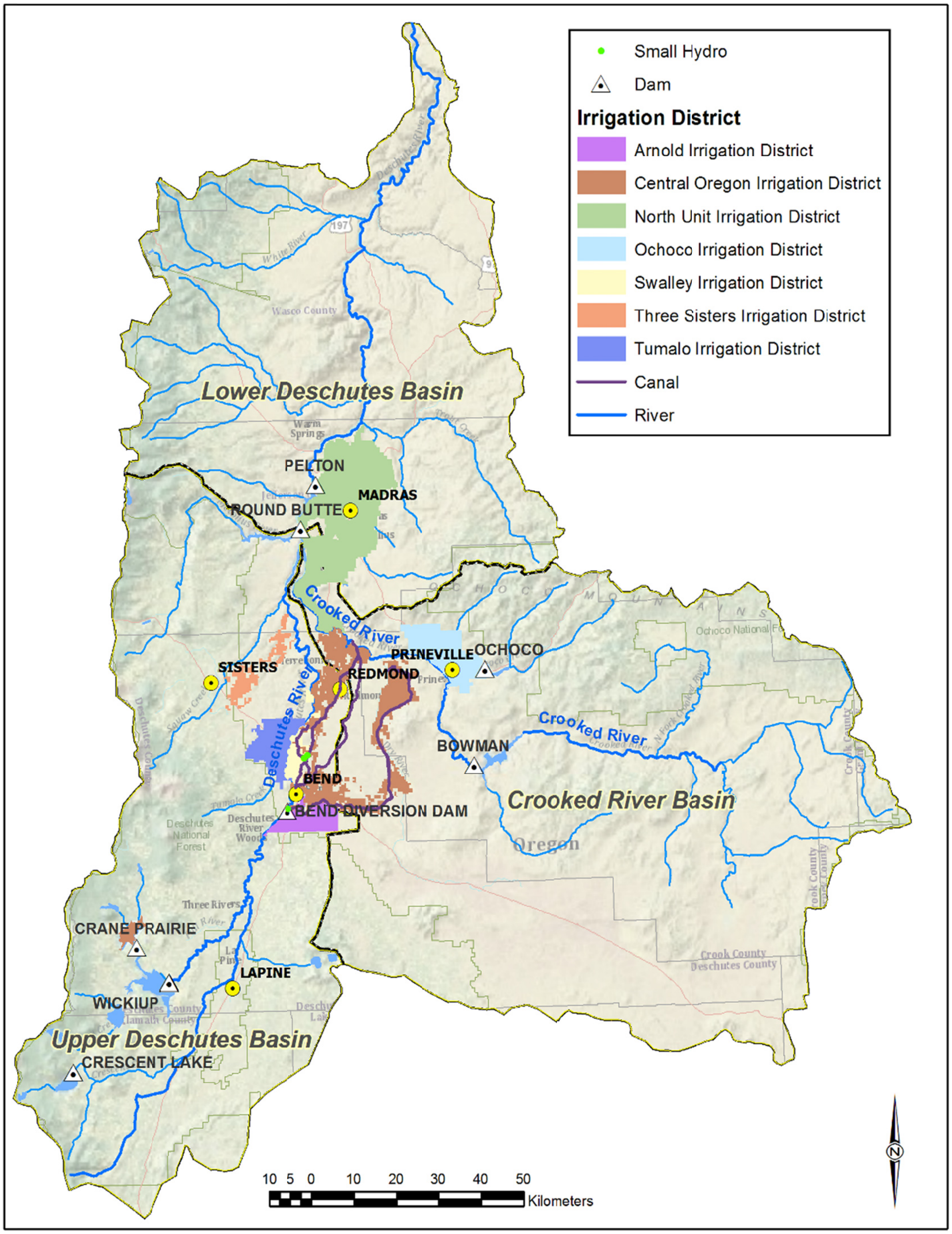

Figure 4.5. Deschutes Basin Showing Irrigation Districts

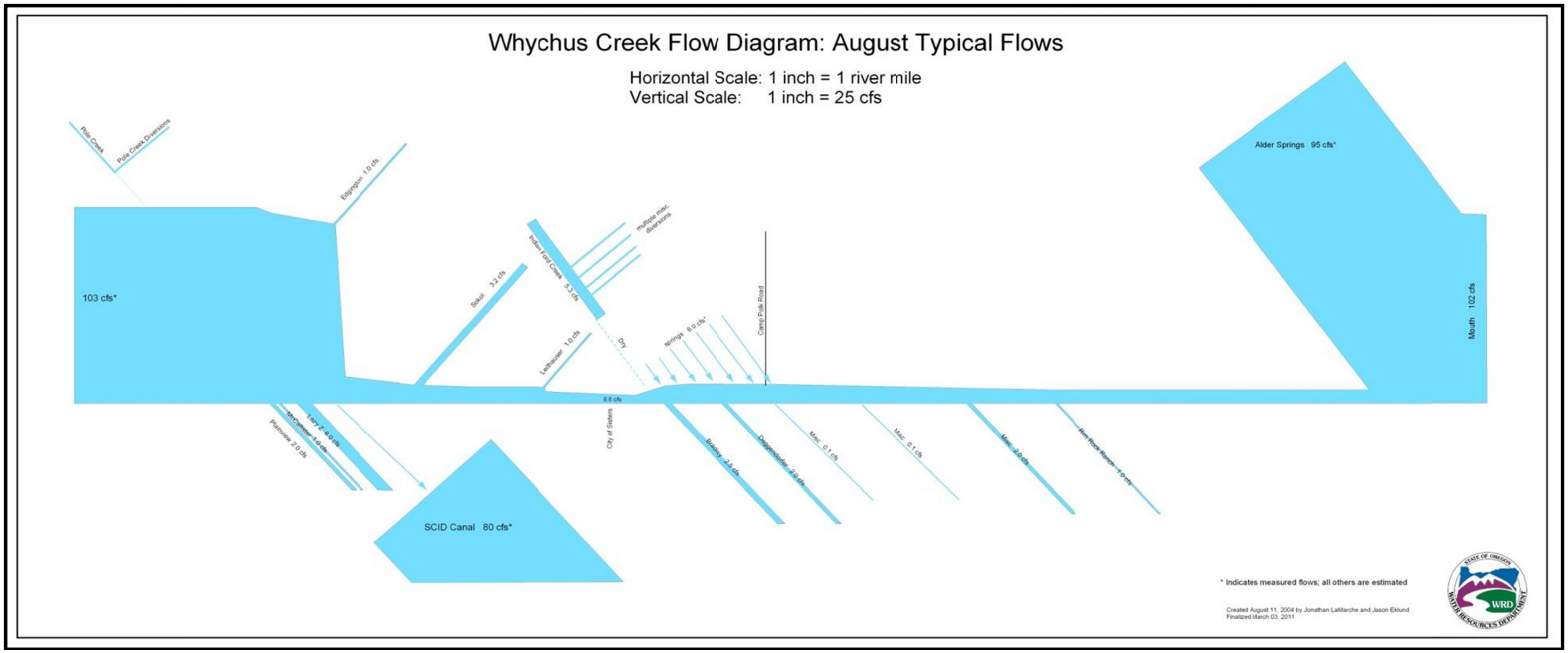

Figure 4.6. Whychus Creek Flow Diagram: August Typical Flows (Source: OWRD 2011)

Lake Billy Chinook was created as part of the Pelton-Round Butte Hydroelectric Project. Built between 1957 and 1964, Pelton-Round Butte is the largest Hydroelectric Project located entirely in Oregon. The project, which has an installed capacity of 366.82 MW and generates nearly 1.6 million MWh per year, consists of three developments. The uppermost development, Round Butte (247.12 MW), was completed in 1964 and includes the 4,000-acre Lake Billy Chinook. Lake Billy Chinook impounds about 9 miles of the Deschutes River, 7 miles of the Crooked River (discussed separately in Section 4.2.1.4), and 13 miles of the Metolius River (LIHI 2007; UNEP 2011; PGE 2011a).

The Metolius River drainage covers 315 square miles and contains 110 miles of perennial streams, 324 miles of intermittent streams, 42 lakes, and 121 ponds (NPPC 2004). The river flows 29 miles from springs near Black Butte to join the Deschutes at Lake Billy Chinook. Constant flow from springs keeps the Metolius River running near bankfull at all times. Average flows at the river's mouth range from 1,653 cfs in June to 1,360 cfs in October, with an average August flow of 1,456 cfs (NPPC 2004; DRC 2011). The stable nature of the Metolius River provides outstanding habitat for native fish, including redband trout, bull trout, mountain whitefish, and a number of non-game fish. Historic runs of spring Chinook, sockeye salmon, and Pacific lamprey used the Metolius River as well before construction of the Pelton-Round Butte project blocked fish passage in the Middle Deschutes (NFS 2010).

The dam for the Pelton-Round Butte project's middle development, Pelton (100.8 MW), is located on the Deschutes River about 7 miles downstream from Round Butte Dam. Pelton was completed in 1958 and has a 540-acre reservoir (Lake Simtustus), which begins at the base of Round Butte Dam. The most downstream development, the Reregulating Development (18.9 MW), was also completed in 1958. The Reregulating Development has a 190-acre reservoir on the Deschutes River that extends downstream 2.5 miles from the tailwater of Pelton Dam. The project's total length within the Deschutes River Canyon is about 20 river miles (LIHI 2007; UNEP 2011; PGE 2011a). The Round Butte and Pelton developments are operated as peaking facilities, typically generating between 6 a.m. and 11 p.m. daily. Lake Billy Chinook provides seasonal storage and may be drawn down as much as 85 feet in the winter, although typically the lake is only drawn down about 10 feet. The lake is typically refilled by snowmelt during the months of April and May. During the summer, the reservoir is held at the highest practicable level with a relatively stable pool elevation that usually does not fluctuate more than 1.0 foot below the normal maximum pool elevation. The surface elevation of Lake Simtustus usually fluctuates less than 0.75 feet per day but exceeds 3.5 feet per day about 25 percent of the time due to flow fluctuations produced by Round Butte (LIHI 2007).

The Reregulating Development is operated to attenuate high and low peak flows produced by the upstream developments. Flow releases are controlled to maintain an average daily flow in the Deschutes River downstream of the Reregulating Dam that approximates the average daily inflow to the project. The Reregulating Reservoir surface elevation fluctuates as much as 27 feet daily, but typical fluctuations are about 15 feet daily. The turbine and spillway gates automatically respond to river stage measurements recorded at a United States Geological Survey (USGS) gauge located at the dam (LIHI 2007).

Historically, the Deschutes River was among the most productive anadromous fisheries in the western United States, with summer steelhead, spring Chinook, sockeye, and Pacific lamprey (NFS 2010). Sockeye had been extirpated from the Deschutes Basin by 1940 (NFS 2010), but the dams of the Pelton-Round Butte project were originally constructed with both upstream and downstream fish passage facilities to allow salmon and steelhead migration. Once the dams were built, however, changes in the river currents and water temperature made it improbable that the fish would find the downstream pipeline (PGE 2011a).

Water from the Metolius River, being colder than that from the Deschutes and Crooked rivers, sank to the bottom of Lake Billy Chinook. Much of the warmer water of the Deschutes and Crooked rivers flowed over the top of the colder water and back up the Metolius. The water that flowed down toward the dam, where the downstream fish passage was located, ended up swirling in eddies with no distinct current. Because the fish follow the river currents, they could not find the downstream fish passage. The system also made the Lower Deschutes much colder than it was before (PGE 2011a).

With no way for the young fish to migrate downstream and begin the anadromous cycle, upstream passage for the adult fish was not needed. So in 1968, the program that used the upstream fish ladders was terminated and a fish hatchery was built below the dams to maintain the fish population in the Lower Deschutes (PGE 2011a).

In 2005, FERC issued a new 50-year license for the Pelton-Round Butte project to joint licensees PGE and CTWS. As part of the relicensing agreement with FERC, PGE and CTWS worked for several years to solve the fish passage issues. After several years of planning, PGE and CTWS settled on a solution to restore fish passage: an underwater tower and fish collection facility 700 feet upstream from Round Butte Dam. With its unique design, the tower mimics the natural conditions of the river, drawing warmer water off the surface to modify the reservoir currents and water temperatures and attract fish into the collection facility. In this facility (the only visible part of the structure), the fish are gathered, sorted by size, and piped to a fish handling facility. The fish are then transported downstream to continue their migration to the sea (PGE 2011a).

The existing upstream passage of fish ladders and truck transportation will be put to use once the fish return to spawn. The plan also includes projects to improve the habitat along the creeks and streams above and below the dams to provide shelter and protection for the young fish on their journey downstream (PGE 2011a).

The new FERC license for the Pelton-Round Butte project was the result of a comprehensive settlement agreement that PGE and CTWS signed with 20 other parties, including every resource agency with mandatory or other authority over the resources affected by the project. Based on the provisions of the new license, in 2007 the Low Impact Hydropower Institute (LIHI) certified the Pelton-Round Butte project as “Low Impact” (LIHI 2007).

Some segments of the Middle Deschutes and its tributaries have been designated as wild, scenic, or recreational under the Federal Wild and Scenic Rivers Act. The Deschutes River from Odin Falls to Lake Billy Chinook is designated as a recreational river. The 6.6-mile segment of Whychus Creek from its source to the Three Sisters Wilderness Boundary is designated as a wild river, and the 8.8-mile segment of Whychus Creek from the Three Sisters Wilderness Boundary to the Whychus Creek Gauging Station is designated as a scenic river. The Metolius River is designated as a recreational river from Metolius Springs to Metolius River Bridge 99, and as a scenic river from Metolius River Bridge 99 to Lake Billy Chinook (NPPC 2004).

Two segments of the Middle Deschutes have been designated as scenic waterways under the State of Oregon's Scenic Waterway Act: from Sawyer Park to Tumalo State Park and from Deschutes Market Road Bridge to Lake Billy Chinook. The Metolius River from its headwaters to Candle Creek is also designated a scenic waterway (UDWC 2003; NPPC 2004).

4.2.1.4 Crooked River Basin

The Crooked River begins at the confluence of the South Fork Crooked River and Beaver Creek near Paulina, Oregon, and runs a total of 155 miles to join the Deschutes River in Lake Billy Chinook (Figure 4.1). The Crooked River drains a watershed of about 4,300 square miles (NFS 2010).

The South Fork Crooked River originates in Crook County near Hampton Butte, and flows north 76 miles to join Beaver Creek and form the Crooked River. From the confluence of the South Fork and Beaver Creek, the Crooked River flows west and is joined by the North Fork Crooked River between Paulina and Post, Oregon.

Below its confluence with the North Fork, the Crooked River flows west between the Ochoco Mountains and the Maury Mountains, past Post, and into Prineville Reservoir. Below the reservoir's dam (Bowman Dam), the river flows north past Prineville, Oregon, and is joined by Ochoco Creek. The Crooked River continues to flow northwest to join the Deschutes River at Lake Billy Chinook.

Unlike the Deschutes, the Crooked River is not primarily a spring-fed system. Springtime flows are from snowmelt and summer flows are relatively low. Many of the Crooked River's headwater tributaries arise as springs, but much of the flow is diverted during irrigation season, leaving very low summer flows (NFS 2010).

Native fish in the Crooked River Basin include redband trout, mountain whitefish, and several species of non-game fish. Bull trout historically used the lower Crooked River for rearing and foraging, but upper system spawning is uncertain. Bull trout are now confined to the lower river below Opal Springs Dam. Historic runs of summer steelhead and spring Chinook occurred well into the upper Crooked, but construction of the Pelton-Round Butte project created an anadromous fish barrier below Lake Billy Chinook (NFS 2010).

For this assessment, the Crooked River Basin is divided into two subbasins. The Upper Crooked includes the drainages above Bowman and Ochoco dams, including upper Ochoco Creek, the north and south forks of the Crooked River, Beaver Creek, and Camp Creek. The Lower Crooked includes the drainage below Bowman and Ochoco dams, including lower Ochoco Creek and McKay Creek (NPPC 2004).

As discussed in Section 4.1, this opportunity assessment includes the Crooked River Basin because it offers opportunities for increasing hydropower generation while improving environmental conditions. The following paragraphs provide background information on the Crooked River Basin.

4.2.1.5 Upper Crooked Basin

The Upper Crooked includes the Crooked River drainage above Bowman Dam (formerly Prineville Dam) and the Ochoco Creek drainage above Ochoco Dam. Both dams are part of BOR's Crooked River

Project, which provides irrigation water for approximately 20,000 acres in the Ochoco Irrigation District (OID). In addition to Bowman Dam (and Prineville Reservoir) and Ochoco Dam (and Ochoco Reservoir), the Crooked River Project includes a diversion canal and headworks on the Crooked River, Lytle Creek Diversion Dam and Wasteway, two major pumping plants, nine small pumping plants, and Ochoco Main and distribution canals (BOR 2011a).

Bowman Dam, completed in 1961, is located on the Crooked River about 20 miles upstream from Prineville, Oregon. The dam is 245 feet tall and 800 feet long. A reservoir sedimentation survey completed in 1998 estimates the total capacity of Prineville Reservoir at 150,200 acre-feet (active 148,600 acre-feet) (BOR 2011a).

Ochoco Dam, completed in 1921, is located on Ochoco Creek about 6 miles east of Prineville, Oregon. The original dam leaked badly, so in 1949 the BOR rehabilitated it and increased Ochoco Reservoir's capacity. As repaired and reconstructed by the BOR, Ochoco Dam is 125 feet tall and 1,350 feet long. Work completed in 1998 under the Safety of Dams Program resulted in an active reservoir capacity of 39,600 acre-feet (BOR 2011a).

Congress authorized the Crooked River Project in 1956 to include both the existing Ochoco Dam and the proposed Prineville (Bowman) Dam. The 1956 Congressional Act authorized the project for irrigation and other beneficial purposes, primarily flood control (BOR 2011a).

Water withdrawals for irrigation significantly reduce summer flows in the Upper Crooked Basin. As indicated in Figure 4.7, the natural mean annual flow in the Crooked River above Prineville Reservoir is 280 cfs (OWRD 2006a). However, summer irrigation withdrawals reduce the August median flow above Prineville Reservoir to as little as 5 cfs (Figure 4.8) (OWRD 2006b). In the North Fork Crooked River drainage, streams commonly carry late summer flows of less than 2 cfs, although Deep Creek and the North Fork below its confluence with Deep Creek generally have flows of 5 to 10 cfs. Summer flows typically range from 2 to 9 cfs in the South Fork Crooked River and from 0 to 5 cfs in the Beaver Creek drainage (Figure 4.8) (NPPC 2004; OWRD 2006b).

Most of the water in Ochoco and Mill creeks above their confluence at Ochoco Reservoir is also diverted for summer irrigation. As indicated in Figure 4.7, the natural mean annual flow in Ochoco Creek above Ochoco Reservoir is 44 cfs, and it is 36 cfs in Mill Creek (OWRD 2006a). However, summer irrigation withdrawals frequently remove all the water from both Ochoco and Mill creeks above Ochoco Reservoir (Figure 4.8) (NPPC 2004; OWRD 2006b).

In the winter, flows in the Upper Crooked River Basin are closer to natural flows than during the summer because there are no water withdrawals for irrigation. As indicated in Figure 4.9, the December median flow in the Crooked River above Prineville Reservoir is 120 cfs (OWRD 2006c). In the North Fork below its confluence with Deep Creek, the December median flow is 40 cfs. December median flow in the North Fork above Deep Creek is 20 cfs, and in Deep Creek it is 10 cfs. December median flow in the South Fork Crooked River is 40 cfs, and it is 30 cfs in Beaver Creek (Figure 4.9) (OWRD 2006c). Winter flows in both Ochoco and Mill creeks above Ochoco Reservoir are also closer to natural flows than during the summer (Figure 4.9) (OWRD 2006c).

Under the Federal Wild and Scenic Rivers Act, the North Fork Crooked River is designated as three different segments from its source at Williams Prairie to 1 mile above its mouth: an 11.1-mile wild segment, a 9.5-mile scenic segment, and an 11.7-mile recreational segment (NPPC 2004).

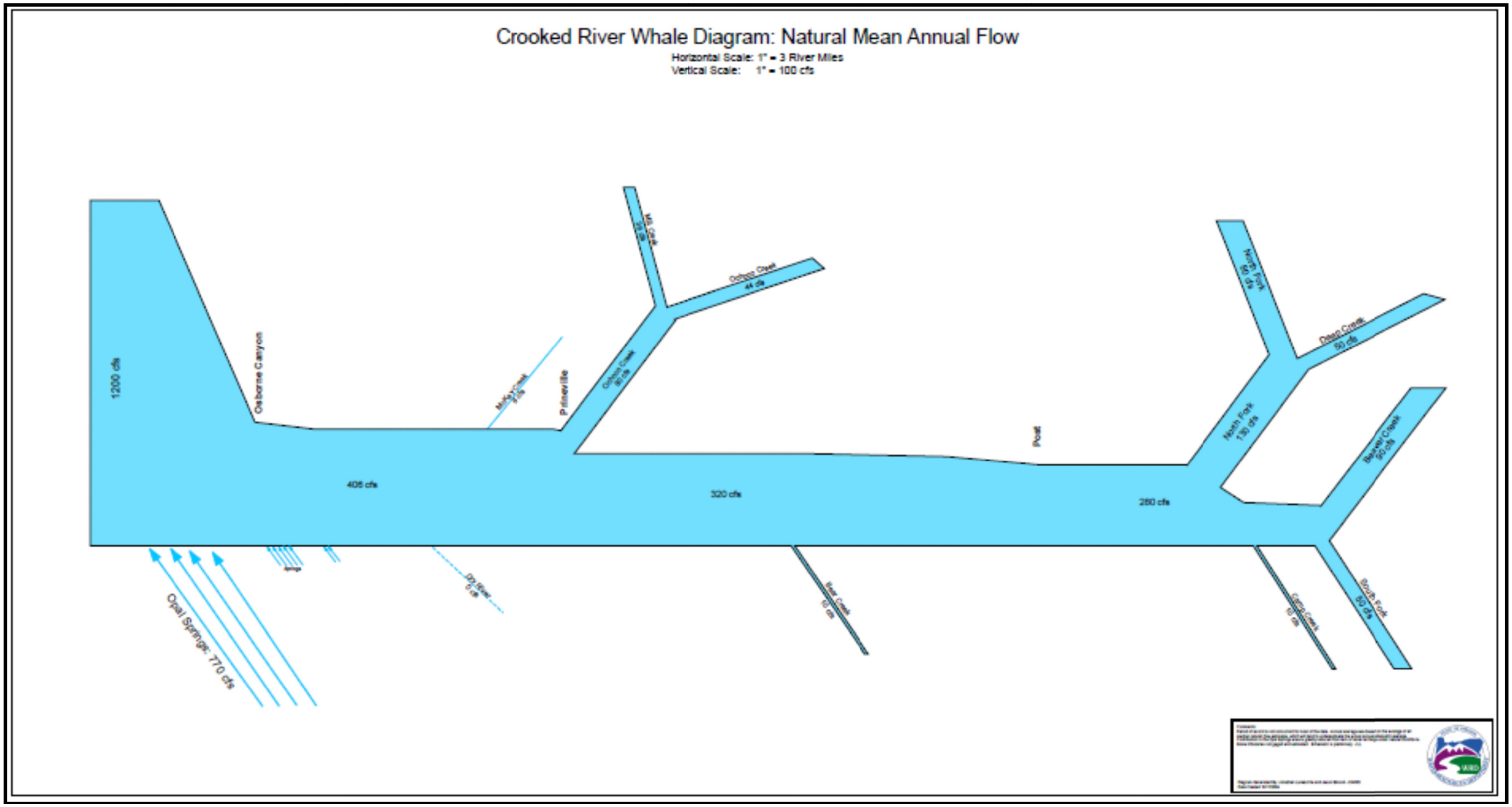

Figure 4.7. Crooked River Flow Diagram: Natural Mean Annual Flow (Source: OWRD 2006a)

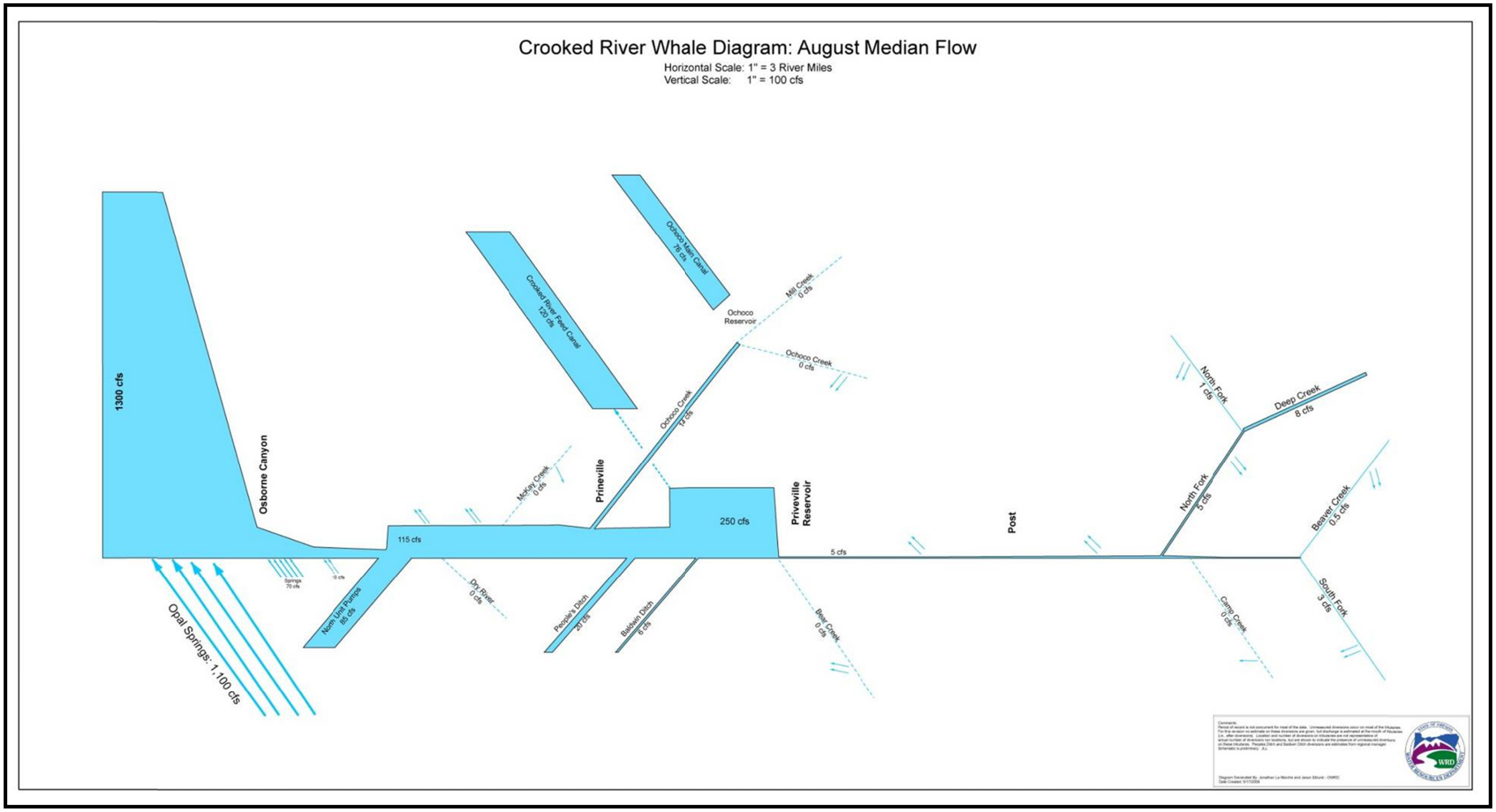

Figure 4.8. Crooked River Flow Diagram: August Median Flow (Source: OWRD 2006b)

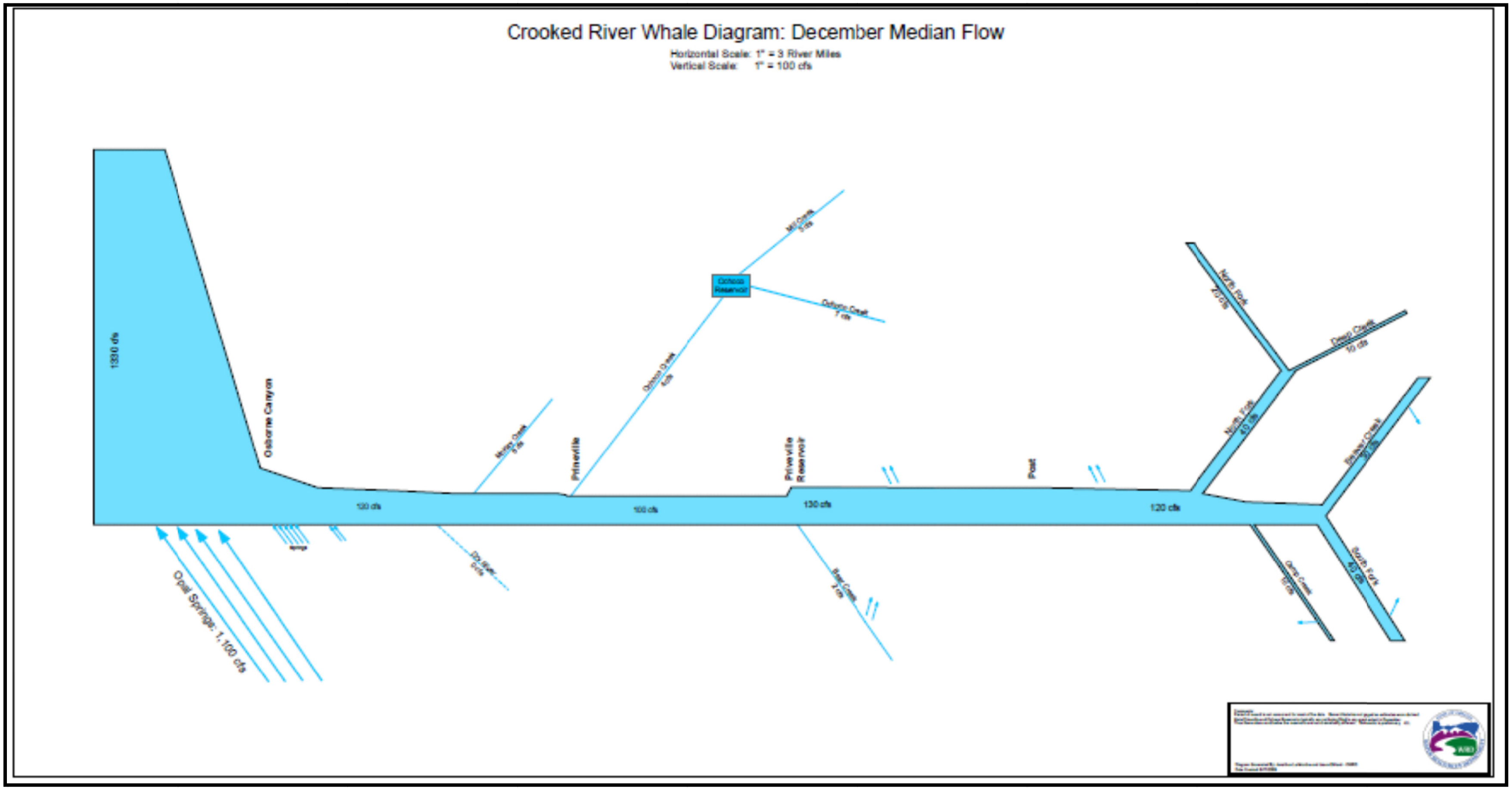

Figure 4.9. Crooked River Flow Diagram: December Median Flow (Source: OWRD 2006c)

4.2.1.6 Lower Crooked River Basin

The Lower Crooked includes the drainage below Bowman and Ochoco dams, including lower Ochoco Creek and McKay Creek. Operations at Bowman and Ochoco dams alter flow patterns and restrict fish production in the lower 68.2 miles of Crooked River and the lower 10 miles of Ochoco Creek.

Flows below Bowman and Ochoco dams are regulated by the BOR and managed by the OID. As indicated in Figure 4.7, the natural mean annual flow in the Crooked River below Bowman Dam is 320 cfs, it is 80 cfs in Ochoco Creek below Ochoco Dam, and it is 406 cfs below the confluence of Ochoco Creek and the Crooked River (OWRD 2006a).

Summer irrigation flows just below Bowman Dam typically range from 200 to 250 cfs (Figure 4.8) (NPPC 2004; OWRD 2006a). Most of the water in Ochoco Creek just below Ochoco Dam is also diverted for summer irrigation, reducing the median August flow below Ochoco Dam to 14 cfs—this is higher than inflow so storage is being released to augment flows. (Figure 4.8) (NPPC 2004; OWRD 2006b).

Summer flows in the Crooked River drop significantly at RM 57, where 160 to 180 cfs is diverted during the irrigation season (NPPC 2004). Several other diversions remove additional flow below RM 57. Together, these diversions remove most remaining water and leave the Crooked River below Prineville, Oregon, with low summer flow (Figure 4.8) (BOR 2011a; OWRD 2006b; NPPC 2004). Some irrigation return water from Ochoco and McKay creeks augments summer flow in the lower Crooked River (Figure 4.8), but additional irrigation diversions downstream continue to withdraw water (NPPC 2004; OWRD 2006b). Natural spring releases augment flows in the Crooked River below Highway 97. The volume of spring flow increases as the river flows north, with Opal Springs discharging up to 1,100 cfs (Figure 4.8) (NPPC 2004; OWRD 2006b).

During the winter, when water is stored in Prineville and Ochoco reservoirs for irrigation and flood control, flows are significantly reduced below the Bowman and Ochoco dams. Winter storage reduces the December median flow below Bowman Dam to 100 cfs as far downstream as McKay Creek (Figure 4.9), and winter flows can drop to as low as 30 to 75 cfs in this segment of the Crooked River (OWRD 2006c; NPPC 2004). Winter flows in Ochoco Creek below Ochoco Dam are also greatly reduced, with a December median flow of 4 cfs due to water storage in Ochoco Reservoir (Figure 4.9) (OWRD 2006c).

The 17.8-mile segment of the Crooked River from Bowman Dam downstream to the Crooked River National Grasslands is designated as a Wild and Scenic River under the Federal Wild and Scenic Rivers Act (NPPC 2004). Within the Wild and Scenic River segment, the 8-mile segment from Bowman Dam downstream to Dry Creek (the Chimney Rock Segment) is designated as a recreational river. In May 2011, U.S. Representative Greg Walden introduced legislation that would move the boundary of the Wild and Scenic River 0.25 mile downstream from Bowman Dam "to provide water certainty for the City of Prineville, Oregon, and for other purposes" (HR 2060).

Water from the Deschutes River has been used to generate hydropower since the early 20th Century, and one of the two initial Federal Power Commission (FPC) (now FERC) assessments of hydropower potential in the United States was conducted on the Deschutes in 1921–1922 (FPC 1922). The *Report to the Federal Power Commission on Uses of the Deschutes River, Oregon* states that there are:

> "six small water power plants in the basin, all located above the mouth of the Crooked River. The aggregate installation is 3,230 horsepower. During low water the total output has dropped to 1,600 horsepower. Power is mostly put to urban use; a small amount of irrigation is also done" (FPC 1922).

With regard to the potential for hydropower development in the Deschutes Basin in 1922, the FPC report states:

> "The canyon of the lower Deschutes affords good opportunities for the construction of power dams. The river flow is remarkably uniform . . . If all upper Deschutes water be dedicated to irrigation about 555,000 horsepower can be developed on the lower Deschutes without Post storage, of which 362,000 horsepower is likely to be obtainable at reasonably low cost. Post storage will permit this latter amount to be increased to about 388,000 horsepower" (FPC 1922).

The FPC report also cites "power possibilities" on the Metolius River (88,000 horsepower) and on the upper Deschutes River below Benham Falls (6,600 to 9,000 horsepower), at Tumalo Creek (2,700 horsepower), and at Pringle Falls (5,400 horsepower) (FPC 1922).

Since the 1922 FPC report was published, much of the hydropower potential of the main stem Deschutes River has been developed, primarily with the construction of the Pelton-Round Butte project from 1957 through 1964. Existing hydropower projects in the Deschutes and Crooked basins are discussed below in Section 4.2.2.1.

In 2011, the three most likely opportunities for increasing hydropower generation in the Deschutes and Crooked basins are to

- increase generation at existing hydropower facilities
- add new generation at existing non-powered dams and large diversions
- add new generation in existing irrigation canals and conduits.

According to the National Hydropower Asset Assessment Project (NHAAP) database (ORNL 2011), there are 71 existing dams and large diversions in the Upper and Middle Deschutes River Basin and the Crooked River Basin (Figure 4.10). Of these 71 dams and large diversions, 7 have hydropower facilities and 64 are non-powered.

4.2.1.7 Existing Hydropower Facilities

Between 1999 and 2008, the total average annual generation of the seven existing hydropower facilities listed in Table 4.1 was nearly 1.6 million MWh. These data do not include COID's new Juniper Ridge Micro Hydroelectric Project or Swalley Irrigation District's (SID's) new Ponderosa Hydroelectric Project, both of which came on line after 2008 and are discussed below. The existing Pelton-Round Butte Hydroelectric Project (FERC No. 2030) is discussed in Section 4.2.1.8 of this document.

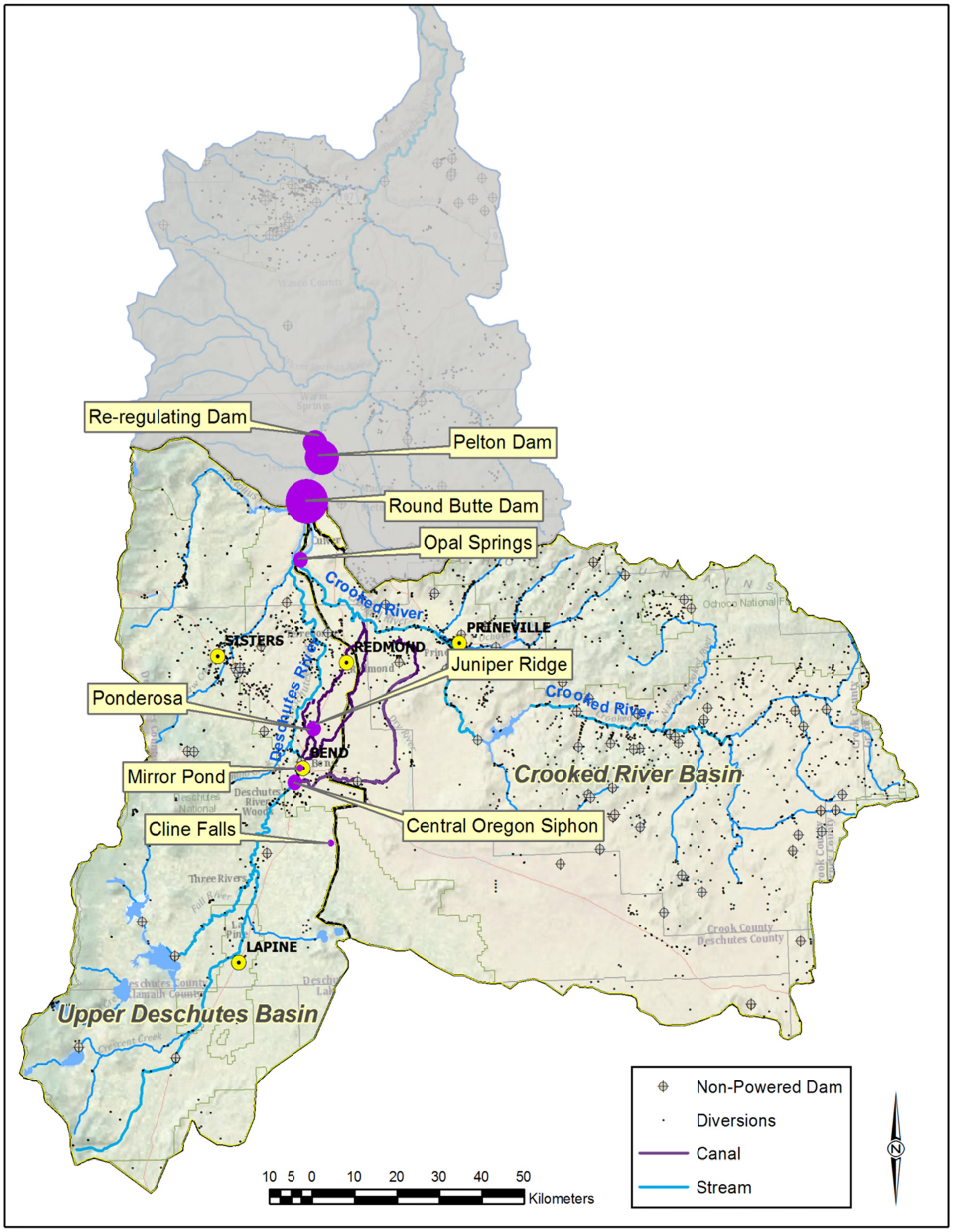

Figure 4.10. Existing Hydropower Facilities and Non-Powered Dams in the Upper and Middle Deschutes and Crooked River Basins (Source: ORNL 2011; all data are provisional and are subject to change after verification.)

Table 4.1. Existing Hydropower Facilities in the Upper and Middle Deschutes and Crooked River Basins as of 2008

Facility Name	Owner	Nameplate Capacity (MW) 2008	Average Annual Generation (MWh) 1999–2008	Dam Height	Mean Flow (cfs)[(a)]
Round Butte	PGE/CTWS	246.9	987,902.7	440	11,987
Pelton	PGE/CTWS	109.8	416,079.8	204	12,166
Pelton Re-Regulating	PGE/CTWS	19.6	156,287.1	40	12,184
Central Oregon Siphon	Central Oregon Irrigation District	5.4	5,186.9		3,913
Opal Springs	Deschutes Valley Water District	4.3	23,968.6	20	3,685
Bend Hydro (Mirror Pond)	Pacific Power and Light	1.1	3,327.1	18	4,034
Cline Falls	PacifiCorp	1.0	1,677.1	5	5,005

(a) Stream flow data were computed by the USGS-EPA NHD Plus.
Source: ORNL 2011; all data are provisional and are subject to change after verification.

COID's Siphon Power Hydroelectric Project (FERC No. 7590) is located on a diversion from the Deschutes River in Bend, Oregon. COID applied for the project's FERC license in 1982, and FERC issued the license in 1987. Water for the Central Oregon Canal is diverted from the Deschutes River about 3.0 miles upstream of the Colorado Street Bridge in Bend. About 1.25 miles downstream from the diversion, COID constructed an underground powerhouse containing two generators and turbines. The amount of water diverted for power generation at the Siphon Power Hydroelectric Project varies from a minimum of about 80 cfs up to about 640 cfs, depending on the capacity of the siphon pipe in excess of the irrigation demand and the minimum instream flow requirement of 400 cfs below the diversion. During the irrigation season, the amount of water available for power generation depends on irrigation flow releases from the upstream storage reservoirs. During the non-irrigation season, available flow ranges from 0 cfs to the maximum generation capacity of about 640 cfs. The Siphon Power Hydroelectric Project has been certified as "Low Impact" by LIHI (2011).

Deschutes Valley Water District's (DVWD) Opal Springs Hydroelectric Project (FERC No. 5891) is located above Opal Springs on the lower Crooked River in Jefferson County, Oregon The project was licensed by FERC in 1982 and construction was completed in 1985. Project construction included building a new powerhouse, raising an existing diversion dam by 12 feet, and installing two 12.5-foot-diameter conduits. Water is transmitted about 1,500 feet from the dam to the powerhouse (DVWD 2011).

The Bend (Mirror Pond) Hydroelectric Project was completed in 1910 in downtown Bend, Oregon, and is owned by Pacific Power and Light. The project dam created Mirror Pond, the area of the Deschutes River between Galveston Bridge and Newport Avenue Bridge. Mirror Pond has been an identifying feature of the City of Bend since it was impounded.

The Cline Falls Hydroelectric Project is an existing PacifiCorp facility located on the Deschutes River about 4 miles west of Redmond, Oregon. The original project was completed in 1943. In October 2010, COID filed an application with FERC for a preliminary permit (FERC No. 13858) to study the feasibility of upgrading and operating the Cline Falls Project. COID's proposed project would include the existing 300-foot-long, 5-foot-high diversion structure, a pool upstream of the diversion structure with a storage capacity of approximately 2-acre-feet, a 400-foot-long lined canal and flume channel, a 45-foot-long, 8-foot-diameter steel penstock, a powerhouse containing one 750-kW turbine/generator, and other facilities. The proposed project would have an annual average generation of about 2 gigawatt-hours (GWh) (75 FR 74697).

There are also two new hydroelectric projects in the Deschutes Basin that are not listed in Table 4.1: the Ponderosa Hydroelectric Project and the Juniper Ridge Hydroelectric Project. Both projects were constructed by irrigation districts on existing irrigation canals and are classified by FERC as "conduit exemptions" from licensing.

The SID completed the Ponderosa Hydroelectric Project in 2010. The 0.75-MW project was built in conjunction with a 5-mile irrigation canal-lining project, and operates at 65 cfs during the irrigation season (Butterfield 2011).

COID completed the Juniper Ridge Hydroelectric Project in 2010. The 5-MW project was built in conjunction with a 2.25-mile irrigation canal-lining project. The project operates at 500 cfs during the irrigation season and generates about 13.6 GWh per year.[1]

4.2.1.8 Existing Non-Powered Dams and Large Diversions

The NHAAP database lists a total of 64 non-powered dams and large diversions in the Upper and Middle Deschutes River Basin and the Crooked River Basin (Figure 4.10 and Appendix C). Of these 64 dams and large diversions, the NHAAP database indicates that 3 have a potential hydropower capacity of over 3 MW each: Wickiup Dam (4.0 MW), North Unit Diversion Dam (3.6 MW), and Bowman Dam (3.3 MW) (ORNL 2011). Data from the Oregon Water Resources Department list 6,299 diversions in these basins, including diversions for fire protection, fish rearing, irrigation, and a multitude of other uses (Figure 4.10).

The BOR's 2011 *Hydropower Resource Assessment at Existing Reclamation Facilities* also models Wickiup Dam as having a potential capacity of 3.95 MW and Bowman Dam as having a potential capacity of 3.29 MW. The study identifies and ranks potential hydropower sites at BOR dams in the Pacific Northwest region on the basis of benefit/cost ratios (with green incentives) above 0.75. Bowman Dam ranked the highest in the Pacific Northwest region with a benefit/cost ratio of 1.90 and an internal rate of return of 11.2 percent (Table 4.2). The model used in the BOR's analysis selected a Francis turbine for the Bowman Dam site, with an installed capacity of about 3 MW and annual energy production of about 18,000 MWh. As indicated in Table 4.2, two other BOR dams in the Deschutes River Basin had benefit/cost ratios over 0.75: Wickiup Dam (0.98) and Haystack Canal (0.85). Other BOR sites in the Deschutes and Crooked river basins that were evaluated but did not meet the 0.75 benefit/cost ratio threshold include Arnold, Crane Prairie, Diversion Canal Headworks (Crooked River), Lytle Creek, North Canal Diversion Dam, and North Unit Main Canal (BOR 2011b).

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[1] Presentation on Central Oregon Irrigation District's Juniper Ridge Hydroelectric Project during the Deschutes River Basin Site Visit by Steve Johnson, Central Oregon Irrigation District. June 1, 2011.

Table 4.2. BOR Dams with a Benefit/Cost Ratio (with Green Incentives) Greater Than 0.75 in the Deschutes and Crooked Basins

Site Name	Project	Potential Installed Capacity (MW)	Potential Annual Production (MWh)	Plant Factor	Cost per Installed Capacity ($/kW)	Benefit/Cost Ratio with Green Incentives	IRR with Green Incentives	Constraints	Data Confidence
Arthur R. Bowman Dam	Crooked River	3.29	18,282	0.65	$2,732	1.90	11.2%	Recreation (Wild and Scenic River)	High
Wickiup Dam	Deschutes River	3.95	15,650	0.46	$3,843	0.98	4.2%	Recreation (Wild and Scenic River)	High
Haystack Canal	Deschutes River	0.805	3,738	0.54	$4,866	0.85	2.9%	None	High

Source: BOR 2011b

In March 2011, Symbiotics, LLC, filed a license application with FERC to construct and operate the Wickiup Dam Hydroelectric Project (FERC No. 12965) on Wickiup Dam (Symbiotics 2011a). The proposed run-of-river project would have an installed capacity of 7.15 MW from one turbine/generator unit and on average would produce 21.15 GWh annually (Symbiotics 2011b).

Also in March 2011, PGE filed a preliminary application with FERC for the Crooked River Hydroelectric Project (FERC No. 13527) on Bowman Dam (PGE 2011b). The proposed run-of-river project would have an installed capacity of 6.0 MW and on average would produce 23.0 GWh annually (PGE 2011b).

4.2.1.9 Existing Irrigation Canals and Conduits

The potential for adding new hydropower generation in existing irrigation canals and conduits is exemplified by the Ponderosa and Juniper Ridge projects discussed in Section 4.2.1.7. As indicated in Figure 4.5 and Table 4.3, there are seven irrigation districts in the Deschutes and Crooked basins. Many of these irrigation districts have identified opportunities for adding hydropower generation to their systems.

Table 4.3. Deschutes/Crooked Basin Irrigation Districts Delivery Systems (Source: DWA 2006)

District	Canals (miles)	Laterals (miles)	Irrigation System Diversions (1,000 acre-feet)	Transmission Loss (1,000 acre-feet)	Delivery Efficiency (%)
Swalley	11.6	16.8	42.4	23.1	45
Central Oregon	76.5	129.7	351.5	91.3	74
Arnold	15.5	24.5	38.4	20.5	47
North Unit	65.0	83.9	221.8	87.5	61
Tumalo	35.7	26.3	67.0	39.0	42
Three Sisters	20.9	39.5	26.4	9.8	63
Ochoco	33.9	37.5	20.5	7.6	63
Totals	**299.2**	**363.6**	**782.6**	**287.9**	**63**

BOR staff did an informal assessment of potential hydropower sites on its irrigation canals that are operated by NUID and OID.[1] The assessment set the criteria for potential sites as having a 5-foot or greater drop and 137 cfs or greater flow. The assessment identified at least 45 potential sites on the NUID main canal, but none for OID (BOR 2011g).

In 2010, the Energy Trust of Oregon (ETO) published *Irrigation Water Providers of Oregon:* Hydropower *Potential and Energy Savings Evaluation* to "evaluate the state's largest irrigation water users to provide base feasibility evaluations which could result in subsequent development of hydropower projects in Oregon" (ETO 2010). The report evaluated nine potential hydropower sites associated with

[1] North Unit Irrigation District Main Canal Hydropower Assessment. Unpublished report provided via e-mail from Dawn Wiedmeier, Deputy Area Manager, Bureau of Reclamation, to Bo Saulsbury, Research Staff, Oak Ridge National Laboratory. August 2. Resources Investigations Report 00–4162, Portland, Oregon.

irrigation districts in Central Oregon (Table 4.4), six of which are owned by the COID, one by the Three Sisters Irrigation District (TSID), and two by the Tumalo Irrigation District (TID).

The ETO report excludes three (NUID, OID, and SID) of the seven Deschutes Basin Board of Control (DBBC) irrigation districts from analysis because for them "preliminary investigations were already underway through Energy Trust" (ETO 2010). The report concludes that four (AID, COID, TSID, and TID) of the DBBC districts deserve further evaluation for hydropower potential (ETO 2010).

Table 4.4. Potential Irrigation District Hydropower Sites in Central Oregon Evaluated by the Energy Trust of Oregon (Source: ETO 2010)

	Site	Net Head (feet)	Average Flow Rate (cfs)	Peak Power (MW)	Annual Power (MWh)
Central Oregon					
	Ward Road	25	330	0.80	2,480
	Brinson Boulevard	17	370	0.50	2,000
	10 Barr Road	27	260	0.65	2,100
	Dodds Road	79	245	1.85	5,800
	Shumway Road	79–89	150	1.20–1.36	3,650–4,000
	Yew Avenue	45	190	0.94	2,600
Three Sisters					
	McKenzie Reservoir	96	30	0.28	907
Tumalo					
	Columbia Southern Main	1,005	30	2.10	9,040
	Columbia Southern Lateral	68–111	65	0.38–0.61	1,325–2,160

4.2.2 High-Level Scoping of Initial Environmental Opportunities

This section presents a preliminary compilation of identified environmental opportunities in the Deschutes Basin. Section 5.6 describes FY 2012 activities to build on this initial list to create a more comprehensive database of site-specific opportunities.

Opportunities to improve river, riparian, and floodplain environmental conditions in the Deschutes Basin are inextricably linked to changes in management of the hydrologic regime. As summarized in Section 4.2.1, the hydrologic regime throughout the Deschutes Basin has been altered from natural conditions to meet the needs of agricultural irrigation supply, flood control, municipal supply and other uses. Recognizing the need for changes in long-term management of water resources, a diverse coalition of partners from the Deschutes Basin initiated a series of planning studies to address the overall vision of balanced water resources use among agriculture, urban, and ecosystem needs (Aylward and Newton 2006). Among the set of objectives developed by the coalition is the objective to "Move stream flows toward a more natural hydrograph while securing and maintaining improved instream flows and water quality to support fish and wildlife."

Modifications of the hydrologic regime toward a more natural hydrograph would increase the potential for improving river, riparian, and floodplain environmental conditions throughout the Deschutes Basin. It is widely accepted throughout the science, engineering, and management communities that some semblance of natural flow variability, magnitude, timing, frequency, duration, and quality is a desirable goal for sustaining riverine function and native biodiversity (Poff et al. 2003, 2010; Locke et al. 2008). Incremental changes toward a more natural hydrologic regime could result in associated improvements to other riverine ecosystem components such as water quality, biology, geomorphology, and connectivity throughout the river corridors within the Deschutes Basin.

Among the many general opportunities for improving environmental conditions throughout the Deschutes Basin as a result of changes to the hydrologic regime, improvements within specific subbasins (Figure 4.3) may be realized through river reach- and site-specific actions. Many of these opportunities are based on changes to the magnitude and timing of stream flows, and associated effects on fish habitat and water quality. Other opportunities related to fish passage, habitat restoration, and fish passage also exist within the basin, and will be examined as appropriate in FY 2012.

4.2.2.1 Upper Deschutes River

The hydrologic regime in this section of river is affected most by the operations of Crane Prairie and Wickiup reservoirs. The water management of these reservoirs for irrigation purposes results in downstream low winter flows when the reservoirs are being filled, and high summer flows when water is conveyed to downstream irrigation canals (Golden and Aylward 2006). Adjustments to this existing hydrologic regime would likely result in positive benefits to the aquatic and riparian ecosystems in this section of river. These benefits include the potential for improved quantity and quality of spawning and rearing habitat for bull trout and redband trout (NPCC 2005). Additional opportunities for environmental improvements would be realized through improved water quality, particularly temperature and dissolved oxygen (Golden and Aylward 2006).

4.2.2.2 Middle Deschutes River

Environmental improvement opportunities for this section of river are also likely to be derived largely from an improved hydrologic regime. The existing flow regime is affected by low winter flows when reservoirs are being filled, and low summer flows when water is diverted at the North Canal Dam for irrigation purposes (Golden and Aylward 2006). As with the upper Deschutes River, modifying the existing hydrologic regime in this section would likely result in positive benefits to the aquatic and riparian ecosystems, including improved habitat for bull trout and steelhead (NPCC 2005). Additional opportunities for environmental improvements would be realized through increased water quality, particularly for temperature and pH (Golden and Aylward 2006).

4.2.2.3 Tumalo Creek

The hydrologic regime of Tumalo Creek is adversely affected primarily during the April through September time period encompassing the irrigation season. While seasonal irrigation water management is not controlled by upstream storage reservoirs, direct irrigation diversion withdrawal from Tumalo Creek results in seasonal flows much lower than targeted values (Golden and Aylward 2006). An improved hydrologic regime would likely result in improved quantity and quality of fish habitat, primarily for redband trout (NPCC 2005). Water quality in Tumalo Creek is better than much of the Deschutes River Basin, but increased flows during the irrigation season would like result in improved summer water temperature conditions (Golden and Aylward 2006).

4.2.2.4 Whychus Creek

The hydrologic regime of Whychus Creek is adversely affected primarily by direct irrigation diversion withdrawal during the April through September time period encompassing the irrigation season (Golden and Aylward 2006). During this season instream flows are significantly lower than targeted values. Adjustments to this existing hydrologic regime would likely result in positive benefits to the aquatic and riparian ecosystems in this section of river. These benefits include the potential for improved quantity and quality of habitat for bull trout, redband trout, and steelhead (NPCC 2005). Additional opportunities for environmental improvements would be realized through increased water quality, because flow alterations in this reach are a major factor contributing to water temperature impairment (Golden and Aylward 2006).

4.2.2.5 Lower Crooked River

The hydrologic regime in this section of river is affected most by the operations of Prineville Reservoir and downstream irrigation diversions (Golden and Aylward 2006). The water management of this reservoir for irrigation purposes results in downstream low winter flows when the reservoir is being filled, and high summer flows when water is conveyed to downstream irrigation diversions. The high summer flows extend only 14 miles downstream from the reservoir (RM 70) to the Crooked River Feed Canal (RM 56). Downstream from RM 56 to RM 18 (Highway 97), irrigation water management results in significantly low seasonal flow. Improvements to irrigation season flows in this section of river would likely result in positive benefits to the aquatic and riparian ecosystems. An improved hydrologic regime would likely result in improved quantity and quality of fish habitat, including for steelhead and bull trout (NPCC 2005). Additional opportunities for environmental improvements from changes in the hydrologic regime would be realized through increased water quality, particularly for temperature, pH, and total dissolved gas (Golden and Aylward 2006).

4.2.3 Initial Integrated Opportunity Identification

The Deschutes Basin pilot opportunity assessment views the basin as an integrated system, wherein evaluations and analyses will identify specific opportunities where hydropower value/generation could be increased while simultaneously improving environmental values. This pilot opportunity assessments focus on three water uses in the basin: Hydropower + Environment + Irrigation and Water Supply. However, stakeholders from irrigation, municipal, recreational, and other water user groups are involved to ensure that assessments are feasible within the context of existing water rights and uses. Identification of hydropower and environmental opportunities may also benefit other water user groups, whose interests often intersect with hydropower and environmental issues.

After the Deschutes Basin was selected as the BSOA pilot study in February 2011, the project team began formal stakeholder engagement activities (approach described in Chapter 2.0) to initiate the process of opportunity scenario identification. This process ran parallel with development of the Basin-Scale Opportunity Assessment Toolbox and was intended to assess stakeholder needs and interest around which opportunities were appropriate for further analysis and which tools in the toolbox were best able to provide those analyses.

The project team used two coordinating bodies (see Chapter 2.0) and three Stakeholder Interaction Activities to identify opportunity scenarios:

1. In-Basin Logistics Committee (*Coordination Structure*)
2. Site Visit (Stakeholder Interaction Activity)
3. Stakeholder Interviews (Stakeholder Interaction Activity)
4. Stakeholder Workshop (Stakeholder Interaction Activity)
5. In-Basin Interest Group (Coordination Structure resulting from the workshop).

4.2.3.1 In-Basin Logistics Committee

Recognizing the need for efficient identification of key issues, stakeholders, and sensitivities in the pilot basin, the project team's first action after pilot basin selection was to establish a small working group consisting of agency, hydropower, environmental, and irrigation leaders in the basin. This working group came to be known as the "Logistics Committee" because of its willingness and ability to help project team members deal with the logistics of stakeholder outreach activities. The Logistics Committee served as the primary liaison between the project team and the larger stakeholder community, connecting the project team with individuals and information needed to understand hydropower and environmental opportunity scenarios.

4.2.3.2 Site Visit

On June 1 and 2, 2011, project team members met with 17 stakeholders in the basin and visited the major reservoirs, dams, small hydro facilities, diversions, as well as wild and scenic stretches of the Crooked River and salmonid habitat on the Deschutes River. The purpose of this site visit was to introduce technical staff from ORNL and PNNL to the stakeholders and opportunities for hydropower and environmental improvements in the Deschutes and Crooked basins. A better understanding of the interplay between hydropower, environment, and irrigation was an important outcome of this site visit. Technical staff returned with a much fuller understanding of the key issues, stakeholders, and sensitivities in the basin as context for application of analysis tools during FY 2012. Another important benefit of the site visit was an opportunity for the project team to meet technical experts in the basin and establish lines of communication for future data sharing. As discussed previously, the technical approach for opportunity assessments is intended to use, leverage, and build on previous technical work in the basin. This approach is necessary given the desire for a relatively rapid assessment timeframe. The site visit was by far the most efficient way for the project team to begin to understand the breadth of previous work and resources that are available for FY 2012 assessment activities.

4.2.3.3 Stakeholder Interviews

After the site visit, the project team worked with the Logistics Committee to identify relevant stakeholder organizations. The team then enlisted a professional facilitator (Kearns & West) to design and conduct telephone interviews with representatives from a cross section of the stakeholder organizations. The goal of the interviews was to develop preliminary lists of 1) potential opportunities for increasing hydropower generation while improving environmental conditions and protecting other resources, and 2) potential needs for additional information and research to support the opportunity assessment. Kearns & West conducted 14 telephone interviews, the results of which were used to help plan the stakeholder workshop and as a starting point for discussions in the workshop. The Deschutes Basin Workshop Report, included as Appendix B in this document, captures the results of the telephone interviews as part of the workshop discussions and conclusions.

4.2.3.4 Workshop

The project team worked with the Logistics Committee and Kearns & West to plan and conduct a 2-day stakeholder workshop in Bend, Oregon, on July 25 and 26, 2011. The workshop included 37 participants (not including project team members or Kearns & West staff), and the facilitators used the results of the stakeholder telephone interviews to prompt discussion. The workshop participants identified a suite of potential opportunities and needs for additional information and research. The Deschutes Basin Workshop Report (see Appendix B) lists the workshop participants and summarizes the results of the workshop.

Workshop participants agreed to serve as a review committee for reports and products produced by the project team. This group serves as a general In-Basin Interest Group and will be invited to participate in future workshops and collaborative opportunity analysis activities in FY 2012.

4.2.4 Opportunities Identified by Stakeholders for Further Analysis

Through the outreach activities described above, culminating in the Deschutes Basin Workshop, the project team worked together with stakeholders to develop an initial list of potential opportunities and assessment criteria for increasing hydropower generation, improving environmental conditions, and protecting other water uses. This list, covering broad topical areas, will be used to generate a set of narrative scenarios that will focus modeling and analytical activities during FY 2012 around specific opportunities. The list is provided here; additional context is provided in the Workshop Report in Appendix B.

- Increase Hydropower Generation and Value in a Way That Supports Other Values in the Basin—Powering Non-Powered Dams and In-Canal/Conduit Hydropower
  - Increase hydropower generation, including potentially at Bowman Dam, Ochoco Dam, Wickiup Dam, Crane Prairie Dam, and Crescent Dam. Also, include small hydro (in conduit/in canal) in irrigator and BOR canals/conduits, as well as municipal in conduits. Also, potentially increase higher value generation at Pelton-Round Butte Hydroelectric Project.
  - Site potential new hydro projects in ways that do not establish incentives precluding opportunities for changing the flow regimes benefiting agriculture, fish, and other values in the Deschutes River Basin going forward.
  - If there are associated releases for hydropower generation at Bowman Dam, connect these as associated municipal mitigation for groundwater.

- Improve Aquatic Biota, including Cold Water Fisheries
  - Restore ecological processes in the both river basins.
  - Improve flows and habitat:
    - for salmon and steelhead downstream of Prineville Reservoir, in historic habitat in the Crooked River
    - for all species downstream of Prineville Reservoir in the Crooked
    - for native species (native redband) downstream of Wickiup Reservoir in the Deschutes
    - in McKay Creek (Crooked Basin), achieve better consistency in the currently flashy system.
  - Improve habitat restoration and bank stabilization.
  - Increase connectivity for fish.
  - Enhance tourism/other values with an enhanced cold water fishery.
  - Improve riparian habitat for fish; address animal impacts on streams (cattle/horses).
  - Improve water quality, including temperature, sediment, pH, dissolved oxygen, chlorophyll, and other dissolved gases.
- Protect Water Supply
  - Protect water supplies for agriculture, including considering increased water conservation.
  - Protect water supply for municipal uses.
  - Create certainty for water supply.
  - Have adequate water supplies for all needs.
- Protect Recreation
  - Protect tourism/recreation with retained flat water, warm water recreation, including retaining values on Prineville Reservoir.
  - Protect or enhance instream tourism/recreation benefits with an enhanced cold water fishery.
  - Define ways to achieve natural flow regime for boating.
  - Support broader recreation values in the Deschutes River Basin including scenic values, bird watching, fishing, boating, etc.
  - Maintain and improve riparian habitat and wildlife.
- Flood Management
  - Retain flood management objectives for the Deschutes River Basin; explore opportunities for greater flexibility in flows.

5.0 FY 2012 Research Plan for Assessment of Integrated Opportunity Scenarios

The goal of the FY 2012 BSOA effort is to complete the Deschutes River Basin pilot study and produce tools that can be used by stakeholders for collaborative opportunity analysis. The following sections describe specific activities planned for FY 2012 in the Deschutes River Basin to further describe and analyze opportunities presented in this draft preliminary opportunity assessment. The analyses proposed here were selected based on stakeholder input during the Deschutes Basin Workshop in Bend, Oregon, in July 2011 (described in Section 4.2.4 and Appendix B of this report).

The suite of activities and analyses described here include the following:

1. Refinement of opportunity scenarios previously described in Section 4.2.4 of this report
2. Development and application of numeric models to describe basin hydrology, water quality, hydropower operations, and reservoir operations
3. Data aggregation building on the FY 2011 analysis to catalog and display previously identified hydropower and environmental opportunities
4. A visualization and collaborative tradeoff analysis tool to make model outputs and other data accessible for collaborative stakeholder analysis of opportunity scenarios
5. A case study analysis to describe small hydropower opportunities in canals and conduits
6. Stakeholder collaboration activities to ensure input and transparency in tool development and application.

As described in Chapter 2.0, the technical approach to opportunity assessment will to the extent possible use existing tools and models, strive for transparency and collaborative application of tools with stakeholders, and provide information and analyses to inform creative dialog among stakeholders without making specific recommendations. Because this pilot assessment is testing a “rapid assessment approach,” activities and analyses described below are intended to be completed by the end of FY 2012, subject to the availability of funding.

5.1 Screen and Refine Opportunity Scenarios

The Deschutes River Basin is home to a number of diverse groups of stakeholders that rely upon the river to support their needs, livelihoods, and interests. The contribution of those groups to the BSOA process has helped identify a broad set of creative opportunities to better meet their objectives for hydropower, environmental improvements, and protection or enhancement of other important water uses (as described above in Chapter 4.0). Before moving forward with an intensive analysis of each item in that set, it will be useful to do a preliminary analysis of whether opportunities are compatible with the objectives of the group. It will also be useful to consider whether legal, regulatory, or other constraints exist that would prevent or limit the implementation of certain opportunities. Only the opportunities that are found to be consistent with objectives and constraints would be carried forward for a more thorough analysis. Opportunities that are found to be in conflict with an objective or a constraint would be re-examined to see if a refinement of the opportunity could remove the conflict. If such a refinement were possible, the refined opportunity would be carried forward for analysis. Opportunities for which no option was found to remove the conflict would be screened from analysis.

Screening will be carried out using a set of narrative “scenarios” that describe and integrate opportunities across hydropower, environment, and water use parameters. The spatial and temporal scope of opportunities may vary, but a scenario will be defined as encompassing the entire area of interest across the timeframe of interest. A scenario is defined at the basin scale, which is where benefits beyond a specific project or reach become evident. By combining opportunities that are compatible, each alternative scenario will include a more comprehensive set of actions and the interactions among those individual actions. Where two or more opportunities are incompatible, they will have to be included in separate alternative scenarios.

By screening opportunities at an early stage of the process, the number of alternative scenarios is potentially reduced. The eventual outcome remains the same, but the time and effort required for analysis can be reduced. Opportunity scenarios will be used to design models described below in Section 5.2 to ensure that modeling tools are capable of illuminating the key questions of concern in the basin. Scenarios will also be used as the basis for hydropower, environment, and irrigation system-scale simulation modeling, as described in Section 5.3.

5.1.1 Technical Approach

The process of screening opportunity scenarios will begin with the In-Basin Logistics Committee, whose local experience will help identify infeasible aspects of opportunities that have been proposed. That experience will also help identify refinements that might make an opportunity feasible. The screening process will consider in a simple and straightforward manner how a given opportunity will move water in space and time. The committee will consider whether the expected changes are compatible with constraints and whether they have a potential to move the system closer to meeting objectives. The goal of screening is to rapidly identify the opportunities with no chance for success or with obvious conflicts. By removing these items at early stages, it will be possible to narrow the scope and quicken the pace of analyses required to evaluate promising opportunities and compile alternative scenarios.

The opportunities that successfully pass the screening stage are considered promising, but are not guaranteed to be successful. More thorough quantitative analysis to be conducted on opportunities passing this stage will be needed to demonstrate the potential for an opportunity or complete scenario to provide the desired benefits and to operate within established constraints (as described in Sections 5.2, 5.3, and 5.7).

The product of this effort will be the original list of opportunities presented in Section 4.2.4 annotated with assignments into screening categories. The first category will be “Feasible” and will include the opportunities for which feasibility appears likely with no modification. The second category will be “Modify” for the opportunities that require modification to achieve feasibility. The third category will be “Infeasible” for opportunities that are considered infeasible. For items falling into the Modify category, a description of the revised opportunity will be provided. For items falling into the Infeasible category, a description of the conflicting objective or constraint will be provided. This list will provide the basis for building alternative scenarios for further analysis and discussion.

5.2 Improved Water Resources Modeling

Potential hydropower generation and environmental improvements are linked to the hydrology of the basin (as described in Sections 4.2.2 and 4.2.3). It is essential for opportunity scenarios to account for changes in flow and hydrology so that we understand how Hydropower + Environment + Irrigation and Water Supply scenarios affect other water uses. A key outcome of the Deschutes Basin Workshop described in Section 4.2.4 was the stated need for improved hydrology/water-resources modeling in the basin to allow for accurate and transparent tracking of water. This model will serve as a foundational resource for the BSOA pilot study, enabling analysis of opportunity tradeoffs (described in Section 5.3).

Understanding the hydrology in the Deschutes River Basin requires an understanding of both surface water and groundwater flows. This task will build on previous work. The end product will be an improved understanding of the hydrology in the basin and in particular, human impact on the hydrology and the basin ecosystem.

5.2.1 Technical Approach

To the extent possible, the technical approach will build on existing models in the basin modified to meet the specific needs of this opportunity assessment. Assessments of hydrological responses will be made using an existing model called the Variable Infiltration Capacity (VIC) model. Monthly operational water-resources management will be based on model simulations performed using an existing software platform called MODSIM (Shafer and Labadie 1978; Labadie 2005; BOR 2010). Daily operational water-resources management will be based on model simulations using a newly parameterized RiverWare model. As development continues, each model will be validated to the extent possible.

Proper setup, execution, and performance assessment of each of these models is important due to the interdependent nature of model use. Hydrologic responses of the system for dry, average, and wet years are used to validate monthly and daily flows in the water-resources management models. The resulting validated "water-balance" models will be used to simulate effects of potential generation and environmental improvements, as noted in Section 5.3, within contexts of rules and constraints for scenario activities, as noted in Section 5.1.

The tasks required for developing a validated water-balance model are outlined in the Figure 5.1 and explained in detail below in terms of tasks. The workflow and tasks describe a process to build on and modify the basin's existing MODSIM monthly reservoir model to allow for simulation of environmental and power opportunities at the daily timestep.

5.2.1.1 Task 1 – Develop Daily Surface Water Hydrology Model

In the absence of adequate USGS flow gauge data for determining typical basin and systems responses to dry, average, and wet years, a surface water hydrology model is required. The VIC model has been selected for this purpose. The VIC model developed by the University of Washington and Princeton University (Liang et al. 1994) is a semi distributed macroscale hydrology model which solves for water and energy balances. Each grid cell allows for varying infiltration patterns and shows a mosaic of vegetation covers distributed over elevation bands. Three soil layers are simulated, which allows for an improved representation of evapotranspiration and distribution of flow into fast flow and slow flow components.

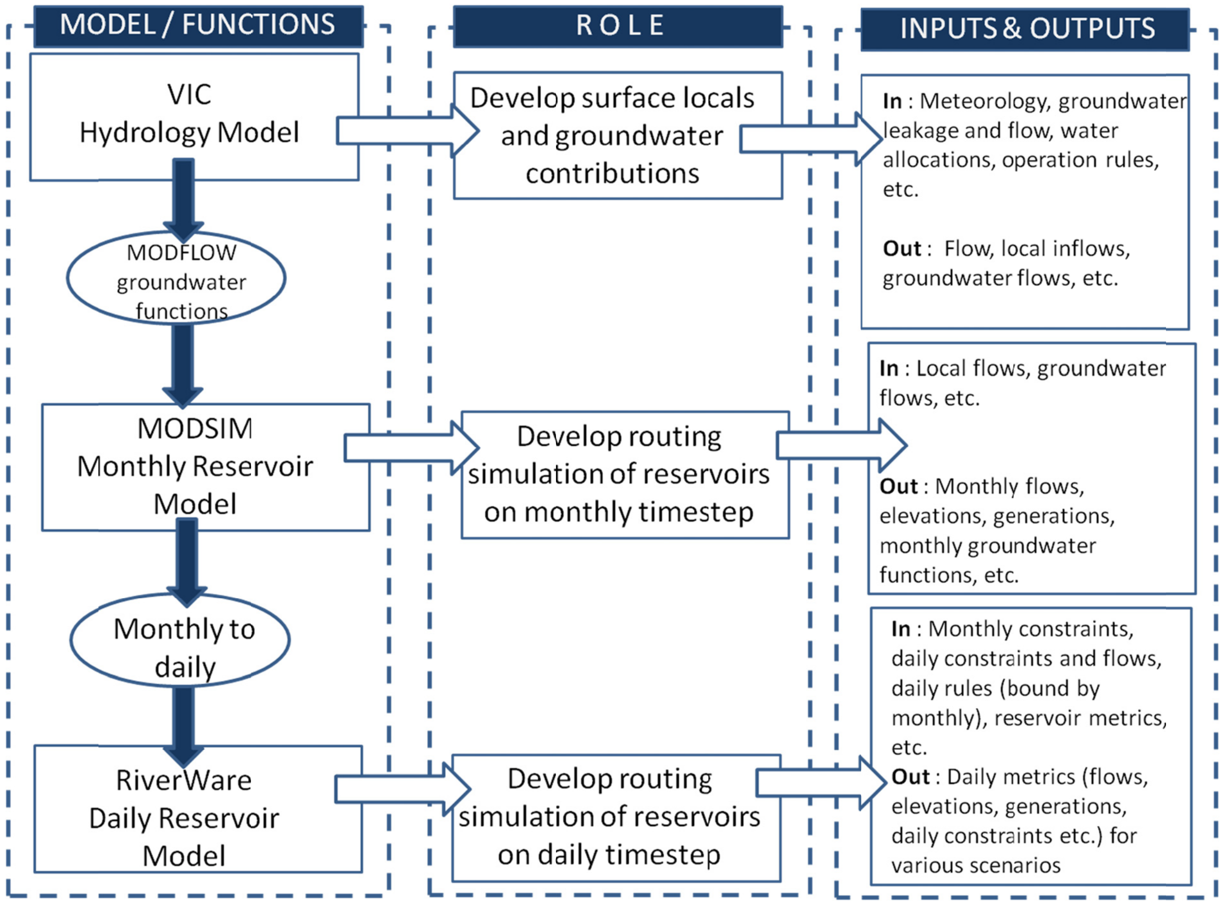

Figure 5.1. Flowchart Showing Integration of Hydrology Modeling Software at Monthly and Daily Timesteps

The VIC model has been applied and validated extensively over spatial scales and diverse hydrometeorological conditions over medium to large river basins across the globe, and in global energy and water balance studies (Nijssen et al. 2001; Maurer et al. 2002, 2004; Wood and Lettenmaier 2006 among many others). A current application of the model to the Deschutes River Basin exists at the 1/16th degree spatial resolution with meteorological forcing spanning the 1929–2005 period (Elsner et al. 2010). This application of the model was recently used for an analysis of climate change impacts on the water resources of the Deschutes River lead by BOR in collaboration with the University of Washington (BOR 2010).

The model was initially calibrated at a monthly time scale with respect to water-management model work referred to here as "BOR modified flows," i.e., naturalized flow. Although VIC simulations underwent an extended bias correction procedure at the monthly time scale, it may be necessary to link groundwater response functions to achieve reasonable naturalized flow during calibration.

Application of the model to the generation of electrical power in the basin requires a daily timestep. To convert the existing monthly MODSIM model (described further under Task 3) monthly modified flows to daily flows, it will be necessary to gather additional information about daily flow diversions and retrieval trends and the daily natural flows, as well as the proper timing and distribution of flow through the system for dry, average, and wet scenarios.

Monthly BOR natural flows need to be disaggregated to a daily timestep. This work is in progress with the BOR but an approach regarding the determination of the timing of diversions and the daily consumptive use retrieval has not been defined yet. USGS observed but regulated daily flow, if available, could be used.

The daily model of surface water will offer many advantages. It will do the following:

1. Provide daily flow in all necessary locations and in particular where infrastructure changes might be considered within the opportunity assessment.
2. Provide the natural flow, instead of regulated flow (diversions, evaporation from reservoir, increased evapotranspiration from irrigation practices).
3. Allow for prospective analysis in the future: land use change, climate change, application over other basins that might not be heavily gauged.
4. Provide a surface water input for calibrating ground water models.

5.2.1.2 Task 2 – Groundwater Response Functions

Tracking groundwater in the Deschutes River Basin is especially important because of volcanic soils and deep infiltration; the existing monthly MODSIM model is linked to a ground water model (Ganneth and Lite 2004) that has been simplified (BOR 2010). Conversations with modeling experts in the basin from the USGS, BOR, and Oregon Water Resources Department (OWRD) have suggested that the existing simplified groundwater model might be sufficient for opportunity assessment activities. However the approach has not been validated through the peer review process and might need technical adjustments. BOR, OWRD, USGS and PNNL are collaborating to improve and validate this groundwater model.

Performing an analysis showing how sensitive the response functions are to water demand across a range of water years and irrigation patterns (wet, dry or average) would allow us to do the following:

- Quantify the range of uncertainty due to groundwater in the present operations.
- Evaluate whether the current method to account for the groundwater is appropriate for our goal and determine whether the uncertainty is large enough to significantly adversely affect our metrics.
- Focus on the primary uncertainty to target further work, if needed (demand, irrigation pattern, or other).

We will collaborate with BOR on disaggregation of the response functions to provide sub-monthly time scales, if necessary.

5.2.1.3 Task 3 – Monthly MODSIM Model

The current NRCE/BOR MODSIM model will be used to define the baseline for a monthly water-management simulation model. Additional rules for water conservation and hydropower generation will be added. Current operations will define the constraints for running the scenarios at a monthly time scale and for defining the daily operating rules. Note that the daily model is required for assessing performance metrics related to environmental and energy questions. Some other performance metrics, in particular water rights accounting, will be kept at a monthly timestep for simplicity.

As mentioned above, the groundwater response functions might need to be updated. Minimal validation of the monthly MODSIM model is planned because this is the current model in use.

This MODSIM model has been jointly developed as a collaborative effort that has been led by the CTWS, through their consultant Natural Resources Consulting Engineers, Inc., (NRCE), and the sponsorship of Warm Springs Power Enterprises (WSPE) in association with the BOR, OWRD, and USGS. This model was developed for use in planning future water use, development, and potential management strategies in the Deschutes River Basin. It simulates monthly stream flows and the effects of reservoir operations, irrigation and municipal diversions, and groundwater pumping on the flows of the major streams.

The OWRD developed the initial upper Deschutes model (La Marche 2001) and made some improvements in the model since the NRCE effort. The OWRD and USGS developed the MODFLOW model of the basin which was used for the development of the groundwater response functions in the MODSIM model. BOR developed the groundwater response functions and the initial Crooked River MODSIM model. The groundwater response functions were developed by applying stresses in the top layers in the USGS/OWRD MODFLOW model setup over the basin. The groundwater response functions are used to determine the timing and amount of groundwater discharging in a certain river reach for a certain amount of infiltration over a specific irrigation district. The response functions represent the groundwater stress mostly due to irrigation practices and canal and reservoir leakage. With inputs such as the reservoirs' head and monthly extractions, the inverse groundwater response functions in conjunction with the reservoir operations and observed regulated flow are used to construct the BOR monthly modified flow. NRCE (2007) developed the demands and undepleted flows inputs, and integrated, expanded, and improved existing models within the new MODSIM model (combined Upper Deschutes and Crooked River). They calibrated and verified the model and developed a baseline and a groundwater withdrawal scenario such as pumping.

In operational mode, the modified observed flow (reconstructed naturalized flow based on observed flow and diversions) and observed reservoir storage are used to initialize the monthly water-resources model MODSIM. Winter seasonal flow forecasts at specific locations are derived from a regression relationship based on observed snowpack. The relationship is derived from an antecedent observed snowpack-seasonal flow. Based on the seasonal flow forecasts (wet, average or dry year), pre-set monthly operating rules are adopted for the year. The simplified groundwater model (groundwater response functions) isolates and anticipates the effects of irrigation practices and leakage from canals into downstream water resources. Deep groundwater pumping is assumed to have a long enough response time before reaching equilibrium and is not taken into account in the current MODSIM groundwater module. The MODSIM model, operated by the BOR, currently allows for water rights accounting, environmental metrics monitoring, and managing diversion amounts.

The following modeling activities, which are closely linked with the monthly model, will be required to build the sub-monthly basin-wide water-balance model described under the next task:

1. Obtain daily naturalized flows. Because the BOR modified (naturalized) flow is available at a monthly timestep only, daily naturalized (unregulated) flows are necessary for driving the sub-monthly water-resources model. They can be obtained either from a hydrology model (as defined under Task 1), or from temporally and spatially disaggregating the BOR-modified flow.
2. Explore the sensitivity of the simplified groundwater model for sub-monthly time-step applications. Depending on the travel time and the sub-monthly variability, the existing response functions might need tuning in order to respond to daily stresses (stress on the upper soil layers generated by canal lining leaking and irrigation practices) that are not taken into account in the surface hydrology model.
3. Add additional capabilities like environmental monitoring and hydropower targets (set amount of water allocated to hydropower) in the monthly water-resources management model MODSIM.

5.2.1.4 Task 4 – Daily Water-Resources Management Model

To assess environmental and energy-related questions, a sub-monthly basin-scale water-resources model is needed. A system-wide water balance must first be achieved to ensure that all instances of water flow, water usage, and reservoir storage changes are appropriately accounted for. This also serves as a data validation process by which any discrepancies and errors in the data can be appropriately handled. This effort helps establish a level of confidence in the framework of the operation of the system from which simulations (described in Section 5.3) are performed.

Existing rules and constraints in the current BOR model define monthly operations. Because hydropower production varies in relation to daytime and week-time peak electrical demands and reservoir control, a daily or even hourly timestep will be required to assess all potential opportunities identified by stakeholders. A daily time step constrained by the existing monthly model will allow flow scenarios to account for both environmental and hydropower values within the constraints of existing monthly water uses. In the future, exploration of flow-shaping to increase hydropower generation at peak value or demand periods may require an hourly time step. While an hourly time step may be outside of the time and budget constraints of this initiative, the daily model will be designed so that moving to an hourly time step in the future can be achieved.

Developing a daily model from monthly constraints will be challenging because of the unknowns associated with 1) data quality and validation; 2) achieving water balance on sub-monthly basis without major issues (such as assessing possibilities of spurious data causing unnatural results, ensuring consistent transformation of monthly to daily or hourly constraints within a reasonable and accepted manner, etc.); and 3) having model assumptions and constraints accepted by stakeholders. We are currently working with stakeholders to disaggregate the monthly into daily operation rules.

This task includes two main components: 1) choosing the appropriate tool and 2) identification of specific (hydropower and environmental) constraints and rules.

Choosing the Appropriate Tool

Three software packages that are widely used nationwide and would fit in our generic basin-scale assessment approach:

- **RiverWare** is a river basin modeling system at the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES), University of Colorado (Zagona et al. 2005). It is capable of simulating and optimizing reservoir operations based on user-specified reservoir systems controls, rules, and constraints (CADSWES 2011) for a specific timestep, which can be a function of future incoming flow. The BOR is potentially transitioning to RiverWare. The optimization module, while not necessary for this initial pilot study, could be used in later applications and performs well at the daily and sub-daily timesteps.
- **MODSIM** offers the advantage of being already set up at the monthly timestep. However stakeholders shared reservations about the ability of the current setup to function well at sub-monthly timesteps. The current MODSIM setup does not offer a functional optimization option.
- **HEC-ResSim** is developed and maintained by the Corps' Hydrologic Engineering Center. The model can operate at a sub-daily timestep and is designed to simulate reservoir operations defined by a variety of operational goals and constraints. The model is being used by the Corps along the main stem of the Columbia River. There is no present setup for the Deschutes River Basin, and the model does not allow for optimization.

For any of those software packages, the present inputs and tasks are necessary, as follows:

- daily naturalized flow, given by a surface water hydrology model or nesting model
- disaggregate monthly to daily operating rules and constraints
- present monthly operating rules with wet, dry, and average year patterns
- define the day the diversions start, each year
- understand daily groundwater model interaction: evaluation of the groundwater response functions.

Because the BOR is currently using RiverWare in other western basins, is considering its use in the Deschutes, and because the tool offers the option of an optimization module, RiverWare has been chosen as the simulation tool of choice for this effort. Many stakeholders are interested in its use for future applications due to its ability to produce simulation outputs for collaborative decision-making as well as its optimization capability. We will likely not use the optimization module for this pilot study but that capacity could be applied for later applications in the basin, or in future opportunity assessment activities in other basins. The PNNL/ORNL/ANL project team has limited in-house expertise constructing a constraint- and rule-based RiverWare model at a daily timestep. Because of this, some of this work is expected to be subcontracted to reduce risk and ensure a functional model.

Identification of Specific (Hydropower and Environmental) Constraints and Rules

Simulation of the various scenarios described in Sections 5.1 and 5.3 will capture the system's response to potential modifications and provide a means by which to identify the behavior and differences in system parameters. Performing the simulation will require imposing constraints on the system and applying rules to identify changes in parameters. In cases where daily constraints and rules are not defined, reasonable assumptions based on sound engineering judgment are made in defining them or disaggregating them from monthly ones. In some cases, this involves having the rules and constraints developed through simulation based on rules and constraints imposed for higher priority situations. Constraints and rules may include the following:

- reservoir elevations, storage, and flows for recreation and water quality
- environmental function as related to flows (quality, quantity, and timing)
- existing and future significant withdrawals within the system
- generation needs.

5.2.2 Data and Information Gaps

A number of parameters are used in developing and simulating a reservoir system simulation model. They include the following:

- reservoir dam flows (inflow and/or outflow, bypass, spill, minimum releases)
- stream-flow gauge data
- reservoir elevation-storage curves
- evaporation rates
- known withdrawal flows within the reservoir and location
- river branch routing parameters (length, depth, slope, etc.).

The project team will continue to work with BOR, USGS, OWRD, and other experts in the basin to assess existing modeling resources available to leverage for this effort. Data contained in the monthly MODSIM setup will be used to build the RiverWare daily model. Observed records of stream flows, diversions, groundwater withdrawals, reservoir storage levels, and water rights data have been obtained from OWRD, USGS, and the BOR. As mentioned earlier, there will be uncertainties in the daily meteorological forcing, the surface hydrology model, and groundwater components because most of the observations do not exist at the daily timestep or without regulation for calibration and validation purposes.

The modeling setup will be able to provide performance metrics directly for water rights accounting, environmental flow, and energy generation at specific locations in the basin. Output from the modeling scheme will also be used for further analysis, particularly for simulation of environmental performance at the system scale outside of the specific nodes described in the model (Section 5.3), and for visualization (Section 5.7).

5.3 Model Simulation of Integrated Opportunity Scenarios

Model simulations will investigate the scenarios to be developed (see Section 5.1) using the calibrated and validated hydrology and water-balance models described in Section 5.2. Specific qualitative and quantitative guidelines for both power production and environmental improvements will serve as rules and constraints and help guide the development and use of the model. Simulations will assess the related changes that result from various hydropower and environmental changes to the system as articulated in the scenarios. Simulation is intended to be a collaborative activity with stakeholders through the data display and visualization module described in Section 5.7 of this report.

5.3.1 Technical Approach and Existing Resources

Determining the potential for hydropower while improving the environment in the Deschutes River Basin entails simulating the passage and timing of water through the existing system with the addition of new controls such as hydropower. The associated rules and constraints of the system operation related to hydropower and environmental improvement are either imposed, if known, or developed, if not known. Various scenarios incorporating hydropower additions and various flow and withdrawal operations based on users' and environmental requirements are simulated.

The calibrated and validated models that demonstrate the water balance in the system (see Section 5.2) are used as a basis for performing the scenario simulations. A properly developed water-balance model helps establish confidence in the response and performance of a model and provides a transparent framework upon which to build.

The simulations are based on scenarios developed under the task described in Section 5.1. Comparisons of the different simulated scenarios are made by comparing a variety of metrics based on quantity and timing of 1) hydropower generation, 2) irrigation withdrawal, 3) reservoir water levels, 4) reservoir storage, 5) river discharge, and 6) water quality. For each scenario, these metrics will be evaluated at particular points of interest (i.e., index sites) throughout the basin, such as at river gauging locations and downstream of irrigation diversions.

Simulations are performed for sub-monthly timesteps (e.g., weekly, daily, or hourly) such that existing monthly targets are observed. Any existing sub-monthly rules, targets, and constraints are also observed. Those that do not exist will be developed through simulation trials based on the stakeholder's interests (e.g., environmental, hydropower, irrigation, municipal, etc.).

The monthly results from the MODSIM validation and the sub-monthly results from the water-balance validation (as described under Tasks 3 and 4, respectively, in Section 5.2) will be used as a basis for constructing and performing the simulation runs for the system-scale analysis. The simulation results will provide inputs for modeling river discharge and water quality within reaches of interest. Where available and appropriate, existing models (e.g., HEC-RAS, HeatSource) within the Deschutes River Basin will be used for modeling these reaches. The goal of the simulation is to determine the effects that the addition of hydropower and improvements to the environment have on the Deschutes system. The following are required to accomplish this simulation:

- **Identification of the Baseline**. In helping to define simulations, it is crucial to identify a matrix of hydrologic baseline scenarios to consider. Simulation results posed in matrix form help in understanding system response and increase confidence in systematically inferring conclusions within a bounded framework. The baseline scenarios include a base case or "natural system" for which no changes to the system occur (i.e., "as-is") to help properly bound the problem. The base case will include specific historical events that include a dry, average, and wet year. In addition, if instream flows and operations are found to vary significantly with air temperature, then it may be of interest to include warm and cool meteorological years in the scenarios as well.

- **Identification of Specific (Hydropower and Environmental) Case Scenarios**. Opportunity scenarios developed under activities described above in Section 5.1 will serve as the basis for specific hydropower and environmental baseline scenarios for simulation modeling, combined with the baseline hydrological for the dry, average, and wet years.

The simulations will be performed based on the defined scenarios with the base hydrologic cases for "as-is" conditions being performed first. Systematic and combinatory changes are added (i.e., hydropower generation, altered flow regimes, alternate reservoir operations, etc.) to assess the system's response. Any required sensitivity analyses or further refinement of the scenarios to bound specific interests can also be accomplished. Important metrics and associated comparisons will be plotted.

Metrics derived from the organized results of the opportunity scenario modeling will be used to assess the value and effect the proposed hydropower and improved environmental cases have on both small hydropower projects and irrigation, as described in Section 5.4, and on site-specific hydropower and environmental opportunities, as described in Sections 5.5 and 5.6.

Model outputs will be displayed and communicated in combination with other data and information in the basin in order to describe fully the changes that result under various scenarios. Outputs will be exported and incorporated as a module in the data visualization tool described in Section 5.7.

5.3.2 Data and Information Gaps

Most of the data for the base cases should be available from the validation of the water-balance hydrology models described in Section 5.2. Information used to determine the wet, average, and dry case years will need to be gathered and compiled. This entails retrieving and analyzing BOR-modified flow data to determine the different base case scenarios, i.e., wet, average, and dry years. Current irrigation use and pumping schedules are also needed. Specific quantitative scenarios need to be defined and/or refined such that the constraint model can be designed and built.

5.4 In-Canal Small Hydropower Case Study and Lessons Learned

Small-scale, in-canal, and in-conduit hydropower has been a recent focus in the Deschutes River Basin, with COID and SID both developing small facilities on irrigation canals north of Bend. These facilities combine multiple value streams and involve a collaborative approach between the environmental and irrigation communities—hydropower provides revenue to the irrigation district that is used for water-conservation projects such as piping unlined irrigation canals. Tradable renewable energy credits provide another income stream for irrigation districts coping with a declining patron base. Water-conservation projects also allow irrigation districts to contribute to instream flow improvements and the hydropower is a local source of clean renewable energy. Irrigation districts are also interested in pursuing micro hydropower projects in existing canals and conduits to offset the cost of pumping irrigation water.

Because the Deschutes River Basin is a national leader in developing small hydropower projects in canals and conduits, in FY 2012, the project team will work together with irrigation districts to capture lessons learned through a case study approach. A fuller understanding of the costs, benefits, incentives, funding streams, and challenges of developing new small hydropower projects will also benefit Deschutes irrigation districts looking to add new facilities.

5.4.1 Technical Approach

The case study will select from small hydropower projects identified and catalogued under activities described below in Section 5.5. The Juniper Ridge and Swalley projects will serve as lead case studies with a focus on documenting the process and lessons learned from development of those two projects. The project team will collaborate with COID and SID through interviews and direct meetings to describe the development and operation of the Juniper Ridge and Swalley projects with a particular focus on the following variables:

- expected benefits of the project
- conditions and incentives that enabled development
- collaboration and multiple value streams—irrigation, environment, and hydropower
- sustainability and green hydropower certification
- project funding and financing
- interconnection, wheeling, and power marketing
- technology/engineering challenges and solutions
- realized benefits
- ongoing challenges
- lessons learned for future similar developments.

Building on the experience of SID and COID, the project team will investigate the political, environmental, economic, and technical feasibility of a selection of other identified potential in-canal projects (as identified in Section 5.5). To the extent possible, this investigation will integrate with the water-balance modeling and scenario simulation activities described in Sections 5.2 and 5.3 to better understand system effects of canal lining, piping, and hydropower generation in irrigation canals.

5.5 Site-Specific Hydropower Opportunities

As discussed in Section 4.2.2, two of the most likely opportunities for increasing hydropower generation in the Deschutes and Crooked river basins are 1) adding new generation at existing non-powered dams and large diversions and 2) adding new generation in existing irrigation canals and conduits.

According to the NHAAP database (ORNL 2011), there are 71 existing dams and large diversions in the Upper and Middle Deschutes River Basin and the Crooked River River Basin. Of these 71 dams and large diversions, 64 are non-powered (see Section 4.2.2.2). There are also numerous irrigation canals and conduits without hydropower facilities throughout both basins (see Section 4.2.2.3). Some of these non-powered dams and irrigation facilities represent site-specific opportunities for increasing hydropower generation. Furthermore, many of them represent opportunities to help conserve water for other uses in the basins through associated projects, such as canal lining and pipe extension projects to support hydropower development.

Work under this task will serve to aggregate existing data through the NHAAP and other sources and make those data available for the modeling work described in Sections 5.2 and 5.3. Data will be output in the data visualization and collaborative analysis tool described in Section 5.7.

5.5.1 Technical Approach

The assessment of site-specific hydropower opportunities will begin by cataloging existing opportunities for powering non-powered dams and optimal locations for new in-canal and in-conduit hydropower. This effort will start with the existing information presented in Section 4.2.2. For non-powered dams, the assessment will start with the NHAAP database, the BOR's 2011 *Hydropower Resource Assessment at Existing Reclamation Facilities*, Symbiotics LLC's license application for the Wickiup Dam Hydroelectric Project (FERC No. 12965), and PGE's preliminary application document for the Crooked River Hydro Project (FERC No. 13527) at Bowman Dam.

For in-canal and in-conduit opportunities, the assessment will start with information on SID's existing Ponderosa Hydroelectric Project, COID's existing Juniper Ridge Hydroelectric Project, the BOR's assessment of hydropower potential on its canals that are operated by NUID and OID, and Energy Trust of Oregon's 2010 *Irrigation Water Providers of Oregon: Hydropower Potential and Energy Savings Evaluation.*

Existing information will be supplemented with additional, site-specific information from the BOR, the hydropower license applicants, the irrigation districts, and others. The additional site-specific information to be obtained includes, but is not limited to, site location, data on head and flow, distance to and voltage of closest transmission line, closest road access, and other characteristics pertaining to hydropower development. Opportunities for associated canal lining and/or piping extension projects will also be evaluated at each location. The result of the assessment will be a catalog of site-specific opportunities for 1) generating hydropower at non-powered dams and in irrigation canals and conduits and 2) conserving water through associated canal lining and pipe extension projects. The catalog will be a stand-alone document, but will be incorporated into the larger Deschutes BSOA report, with relevant data incorporated into the data visualization and collaborative analysis tool (see Section 5.7).

5.6 Site-Specific Environmental Opportunities

In parallel with the activities described above in Section 5.5, information about identified site-specific environmental opportunities will be aggregated into a database for inclusion in the data visualization and collaborative analysis tool described in Section 5.7 (Figure 5.2). Environmental opportunities will be identified via stakeholder discussions and analysis of public resources. Site-specific environmental opportunities will be tied to four types of geographic features: 1) dam represented as a point; 2) major irrigation diversion as a point; 3) canal or stream reach as a line. To communicate the location and type of opportunity, the data will be made accessible via a publicly available web GIS application described in detail in Section 5.7.

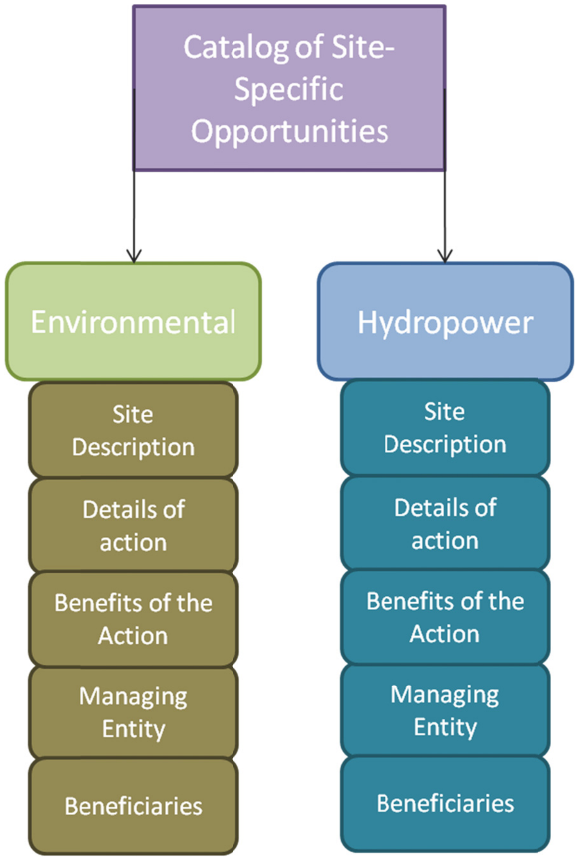

Figure 5.2. Schematic of the Site-Specific Environmental Opportunities Catalog

5.6.1 Technical Approach

Official data derived from ArcGIS Server/Spatial Database Engine-based geodatabase will be structured following draft Data Reduction Protocols and checked into the geodatabase. Web-based map services will be turned on to allow direct access to the official data sets via OpenGIS-compliant GIS software. Custom programming for the web-based map-centered interactive data and analysis environment will be implemented to meet management questions and other requirements identified under Task 1.1. Periodic internal reviews, invited reviews from outside experts, and coordinated reviews through the Logistics Committee will ensure that the development trajectory is meeting original objectives.

The database will be stored in a commercial off-the-shelf format to be transferrable to external parties. The site-specific opportunities will be published to a public website in a user-controlled map interface with environmental opportunities represented as clickable icons. Selecting the individual opportunity icons will allow a user to see a dynamic report of the opportunity, including a description of the site, the details of the possible action, the likely benefits of a project, the primary beneficiaries of such a project, and the party responsible for the management of the area. Periodic updates of the database will be loaded to the web-based mapping interface. The web-mapping system will be built on ArcGIS geospatial resources as described in Section 5.7.

5.7 Data Visualization and Collaborative Analysis

As a collaborative process, the BSOA must strive to achieve a shared understanding of the alternative scenarios and their influences on the river system. In particular, it will be important to communicate how scenarios differ in delivering outcomes of interest to stakeholders. To facilitate communication and understanding, a collaborative visualization and decision support environment is being created. While the modeling effort described in Sections 5.2 and 5.3 will provide valuable data, the visualization system will synthesize that data into a common framework accessible to all stakeholders. The following sections describe the framework and how it will support an assessment.

5.7.1 Framework for Collaborative Visualization and Decision Support

A collaborative visualization and decision support environment will provide data synthesis and analysis capabilities that facilitate a shared understanding of the outcomes of different scenarios (see Section 5.1). The design calls for an intuitive, interactive, web-accessible, map-based, information and decision-support environment. This environment can incorporate baseline spatial data, regularly updated remotely sensed data (e.g., greenness index, NDVI, snow-covered area, etc.), real-time and historic observation data (e.g., stream gage, SNOTEL, flux tower, etc.), and a project library. Through the use of visualizations and data summaries, it can support the evaluation of site-specific opportunities, evaluation of modeling results, and provide metrics that summarize simulated scenarios relative to stakeholder decision points.

This section provides a top-level conceptual design of the collaborative visualization and decision support environment to support integrated opportunity scenarios. The results of scenario analysis will be communicated through a "dashboard" that includes metrics of interest to stakeholder groups. Depending on the user-determined analysis, the dashboard can be updated on-the-fly based on user-selected criteria or will use pre-determined and stored metrics from the geographic database. Using the interactive mapping system, once the user performs an opportunity assessment, the results will be available via the dashboard for the reach(es) and time periods of interest (see Figure 5.3 and Figure 5.4). The conceptual design of the collaborative visualization and decision support environment is composed of four modules (Figure 5.5) briefly described below:

- The "Data" module gives the user the ability to explore the base data, regularly updated remotely sensed data, real-time observation data, historic observation data, and any other spatially linked data deemed relevant to contribute to the decision-making process (for examples, see Figure 5.6, Figure 5.7, and Figure 5.8). The "Data" module can also serve as a tool for identifying data gaps.
- The "Site Specific Opportunity" module (Figure 5.9) consists of separate sub-modules for environmental and hydropower opportunities. An opportunity would be an action or closely related set of actions that serves to increase energy production or improve environmental function. Each opportunity would include background information about the opportunity, site description, potential benefits, the beneficiaries, and the entities where the responsibility of the action will fall.

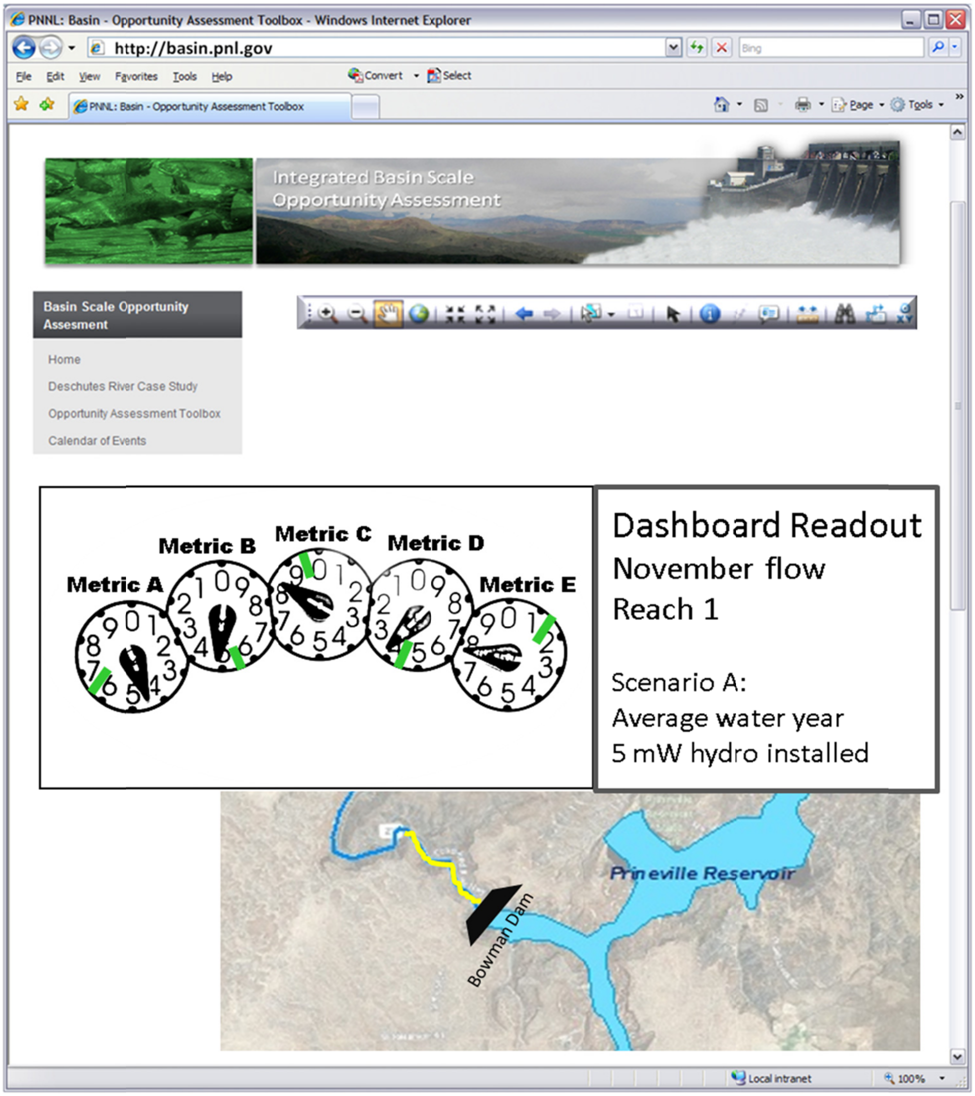

Figure 5.3. Mockup View of Dashboard Readout for a Stream Reach Under a Specific Climate and Operating Scenario

- The "Basin Scale Opportunity Scenarios" module encompasses four sub-modules that allow integrated scenarios to be evaluated. The "Environmental" and "Hydropower" sub-modules function similarly to the sub-modules of the same name in the "Site-Specific Opportunities"; however, these modules operate on integrated scenarios, rather than on individual opportunities. Through the analysis of an integrated scenario, it will be possible to update the dashboard values for comparison with other scenarios, via access to pre-run model results. In addition to the specific environmental and hydropower opportunity scenarios, a graphics-emphasized metadata tool will provide the screening criteria as defined by the stakeholders. Finally, the "Model Visualization" module will provide direct access to explore in graph or map form, the numerical model results behind the calculation of the opportunity indices. Figure 5.10 below provides the conceptual workflow of the "Model Visualization" module, giving the user the opportunity to select various scenarios, temporal scales, flow regimes, and visualization options.

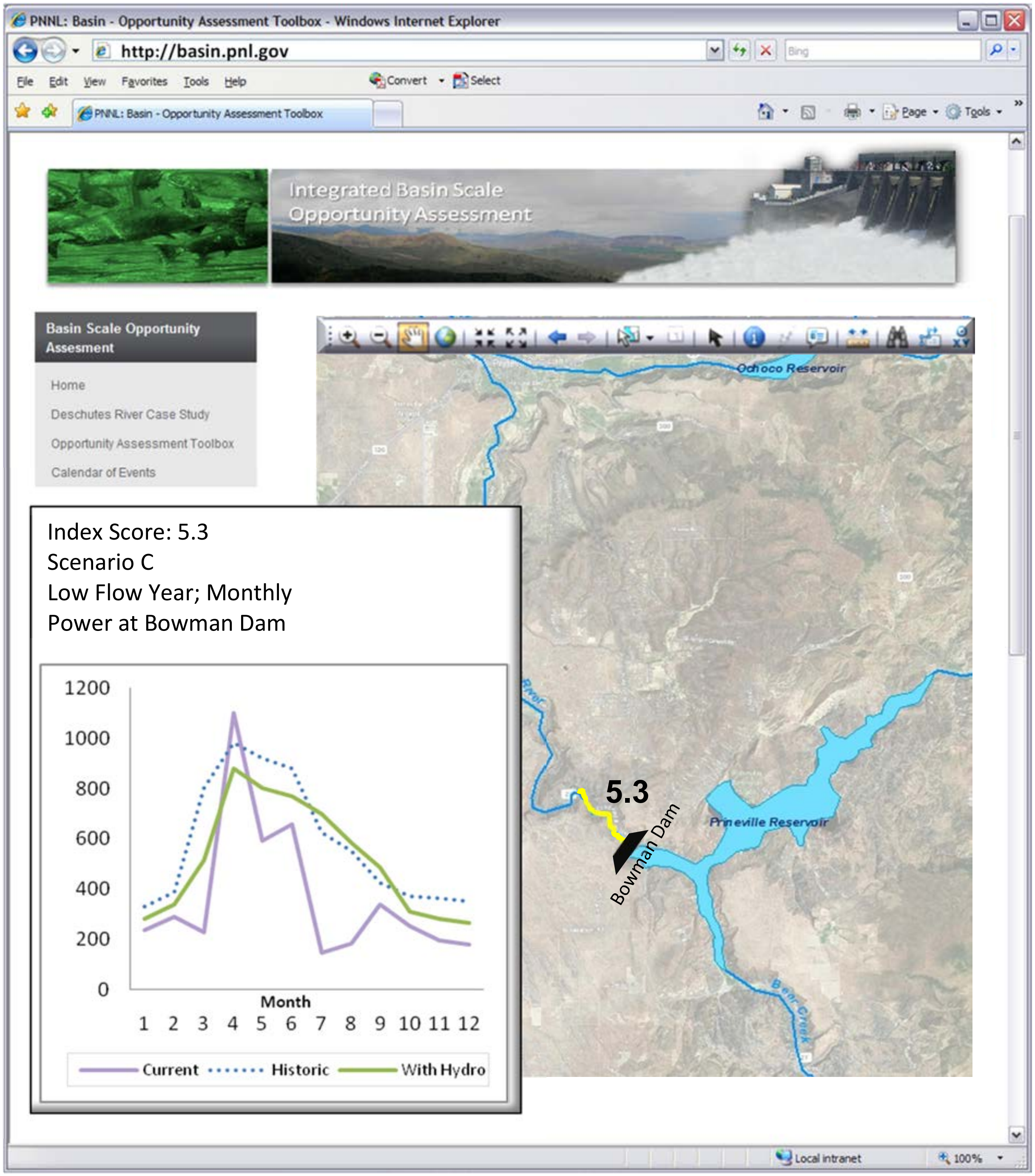

Figure 5.4. A Visualization Mockup for the Deschutes Basin Demonstrates the Notion of a Dashboard Display with the River Reach Below Bowman Dam Selected (yellow highlight) for Analysis

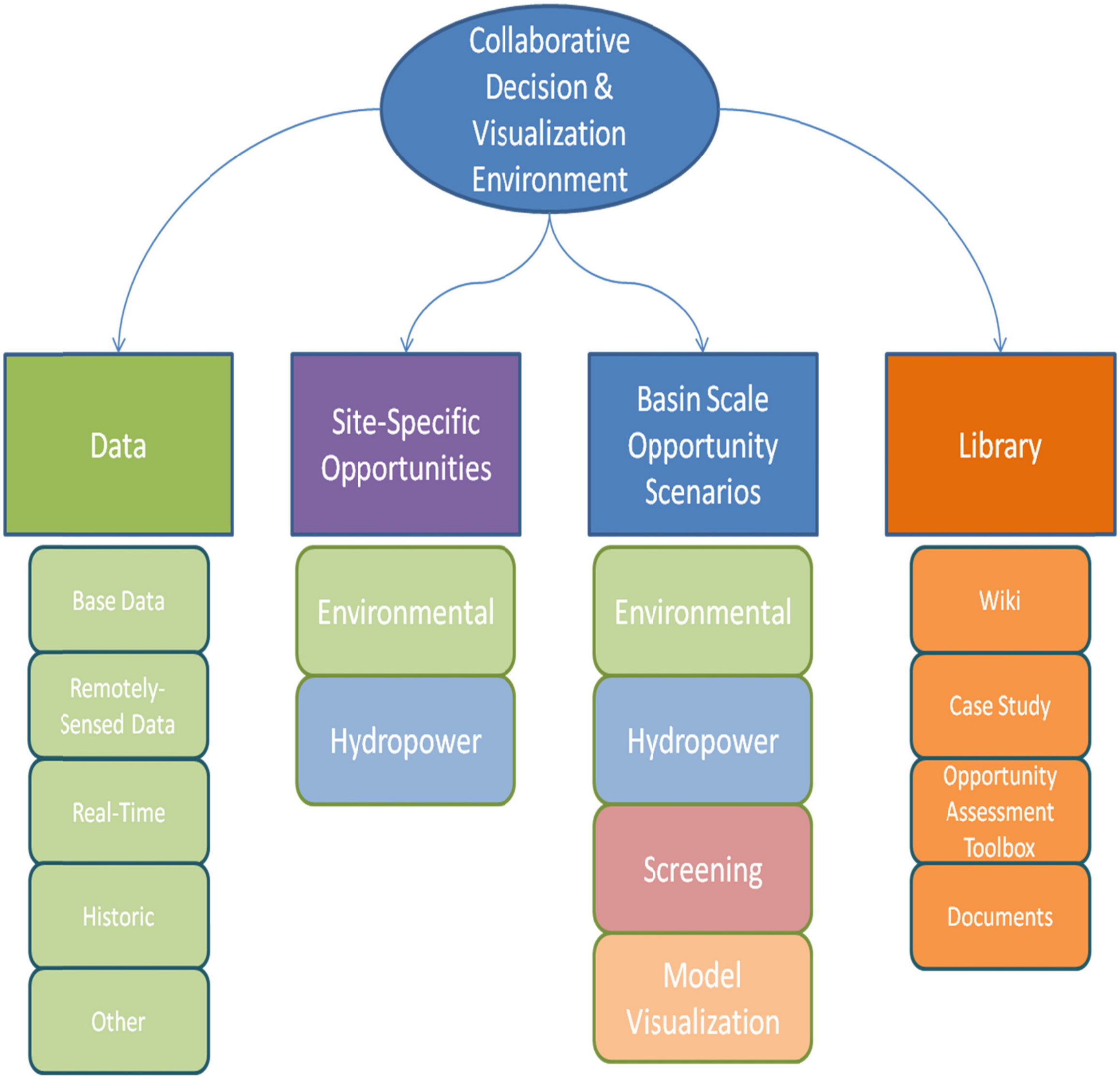

Figure 5.5. The Conceptual Design of the Collaborative Visualization and Decision Support Environment Provides Multiple Dimensions to Evaluate and/or Analyze Static and Dynamic Basin Features and Phenomena, Opportunities at the Site and Basin Scale, Stakeholder Decisions, Model Results, Public/Stakeholder Wiki, and Supporting Document Library

- The "Library" module will also function within the main collaborative visualization and decision support environment providing access to several types of information including 1) a Wiki page that provides a collaboration and information environment for stakeholders, researchers, and others; 2) details of the current case study; 3) access to the comprehensive set of tool and model descriptions in the Basin-Scale Opportunity Assessment Toolbox; and 4) an indexed and searchable document library providing easy access to the compendium of research articles and other documents that are relevant to the basin.

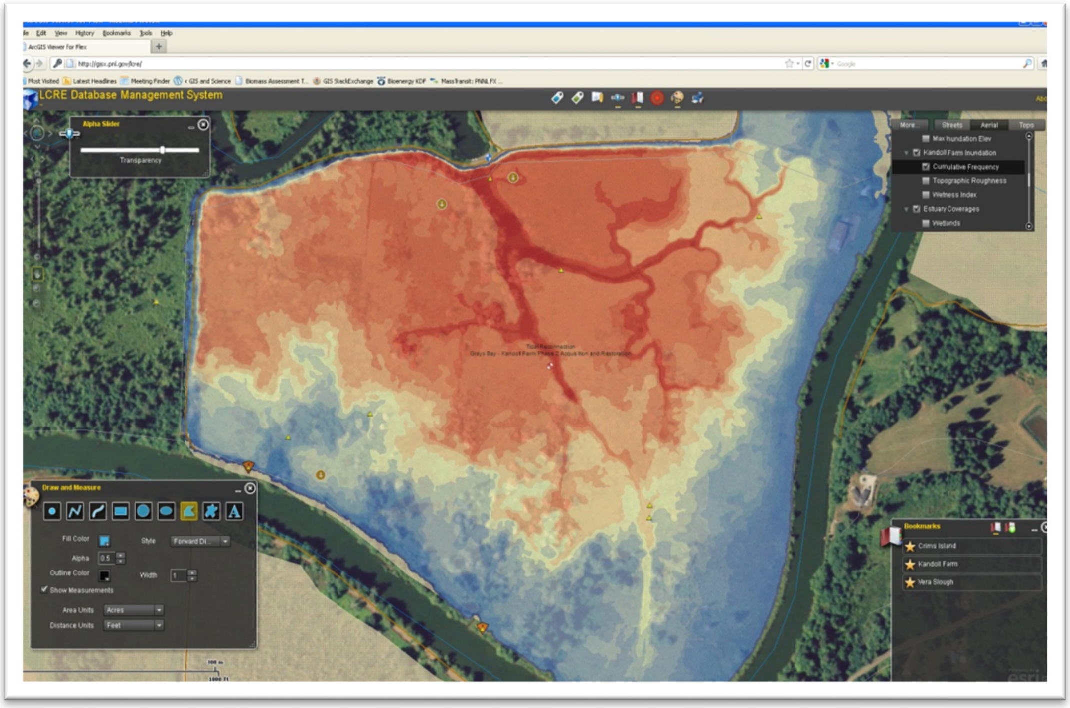

Figure 5.6. Example of a Web-Based Interactive Mapping System Similar to What Is Designed for the Collaborative Visualization and Decision Support Environment. The user has control to display an array of data layers, query the tabular data associated with the geographic features, and perform key analysis functions.

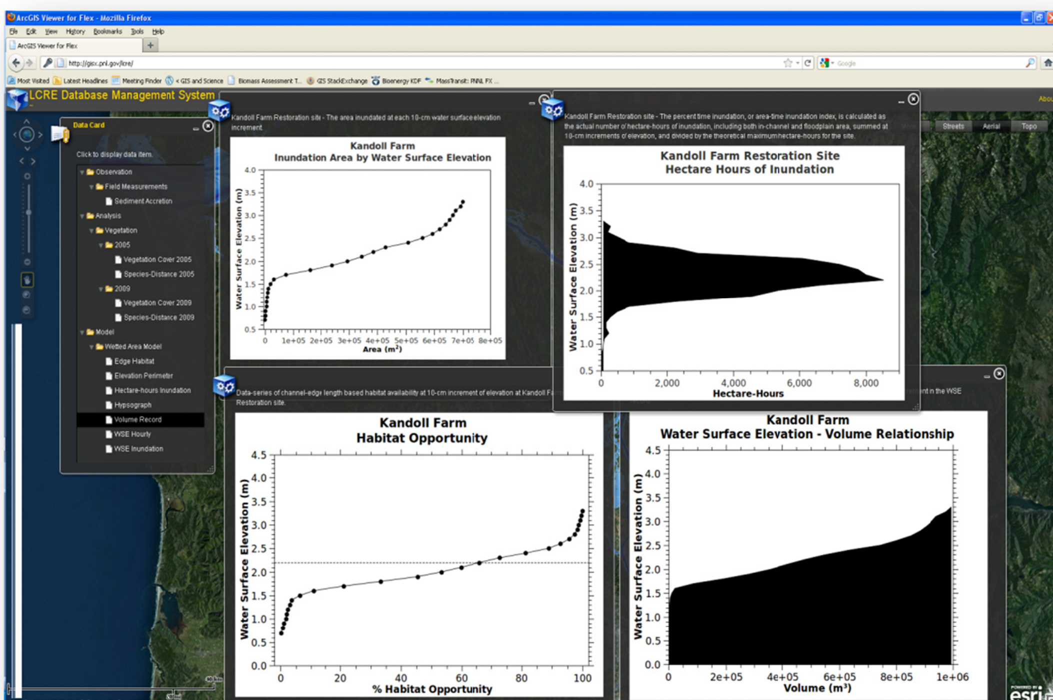

Figure 5.7. Example of a Web-Based Interactive Mapping System Similar to What Is Designed for the Collaborative Visualization and Decision Support Environment. The user has the ability to query and/or perform various analyses that are tied to specific geographic features.

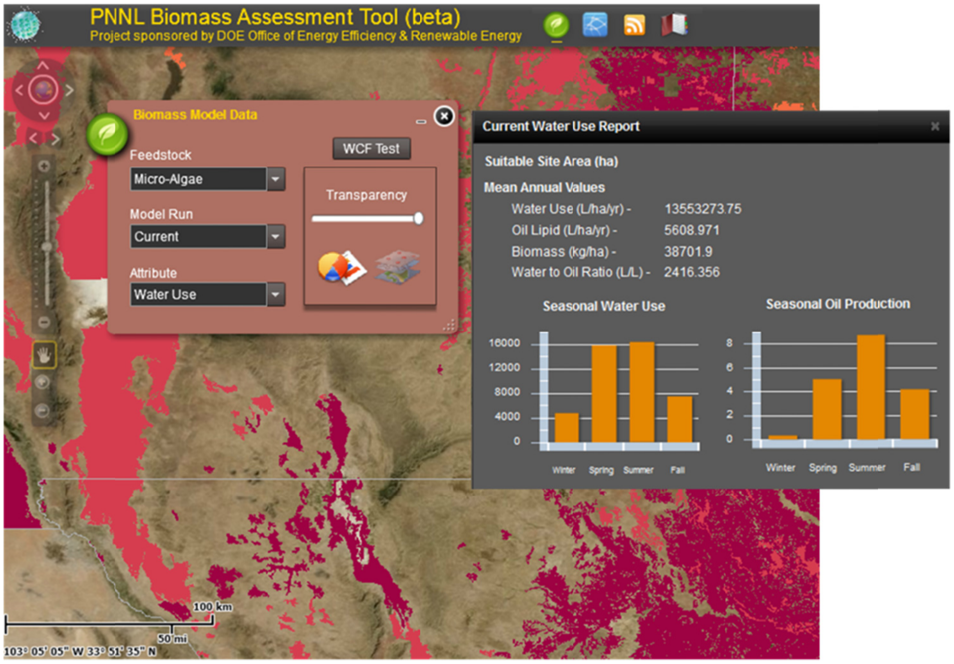

Figure 5.8. Example of a Web-Based Interactive Mapping and Analysis System That Provides Reusable Components for the Collaborative Decision and Analysis Environment

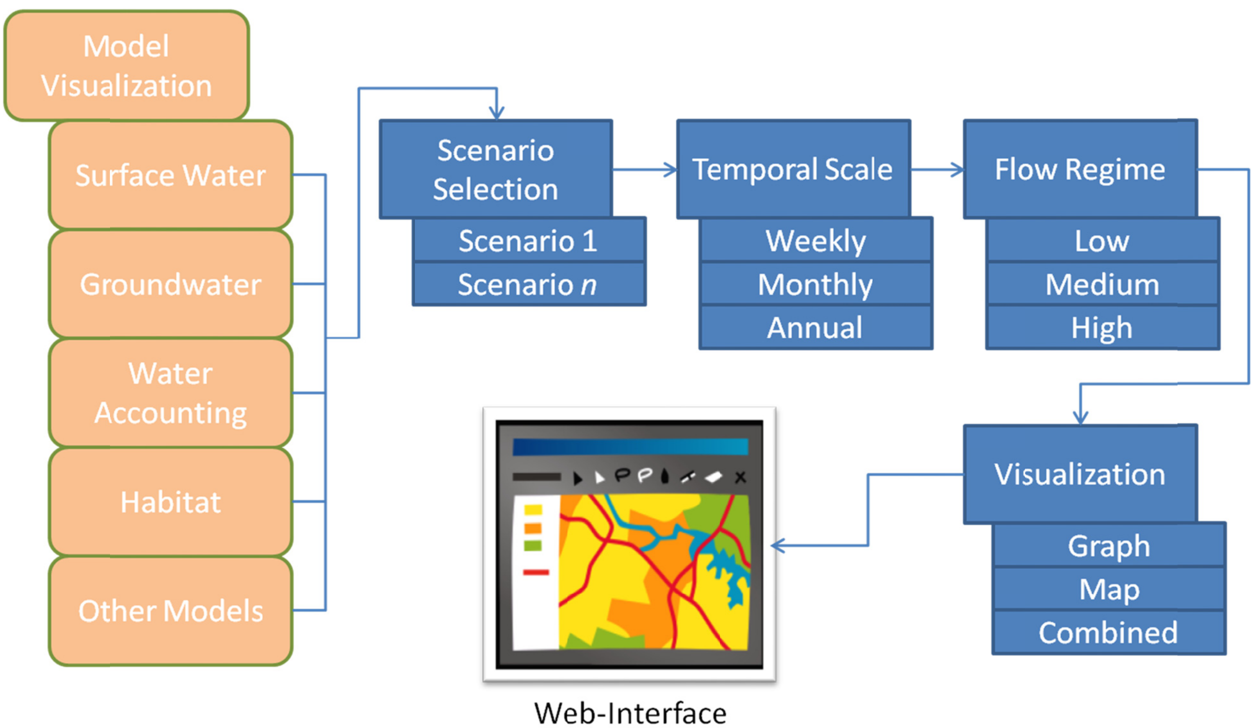

Figure 5.9. The Conceptual Workflow for the "Model Visualization" Module Within the "Basin Scale Opportunity Scenarios." This module allows the user to select specific numerical models, scenarios, timeframes, flow regimes, and visualization method to explore modeling results.

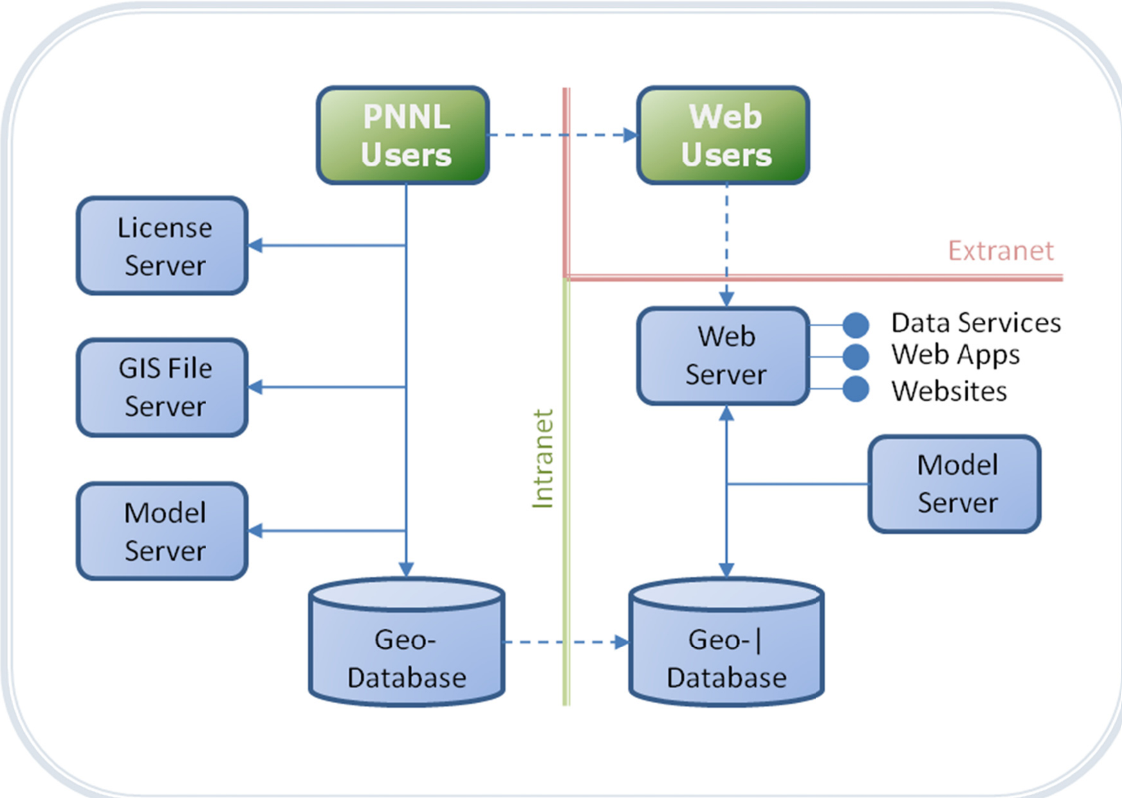

Figure 5.10. The PNNL GIS "Pipeline." It provides a robust architecture capable of coupling numerical models and integrating these results, as well as traditional spatial data sets, into an enterprise geospatial database that is served to the web via an interactive website and data services (directly consumable data via other software using OpenGIS compliant standards).

5.7.2 Technical Approach

To deliver a collaborative environment that supports a basin-scale opportunity assessment, state-of-the-art geoinformatics tools will be integrated in a coherent system. The system will include a relational geospatial database, spatial modeling and analysis tools, and web-based visualization technology. This environment will be built upon an existing and robust web architecture (commonly referred to as the "PNNL GIS Pipeline") based on the ArcGIS Server and a series of commercial and open-source enterprise-level tools, to distribute geospatial data and linked model results as both a web application and web data services available to users on the web (see Figure 5.10). The web interface will be located on a public web server controlled by PNNL and will be developed using the Adobe Flex open-source framework. The current design architecture is modular and dynamic in order to support the addition of updated or new data sets and models.

5.7.3 Conclusion

The collaborative visualization and decision support environment will provide a robust structure to capture, archive, and deliver the information needed to support comparison of scenarios. It will make that information easily available to non-technical users and will provide the metrics that are of interest to all parties. By providing an accessible set of information that enables shared understanding, this environment strives to facilitate discussion among stakeholders about whether the scenarios provide an acceptable mix of costs and benefits.

5.8 Ensure Stakeholder Collaboration in Technical Activities

As discussed in Section 2.3, stakeholder collaboration is critical for this opportunity assessment because the stakeholders 1) are most familiar with the Deschutes and Crooked river basins and with previous and ongoing assessment and planning efforts in the basins; 2) are most familiar with the potential opportunities and needs for additional information and research in the basins; 3) live and work in the basins, and thus have a direct interest in the results of the opportunity assessment; and 4) will decide whether and how to pursue any of the opportunities identified once the project team has completed its opportunity assessment.

In FY 2011, the project team took a number of steps to begin engaging stakeholder organizations in the Deschutes and Crooked river basins. First, the team identified relevant stakeholder organizations and began to map their interests, roles, and responsibilities within the basins. The team then organized and began to engage with a local logistics committee—the In-Basin Logistics Committee or Logistics Committee—that represents a cross-section of stakeholder organizations (see Section 2.2). The local Logistics Committee helped further refine the list of stakeholder organizations. Next, the project team worked with the local logistics committee to plan and conduct a site visit so that members of the project team members could become more familiar with the basins and begin to interact with representatives of some of the stakeholder organizations (Section 2.3). After the site visit, the project team worked with a professional facilitator (Kearns & West) to design and conduct telephone interviews with a cross-section of the stakeholder organizations to identify preliminary lists of potential opportunities and needs for additional information and research (Section 2.4). Finally, the project team worked with Kearns & West to plan and conduct a stakeholder workshop in Bend, Oregon, in July 2011. This workshop, which used the telephone interview results to prompt discussion, identified a suite of potential opportunities and needs for additional information and research (Section 2.5). Stakeholders invited to the workshop were asked to review and suggest revisions to the draft Workshop Report, and in FY 2012 they will be asked to review and suggest revisions to this Preliminary Draft Opportunity Assessment Report.

5.8.1 Technical Approach

In FY 2012, the project team will continue to map and engage with the stakeholder organizations as the opportunity assessment proceeds. Three goals of the continued mapping and engagement are to 1) understand the roles, responsibilities, and constraints associated with stakeholder organizations, particularly focusing on underlying authorities and policies that govern each organization's operations and decision-making and requirements for effecting changes in authority or policy; 2) convey this information to stakeholders systematically in an at-a-glance reference guide format; and 3) identify the information and "products" stakeholder organizations need from the project team to pursue any opportunities identified in the opportunity assessment.

Mapping and engagement in FY 2012 will be an ongoing process that will rely on communication among the project team and stakeholder organizations via the opportunity assessment website, e-mail messages, and telephone interviews. The team will also explore alternative ways to encourage focused, productive interactions among team members and stakeholders, including online webinars and Live Meetings. The team also will conduct at least one stakeholder workshop in Bend, Oregon, to solicit stakeholder feedback on this FY 2011 Preliminary Draft Opportunity Assessment Report and products of the Opportunity Assessment. If additional funding is available, a second workshop could be held to present the results of the FY 2012 Draft Opportunity Assessment Report and to solicit stakeholder feedback in preparing the FY 2012 Final Opportunity Assessment Report and any associated products. The team will prepare a stand-alone report on stakeholder identification and mapping, which will be incorporated into the larger Deschutes BSOA report, the final deliverable of the FY 2012 pilot test for the BSOA Initiative.

6.0 Conclusions and Next Steps

This report presents mid-project progress for the BSOA Initiative. It documents FY 2010 and FY 2011 project activities since the March 24, 2010, sustainable hydropower MOU between DOE, the BOR, and the Corps; describes the opportunity assessment approach; presents preliminary results from the Upper Deschutes/Crooked River opportunity assessment pilot study; and charts a course for integrated analysis of opportunity scenarios in collaboration with basin stakeholders in FY 2012.

During FY 2011, the project team moved from national-scale visioning activities into the tangible and specific challenges of a basin-scale pilot opportunity assessment. Through this process, we have developed a fuller sense of the potential benefits and limitations of the BSOA Initiative. There is no one-size-fits-all formula for a successful opportunity assessment; the challenge is to maintain a clear view of national goals, use a defined but flexible approach, and be willing to adapt and tailor assessment activities to provide value to stakeholders in the assessment basin.

Stakeholders in the Deschutes River Basin have been tremendously generous with their time and resources, working side-by-side with the project team to inform assessment activities; define needed work products; share opportunities, insights, data, and information; and provide space and resources for site visit and workshop activities. Without this support, it is doubtful we would have been able to achieve our FY 2011 work plan goals and the national goals of the BSOA Initiative as articulated in the MOU. Continued stakeholder support depends on the ability of the project team to deliver useful information products that add value to the hydropower/environmental/water-use discussions already occurring in the Deschutes Basin.

The project team recognizes that it is **not** its job to "solve the problems" of the Deschutes River Basin—a tremendous amount of existing energy and capacity in the basin is already being applied to address hydropower/environmental/water-use issues. The potential benefit of our work is to provide a neutral forum where creative opportunities can be discussed, data and information from multiple parties can be aggregated and integrated, and additional resources can be leveraged to build modeling and analysis tools that can catalyze dialog about opportunity scenarios. The results of the opportunity analysis will not be a decisional document or plan, but rather a portfolio of options and the means to understand how they relate to the values that are important in the basin.

The project team also recognizes that the success of the BSOA Initiative and continued federal support depends upon the team's ability to learn from the pilot basin and apply that knowledge to meeting national goals for integrated assessment of hydropower and environmental opportunities. This drives activities such as the Basin-Scale Opportunity Assessment Toolbox, development of a basic assessment approach, selection of modeling tools that can be applied in other basins, and the "rapid assessment" timeframe of the Deschutes pilot study. As in the case of the Deschutes River Basin, future opportunity assessments have to balance both local and national audiences and goals.

Subject to the availability of funds, in FY 2012, we plan to continue pilot assessment activities in the Deschutes River Basin and carry out the research plan described in Chapter 5.0. Figure 6.1 diagrams the four phases of the pilot study. In FY 2011, we completed Phase 1 and began Phase 2. In FY 2012, we will continue with iterative aspects of stakeholder interaction in Phase 2, and focus resources on completing Phases 3 and 4. As Figure 6.1 shows with multiple arrows between Phases 2, 3, and 4, stakeholder input and collaboration will be sought at all project phases through the collaborating bodies described in Chapter 2.0.

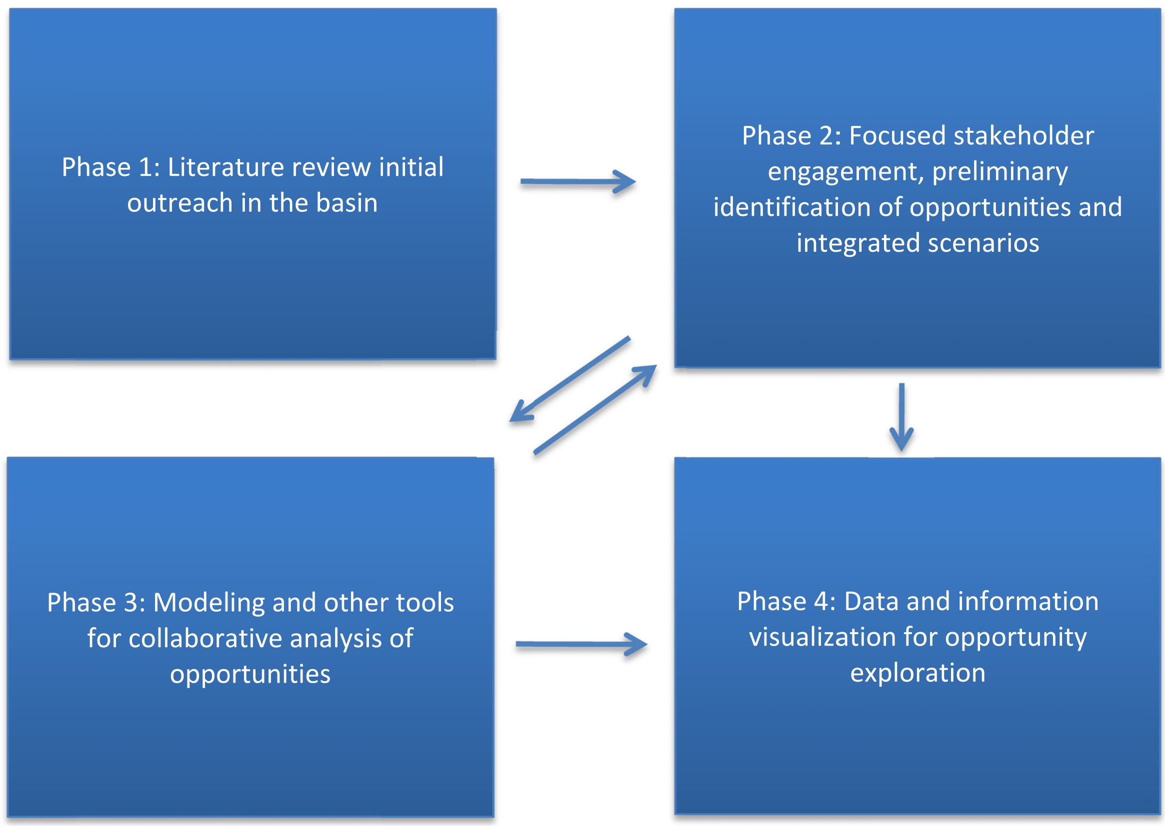

Figure 6.1. Four Phases of the Deschutes Pilot Study

The first activity for FY 2012 is stakeholder review of this report and feedback on the proposed research plan in Chapter 5.0. A workshop in late November/early December is being planned to solicit feedback.

Upon completion of assessment activities in the Deschutes River Basin in FY 2012, the project team will work with MOU agencies and the Steering Committee to select additional basins for opportunity assessments in FY 2013.

In conclusion, the Basin-Scale Opportunity Assessment Initiative has established a vision, built strong working relationships with stakeholders in the pilot test basin, developed a solid technical approach and analytical toolbox, and successfully started the pilot assessment in the Deschutes River Basin. The BSOA effort is on track to complete the first-ever BSOA by the end of FY 2012, fulfilling an objective of the Sustainable Hydropower MOU to increase generation of renewable energy while enhancing environmental conditions and protecting irrigation and municipal water supplies and other resource uses.

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Appendix A

Denver Methodology Workshop Agenda and Summary

Appendix A

Denver Methodology Workshop Agenda and Summary

Basin-Scale Opportunity Assessment Initiative
Goals, Process, Methodologies and Products Workshop
September 8 and 9, 2010
Golden, Colorado

Introduction

As stated in the March 2010 Memorandum of Understanding for Hydropower between the Department of Energy, Bureau of Reclamation, and the Army Corps of Engineers, the purpose of conducting Basin-Scale Opportunity Assessments is to "identify river basins where renewable power generation and environmental sustainability could both be increased, with appropriate consideration of other values." Following signing of the MOU, a Basin-Scale Opportunity Assessment Steering Committee was formed consisting of members from the environmental community, the hydropower industry, and signatory agencies. Over the past several months, this Steering Committee has worked to scope the initiative; a key initial task identified in this scoping process was a workshop to solicit expert opinion on the goals, process, methods, and products that will guide basin-scale opportunity assessments.

We have three primary objectives for this workshop:

1. *Vision for success.* At this early stage in the Basin-Scale Opportunity Assessment Initiative (the Initiative), participating agencies and organizations are working to define successful outcomes within the context of their own missions. Articulating a vision for success and receiving feedback from workshop participants is a primary goal of this workshop.

2. *Stakeholder engagement.* Based on experience from basin-scale collaborations to date, successful engagement with stakeholders will play an essential part in meeting Initiative goals. Therefore, through this workshop we seek to improve our understanding of methods for effective stakeholder engagement and to gain insights into how these opportunity assessments can meet stakeholder needs.

3. *Technical approaches and products.* Finally, we expect basin-scale opportunity assessments to be data and information intensive activities, and with this workshop we hope to gain a better understanding of the products (i.e., reports, databases, maps, etc.) basin-scale assessments must deliver to be successful.

This workshop seeks to *begin* answering these questions through presentations by and discussions among the Steering Committee members and invited experts. This is the first opportunity to share and receive input on Basin-Scale Opportunity Assessment activities with an audience beyond the Steering Committee, and an opportunity to begin expanding the Initiative to a larger community.

Day 1 Agenda

Workshop Facilitator: Erik Swanson, American Public Lands Exchange, Co.

Morning Session: Visions and a Process for Success for the Basin Scale Opportunity Assessment Initiative.

8:00 **Continental Breakfast, Denver Marriot West, Salons F, G and H**

8:15 – 8:30 Introductions, Workshop Logistics, Agenda Review– Erik Swanson

8:30 – 8:45 Welcome and Overview of Overview of Basin-Scale Initiative—Alejandro Moreno, DOE; Kamau Sadiki, US Army Corps of Engineers; Dave Sabo, Bureau of Reclamation

8:45 – 10:15 Defining Success and Goals for the Integrated Basin Scale Opportunity Assessment Initiative—Basin-Scale Opportunity Assessment Steering Committee

- Federal Steering Committee Partners—20 minutes
- Environmental NGO Steering Committee Partners—20 minutes
- Hydropower Industry Steering Committee Partners—20 minutes
- Discussion—30 minutes

10:15 – 10:30 **Coffee/Tea Break**

10:30 – 12:00 Background Case Studies: Presentation and panel discussion from two basins where hydropower and environmental goals were pursued collaboratively. What worked in the process and how were stakeholders engaged? What analytical tools were necessary? What were the key outcomes from each case?

- Session Chair: Jeff Opperman, The Nature Conservancy
- Penobscot—30 Minutes
  - Jeff Reardon, Trout Unlimited
  - Scott Hall, Black Bear Hydro
- Clark Fork—30 Minutes
  - Chip Corsi, Idaho Department of Fish and Game
  - Tim Swant, Avista
- Discussion—30 minutes

12:00 – 1:15 **Lunch on your own** (There are a number of options within walking distance of the conference center and there is also a restaurant in the hotel itself)

Day 1: Afternoon Session: Engaging Stakeholders and Break Out Discussions.

1:15 – 2:45 Engaging Stakeholders in Opportunity Assessments. Panel discussion—tools, methodologies, best practices for stakeholder engagement and negotiation.

- Session Chair: Fred Ayer, Low Impact Hydropower Institute
- Hal Cardwell, US Army Corps of Engineers—15 minutes
- Berton Lee Lamb, Negotiation Guidance Associates—15 minutes
- Anna West, Kearns and West—15 minutes
- Julie Keil, Portland General Electric—15 minutes
- Facilitated discussion—30 minutes

2:45 – 3:00 **Snack Break**

3:00 – 4:30 **Breakout Session 1**

Purpose: To discuss process barriers (regulatory, social, coordination) and tools to overcome those barriers to meet the goals the initiative. **(See separate attachment describing breakout session for more detail)**

Discussion Topics:

1. **Process Barriers to Working across the Basin Scale:** What are the key process barriers (regulatory, social, coordination, etc.) to a basin-wide approach to hydropower assessment and planning? What impedes coordination and collaboration across scales greater than the project scale?

2. **Overcoming Barriers with Existing Tools and Current Best Practices:** What tools and methods are available to overcome these barriers—what processes or approaches have worked well in the past to engage stakeholders and move past process barriers in basin scale analyses?

3. **New Approaches or Tools:** Are new tools and approaches needed to overcome barriers?

4:30 – 5:10 Report out and discussion from breakout groups

5:10 **Adjourn for the Day**

Day 2 Agenda

Morning Session: Analytical Products and Deliverables.

8:00 **Continental Breakfast**

8:30 – 10:00 Delivering information products for analysis of environmental and hydropower opportunities. Panel discussion—Existing and planned information products to drive analyses at the basin scale. And importantly, how do these products integrate with the existing regulatory process and guide decision making?

- Session Chair: Mike Sale, M.J. Sale & Associates
- Chuck Howard, CDD Howard: **Tools to Analyze and Understand the Value of Hydropower Resources in River Basin Opportunity Assessments** —15 minutes
- Brennan Smith, Oak Ridge National Lab: **DOE Water Power GIS Database and other Renewable Energy Knowledge Management Tools** —15 minutes
- Alexa McKerrow, USGS GAP Program: **The National Biological Information Infrastructure and GAP Analysis Programs—Data Sets and Tools for Ecological Analysis**—15 minutes
- Rick Skaggs, Pacific NW National Lab: **Integrated Resource Assessment to Consider Future Basin Conditions and Water Availability**—15 minutes
- Facilitated discussion—30 minutes

10:00-10:15 **Coffee/Tea Break**

10:15 – 11:45 **Breakout Session 2**

Purpose: Discuss analytical tools, products, and deliverables needed to meet goals of this initiative. **(See separate attachment describing breakout session for more detail)**

Discussion Topics

1. **Data and Information Needs:** What are the key data and information needs to assess hydropower and environmental opportunities at the basin scale? Are these data currently available and accessible? Are there areas where we have major gaps?

2. **Existing Tools and Information Products:** What existing tools and products are available to meet data and information needs?

3. **Necessary New Tools and Information Products:** What new information products, analytical tools, or syntheses are necessary to understand and communicate opportunities to improve both hydropower and environmental conditions within a river basin?
4. **Effective use of Tools and Information Products:** How can we tailor analytical tools to be most effective meet the needs of regulators and stakeholders?

11:45 – 12:30 Report out and discussion from breakout groups

12:30 – 1:45 Lunch on your own

Day 2 Afternoon Session: Conclusions and Next Steps – Bringing It All Together

1:45 – 3:15 Facilitated Round table Discussion: Erik Swanson

- Revisit workshop objectives—Are goals achievable, can we effectively engage stakeholders in opportunity assessments, and is there a clear understanding of the analytical products we need to deliver to meet hydropower and environmental goals within a given basin?

- How can basin-scale opportunity assessments best integrate in to and provide value to future planning activities being carried out by stakeholders in a given basin?

- Opportunity assessment pilot study—At this time, is a pilot study a feasible next step? If so, how can we best structure a pilot? If not, what is the appropriate next step?

- Final thoughts from workshop participants.

3:15 **Adjourn**

Basin-Scale Opportunity Assessment Initiative
September 8 and 9, 2010
Golden, Colorado

Meeting Summary

Introduction

As stated in the March 2010 Memorandum of Understanding for Hydropower between the Department of Energy, Bureau of Reclamation, and the Army Corps of Engineers, the purpose of conducting Basin-Scale Opportunity Assessments is to "identify river basins where renewable power generation and environmental sustainability could both be increased, with appropriate consideration of other values." Following signing of the MOU, a Basin-Scale Opportunity Assessment Steering Committee was formed consisting of members from the environmental community, the hydropower industry, and signatory agencies. Over the past several months, this Steering Committee has worked to scope the initiative; a key initial task identified in this scoping process was a workshop to solicit expert opinion on the goals, process, methods, and products that will guide basin-scale opportunity assessments.

This workshop was held September 8 and 9th in Golden, Colorado, and was attended by 50 participants representing a mix of the hydropower industry, environmental NGOs, science and research community, and federal agencies with a role in hydropower planning.

The workshop consisted of formal and informal presentations followed by facilitated discussion and breakout groups. These notes summarize major points from the presentations and capture key discussion points. Notes from the two breakout groups are also included (two breakout sessions, three groups each session). Rather than reconstruct a blow-by-blow based on the workshop agenda, this workshop summary is organized around the workshops' three major objectives:

1. *Vision for success.* At this early stage in the Basin-Scale Opportunity Assessment Initiative (the Initiative), participating agencies and organizations are working to define successful outcomes within the context of their own missions. Articulating a vision for success and receiving feedback from workshop participants is a primary goal of this workshop.

2. *Stakeholder engagement.* Based on experience from basin-scale collaborations to date, successful engagement with stakeholders will play an essential part in meeting Initiative goals. Therefore, through this workshop we seek to improve our understanding of methods for effective stakeholder engagement and to gain insights into how these opportunity assessments can meet stakeholder needs.

3. *Technical approaches and products.* Finally, we expect basin-scale opportunity assessments to be data and information intensive activities, and with this workshop we hope to gain a better understanding of the products (i.e., reports, databases, maps, etc.) basin-scale assessments must deliver to be successful.

Workshop participants explored the definition of success for basin-scale opportunity assessments during the morning of day one. Members of the Basin-Scale Opportunity Assessment Steering Committee each had an opportunity to voice the goals of the initiative from the perspective of their own agency or interest group.

Alejandro Moreno, Team Lead for the DOE Water Power Team, led off the workshop by explaining the background behind the basin-scale opportunity assessment initiative. The concept of opportunity assessments arose from DOE conversations with both the hydropower industry and environmental non-governmental organizations (NGOs) centered around improving the sustainability of hydropower—In separate conversations, both industry and NGOs voiced support for DOE-supported analyses at the basin, or "system" scale, focused on identifying improvements in hydropower and environmental conditions within a given river basin. Basin-scale planning exercises in the Penobscot Basin and in other FERC relicensing activities had shown that collaboration and detailed analysis could produce "win-win" outcomes for both hydro and environmental conditions when planning scales were expanded beyond the project scale to consider the basin as an entire system. Both industry and NGOs saw benefits in a "win-win" analytic frame and were interesting in exploring tools and processes to investigate opportunities in a pro-active manner.

In early 2010, the idea of basin-scale opportunity assessments coalesced around applying agency, NGO, and industry analysis and collaborative tools to identify a suite of opportunities to achieve the twin goals of increasing hydropower generation and improving environmental conditions within a river basin. Opportunity assessments were envisioned as **separate from planning**—the value of an opportunity assessment is to proactively examine environmental and hydropower opportunities and to produce an **assessment** that can be used by basin stakeholders to **inform** future planning exercises.

Early in 2010, DOE organized a Steering Committee consisting of a small number of individuals who had initiated discussions of basin-scale opportunity assessments—this initial Steering Committee consisted of the following individuals:

- Jeff Leahy and Linda Church Ciocci, National Hydropower Association
- Jeff Opperman, the Nature Conservancy
- Richard Roos Collins, National Heritage Institute and Hydropower Reform Coalition
- Fred Ayer, the Low Impact Hydropower Institute.

At the same time that ideas were forming on basin scale opportunity assessments, DOE, the U.S. Army Corps of Engineers, and the Bureau of Reclamation were in discussions about formalizing a Memorandum of Understanding in support of sustainable hydropower. Basin-scale opportunity assessments were seen as one tool to investigate sustainable hydropower opportunities and were included in the MOU as a specific action item. In early February the Bureau and the Corps joined the Basin-Scale Steering Committee:

- Kamau Sadiki and Lisa Morales, US Army Corps of Engineers
- Dave Sabo, Kerry McCalman, U.S. Bureau of Reclamation
- Lori Caramanian, Department of Interior.

Soon thereafter, two additional members were added to include further input from industry and the environmental community:

- John Seebach, American Rivers
- Julie Kiel, Portland General Electric.

In the months leading up to this workshop, the Steering Committee met by phone and in person regularly to scope the initiative, investigate potential pilot studies, plan the content of this and future workshops, and develop outreach materials. The Steering Committee will continue to serve a guiding role, but recognizes the need to seek input from a larger community—input from participants at this workshop will be helpful in refining the initiative's scope, assessing the relevance of its goals, and targeting activities to benefit stakeholders within river basins.

Following Alejandro's remarks, Steering Committee members were asked articulate their vision for success of the basin-scale opportunity assessment initiative, and to consider the five following questions in preparing their remarks:

1. What is your organization's vision for Integrated Basin-Scale Opportunity Assessments?
2. How might your organization define "success" with regard to Integrated Basin-Scale Opportunity Assessments?
3. What does your organization need to view its participation in Integrated Basin-Scale Opportunity Assessments as a success?
4. What, from the standpoint of your organization, would be unacceptable or should be avoided with regard to Integrated Basin-Scale Opportunity Assessments?
5. What does your organization see as the key barriers or constraints that may inhibit the achievement of successful Integrated Basin-Scale Opportunity Assessments

Themes that emerged from this session and following discussion included the following:

Success:

- Focus on identifying opportunities to increase hydropower generation and improve the health of river basins—both goals have equal footing, and all options need to be on the table in the analysis.

- Think beyond generation to articulate the ancillary values of hydropower—must also understand the context of other important river uses.

- Collaboration is essential—this is not just a federal activity, it needs to also address information needs of private developers looking to site at federal facilities and potentially investigating new small-scale hydropower. Stakeholders need to have ownership for the process. There is an art in balancing the broad range of values apparent in any collaborative river basin project.

- Deliver worthwhile products and methodologies that are helpful to stakeholders—Opportunity assessments must address the needs of basin stakeholders and deliver timely information that can inform (but not dictate) decision-making.

- Identify opportunities that encourage development of hydropower in a sustainable way and recognize the need to improve the health of our rivers.

- Look to successful examples of basin-scale planning; tailor opportunity assessments to support future similar activities.

- Add value to the FERC process, without changing or interfering with it.

- Opportunity assessments could elevate the profile of hydropower within agencies and provide information to build political support for taking on big challenges.

Challenges:

- Convincing industry and environmental interests within a given basin that opportunity assessments will benefit them.

- Recognizing and appreciating the risks involved in opportunity assessments, from the standpoint of industry and agencies. Need to ensure that assessments don't lead to site banking, delay ongoing processes, or lead to unfunded mandates.

- Avoiding scope creep—staying true to the environmental and hydropower goals of this Initiative, while recognizing the need to understand the context of other basin uses and interests.

Things to Avoid:

- Take care that opportunity assessments do not interfere with local processes already underway—need to work with collaboratively with stakeholders and be sensitive to the potential impacts that assessments might have within the basin.

- Opportunity assessments can't dictate or impose new requirements—participation is voluntary and opportunities identified in assessments can't be viewed as requirements.

- Avoid adding further complexity to already complex regulatory and planning processes.

- Don't let the perfect be the enemy of the good—Waiting until we have the perfect tools, and perfect process may delay action and miss opportunities. Need to get started now within a test basin and refining the approach over time.

Big Picture:

- Need to get started—Climate change will require that we increase the share of renewables in our energy portfolio—hydro is and will be a big part of this.

- Success of basin-scale opportunity assessments, and sustainable hydropower in general comes down to will, time, and money. If assessments can be carried out in a collaborative way, a timely manner, and if money is available they can serve to advance energy and environmental solutions for river basins.

- Understand the advantages of analysis at complex systems scales: The more complex the system, larger the scale of analysis, the more likely you are to identify new opportunities for both hydro and environmental improvement. Basin scale may not be sufficiently large for all types of analysis. **But**, at the same time pragmatism is important, too, especially for demonstration projects—select initial case studies that are **solvable**.

- Recognize that many tools already exist and use those tools and existing expertise—also recognize that good vision and process are as important as good tools: “Good carpenters build good houses.”

Appendix B

Deschutes Basin Workshop Agenda and Report

Appendix B

Deschutes Basin Workshop Agenda and Report

DESCHUTES RIVER BASIN-SCALE OPPORTUNITY ASSESSMENT COMMUNITY STAKEHOLDER WORKSHOP
July 25-26, 2011 MEETING SUMMARY

Workshop Attendees	
Leslie Bach Director, Freshwater Programs The Nature Conservancy	Bonnie Lamb Deschutes Basin TMDL Coordinator Oregon Department of Environmental Quality
Scott Boelman Bend Field Office Manager U.S. Bureau of Reclamation	Peter Lickwar Fish and Wildlife Biologist U.S. Fish & Wildlife Service
Rod Bonacker Special Projects Coordinator U.S. Forest Service	Emily McGrath Project Coordinator Kearns & West, Inc.
Don Boyer Board Member Three Sisters Irrigation District	Kate Miller Legal Analyst, Pacific Salmon and Steelhead Office Trout Unlimited
Mike Britton Manager North Unit Irrigation District	Dave Newton Engineering Consultant Newton Consulting
Jerry Brummer City of Prineville	Debra Nudelman Vice President, Senior Mediator Kearns & West, Inc.
Scott Carlon Fisheries Biologist NOAA Fisheries	Rich Pastor Hydrologist, Prineville District Bureau of Land Management
Joyce Casey Branch Chief, Environmental Resources US Army Corps of Engineers	Kimberley Priestley Senior Policy Analyst WaterWatch
Tom Davis River Steward Native Fish Society	Mike Riehle Fishery Biologist U.S. Forest Service
Thayne Dawson Board Member Three Sisters Irrigation District	Betty Roppe Mayor City of Prineville

Nancy Doran Assistant HydroPower Program Coordinator Oregon Department of Fish & Wildlife	Bo Saulsbury Senior Research Staff Oak Ridge National Laboratory
Robin Estes OR/WA BLM FERC Coordinator Bureau of Land Management	Bill Seitz Conservation Central Oregon Fly Fishers
Simon Geerlofs Marine Science and Policy Analyst Pacific Northwest National Laboratory	Brennan Smith Water Resources Engineer, Environmental Sciences Division Oak Ridge National Laboratory
Kyle Gorman South Central Regional Manager Oregon Water Resources Department	Jerry Tagestad Geospatial Analyst Pacific Northwest National Laboratory
Patrick Griffiths Water Resources Coordinator City of Bend	Marc Thalacker Manager Three Sisters Irrigation District
Jason Gritzner Forest Hydrologist – Deschutes/Ochoco Watershed Program Leader US Forest Service	Mike Tripp Conservation Chair Deschutes Trout Unlimited
Kenneth Ham Pacific Northwest National Laboratory	Tom Veselka Hydropower Expert/Energy System Engineer Argonne National Laboratory
Tim Hanrahan Research Scientist, Hydrology and Aquatic Biology Pacific Northwest National Laboratory	Megan Vinett Associate Kearns & West, Inc.
Tod Heisler Executive Director Deschutes River Conservancy	Nathalie Voisin Hydrology ad Water Resources Modeling Pacific Northwest National Laboratory
Ken Homolka Hydropower Program Leader Oregon Department of Fish and Wildlife	Anna West Principal, Senior Mediator Kearns & West, Inc.
Angela Jacobson Manager Pacificorp/Pacific Power	Dawn Wiedmeier Deputy Area Manager Bureau of Reclamation
Steve Johnson District Manager Central Oregon Irrigation District	Ted Wise High Desert Region Hydropower Coordinator Oregon Department of Fish & Wildlife
Gary Johnson Pacific Northwest National Laboratory	Amy Wolfe Leader, Society-Technology Interactions Group Oak Ridge National Laboratory
Mike Kasberger District Manager Ochoco Irrigation District	
Julie Keil Director, Hydro Licensing and Water Rights Portland General Electric	

Action Items	Who	When
1. Develop action items and meeting summary; distribute to stakeholders; clarify lead for stakeholder communications.	Kearns & West/Project Team	August 19, 2011
2. Stakeholders review, redline strikeout comments on action items and meeting summary.	Kearns & West/Project Team	August 26, 2011
3. Develop and distribute Preliminary Draft Opportunity Assessment Report, including the research plan to Stakeholders.	Project Team/Local Logistics Committee	August – October 1, 2011
4. Review and Provide Feedback on Preliminary Draft Opportunity Assessment Report.	Deschutes River Basin Stakeholders	October – November
5. Provide periodic updates to all stakeholders via website, e-mails, etc.	Project Team	As needed
6. Notify stakeholders when the website is established.	Project Team	August 31
7. Hold proposed meeting date of November 9, 2011 to review Preliminary Draft Opportunity Assessment Report.	All	ASAP

Meeting Objectives

- Understand the purpose of the Basin-Scale Opportunity Assessment Initiative, nationally and in the Deschutes River Basin.
- Identify opportunities for increasing hydropower generation, improving the environment, while also protecting water supply for agriculture and municipal purposes, recreation, flood management, and other values important to the Basin.
- Identify additional research and analysis needed to achieve these opportunities in the Deschutes River Basin.

Meeting Summary

I. Introduction

- Simon Geerlofs opened the Workshop by expressing appreciation to all for attending, introducing the Project Team and facilitation team, and reviewing the Workshop objectives. He also thanked Julie Keil and Portland General Electric for their help in organizing the Workshop.

- The group did roundtable introductions sharing their names, organizations, roles within their organizations, roles in the Basin, and one thing they were looking forward to in the Workshop.

II. Overview of the Basin-Scale Opportunity Assessment Initiative, Nationally and in the Deschutes River Basin

- Simon Geerlofs presented a PowerPoint, attached to this meeting summary, which gave an overview of the federal agency Memorandum of Understanding (MOU) among the Department of Energy (DOE), the Department of the Interior (DOI) and the U.S. Army Corps of Engineers (Corps) that includes the Basin-Scale Opportunity Assessment Initiative. He explained how this led to selecting the Deschutes River Basin as a pilot case study. The purpose of the Basin-Scale Opportunity Assessment is to increase hydropower while improving environmental resources and protecting other values in the Basin. He emphasized that stakeholder engagement and participation are essential to understanding the key issues, and that the purpose of the effort is to focus on a system-scale, basin-wide perspective. With the Deschutes River Basin as a pilot, this effort is testing how this might be done within this Basin to best achieve the program objectives.

- Simon explained that the effort will tap into the local resources, expertise, studies/models, and other local resources combined with the resources of the national laboratories to conduct a research effort over 2012. After this effort it is hoped that the information developed will be useful to the Deschutes River Basin stakeholders moving forward.

- The phases of the approach are:
  1) Literature review initial outreach in the basin (FY 2011);
  2) Focused outreach, qualitative identification of opportunities (FY 2011);
  3) Collaborative analysis of opportunities through models (FY 2011- FY 2012).
  4) Data and information display for opportunity exploration with stakeholders (FY 2012)

Discussion

- The geographic scope for this project is the Upper Deschutes Basin (to Lake Billy Chinook, and not further downstream) and the Crooked River Basin because they are the areas with the most potential for increasing hydropower generation while improving environmental resources.
  - Simon explained that funding for FY 2012 is dependent on a Congressional budget, though some carryover funds should be available to bridge a potential funding gap. He and others conveyed that this project has strong DOE support, but that FY 2012 funding is still to be determined.

- Next steps for the effort:
  - Workshop meeting report drafted by the facilitation/project team, and reviewed by the stakeholder group.
  - By October 1, a Preliminary Draft Opportunity Assessment Report will be completed; this is a preliminary identification of opportunities reviewed by this group, including also an FY 12 research plan for detailed opportunity assessment.
  - November workshop to discuss input on preliminary report and move forward with the technical assessment.
  - Website development to house documents and other information. The website will include a portal to post documents, a calendar, a schedule of events, and the designers are looking into how to best process public comments. The website will be www.basin.pnl.gov.

III. Interview Feedback on Opportunities and Discussion

- Anna West and Simon reiterated to the group that this initiative's goal is to identify and assess potential opportunities to improve hydro + environment while protecting other water uses in the basin.
- Anna explained to the group that Kearns & West had carried out a series of stakeholder interviews in July to identify potential opportunities and analytical needs for opportunity assessment.
- Anna reviewed the initial interview feedback on Opportunities as a jump-start for Workshop discussion. Based on the group discussion, the Opportunities that Workshop participants identified are as follows.

- Opportunities for the Deschutes River Basin-Scale Opportunity Assessment

  - Increase Hydropower Generation and Value in a Way That Supports Other Values in the Basin—Powering Non Powered Dams and In-Canal/Conduit Hydropower
    - Increase hydropower generation, including potentially at Bowman Dam, Ochoco Dam, Wickiup Dam, Crane Prairie Dam, and Crescent Dam. Also, include small hydro (in conduit/in canal) in irrigator and Bureau canals/conduits, as well as municipal in conduits. Also, potentially increase higher value generation at Pelton Round Butte Hydro project.
    - Site potential new hydro projects in ways that do not establish incentives precluding opportunities for changing the flow regimes benefiting agriculture, fish, and other values in the Basin going forward.
    - If there are associated releases for hydropower generation at Bowman Dam, connect these as associated municipal mitigation for groundwater.
  - Improve Aquatic Biota, including Cold Water Fisheries
    - Restore ecological processes in the both river basins.
    - Improve flows and habitat:
      - for salmon and steelhead downstream of Prineville Reservoir, in historic habitat in the Crooked River;

                - for all species downstream of Prineville Reservoir in the Crooked;
                - for all species (brown trout; native redband) downstream of Wickiup Reservoir in the Deschutes;
                - in McKay Creek (Crooked Basin), achieve better consistency in the currently flashy system.
            - Improve habitat restoration; bank stabilization.
            - Increase connectivity for fish.
            - Enhance tourism/other values with an enhanced cold water fishery.
            - Improve riparian habitat for fish; address animal impacts to streams (cattle/horses).
            - Improve water quality, including temperature, sediment, pH, dissolved O2, chlorophyll, and other dissolved gasses.
        - Protect Water Supply
            - Protect water supplies for agriculture, including considering increased water conservation.
            - Protect water supply for municipal uses.
            - Create certainty for water supply.
            - Have adequate water supplies for all needs.
        - Protect Recreation
            - Protect tourism/recreation with retained flat water, warm water recreation, including retaining values on Prineville reservoir.
            - Protect or enhance instream tourism/recreation benefits with an enhanced cold water fishery.
            - Define ways to achieve natural flow regime for boating.
            - Support broader recreation values in the Basin including scenic values, bird watching, fishing, boating, etc.
            - Maintain and improve riparian habitat and wildlife.
        - Flood Management
            - Retain flood management objectives for the Basin; explore opportunities for greater flexibility in flows.

- There was clarification that “small hydro” for irrigators and municipalities includes all kinds, including 10-20kW projects.
- There was discussion about pumped storage hydropower projects and the benefits they provide, including ancillary services, which improve electric grid reliability. The group concluded, however, that pumped storage need not be assessed as an opportunity in this effort.
- There was discussion about maximizing or optimizing the value of the water resource for multiple purposes – for hydropower, for instream benefits for aquatic biota/fisheries, while protecting other uses including irrigator and municipal water supply.
- There was a discussion of potentially using this opportunity to explore opportunities to improve dissolved gas issues at Bowman Dam.
- It was noted that Outstandingly Remarkable Values (ORVs) such as cold water fisheries and recreation in the Chimney Rock Wild and Scenic River may be affected by changes in existing flows and water quality (mainly total dissolved gasses) from Bowman Dam if hydro is added there.

- It was suggested that while it is essential to retain flood management goals, an assessment of the Corps management of flood control objectives, particularly in dry years, could be an opportunity to determine if there is more flexibility in flows. This was noted as a good topic for a tools discussion.
- Participants suggested that the Labs could add value by developing information and tools, but that tradeoffs and priorities are topics better addressed by stakeholders.
- Participants indicated that cost-benefit ratios are better than putting specific values on X or Y. The group discussed relative scales of values and the need for all relevant information to help resolve controversial issues.
- Challenges and concerns about water laws and current protections were discussed. Participants thought that it might be helpful if this effort identified relevant laws and regulations as context (just list them), but otherwise did not think that this forum was the appropriate venue for discussing laws and regulations. However, laws and regulations have to provide the context for the assessment, as parameters for the modeling effort and metrics for measuring improvements in the basin; an exhaustive policy study is not part of this Assessment.
- It was noted that connectivity for fish might benefit from additional discussion. Also, current state policy requires that new hydropower additions changes water rights and, therefore, triggers fish screening and passage requirements.
- The group discussed that case studies on success stories in the Basin could be helpful: for example, recent in-canal hydro development paired with water conservation efforts at Juniper Ridge and Swalley.
- The group suggested that a list of known models and relevant existing information would be helpful, and that these materials could be posted on the website.
- The group wrapped up the conversation suggesting that the focus should be on existing opportunities or “low-hanging fruit,” with mid-term and longer term opportunities identified for further assessment in FY 2012.
- Day 1 concluded.

IV. Day 2 Welcome, Agenda Review, Reflection

- The group reviewed the agenda for day 2.
- The facilitation team reiterated that the interview summary provided for the Workshop was intended to jumpstart Workshop conversation. Going forward, documents used for this effort will include the Workshop Meeting Summary and the Preliminary Draft Opportunity Assessment Report, both of which will be reviewed by the group of stakeholders invited to this Workshop.

V. Opportunities Revisited

- The facilitation team tested a concept that was agreed to in general by the group with modifications. The description follows.
    - Optimize the value of the resource for multiple purposes.
        - Hydropower, aquatic biota (includes fisheries), water supply for agricultural and municipal uses
    - Increase hydropower opportunities
        - At existing federal facilities (Wickiup and Bowman)
        - In canal/in conduit
        - High value generation at Pelton Round Butte

  - Model to analyze increased or changed flows for hydropower; “levers,” i.e. the impacts on water supply, environment, others; and ways to mitigate potential impacts so as to provide information for future decision making.
  - Use existing information to integrate into the model.
  - Develop scenarios with specific geography and time scale.
  - A Basin-scale effort.
  - Given a one-year time frame and limited budget, it might serve as a catalyst for the Basin.
  - A Basin-scale simulation and assessment of specific reaches.
  - Calibrate current conditions → develop new strategies/scenario → optimize; process is intended to support scenario development and future decision-making in the Basin.
- The group agreed that it would make sense to start the assessment by focusing on hydropower opportunities and their potential costs/benefits to the Basin. It would be useful to explore how hydropower opportunities could create an economic engine to improve environmental protection/restoration and other important values in the Basin. Examples of “other important values” include protecting water supplies by investing in water conservation and/or extending boat ramps to offset the impacts on a reservoir.

VI. Research

- The group suggested it would be helpful to start with a water balance model for the Basin to provide information to stakeholders to assess and clarify opportunity scenarios. Below are highlights of points made during the discussion:
  - It would be helpful to know, for instance, how changing flows at different times might benefit instream fisheries.
  - Incorporate existing models and information in the Basin. Don’t reinvent the wheel.
  - Use models to inform choices and decisions; models are support tools.
  - Develop the existing regime as the baseline, a simulation of the current system. Then develop other scenarios and evaluate the impacts on hydropower, fisheries/aquatic biota, water supply, etc. Then, with the scenarios, stakeholders can evaluate tradeoffs and differing impacts to different resources.
  - Spatial and time scales are needed. (Geography is set—it is the entire Basin down to Lake Billy Chinook.)
  - There was a discussion on whether the model needs to consider precipitation v. runoff. To evaluate flood management one would need to consider precipitation; thus it was determined that incorporating precipitation in the model is important.
- The group discussed the small hydro opportunity/research.
  - It would be helpful to catalog the small hydro opportunities.
  - Also, it would be helpful to highlight the case studies to date, including how they created “win-wins” and noting the significant issues.
  - It is important to remember to highlight site-specific opportunities to improve environment, such as increased water conservation.
  - It was pointed out that by identifying the projects Basin-wide, it is also important to then consider potential environmental improvements Basin-wide. It may be more beneficial to implement an environmental

improvement in a different part of the Basin/not specifically at the proposed project. This offers opportunities for outside-of-the-box "win-wins."
    - It was suggested that potential funding opportunities be identified.
    - This assessment could serve as a catalyst for funding, achieving the projects, and addressing the significant issues.
    - It was noted that this assessment could be helpful in approaching regulators to suggest that flexibility on project mitigation based on a Basin-wide approach may be beneficial. (Note: Approaching regulators would not be part of the Opportunity Assessment process, but might be something Basin stakeholders might pursue.)
- After lunch discussion on the research:
    - The group affirmed the idea of using increased hydropower as a driver to "frame" the effort.
        - It's a three-legged stool with an iterative process.
        - The modeling effort could develop the base case/current flows, and then develop scenarios to help show impacts on each leg of the stool/water uses (instream flows for aquatic biota/fisheries; water supply for agriculture and municipal uses; hydropower, etc.)
        - Lab technical experts indicated that modeling would be based on multiple water years.
        - Identify impacts to various uses. Don't assign values, just understand the impacts to start. Then a values-based discussion can occur based on the information.
        - Participants suggested a systemic, Basin-wide approach. If resources are limited, then participants preferred a narrowing in scope instead of focusing on a subset of the Basin.
        - Assume the opportunity is to consider existing reservoirs/dams, not adding new dams or storage. (Note: One participant suggested that replacing on-reservoir storage (Wickiup, etc.) with off- channel reservoirs be considered.)
        - Consider both the cost of some of the alternatives and the long-term cost effectiveness.
    - Need to figure out how to address groundwater.
        - It was clarified that BLM's main concern is protecting and enhancing the "Outstandingly Remarkable Values" (ORVs) on the Lower Crooked River, both the Chimney Rock segment and the segment below Hwy 97. The section below Hwy 97 needs to protect groundwater and spring sources as a critical value of the river.
    - Need to evaluate how existing groundwater resources travel through the Basin and how possible future hydro projects (e.g. canal piping) may affect groundwater and the springs in this Wild and Scenic River.
    - Need to develop the "front end" user friendly "dashboard" for stakeholder use of the model.
    - The following approach for the entire research package was identified, discussed and agreed to by the group unanimously.

        - **Systemic, Basin-Wide Water Balance Model to Allow for Simulation and Visualization of Opportunity Scenarios**
            - Basin-wide weekly timestep.

        - All reservoirs in the Crooked River (Ochoco, Bowman), and the Deschutes (Crescent, Crane Prairie, Wickiup).
        - Use existing gauging stations (which have historic flow data) as model nodes.
        - Build in installing hydropower at existing dams where it's economic/feasible (Wickiup, Bowman, maybe others).
        - Incorporate the major diversions on both rivers.
        - Use the model with flow information to feed into the ODEQ water quality model.
        - Create a visual, user friendly interface, web-based tool to present results, and analyses of the model.
        - Show how the flow scenarios impact or achieve the outcomes for the Opportunity Assessment goals, including increasing hydropower, improving the environment and protecting existing River Basin uses.
        - The model results allow stakeholders to evaluate policy and other choices.

    - Conduct a Basin-wide analysis of in conduit/in canal hydro opportunities.
        - Through case studies, highlight projects done to date noting the creative approach to achieve in canal hydro along with improved water conservation and combined funding approaches. Note the issues of significance (e.g., interconnection costs, others).
        - Catalog specific small hydro (in canal/conduit) opportunities across the River Basin, including information from the Bureau of Reclamation's assessment underway, the Oregon Energy Trust report, and Irrigation Districts' information, municipalities' information, and others.
        - Include how these projects can both add hydropower and improve the environment, such as increasing water conservation by adding relatively short penstocks, or other means.
        - Identify potential funding sources, including other DOE initiatives.
        - Note: Project team to include Steve Johnson, Central Oregon Irrigation District, and Kimberly Priestley, OR WaterWatch.

VII. Next Steps

- Captured in Action Items, but the following were discussed:
    - Engage the local logistics committee to coordinate with the Project team on the Preliminary Draft Opportunity Assessment Report, and on the process steps moving forward. The local logistics committee was expanded to include:
        - Julie Keil, PGE; Kate Miller, Trout Unlimited; Steve Johnson, Central Oregon Irrigation District; Kyle Gorman, Oregon Department of Water Resources; Dawn Wiedmeier, Bureau of Reclamation; Lisa

Morales, U.S. Army Corps of Engineers; and Tod Heisler, Deschutes River Conservancy.

    - Project team will contact the logistics committee and others in the River Basin to identify existing information/models.
    - Other action items captured in the actions above.
- Simon thanked the group, the facilitation team, and the Project team for an excellent session, and looks forward to the effort moving forward.
- Adjourn.

Appendix C

Table of Existing Non-Powered Dams and Large Diversions in the Deschutes Basin from the ORNL National Hydropower Asset Assessment Project

		ORNL NPD Power Potential Analysis[a]			BOR Assessment[c]	ORNKL NPD Environmental Impact Analysis[d]			ORNL NPD Analysis[e] (Other)	
Dam Name	Dam Height (ft)	Stream Flow (cfs)[b]	Dam Hydraulic Height (ft)	Potential Capacity (MW)	Potential Capacity (MW	Critical Habitats	Protected Areas	Federal Lands	Distance to Closest Transmission Line (miles)	Voltage of Closest Transmission Line (kV)
North Unit Diversion Dam	35.0	869.7	24.5	3.590		NO	NO	NO	0.09	69
Arthur R. Bowman Dam	240	264	173	3.293	3.293	NO	NO	YES	5.95	1000
Wickiup Reservoir (USBR)	103.5	145.6	72.45	1.777		NO	NO	YES	6.76	69
Wickiup Dam	100.0	1157	55	3.950	3.950	NO	NO	YES	7.56	69
Haystack Canal	105	225	57	0.805	0.805	NO	NO	YES	2.44	1000
Crane Prairie Dam	36	270	18	0.306	0.306	NO	NO	YES	13.32	69
Crescent Lake Dam	41.0	32.1	28.7	0.155		NO	NO	YES	13.71	69
Fehrenbacker Reservoir 2	18.0	72.2	12.6	0.153		NO	NO	NO	2.32	115
Merwin Reservoir 2	74.0	16.5	51.8	0.144		NO	NO	YES	22.52	765
Layton Reservoir 2	23.0	47.1	16.1	0.128		NO	NO	NO	8.21	765
Bonnie View Dam	42.0	25.4	29.4	0.126		NO	NO	NO	17.00	69
Gilchrist Log Pond	14.0	63.4	9.8	0.105		NO	NO	YES	0.36	69
Bear Creek (Crook)	63.0	10.9	44.1	0.081		NO	NO	NO	12.60	115
Ochoco Dam	152	19	60	0.069	0.069	NO	NO	NO	2.10	69
Allen Creek	83.0	6.5	58.1	0.064		NO	NO	NO	29.19	765

		ORNL NPD Power Potential Analysis[a]			BOR Assessment[c]	ORNKL NPD Environmental Impact Analysis[d]			ORNL NPD Analysis[e] (Other)	
Dam Name	Dam Height (ft)	Stream Flow (cfs)[b]	Dam Hydraulic Height (ft)	Potential Capacity (MW)	Potential Capacity (MW	Critical Habitats	Protected Areas	Federal Lands	Distance to Closest Transmission Line (miles)	Voltage of Closest Transmission Line (kV)
Watson Reservoir	34.0	14.4	23.8	0.058		NO	NO	NO	22.29	765
Logan Butte Reservoir	50.0	10.0	34	0.057		NO	NO	YES	11.77	115
Lytle Creek	N/A	264	3	0.050		NO	NO	NO	3.22	1000
Wickiup East Dike	29.0	14.0	19	0.045		NO	NO	YES	5.60	69
Morrow Brothers (Jefferson)	24.5	14.2	17.15	0.041		NO	NO	NO	1.00	1000
Lillard Dam	26.5	12.0	18.55	0.037		NO	NO	NO	5.43	765
Mainline 1	57.0	5.4	39.9	0.036		NO	NO	NO	25.47	115
Pine Creek Dam (Crook)	35.0	8.1	24.5	0.034		NO	NO	NO	20.77	115
Dick Dam	30.0	8.8	21	0.031		NO	NO	NO	24.33	69
Fisher-Joe Reservoir	54.0	4.6	37.8	0.029		NO	NO	NO	3.95	1000
Freezeout Reservoir	24.0	9.1	16.8	0.026		NO	NO	NO	5.75	765
Marks Lake Dam	20.0	9.3	14	0.022		NO	NO	YES	20.59	69
Johnson Creek Res (Crook)	44.0	4.2	30.8	0.022		NO	NO	NO	3.22	69
Lower Twelvemile (Buker Reservoir)	25.0	7.2	17.5	0.021		NO	NO	NO	3.01	765
Black Snag Reservoir	38.0	4.4	26.6	0.020		NO	NO	NO	2.22	765

		ORNL NPD Power Potential Analysis[a]			BOR Assessment[c]	ORNKL NPD Environmental Impact Analysis[d]			ORNL NPD Analysis[e] (Other)	
Dam Name	Dam Height (ft)	Stream Flow (cfs)[b]	Dam Hydraulic Height (ft)	Potential Capacity (MW)	Potential Capacity (MW	Critical Habitats	Protected Areas	Federal Lands	Distance to Closest Transmission Line (miles)	Voltage of Closest Transmission Line (kV)
Antelope Flat (Crook)	36.5	4.0	25.55	0.017		NO	NO	YES	15.11	115
Peterson Creek Reservoir	25.0	5.5	17.5	0.016		NO	NO	NO	27.96	765
Kluchman Creek Dam	36.0	3.8	25.2	0.016		NO	NO	NO	12.83	115
Sherwood Creek Reservoir	27.0	4.9	18.9	0.015		NO	NO	NO	18.46	115
Grindstone Reservoir	34.0	3.7	23.8	0.015		NO	NO	NO	0.44	765
Swamp Creek Reservoir (Harney)	24.0	5.4	16	0.015		NO	NO	NO	1.76	765
Camp Creek Reservoir (Crook)	19.0	5.1	13	0.011		NO	NO	NO	11.84	115
Yancey Reservoir	28.0	3.3	19.6	0.011		NO	NO	NO	2.69	69
Williams-Sherman Reservoir	25.0	5.3	11	0.010		NO	NO	NO	0.87	765
Suttle	6.0	12.6	4.2	0.009		NO	NO	YES	14.42	69
Barnes Butte Reservoir	32.5	2.3	22.75	0.009		NO	NO	NO	0.34	69
Mainline 3	42.0	1.7	29.4	0.009		NO	NO	NO	24.87	115
Mckenzie Canyon Dam	18.0	3.9	12.6	0.008		NO	NO	NO	1.35	69
Camp Creek 2 (Crook)	25.0	2.6	17.5	0.008		NO	NO	NO	11.39	115

		ORNL NPD Power Potential Analysis[a]			BOR Assessment[c]	ORNKL NPD Environmental Impact Analysis[d]			ORNL NPD Analysis[e] (Other)	
Dam Name	Dam Height (ft)	Stream Flow (cfs)[b]	Dam Hydraulic Height (ft)	Potential Capacity (MW)	Potential Capacity (MW	Critical Habitats	Protected Areas	Federal Lands	Distance to Closest Transmission Line (miles)	Voltage of Closest Transmission Line (kV)
Pringle Flat Reservoir	15.0	4.5	10	0.008		NO	NO	NO	6.49	115
Gillen Reservoir	26.0	2.1	18.2	0.007		NO	NO	YES	12.57	69
Mainline 2	38.0	1.2	26.6	0.005		NO	NO	NO	25.42	115
Wampler-Werth	20.0	2.2	14	0.005		NO	NO	NO	2.20	115
Twelve Mile Res (OR-109)	9.0	3.5	6.3	0.004		NO	NO	NO	8.42	765
Little Three Creek	8.0	1.5	5.6	0.001		NO	NO	YES	16.04	69
Upper Tumalo Reservoir	13.0	0.9	9.1	0.001		NO	NO	NO	6.35	69
Big Three Creeks Lake	17.0	0.7	11.9	0.001		NO	NO	YES	13.16	69
Cyrus Reservoir	17.0	0.4	11.9	0.001		NO	NO	NO	1.52	69
Mill s Reservoir	8.0	0.5	5.6	0.000		NO	NO	NO	12.46	765
King Reservoir	28.0	NA	19.6	NA		NO	NO	YES	23.51	69
Dry Creek 2 (Crook)	18.0	NA	12.6	NA		NO	NO	NO	3.93	1000
Palmer Reservoir	37.0	NA	25	NA		NO	NO	NO	5.49	765
Merwin Reservoir 1	8.0	NA	5.6	NA		NO	NO	NO	22.44	765
Squaw Creek ID Reservoir	19.5	NA	13.65	NA		NO	NO	NO	1.61	69
Redmond Sewage Pond	19.0	NA	13.3	NA		NO	NO	NO	0.06	230

		ORNL NPD Power Potential Analysis[a]			BOR Assessment[c]	ORNKL NPD Environmental Impact Analysis[d]			ORNL NPD Analysis[e] (Other)	
Dam Name	Dam Height (ft)	Stream Flow (cfs)[b]	Dam Hydraulic Height (ft)	Potential Capacity (MW)	Potential Capacity (MW	Critical Habitats	Protected Areas	Federal Lands	Distance to Closest Transmission Line (miles)	Voltage of Closest Transmission Line (kV)
Layton Reservoir 1	25.0	NA	17.5	NA		NO	NO	NO	9.85	765
Gillworth Reservoir	29.0	NA	20.3	NA		NO	NO	YES	4.55	69
Sunriver Effluent Lagoon	30.0	NA	21	NA		NO	NO	YES	0.15	69
Desert Creek Dam	46.0	NA	32.2	NA		NO	NO	NO	3.03	115

(a) The preliminary results of Oak Ridge National Laboratory's (ORNL) "Non-Powered Dam Power Potential Analysis" are based on data from the NHAAP Database (ORNL 2011) and have not been published.
(b) Streamflow data are computed by the USGS-EPA NHD Plus.
(c) Data are from Reclamation's 2011 *Hydropower Resource Assessment at Existing Reclamation Facilities*. Prepared by the U.S. Department of the Interior, Bureau of Reclamation, Power Resources Office. Denver, Colorado. March.
(d) The preliminary results of ORNL's "Non-Powered Dam Environmental Impact Analysis" are based on data from the NHAAP Database (ORNL 2011) and have not been published.
(e) The preliminary results of ORNL's "Non-Powered Dam Analysis--Other" are based on data from the NHAAP Database (ORNL 2011) and have not been published.

Source: ORNL 2011; all data are provisional and are subject to change after verification.

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