Willamette Basin Reservoir Study

"Planning today for tomorrow's water"

WILLAMETTE BASIN RESERVOIR STUDY
INTERIM REPORT

January 2000

Abbreviations and Acronyms

ASA(CW)	Assistant Secretary of the Army for Civil Works
ASR	aquifer storage and recovery
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
EIS	Environmental Impact Statement
ER	Engineer Regulation
ESA	Endangered Species Act
FY	Fiscal Year
HQUSACE	Headquarters, U.S. Army Corps of Engineers
mg/l	milligrams per liter
NED	National Economic Development
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OMRR&R	operation, maintenance, repair, replacement, and rehabilitation
OWRD	Oregon Water Resources Department
RED	Regional Economic Development
RRDM	Regional Recreation Demand Model
TCMs	Travel Cost Models
TMDLs	Total Maximum Daily Loads
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service

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1. INTRODUCTION

The purpose of this Interim Report is to document the progress of the Willamette River Basin Reservoir Feasibility Study since its initiation in the spring of 1996. A map showing the Willamette Basin study area is shown in figure 1. The feasibility study was initiated on May 31, 1996, with the signing of the *Feasibility Cost Sharing Agreement and Project Study Plan* by the U.S. Army Corps of Engineers, Portland District (Corps) and the Oregon Water Resources Department (OWRD).

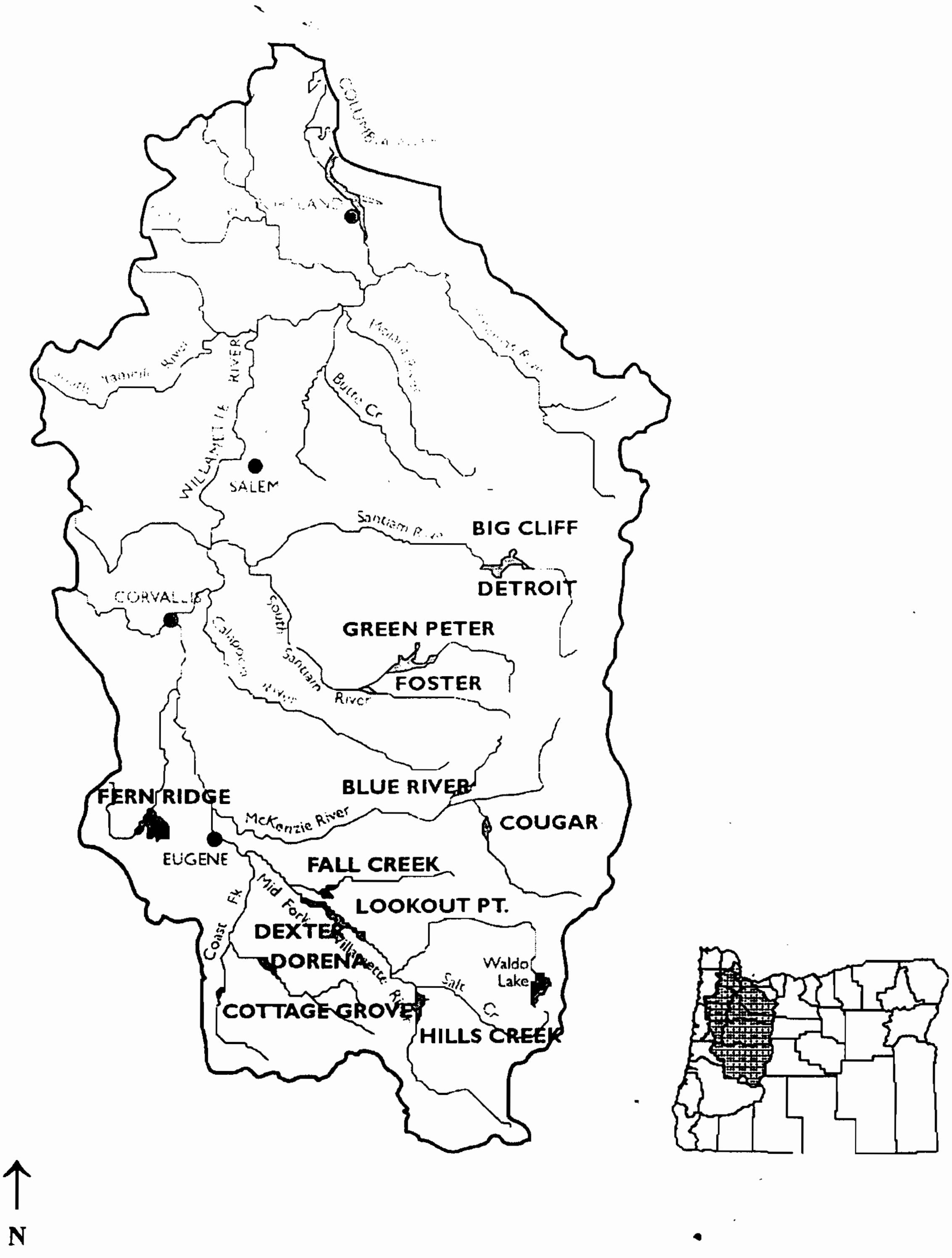
Although the Willamette Basin covers less than 14 percent of the state's total land mass, more than 70 percent of Oregon's residents reside in it. It is the heart of the state's economy and one of the nation's fastest growing areas. The Willamette River and its tributaries make it possible to support today's population, high levels of agricultural productivity, and a healthy natural environment. Water is the key to sustaining cities and reliable jobs. Water for irrigation enhances the principal role that agriculture plays in Oregon's economy and keeps farming as a feasible vocation for future generations. Fish, vegetation, and wildlife require adequate, clean water to support all aspects of their natural life cycle. In communities near the reservoirs, recreational water uses are an increasingly important contribution to local economies. Because water is so important to every resident of the basin, and to other residents in Oregon who rely on a strong economy in the Willamette Valley, the stewardship of its water resources is critical to Oregon's future.

The purpose of the feasibility study is to analyze current water uses in the basin, to project water needs for the variety of uses, and to identify reservoir water allocation options to assure the most public benefit within the policies and regulations of the Corps. The study's outcome will determine if the Corps pursues changes in reservoir operations through recommendations to Congress. Five goals were established for the study:

- Authorize a full range of beneficial uses (including anadromous fishery and water quality needs, municipal and industrial water supply, and recreation).
- Develop an operational agreement for low flow years.
- Determine appropriate institutional arrangements.
- Investigate modifications to water control diagrams and reduce downstream erosion during reservoir drawdown.
- Address municipal and industrial water demands and constraints.

While the Corps and the OWRD are the formal sponsors of the study, an Advisory Committee and a Technical Workgroup assist with data collection, technical analysis, and public outreach. An Executive Committee of senior representatives of the sponsoring agencies generally oversees the study. These committees represent an array of public and private organizations, including state, federal, and local agencies, elected officials, public interest groups, and industry organizations. A complete list of study contributors and participants is located in the Appendix to this report.

Figure 1. Willamette River Basin



This report also provides a starting point for resumption of the study upon the completion of formal consultation as required by Endangered Species Act (ESA). In March 1999, steelhead and spring Chinook salmon in the upper Willamette Basin were listed as threatened species under the ESA. In April 1999, the Executive Committee delayed completion of the study by one year pending the formal consultation between the Corps, the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) as required under Section 7 of the ESA.

2. STATUS OF THE RESERVOIR STUDY

In March 1999, steelhead and spring Chinook salmon in the upper Willamette Basin were listed as threatened under the ESA. As a result of the listing, the Corps is preparing a Biological Assessment on the impacts of the Willamette reservoir projects on salmon, steelhead and other previously listed species, including bull trout. Following review of the Biological Assessment, the NMFS and USFWS are expected to release a joint Biological Opinion which will include recommendations on actions needed to ensure continued survival of the listed species. It is anticipated that the recommendations will include the use of water stored in the reservoirs for flow augmentation and possibly other purposes. The Corps is scheduled to complete its assessment in March 2000. The Biological Opinion is expected in the summer of 2000.

On April 13, 1999, the Executive Committee met to discuss potential effects of the listings on the study. Prior to that time, the study team had been coordinating with state and federal fishery agencies to develop a set of alternative scenarios for the reservoir system that incorporated operating criteria for endangered species. Following the listing, it became obvious that final decisions on operational criteria for fish would be only made as part of the Section 7 consultation process. Since it would be impossible to determine how much of the water stored in the reservoirs would be available for other purposes until after requirements for ESA-listed fish had been clearly specified, the Executive Committee agreed to extend completion of the study by one year.

The extension will allow information developed for the Biological Opinion on reservoir operations to be used in crafting the final alternatives for the study. Criteria developed by fisheries agencies to protect declining runs are likely to play a major role in shaping future reservoir operations. Following the release of the opinion, it is expected that an active schedule will resume for completing study efforts and preparing a draft integrated feasibility report and environmental impact statement (EIS) to comply with the National Environmental Policy Act (NEPA). The first activity will be to determine changes in the study plan needed to respond to recommendations by the NMFS and USFWS and other changing conditions in the Willamette Basin.

3. STUDY SCHEDULE AND MILESTONES

The revised study schedule and key milestones are shown below. All dates are tentative and dependent upon completion of the Section 7 consultation process.

March 2000	Corps completes Biological Assessment of Impacts of Reservoir Operations
Summer 2000	NMFS/USFWS complete Biological Opinion/make recommendations to Corps
July 2000	Study resumes; study plan is reviewed and possibly revised
November 2000	Final alternative operating scenarios are formulated
March 2001	Public review of final alternative operating scenarios initiated
April 2001	Public hearing on alternatives
April 2001	Preferred alternative plan is selected
December 2001	Draft feasibility report and EIS provided for public review
February 2002	Public review of draft report completed
May 2002	Final feasibility report and EIS completed; forward to Corps Headquarters

4. STATUS OF STUDY GOALS AND TASKS

4.1. Update Base Condition

This study task consisted of updating the existing and expected future conditions for the Willamette Basin. An initial report, *Criteria and Discussion of Existing and Base Conditions for the Willamette Basin Reservoir Study* was developed in July 1997 to meet this need. This report was updated in January 2000 to consider changed conditions that have occurred since preparation of the initial report.

4.2. Authorize Full Range of Beneficial Uses

This study goal recognizes that water uses and needs in the Willamette Valley have changed dramatically since the reservoir system was originally authorized. The Corps, OWRD and other agencies involved in the study have developed preliminary short-term and long-term future conditions for the Willamette reservoir system, so that a full range of beneficial uses can be fully recognized in storage allocations and reservoir operations under consideration in the study. Completion of this study goal, however, depends upon the recommendations resulting from ESA consultation and development of final alternative scenarios. A summary description of the current status of short-term (2020) and long-term (2050) future conditions for the beneficial uses under consideration is provided below. Additional discussion is found in *Criteria and Discussion of Existing and Base Conditions for the Willamette Basin Reservoir Study* (Corps, January 2000).

4.2.1. Agricultural Irrigation

The U.S. Bureau of Reclamation (USBR) holds permits from the OWRD to use 1.64 million acre-feet of stored water from the Willamette reservoirs for irrigation. Currently, irrigators use less than five percent of this amount. However, agricultural needs will likely increase with intensified farming practices. Oregon has seen rapid expansion in many high valued, water intensive crops like nurseries and berries. Moreover, the year-to-year consistency in both supply and quality of these crops has encouraged food processing companies to locate in the Willamette Basin, which may spur further development of these water intensive crops. The estimate for irrigation water demand needed from Corps reservoir storage by the years 2020 and 2050 is shown in tables 1 and 2, respectively.

Table 1. Irrigation Water Demands from Storage, 2020 (acre-feet)

Month	Upper Basin (above Harrisburg)	Mid-Valley (Harrisburg to Salem)	Lower Basin (above Oregon City)	Totals
May	1,663	6,177	745	8,585
June	4,989	18,532	2,234	25,755
July	5,913	21,964	2,647	30,524
August	4,250	15,786	1,903	21,939
September	1,663	6,177	745	8,585
Totals	18,478	68,636	8,274	95,388

Source of estimate: Oregon Water Resources Department, based on Oregon Department of Agriculture Reservation Request, 1994.

Table 2. Irrigation Water Demands from Storage, 2050 (acre-feet)

Month	Upper Basin (above Harrisburg)	Mid-Valley (Harrisburg to Salem)	Lower Basin (above Oregon City)	Totals
May	2,063	43,157	4,294	49,514
June	6,189	129,470	12,884	148,543
July	7,337	153,447	15,267	176,051
August	5,274	110,290	10,973	126,537
September	2,063	43,157	4,295	49,515
Totals	22,926	479,521	47,713	550,160

Source of estimate: Oregon Water Resources Department, based on Oregon Department of Agriculture Reservation Request, 1994.

4.2.2. Municipal Water Supply

Currently, some large cities in the Willamette Valley outside the Portland metropolitan area rely on the Willamette River and its tributaries for drinking water. For example, Corvallis currently supplies treated water from the Willamette River to its customers. The Tualatin Valley Water District completed a pilot project at Wilsonville, which confirmed that Willamette River water could be treated, and at costs comparable to other facilities nationwide, to provide high quality drinking water. As population increases throughout the valley, and as environmental and financing issues reduce the likelihood that municipalities will build new reservoirs for drinking water, river flow will continue to be an important water source. Assuring adequate water in the river system to provide for municipal needs requires balancing this demand with other in-stream and out-of-stream uses. The current estimate for municipal water supply demands needed from Corps reservoir storage by the years 2020 and 2050 is shown in tables 3 and 4, respectively.

Table 3. Municipal Water Demands from Storage, 2020 (acre-feet)

Location	June	July	August	September	Totals
Goshen	136	141	141	136	553
Jasper	53	55	55	53	217
Vida	2,304	2,381	2,381	2,304	9,371
Harrisburg	42	43	43	42	170
Monroe	37	38	38	37	151
Albany	1,033	1,067	1,067	1,033	4,200
Waterloo	80	82	82	80	323
Mehama	3,259	3,368	3,368	3,259	13,253
Jefferson	23	24	24	23	94
Salem	1,399	1,446	1,446	1,399	5,690
Wilsonville	2,115	2,186	2,186	2,115	8,602
Oregon City	3,810	3,937	3,937	3,810	15,493
Totals	14,291	14,767	14,767	14,291	58,116

Source of estimate: Oregon Water Resources Department based on data from the League of Oregon Cities, Special Districts Association of Oregon, and the Regional Water Supply Plan (1996).

Table 4. Municipal Water Demands from Storage, 2050 (acre-feet)

Location	June	July	August	September	Totals
Goshen	219	226	226	219	891
Jasper	86	89	89	86	350
Vida	6,259	6,468	6,468	6,259	25,454
Harrisburg	89	92	92	89	363
Monroe	59	61	61	59	241
Albany	3,445	3,560	3,560	3,445	14,012
Waterloo	447	462	462	447	1,817
Mehama	5,600	5,787	5,787	5,600	22,773
Jefferson	49	50	50	49	198
Salem	2,122	2,193	2,193	2,122	8,631
Wilsonville	8,288	8,565	8,565	8,288	33,706
Oregon City	6,021	6,221	6,221	6,021	24,484
Totals	32,685	33,775	33,775	32,685	132,920

Source of estimate: Oregon Water Resources Department based on data from the League of Oregon Cities, Special Districts Association of Oregon, and the Regional Water Supply Plan (1996).

In 1999, using the Willamette River as a municipal water supply was determined to be necessary to meet imminent local demands in the western portion of the Portland area. Since January 1998, a moratorium on the approval of new development applications has been in place in Wilsonville. In September 1999, voters in Wilsonville approved a bond measure to fund construction of a Willamette River water treatment plant. The Tualatin

Valley Water District also has committed funding for treatment plant construction. Voters in Tigard approved a city charter amendment requiring a referral to the voters to use the Willamette River as a long-term water source. The vote may take place in March 2000. A decision to participate in the treatment plant also is pending in Tualatin and Sherwood. Nevertheless, Wilsonville is committed to building the treatment plant, and it could be on line and providing water to residents and businesses by the spring of 2002.

4.2.3. Industrial Water Supply

Throughout the basin, major employers such as pulp and paper mills use river water directly without purchasing it through a municipal provider. The Oregon Economic Development Department estimates a 25 percent increase in water demand for these industrial uses between 1995 and 2005. The needs of these industries, which represent a significant portion of many local economies, must be considered when planning for dry season uses of reservoir water. The current estimate for self-supplied industrial water demands needed from Corps reservoir storage by the years 2020 and 2050 is shown in tables 5 and 6, respectively.

Table 5. Self-supplied Industrial Demands from Storage, 2020 (acre-feet)

Location	June	July	August	September	Totals
Harrisburg	3,864	3,993	3,993	3,864	15,714
Albany	3,312	3,422	3,422	3,312	13,468
Salem	2,870	2,966	2,966	2,870	11,672
Oregon City	994	1,027	1,027	994	4,042
Totals	11,040	11,408	11,408	11,040	44,896

Source of estimate: Oregon Department of Economic Development, 1996

Table 6. Self-supplied Industrial Demands from Storage, 2050 (acre-feet)

Location	June	July	August	September	Total
Harrisburg	6,447	6,662	6,662	6,447	26,218
Albany	5,526	5,710	5,710	5,526	22,472
Salem	4,789	4,949	4,949	4,789	19,476
Oregon City	1,658	1,713	1,713	1,658	6,742
Totals	18,420	19,034	19,034	18,420	74,908

Source of estimate: Oregon Department of Economic Development, 1996

4.2.4. Water Quality

The volume of water in rivers and streams affects the quality of that water. The amount of stream flow determines a waterway's capacity to absorb, break down and eliminate many types of pollutants. Streamflow also affects water temperature, a key element in water quality. The preservation of adequate streamflow and water quality is essential to support industrial and municipal needs. For example, the ability of municipalities to obtain discharge permits for waste treatment relies on these factors. The Willamette Basin's ability to absorb growth, sustain quality of life, and comply with state and federal regulations depends on preserving streamflow and water quality throughout the Willamette River system. The following statements describe potential changes in future conditions that may impact water quality in the basin.

- Increased population and economic growth in the basin will create greater water quality stresses on the Willamette River.

- Existing discharge permits and total maximum daily loads (TMDLs) rely on established flows at Albany and Salem. Releases are made from the Willamette projects to maintain these flows, especially during the low flow season. It will not be possible to decrease these flows without significantly degrading water quality or recalculating permits and waste loads.

- The construction of the proposed selective withdrawal structure at Cougar and Blue River lakes would improve water temperatures downstream of these projects, thereby improving fish habitat for salmonids and native species. This would result in a larger return of spring Chinook salmon to the McKenzie subbasin.

- The ability to impact mainstem Willamette temperatures by changing releases from the projects is somewhat limited without making significant changes to the flows in the mainstem. After release from the projects, meteorological inputs such as solar radiation, air temperature, and dew point, as well as flows from unregulated streams, act to cause water temperatures to reach an equilibrium.

- Tremendous urban growth is expected in the basin. This will result in significant potential for increased point and non-point water quality impacts. It is uncertain whether the continued development of watershed management plans by local, state, and federal groups may offset these and other water quality impacts.

The net affect of these changing conditions may be that water quality will remain about constant in the Willamette Basin for the foreseeable future. Depending on the availability of data, the study is focusing on the following water quality parameters:

Temperature	Biochemical Oxygen Demand
NO_3 – Nitrogen	NH_4 - Nitrogen
Dissolved Oxygen	Phytoplankton
PO_4 – Phosphorus	Total Dissolved Solids

Particular attention will be given to temperature and dissolved oxygen as indicators for analysis of operational changes to the system. Algal dynamics must be considered to gain an accurate picture of the dissolved oxygen in the system. Similarly, biological oxygen demand must be considered to accurately simulate dissolved oxygen.

4.2.5. Fish Populations

Fishery resource agencies have identified a number of fish species in the Willamette River system that are of regional or national significance. Several species including steelhead, Chinook salmon, Oregon chub, and bull trout are now protected under the ESA. The Corps also manages water released from the reservoirs to support rainbow trout, an important species for recreational fishing. As habitat degradation and water quality problems affect fish populations, the importance of providing adequate streamflow in the Willamette River system will likely increase. Recommendations made in the NMFS-USFWS Biological Opinion may likely include the use of stored water for flow augmentation and possibly other purposes.

4.2.6. Reservoir and Downstream Recreation

Reservoir recreation such as boating and water skiing are major revenue sources for many basin communities. With the decline of the timber industry in areas, tourism and recreation have come to play a greater role in local economies. Peak demand for these activities often coincides with the driest part of the summer season, when reservoirs are generally at lowest levels and water for irrigation and in-stream needs is most critical. In some years, by July some reservoirs may be too low to allow use of boat ramps. Summer water releases lower reservoir levels but provide flows for fishing, kayaking, and other forms of recreation on rivers like the McKenzie and North Santiam.

The continued operation and management of the recreation resources of the Willamette projects and their downstream reaches are expected to remain about constant in the future. No major recreation improvements at the projects are planned by the Corps. Small work items such as new trails, landscaping, new signs, fences, gates and other maintenance items are anticipated to increase visitation by less than 5 percent in the foreseeable future. Lane County, Linn County, Oregon State Parks, and the Forest Service also will continue to maintain their respective recreation areas associated with the Corps lakes. The type of recreation activities pursued at the Willamette lakes is anticipated to remain similar to the existing mix of activities. Increases in the amount of recreation use will likely remain a function of summer weather conditions and basin population. Prolonged periods of hot, dry summer weather could be expected to affect recreation use of the Willamette lakes by about 10 percent. Also, those lakes located closest to the basin's population centers can be expected to remain the most heavily used for recreation activities.

4.2.7. Hydropower

The capacity and energy currently produced by the Willamette projects are not expected to change in the future. There are no specific plans for major improvements or major rehabilitation activities for the Willamette power projects, and no commitments to operational changes for power purposes. Due to aging of the projects, some minor reductions in capacity can be expected because of lost reliability and deterioration as units are taken off-line more frequently for maintenance, or experience emergency or unplanned outages due to winding failures or other related problems. Also, it is unlikely that new power facilities will be added to the system by federal or non-federal entities.

4.3. Operational Agreement for Low Flow Years/Institutional Arrangements

These goals of the study deal with developing criteria and procedures to be applied to the operation of the Willamette reservoir system during low flow years as well as for water management into the future. In low flow years, reservoirs may not fill to their full conservation pool levels which limits water management options and operational flexibility of the system. Also, demands from all uses on the reservoir system will continue to increase and become more complex, which requires exploring short- and long-term options for managing and allocating stored water. Allocation options have been discussed during Technical Workgroup meetings but operational options have not yet been considered. Completion of these goals will depend upon ESA recommendations and the final alternatives developed for the study.

4.3.1. Principles of Low Flow Year Operation

It has been suggested by the Technical Workgroup that water year types be defined based on reservoir filling and total conservation storage predicted for the reservoir system for a particular water year. Water year type definitions include average +, average, below average, and critically dry. As shown in table 7, historic data on total conservation storage and reservoir filling was compiled for each water year from 1969 (the first year all the reservoirs were operational) to 1994, and water year type identified.

In December and January, the Soil Conservation Service and the National Weather Service provide initial seasonal flow and snowpack forecasts for many locations in the Willamette Basin. The Corps uses these forecasts to predict whether a low flow winter is evident. The issue during low flow winters is whether or not to fill ahead of the rule curve and the subsequent risk to flood control. The Corps developed a concept for the Rogue Basin to help address this issue. For the Lost Creek and Applegate projects, a series of curves have been developed to show the probability of filling them from various sized flood events (10-year, 20-year, etc.) for any date or pool elevation selected. Therefore, the risk to be potentially taken by filling ahead of the rule curve can be quantified.

At the April 1998 workshops, 128 participants responded to a questionnaire on water allocations during dry or drought years. Respondents generally agreed that water quality, drinking water, and protecting fish should take precedence over other water uses. Most (71 percent) did not agree that all water uses should be given equal priority. Participants ranked water uses in this priority order (average rank on a 1 to 9 scale, with 9 being the highest priority):

1. Minimum flows for water quality (6.32)
2. Community drinking water (6.23)
3. Minimum flows for fish (5.96)
4. Wildlife (5.31)
5. Irrigated agriculture (5.15)
6. Industry water (4.20)
7. Hydropower (4.18)
8. Reservoir recreation (3.86)
9. River recreation (3.68)

Table 7. Total Conservation Storage for the Willamette Reservoirs, 1969 to 1994

Water Year	Rank	Water Year Type	Total Conservation Storage (May 1 to Sep 1 in acre-feet)	Percent of Years Exceeding	Reservoirs Not Filling
1984	1	Average +	1,633,300	3.85	None
1975	2	Average +	1,625,100	7.69	None
1972	3	Average +	1,620,700	11.54	None
1981	4	Average +	1,619,600	15.38	None
1985	5	Average +	1,619,200	19.23	Cottage Grove
1991	6	Average +	1,618,800	23.08	None
1988	7	Average +	1,618,500	26.92	None
1969	8	Average +	1,618,200	30.77	None
1974	9	Average +	1,618,000	34.62	None
1976	10	Average +	1,616,900	38.46	Cottage Grove
1983	11	Average +	1,615,100	42.31	None
1980	12	Average +	1,614,800	46.15	None
1993	13	Average +	1,613,400	50.00	None
1989	14	Average +	1,612,400	53.85	None
1971	15	Average +	1,612,200	57.69	None
1979	16	Average +	1,609,800	61.54	None
1990	17	Average +	1,597,600	65.38	Fern Ridge
1982	18	Average +	1,594,500	69.23	Cottage Grove, Dorena
1986	19	Average +	1,594,200	73.08	Fern Ridge
1970	20	Average	1,583,100	76.92	Hills Creek, Fern Ridge
1977	21	Below average	1,494,300	80.77	Hills Creek, Lookout Point, Fern Ridge
1978	22	Below average	1,452,100	84.62	Lookout Point, Fall Creek, Cougar, Detroit, Fern Ridge
1994	23	Below average	1,450,600	88.46	Cottage Grove, Lookout Point, Cougar
1973	24	Below average	1,411,700	92.31	Hills Creek, Lookout Point, Cougar, Green Peter, Detroit, Fern Ridge
1987	25	Critically dry	1,357,500	96.15	Cottage Grove, Dorena, Lookout Point, Fall Creek, Blue River, Cougar, Green Peter, Fern Ridge
1992	26	Critically dry	1,256,200	100.00	Cottage Grove, Dorena, Hills Creek, Lookout Point, Fall Creek, Blue River, Cougar, Green Peter, Detroit

Source: Corps of Engineers, October 1998

Based on the above information, the Technical Workgroup discussed three options to deal with low-flow years. One option would limit water allocations to 1.5 million acre-feet and use a reduction strategy in years the reservoirs would not fill. As shown in table 7, it is likely that this amount can be reliably supplied between 76 and 80 percent of the time. A second option would provide both a firm and interruptible water supply. Both options would provide a degree of predictability in low-flow years, and warrant additional discussion by the Technical Workgroup.

During a below average water year, applying a small reduction to all water uses was the third option discussed. Unfortunately, percentage reductions would be difficult to implement for uses like recreation where activities may depend on specific water levels and storage volumes. At Fern Ridge, even minor reductions in water elevations may virtually eliminate most recreational use. Consequently, it was decided not to further develop the shared reduction approach.

4.3.2. Institutional Arrangements

Policy options for low flow years as well as for water management into the future would require an implementation structure, which may include some or all of the following elements as initially discussed by the Technical Workgroup. It also may be possible to piggyback on the current procedure of the Corps to hold a Willamette Interagency Coordination Meeting in the spring, where a basic water release plan is presented and discussed for the Willamette reservoir system.

Develop a Willamette Basin Water Management Council

- Composed of decision makers who have authority to act on information and data about water availability (may be similar to the study's executive committee).
- Responsible for making future allocation and operating decisions to meet changing needs and resolve conflicts between users.
- Formalize the council and other committees using a Memorandum of Understanding or Partnership Agreement between the Corps and the State of Oregon.

Develop a Willamette Basin Monitoring and Impact Assessment Committee

- Composed of technical individuals and water users to assess current water supply based on precipitation, runoff, snow pack, and temperatures using the HEC-5 model or other techniques (may be similar to the study's technical workgroup).
- Monitor how much water is available and determine how lack of water is affecting the various water users.
- Develop an operational agreement for low-flow years which could have three primary tasks: monitoring, impact assessment, and response/mitigation.
- Develop refill strategies during the spring of each year with a primary objective to refill the reservoirs to achieve some percentage of reliability.
- Examine the potential impacts of the refill strategies on water uses.
- Disseminate information to agencies and the public using news releases, reports to state and federal agencies, media, mailing list of interested parties, invite the public to council/committee meetings.
- Develop information program about water conservation issues and what can be done by water users to conserve water during low flow years.
- Report findings and recommendations tot he water management council for action.

4.4. Alternative Water Sources

This study task deals with identifying preliminary water needs and supply options for those Willamette subbasins not containing a Corps reservoir. These include the Tualatin, Clackamas, Calapooia, Molalla-Pudding, and Coast Range subbasins. This task has been completed and a report prepared by the OWRD (March 1999). Meeting future water needs in these subbasins, however, will require additional investigations that are beyond the scope of the reservoir study.

Although the Corps operates 13 reservoirs in the Willamette Valley, stored water from these reservoirs may not be available to help meet future water needs in these subbasins. Other water sources are likely to be needed. How to meet the water needs of commercial and industrial users, rapidly growing communities, and agriculture while maintaining a sufficient supply in the Willamette Valley for fish, recreation, and water quality are critical issues. Population growth in the Willamette Valley will continue to increase pressure on available supplies. As pressure builds, seasonal water shortages could occur more frequently and for longer periods of time.

During summer, stored water in reservoirs operated by the Corps may be available to help meet some of these water needs. However, due to pumping and delivery costs, this is generally limited to areas near the Willamette River or tributaries near a Corps reservoir. Although water conservation could satisfy a portion of the short-term water demands, other water sources such as small storage projects; well fields (groundwater); aquifer storage and recovery (ASR); and interbasin transfers will likely be needed to meet long-term needs. A summary of the assessment completed for each subbasin describes the current and future water needs in each area and identifies some potential water supply options.

4.4.1. Tualatin Subbasin

The Tualatin subbasin covers 712 square miles and is located almost entirely in Washington County. The Tualatin River is 83 miles in length, flowing from the Coast Range to the Willamette River near West Linn. Surface water and groundwater in the Tualatin subbasin are a source for drinking, industrial use, irrigation, fish and other uses for a growing population. Groundwater is intensely developed and has limited potential for supplying additional water. The Tualatin has been designated a "water quality limited" river by the Oregon Department of Environmental Quality (ODEQ) because of low dissolved oxygen and high algae levels.

Low summer flows on the Tualatin River are currently a major problem and are not sufficient to meet water demands from May to November. Nearly 85 percent of total subbasin runoff occurs from November to March, with only about three percent from June to October, when the need is greatest. These low summer flows have been a problem in the Tualatin system for many years. The total amount of water needed to meet existing demands is about 60 percent of the subbasin's average annual runoff.

Irrigation is the largest water use in the Tualatin subbasin. Nurseries that use more water than traditional food crops are becoming more prominent. The Oregon Department of Agriculture (ODA) estimates that an additional 16,100 acres of land will be irrigated by 2035, and about 40,275 acre-feet of water will be needed.

Municipal water is another large use in the subbasin. A complex network of pumps uses water from the Tualatin and Trask rivers and from Portland's Bull Run system to supply residents, businesses and industrial customers. Municipal water needs and source options were recently investigated as part of the *Regional Water Supply Plan* (1996) for the Portland metropolitan area. Options that may partially satisfy water needs include new conservation programs focused on outdoor uses, adding regional transmission linkages, water reuse, recycling, and direct use of non-potable sources.

According to studies of the USBR and the Soil Conservation Service in the 1980s, building reservoirs in the subbasin would adversely affect wetlands, wildlife and fisheries, as well as human resources and water rights. Adverse environmental and social problems and high estimated costs continue to limit the development of new storage in the subbasin.

To meet near-term municipal needs and provide more flow for water quality, the Joint Water Commission, the Tualatin Valley Water District, and the Unified Sewerage Agency recently expanded the Barney Reservoir in the Trask River system. The project increased the storage capacity from 4,000 acre-feet to 20,000 acre-feet.

A possible major new water source for the area is aquifer storage and recovery (ASR). This approach stores surface water in aquifers, which are underground layers of porous rock and sand that hold water. Surface water is pumped into the aquifer during high flow winter months and from the aquifer during the summer when more water is needed. Some advantages of aquifer storage are the ability to store large volumes of water and fewer environmental impacts. The Salem Public Works Department successfully conducted an ASR test program and further studies are underway. The Joint Water Commission and the Tualatin Valley Water District have sponsored initial studies for a potential ASR project in the Cooper-Bull Mountain area of Washington County. The ASR project may require up to 28 wells to reach a 20 million gallon per day seasonal yield. A preliminary cost for the project is about $16.8 million.

4.4.2. Clackamas Subbasin

The Clackamas subbasin drains 934 square miles. Most of the subbasin is within Clackamas County, with a portion of the headwaters in Marion County. The Clackamas River begins in the Mt. Hood National Forest and flows for about 83 miles to the Willamette River in Gladstone. Clackamas County is among the fastest growing counties in the state. As the population continues to grow, the dependence on existing water sources will become even greater. Groundwater is intensely developed and has limited potential as a future water source. The water resources in the Clackamas subbasin provide for recreation, hydropower, flows for fish, drinking and industrial water, and irrigation.

The Clackamas River has important populations of anadromous fish, including winter and summer steelhead, fall and spring Chinook, and coho salmon. Due to its proximity to urban centers, high scenic quality, and abundance of fish, the Clackamas attracts large numbers of recreational users. From its mouth to the River Mill Dam, the Clackamas has been designated a "water quality limited" river by the ODEQ due to its high temperature in the summer. Four sections of the river are state scenic waterways; the first 35 river miles are a national wild and scenic river managed by the Forest Service.

About 63 percent of the annual runoff in the subbasin occurs during the late fall and early spring, with about 18 percent during the summer and early fall. During these months, flows fall short of meeting existing water demands, which totals about 913,000 acre-feet annually, or about 34 percent of the subbasin's annual runoff. To protect scenic waterway flows, new water uses in the subbasin are restricted.

Two storage projects in the upper reach of the river were studied in the 1980s as sources of future water. Potential adverse environmental, water right, and scenic waterway issues continue to limit development of new storage projects.

Agriculture, whose principal crops include berries, fruit, and livestock, is an important economic activity in the subbasin. Nurseries are becoming more prominent and use more water than traditional food crops. The ODA expects an additional 7,400 acres of land will be irrigated for a variety of crops by 2035, and about 18,550 acre-feet of surface water will be needed. Much of this new land is low in elevation and close to the Willamette River. It may be possible to use stored water from Corps' reservoirs upstream and transport it by canals, pump, or pipeline to help meet future irrigation needs.

The Clackamas River currently provides municipal water to about 175,000 residents. This is the largest use in the subbasin. The City of Lake Oswego, Clackamas River Water, and the South Fork Water Board have 66 million gallons per day capacity on the lower five miles of the river. Upstream, water from the river supplies the City of Estacada. Though existing municipal water rights appear adequate to serve future needs, as they are developed, flow levels in the river may be reduced.

Municipal water options for the Portland area were investigated as part of the *Regional Water Supply Plan* (1996), and include new conservation programs focused on outdoor uses, adding regional transmission linkages, and water reuse, recycling, and direct use of non-potable sources. The Clackamas system has four existing and planned water intake and treatment facilities. Water providers have committed to developing additional near-term capacity by 2005. The regional plan recommended that new capacity to meet long-term needs be developed at one or more of these sites.

4.4.3. Calapooia Subbasin

The Calapooia subbasin is located near the center of the Willamette Basin in Linn County and discharges directly into the Willamette River at Albany. Annually, 81 percent of the runoff occurs during late fall and winter, and only six percent in the summer. Flows in the subbasin are not controlled by a reservoir. A proposed Corps reservoir on the Calapooia near Holley was deauthorized by Congress in 1986.

The major water resources in this subbasin provide for recreation, power, flows for fish, drinking water, and irrigation. Water flows on the Calapooia River do not meet current summer needs. Future needs may be supplied by natural flow, pump/pipeline delivery from existing storage on the South Santiam River, or from new small storage projects. Power generation for Thompson Mill is the largest water use in the subbasin, and municipal use of water is low. Brownsville uses surface water and groundwater as a municipal supply, while Halsey uses groundwater for drinking. From its mouth to Brush Creek, the Calapooia has been designated a "water quality limited" river by the ODEQ for its high bacteria levels and summer water temperatures.

Summer flows on the Calapooia River fall short of meeting municipal, irrigation and industrial uses. Flows on tributaries to the Calapooia also are insufficient to meet water demands in the summer months. The total water demand could potentially reach about one-third of the annual runoff in the subbasin. Nearly half occurs during the summer when the subbasin yields less than four percent of its average annual runoff.

Agricultural irrigation is a major water use with hay, silage, and field and grass seed the most important crops. The ODA estimates that an additional 10,500 acres of agricultural land will be irrigated in the subbasin by 2035. Although direct flow may be available during the spring to partially meet future needs, additional water may come from pump and pipelines from the South Santiam River or new, small storage projects in the subbasin.

4.4.4. Molalla-Pudding Subbasin

In the north central Willamette Valley, the Molalla-Pudding subbasin is shared almost evenly between two rapidly growing counties, Marion and Clackamas. The subbasin drains a total of 870 square miles. The Molalla River starts in southern Clackamas County, flows northwest and reaches the Willamette River near Canby. The Pudding River originates in the Waldo Hills east of Salem and meanders in a northerly direction for 62 miles to join the Molalla River. Annually, the subbasin yields about 1.7 million acre-feet of water. About three-fourths of the subbasin runoff occurs during fall through spring. About 7 to 11 percent of runoff occurs during the summer.

The Pudding River is a migration route for coho salmon, spring Chinook and winter steelhead. Lower elevation lands in the Pudding drainage are primarily agricultural while the higher elevation Molalla drainage lands are largely forested. Portions of the Pudding River, Zollner Creek, and the Little Pudding River have been designated as "water quality limited" by the ODEQ for water temperature, dissolved oxygen, and bacteria.
The water resources in the subbasin provide flows for fish, drinking and industrial water, and irrigation. Heavy groundwater use may restrict this source as a future water option in this subbasin. Flows in the Molalla and Pudding rivers cannot meet existing uses and water rights. Tributary streams in the subbasin do not meet existing demands in the summer months.

Flows on the Molalla and Pudding Rivers fall short of meeting municipal, industrial and agricultural uses during the summer and early fall. Water levels in tributaries generally cannot meet water demands during low flow months. Total water demands could reach 25 percent of the total runoff of the Molalla drainage. Most of this demand occurs during the summer when the drainage yields only 6 percent of its average annual runoff. Total water demands for the Pudding could reach about 16 percent of the total runoff in the drainage.

Municipal use of water in the subbasin is low. The largest municipal water providers in the subbasin include Canby, Molalla, Silverton, and Woodburn. Only about 19 percent of existing water rights are currently being used and municipal water rights appear adequate to meet projected growth rates. Some cities relying on groundwater, however, may need to find other water sources to replace declining supplies.

Marion County has the highest value of agricultural production in the state. Water supply studies of new source options for irrigation and possibly other uses in the Pudding drainage are underway. The ODA estimates that an additional 69,150 acres of farmland, mostly in the Pudding drainage, will be irrigated in the subbasin by 2035. Irrigation is the largest water use in the subbasin, and about 172,875 acre-feet of water may be needed in the future. Irrigation water may come from pumping and pipeline delivery from existing storage on the North Santiam River, or from new storage projects.

The Pudding River Water Sources Development Association is currently evaluating three water supply options for the Pudding drainage. The Del Aire reservoir site, located about 5 miles upstream from Scotts Mills on Butte Creek, has been found to be the best overall storage site. About 34,400 acre-feet of water would be stored for irrigation, municipal, and flow needs. Water would be diverted from Butte Creek and into a pipeline distribution system. The preliminary estimated cost is about $61.5 million.

Another option for increasing water supply for agricultural use diverts water stored in Detroit reservoir on the North Santiam River by pump. Water would be discharged into a small reservoir (3,000 acre-feet) on the South Fork of the Pudding River. Water delivery to the service area would be by pipeline. The preliminary cost is about $36 million.

A third option considers three small reservoirs to store about 12,300 acre-feet of water for irrigation. One reservoir on Rock Creek (8,000 acre-feet) and two reservoirs on Muddy Creek (total of 4,600 acre-feet) would be supplemented by water diverted by pipeline from Butte Creek. Two pump stations would be needed at the reservoirs to deliver water by pipeline to users. The preliminary estimated cost is about $25 million.

4.4.5. Coast Range Subbasin

The Coast Range subbasin includes four drainages: the Yamhill River, Rickreall Creek, the Luckiamute River, and the Mary's River. Currently, flows in subbasin rivers and streams are not adequate to meet existing uses and water rights during the summer. The subbasin is spread across three rapidly growing counties: Yamhill, Polk, and Benton. Four subbasins in the coast range include those drained by the Yamhill River, Rickreall

Creek, Luckiamute River and the Mary's River. High winter runoff and low summer flows are characteristic of Coast Range drainages. Heavy groundwater use may restrict this source as a future water option in most of the subbasin.

The Yamhill River drains an area of 772 square miles in Yamhill and northern Polk counties. About 85 percent of the runoff occurs from late fall to early spring with about four percent during the summer. High water demand during the summer low flow season is a problem. Total water demand could reach about 17 percent of the drainage's annual runoff. Groundwater has been intensely developed and may be limited in the future. Irrigation is the largest water use in the Yamhill drainage, supporting a growing nursery industry and vineyards. An additional 69,500 acres of land could be irrigated by 2035, and about 173,800 acre-feet of surface water would be needed. Currently, eight cities divert surface water and groundwater for municipal use. Existing in-stream water rights seem adequate to meet projected population growth and water demands. However, communities that use groundwater are finding this source to be unreliable.

With a total of 94 square miles, Rickreall Creek is the smallest drainage in the Coast Range. About 86 percent of the runoff occurs from fall to spring and about four percent during the summer. Flows are insufficient to meet water demands during the summer. New water use permits are conditioned based on water availability. The drainage also has seriously declining groundwater levels. The City of Dallas relies on the Rickreall drainage surface water to supply its drinking water. When severe domestic water supply problems occur in unincorporated parts of the drainage, the city has been temporarily serving these rural communities. Dallas recently conducted a study that addressed future water needs for the Rickreall area. Present supplies appear sufficient to meet water needs through 2010. However, it is anticipated that new winter water rights, raising the Mercer dam for more storage, and possibly a new reservoir may be needed to satisfy long-term water demands.

The Luckiamute River drains 311 square miles in southern Polk and northern Benton counties. Most of the runoff (82 percent) occurs from fall to spring and about 6 percent during the summer months. Flows on the river fall short of meeting water demands during the summer months. The total water demand could reach about 8 percent of yearly runoff. Irrigation is the largest use in the Luckiamute drainage, and an additional 25,700 acres of land could be irrigated by 2035. Falls City and Monmouth hold rights to use water in the drainage for municipal use. These rights seem sufficient for the cities' future needs. Rural residents in some areas, however, are having problems obtaining groundwater.

The Mary's River in Benton County drains about 329 square miles, with total runoff about 334,700 acre-feet per year. About 83 percent occurs from the late fall to early spring, with about four percent during the summer and early fall. Flows on the river do not meet water demands during the summer and early fall. Irrigation is the largest water use in the Mary's drainage. An additional 23,410 acres of land could be irrigated by 2035. Corvallis and Philomath hold water rights to divert water for municipal uses. The cities are currently using only about 17 percent of their allocated amount and should be able to meet future needs if the water and system capacity does not diminish.

To supply additional water, many potential storage sites from about 5,000 to 50,000 acre-feet in size have been identified in the Coast Range subbasin. Studies conducted by the Bureau of Reclamation from 1992 to 1995 found that new storage projects were the only option that could fully meet future demands for municipal and irrigation water, and flows for water quality and fish. However, potential adverse environmental impacts, water rights issues, and high estimated costs continue to limit the development of new storage projects.

4.5. Investigate Rule Curve Modifications

This study task deals with a preliminary evaluation of minor changes to the water control diagrams at the Willamette reservoirs to improve the probability of filling them in the spring. This task has been completed and a report prepared by the OWRD (February 1999). A summary of report conclusions is provided below.

Each Willamette reservoir is operated using specific criteria that determine pool elevations during various seasons of the year. Starting in February, each reservoir's flood storage space is gradually filled to reach full conservation (summer) pool levels by mid-May, which is typically the end of the flood season. The exception is Fern Ridge, which is filled by mid-April. Each project has a specific filling rate developed using historic flooding data that coincides with a decreasing flood potential. Having full reservoirs maximizes the amount of water available for summer uses and the operational flexibility of the system.

Having full reservoirs maximizes the amount of water available for summer uses in the basin. Over the past 37 years, the reservoirs have not filled to full conservation pool levels from 15 to 30 percent of the time. Since the 1970s, those common years in which most projects did not fully fill occurred during very dry conditions in the basin: 1973, 1977-1978, 1987, and 1992. Having inflow to fill the reservoirs is a problem during low flow years, as is balancing reservoir filling and releases for instream flows with having adequate storage for rainfall events. Earlier filling increases the probability of flood damages occurring since flood storage is utilized when additional inflows are retained in the pool.

As water demand increases in the future, having less than full reservoirs may limit water availability for recreation and downstream needs in the summer months. Earlier filling of eight reservoirs was investigated using a Willamette system model called WILMA to modify reservoir operation and allow the projects to fill about 6 weeks earlier than normal. For the larger reservoirs modeled (Cougar, Detroit, Hills Creek, Lookout Point, and Green Peter), no change in reliability of reservoir filling was found using the earlier fill schedule. Most of the runoff that fills these projects comes from snow melt which peaks later in the filling season (mid-April to early June). These reservoirs apparently capture as much runoff as possible given their existing operational criteria. The smaller reservoirs modeled (Cottage Grove, Dorena, and Fern Ridge) showed about a 15 percent increase in reliability of reservoir filling using the earlier fill schedule. This likely occurs because runoff is retained in the reservoirs rather than released to provide additional storage for flood water.

Overall, the gain in total system storage was found to be small, only about 3,500 acre-feet, or about 0.5 percent of the total storage available. During dry years, however, the earlier fill schedule showed a somewhat higher gain in system storage, about 14,400 acre-feet or one percent of the total storage available. The smaller reservoirs again showed the most gain. Although gains in storage were small, some localized benefits would likely occur using an earlier fill schedule at Cottage Grove, Dorena, and Fern Ridge reservoirs. Increasing the reliability of reservoir filling during dry years may provide more stored water for meeting downstream flows and recreation needs in the summer.

Earlier filling at the projects, however, may cause increased localized flooding and flood damages in the early spring. Generally, earlier filling of the reservoirs is not done because most of the runoff before March occurs as rainfall, which is hard to predict beyond a 24 to 48 hour period. The Coast Fork and Long Tom subbasins are low in elevation, and flooding is caused primarily by heavy rains. Most of the total runoff in these subbasins occurs from November to March. In addition, about 26 percent of the annual peak flows on the Long Tom River occur in February and March. The reservoirs in these subbasins are prone to respond very quickly to precipitation events because of their small size. Further studies would be needed to quantify the increased flooding risk and flood damages using an earlier fill schedule at these reservoirs.

Besides flooding, other impacts may be caused by earlier filling of the reservoirs. For example, a previous study at Fern Ridge found that earlier filling would likely cause adverse impacts to a federally endangered plant, *Lomatium bradshawii.* The USFWS and other natural resource agencies believe that earlier filling would trigger reed canary grass invasion of the native prairie habitat areas. It was concluded that maintaining the current filling schedule at Fern Ridge was critical to the existence of this endangered plant.

At this time, no further work on this task has been recommended because the risks from increased flooding and other impacts appear to outweigh the small benefits gained in reservoir filling and total system storage. A reevaluation may be required however, depending upon recommendations made for ESA-listed fish species in the basin.

4.6. Identify Erosion Problems

This study task has been completed and findings documented by the Corps. A summary of findings is shown below. Additional information can be found in the report, *Criteria and Discussion of Existing and Base Conditions*. Any future work on this task has been incorporated into the *Willamette Basin Floodplain Restoration Project* (Corps, 1999). The Willamette River is a meandering system where channel change, bank erosion, and sediment deposition are continuing occurrences. The complex processes causing bank erosion in the Willamette system are not likely to change under future conditions (conservation season operation from April through Labor Day). Evaluation of the erosion problems of the Willamette River and its tributaries indicate that:

- New erosion of Willamette Basin river banks has occurred primarily upstream or downstream of the existing revetments or on the outside bends of the unprotected reaches of the rivers.
- Evaluation of the average weekly discharges during the study period (conservation season operation) revealed that discharge flows are not sufficient enough to produce erosive velocity. Also, changes in discharge flows are not sufficient enough to exceed the cohesion factor of streambank materials and trigger discernible slough or erosion.
- Reduced outflows from the dams during conservation season operation may cause some minor toe erosion and undercutting of the river banks downstream of the projects. This condition would most likely develop into extensive erosion problems during high flow periods particularly in locations where the streambank has existing slope erosion directly above toe erosion, or where undercutting has occurred directly below masses of trees exposing their root structure. On sites of bank undercutting where the overlying slopes have failed, thereby exposing raw soils to aerial erosion, rills and gullies have developed, which cut back into the upper portions of the slope.

4.7. Identify Natural Storage Opportunities

One task of the reservoir study was to make a preliminary determination of whether additional wetland/detention storage is available along the Willamette and major tributaries to provide natural storage to reduce flood damages. Flood risks are increasing in the valley due to floodplain development and loss of natural floodplain wetlands. The valley has lost about 40 percent of its original wetland areas. The greatest losses have been in the southern portion of the valley and in the Santiam subbasin.

Land use practices can accelerate runoff, which leads to increased peak flows and flooding. In many areas, floodplains can be restored to unobstructed and well-vegetated conditions so that flood flows are spread out, flood waters are retained, and water velocities are reduced. Rather than attempting to concentrate flows during storms, land managers along the river and its tributaries should expect flooding at some level and encourage floodable lands to retain floodplain functions.

A conceptual study to assess the hydrologic feasibility and benefits of restoring floodplains for flood management in the valley was completed by River Network (1996). The study concluded that feasible floodplain restoration opportunities exist to reduce flood hazards to homes, public structures, and farms while allowing for fish and wildlife habitat restoration. A restored floodplain would act to absorb excess flood waters, slow the velocity of flood waters, and create habitat for a wide variety of plants, animals, and ESA-listed fish species. According to the study, flood inundation of 20,000 to 50,000 acres would be equivalent to about an 18 percent reduction in peak flows in some areas of the valley.

Regional interest for floodplain restoration in the valley became high after the February 1996 flood event. Numerous federal, state, and local entities have expressed strong support for floodplain restoration efforts. In April 1998, the Corps initiated a reconnaissance study with a purpose to assess opportunities to modify existing floodplain features to reduce flood damage while restoring natural wetlands and promoting ecosystem restoration. The reconnaissance study was completed in April 1999 (Corps, 1999). The study found that federal interest in participating in a more detailed feasibility phase study was warranted based on the following factors.

- Floodplain restoration will achieve multiple objectives related to watershed health and water resource problems in the Willamette Basin, including flood damage reduction and ecosystem restoration, two high priority missions of the Corps Civil Works program. Besides reducing flood flows, restoration of floodplains would restore water quality functions and habitat values. Restoring bottomland forests would slow floodwaters and trap sediments and nutrients, thereby enhancing recovery of rare plant communities. Restoring marsh and open-water habitats, particularly associated with reconnection of sloughs and backwaters along mainstem river reaches, would benefit fish and amphibian populations.
- Restoration of aquatic and riparian habitat will help to restore critical habitat for several fish species currently listed under the ESA.
- Floodplain restoration is consistent with the Plan of Action developed by the Governor's office under the American Heritage Rivers Program.
- Floodplain restoration will help to implement the objectives of the Pacific Northwest Forest Plan of 1996.
- Floodplain restoration will help assist in meeting Clean Water Act standards for the Willamette River system and support the recovery of listed species.

The State of Oregon has indicated willingness to sponsor the feasibility phase study and has entered into negotiations with the Corps for the *Project Study Plan and Feasibility Cost Sharing Agreement*. A phased approach has been recommended for the feasibility phase study. The initial phase would establish a comprehensive, basin-wide framework for integrated river management and floodplain restoration. The framework study would include the following activities.

- Identify the political, institutional, and social conditions in the Willamette Basin and establish a framework for collaboration and coordination with stakeholders.
- Collect and analyze existing data and identify gaps for further technical evaluations.
- Develop a hydrodynamic flow model of the Willamette Basin with a Geographic Information System interface as a tool in assessing the reduction of flood risks, geomorphic changes in the channel, and improvements to water quality, as well as assisting in the prioritization of restoration sites.
- Identify potential restoration measures, projects, and/or areas.
- Establish criteria to evaluate and prioritize the basin by subreach and/or subbasin.
- Establish a cooperative long-term implementation program.

The second phase of the feasibility phase study would focus at a greater level of detail on floodplain problems and restoration opportunities on a site-specific, subreach or subbasin level. A list of potential site-specific, structural and non-structural floodplain restoration measures was identified in the reconnaissance report. Also, potential programmatic and/or policy measures were identified that could be implemented to assist in floodplain restoration in the basin.

4.8. Address Municipal and Industrial Demands and Constraints

This study goal deals with determining the future municipal and industrial water demand in the basin, especially the demand likely to be supplied by Corps storage and the possible policy and cost issues of purchasing storage from the Corps. Section 4.2 of this report describes the projected future municipal and industrial water demands by 2020 and 2050. Also, a multiple water use concept was included in the *Project Study Plan* at the request of the sponsor, which resulted from discussions with water providers and their concerns over the high cost of purchasing storage from the Willamette reservoirs. Release of stored water for water supply in the lower end of the basin could have multiple benefits as it travels downstream which may make it possible to share the cost of the storage. The policy and cost issues of purchasing reservoir storage and the multiple water use concept are described in Section 6.2 of this report.

4.9. Evaluate Effects of Alternative Scenarios

Alternative scenarios for changing the operations of the Corps' Willamette reservoirs are being formulated to meet future water needs for agricultural irrigation, municipal and industrial water supply; in-stream flows uses to ensure water quality and improve wildlife and fisheries habitat; and recreation. A Willamette system model called WILMA was used by the Technical Workgroup and Corps study team to develop a set of initial alternative scenarios for the April 1998 public workshops. The initial scenarios are described in Section 5.3.2 of this report. The WILMA model allowed a rapid screening of initial scenarios by changing different operational parameters, such as minimum releases, water withdrawals from the system, and downstream flow targets. The model provided the opportunity to investigate basic system configuration and explore system impacts of altered or changed demands resulting from the initial scenarios.

Following the completion of the consultation between the Corps, NMFS, and USFWS on ESA-listed fish issues, final alternative operational scenarios for the study are expected to be developed and evaluated by the Technical Workgroup and Corps study team.

5. Description of Completed Study Tasks

5.1. Plan Formulation and Evaluation

The water resources problems and expected future conditions identified for the study are described in the report, *Criteria and Discussion of Existing and Base Conditions* (Corps, January 2000). Early in the study process, the Technical Workgroup developed initial planning objectives in response to the water resource problems identified for each beneficial water use. A discussion of the planning objectives developed to date, including identified performance measures, priorities, risks and uncertainties, and tradeoffs, if available, are shown on the following pages.

Planning constraints identified for the study include:

- Modifications investigated for system operational changes must not affect the flood protection aspects of the projects and the system as a whole.
- Construction or modification of structural facilities at the Willamette projects is not being considered in the alternative scenarios developed for the study.

The Technical Workgroup and Corps study team then formulated various reservoir operation/allocation scenarios using the WILMA model. It provided the opportunity to investigate system configuration and the impacts of changing different reservoir operational parameters and system demands. The initial alternative scenarios developed in this manner were the focus of the public workshops held throughout the basin in April 1998. More information on the initial scenarios and the resulting public comments can be found in Section 5.3.2 of this report. The development of final scenarios has been delayed until resolution of the Corps' ESA consultation with the NMFS and USFWS concerning listed fish species in the Willamette Basin.

There is an ongoing effort by the Technical Workgroup and Corps study team to identify and categorize the types of tradeoffs expected for the study. The types of tradeoffs identified to date are shown below, although the list is not complete and will be refined and expanded as the study progresses.

- Monetary versus non-monetary outputs. This is a key issue and reflects the problem in attempting to compare market-based monetary values with aesthetic, environmental, or inherent values of society at large. The study team is planning to perform cost effectiveness and incremental cost analysis (ECO-EASY) to quantify National Economic Development (NED) benefits and other costs required to obtain both a fixed level and added increments of environmental output. Also proposed for use is IWR-PLAN, which builds upon the incremental/cost effectiveness analysis of ECO-EASY. IWR-PLAN also includes the ability to account for both the economic and environmental effects of plans, and organizes information about effects to facilitate decision-making.

- Tradeoffs between different kinds of monetary outputs. For the purposes of NED analysis, all monetary units are equal. Whereas monetary values for different outputs may be derived by different methods (least cost, user day, etc.), they are equivalent in that they represent NED values (benefits). However, the sponsor may place a higher priority on some types of outputs than others.

- Tradeoffs within output categories. These types of tradeoffs may have significance is improving one compromises the quality or accessibility of the other. For example, in cases where downstream outputs will be adversely affected at the expense of reservoir outputs, those effects may be subject to, or require, mitigation. For outputs such as recreation, the NED benefits and costs of the different alternative scenarios can be directly compared. Increasing one output at the expense of another may result in a new zero effect (if they cancel each other out). In regards to non-monetary outputs such as fish and wildlife, decision criteria will be based on output as well as other significance factors such as threatened and endangered status of species.

- System versus subbasin tradeoffs. The focus of the study is on the Willamette River system (basin-wide). Typically, NED benefits would take precedence over regional benefits. In some cases, the study may need to identify and track subbasin outputs if they can be shown to be unique or otherwise of critical importance to the region or the state.

- Tradeoffs across subbasins. Generally, NED outputs are the primary objective in the Corps' economic analysis. Although regional impacts are recognized as being important, they generally do not drive the study and in some cases, can be mitigated. However, some regional preferences and prioritization may be desired by the sponsor to meet other objectives. Those preferences will need to be explicitly identified for the study.

- Tradeoffs between projects. Current operation of the system does afford priority for some uses, such as for recreation at Fern Ridge and Detroit. Reservoirs having higher levels of use are weighted on this basis, i.e. the amount of outputs/benefits assigned to those projects are proportionately greater, whether applying contingent value or travel cost methodology. Visitation, which significantly influences the beneficial effect; is accounted for either way. The study will need to track these relative benefits, however, and be able to clearly describe them to the constituents of the individual reservoirs.

Municipal and Industrial Water Supply Planning Objectives

- Operate and allocate storage in the Willamette reservoirs to reliably meet future municipal peak-week demands for stored water from these facilities.

- Maintain and enhance water quality through operation of the reservoir system to foster accessibility to quantity and reduce potential increases in the cost of municipal water supply treatment.

Performance Measures. Metrics would measure how well various reservoir operation/allocation scenarios would meet forecasted municipal and industrial water demands in aggregate and by subbasin. Units of measurement should include both volume (acre-feet and millions/billions of gallons) and flow rates (cubic feet per second and millions of gallons per day). Parameters should include both demands met and demands unmet. Deficiencies should be characterized in terms of frequency, magnitude, duration, and geographic variables.

Priorities. A major priority for municipalities is the reliability of supply. Certainty as to the availability of contracted supply is especially important to municipalities given the public health and safety issues associated with providing domestic water supplies and fire flows. Reliability is also needed to justify committing public funds to develop costly treatment facilities in order to make use of the resource.

Risks and Uncertainties. It may not be possible to evaluate how different operating scenarios affect those water quality constituents of concern from a treatment perspective. It would be difficult to translate such effects into quantifiable changes in treatment requirements and costs. It also must be recognized that there is error associated with long-range demand forecasts and that the characteristics of all types of demands may change over time. Water providers recommend leaving some room for adjustment to be made over time, that the study include identifying a future process for revisiting and updating needs and constraints, and to address changing conditions through viable modifications to reservoir operating strategies.

Tradeoffs. There is a concern about the pros and cons or tradeoffs associated with using existing Corps storage to meet future demands versus having to obtain supplies from alternative sources. One tradeoff that is exceedingly challenging is to evaluate the relative costs and benefits of releasing water downstream (and keeping it in-stream) for water quality versus allocating the water to consumptive uses and potentially requiring additional treatment to address water quality degradation. There may also be tradeoffs between "up-basin" and "down-basin" users - both in-stream and out-of-stream uses as well as upstream and downstream municipalities. While there are likely to be some constraints in parts of the basin that limit the amount of water that can be allocated to consumptive versus non-consumptive uses, there are also likely to be areas where synergistic or complementary effects can be generated among uses through operation of the reservoirs to meet downstream needs.

Agricultural Irrigation Planning Objectives

- Operate the Willamette system of reservoirs to provide a source of water from May through September to meet all current and future agricultural irrigation demands to 2050.

Performance Measures. Metrics should measure how well the alternative scenarios meet the forecasted increase in irrigation demand from water stored in the reservoirs by subbasin and for the system (number of weeks demand is met); and also the volume (acre-feet, cubic feet per second or cfs) duration (weeks), and location (subbasin) of shortages if they occur.

Priorities. The use of stored water to meet future irrigation demands is extremely important to the agricultural community in the Willamette Valley. The valley is one of the nation's most fertile agricultural areas, and reservoir water supports farming and nursery production, adding significantly to the state's economy. The importance of assuring a sufficient water supply for irrigation was reflection in the comments received at the phase one and two public workshops.

Risks and Uncertainties. The lack of conveyance and distribution facilities currently constrains the use of stored water for irrigation in some parts of the basin. The forecasted increase in irrigation demand for stored water assumes the additional development of water delivery systems. Also, many landowners along basin streams below the reservoirs view the availability of stored water as an "insurance policy" in the event of reductions in availability of natural flow. The estimates of future irrigation use were based on current economic, social, and environmental conditions. Changes in any one of these could significantly alter the demand for irrigation water. For example, the expansion of international markets may drive the development of more irrigated farmland in the basin. As agricultural land development occurs along basin streams, so will the water needs for many related purposes and services, including food processing. Significant population growth in the basin, however, may influence whether land is developed for agriculture or not.

Tradeoffs. Increased irrigation water use may impact other uses dependent on high reservoir levels especially in low flow years, by lowering lake levels earlier in the conservation season. The forecasted demand for irrigation water may limit the amount of stored water available for other downstream uses, especially in low flow years, for both in-stream (water quality and fish) and out-of-stream (municipal and industrial) uses. Increased releases from the projects to meet future irrigation demands may improve in-stream conditions to the point of diversion, however. Maintaining stable, below normal conservation pool elevations to meet fish, wildlife, and wetlands objectives would reduce the amount of stored water available for future irrigation needs. Not meeting the future water needs for irrigation may limit the ability to expand many high-valued agricultural crops like nurseries and the overall economic activity generated by agriculture in the basin.

Water Quality Planning Objectives

- Operate the Corps Willamette reservoir projects during the conservation season to maintain existing downstream and reservoir water quality.

Performance Measures. Performance measures will be split into an initial screening phase and a final evaluation phase. The lack of a basin-wide water quality model makes quantitative analysis of alternatives difficult. The screening tool will utilize the HEC-5 model output by control point (figure 2). The initial evaluation phase will measure the frequency of greater than 10 percent deviation from base condition flow at the control points or depth in the reservoirs. The frequency of the deviation during the conservation season will be combined with ODEQ's 303(d) list of water quality limited streams to determine how many "impacted water bodies" are further impacted by the proposed alternative (table 8). The screening criteria used will be frequency of deviation and number of water quality stream segments affected. These criteria can be combined to rank alternatives according to low, medium and high water quality impacts. This ranking will serve as a relative ranking and cannot be used to quantitatively judge alternatives actual impacts.

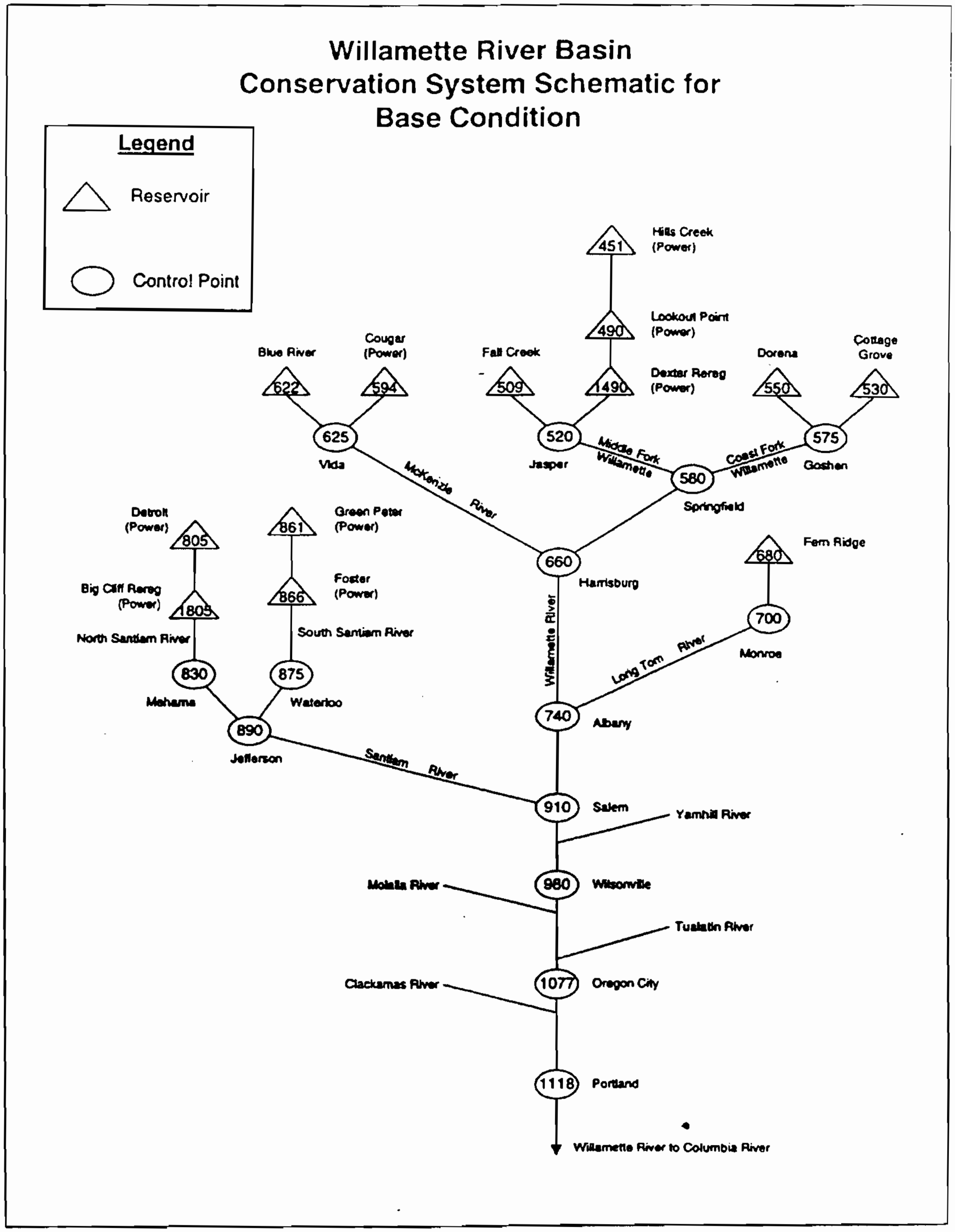
Final evaluation of the scenarios will incorporate additional analysis of water quality impacts using an existing water quality model developed by ODEQ. The model is only applicable to the main stem Willamette and the focus of the analysis will be at Albany and Salem. The model will compare temperature, dissolved oxygen, chlorophyll a and carbonaceous biological oxygen demand between the alternatives. This will involve taking the HEC-5 output, adapting it for use in the QUAL2E model and running that water quality model. Additionally, ODEQ will perform sensitivity analysis using QUAL2E. The analysis will determine the magnitude of flow changes required to produce negative and positive effects on the above parameters at Albany and Salem. For instance, sensitivity analysis will provide some idea of the flow change required to lower stream temperature one degree during the conservation season.

Priorities. The priority of this study is to insure that alternative operating scenarios do not adversely affect water quality in the basin. The study will not focus on strategies to improve water quality in the basin. The quantitative tools to accomplish this do not exist at this time and the study does not have the resources to create those tools. Further, to focus on water quality would also require consideration of a range of factors that are beyond the scope of the study. These include land uses, stormwater management, agricultural practices and point sources of pollution to name a few. Although improving water quality is a high priority in the region, there are other groups and agencies addressing these issues and the study team understands the limitations of this study. The performance measures for this objective are mainly qualitative in nature and will rely on identifying existing water quality problems on the 303(d) list and determining if changes in flow or reservoir depth adversely affect the water quality limitation.

Risks and Uncertainties. It is understood that basing the screening level water quality performance measures exclusively on in-stream flows and reservoir depths does not provide a clear understanding of the true impacts on water quality. Stakeholders concerned with improving water quality in the basin will probably not look favorably on using flow and depth exclusively. The study will address these concerns by stressing that strategies to improve water quality were never part of this study and that the comparison between alternatives using flows and depths will provide some insight into where and when water quality impacts may occur. Although the water quality analysis of the final alternatives will utilize an existing water quality model, there are uncertainties associated with this as well.

Water Quality Planning Objectives (continued)

Figure 2. Willamette Basin Schematic and HEC-5 Model Control Points



Water Quality Planning Objectives (continued)

Table 8. Proposed Control Points Affecting Water Quality Impacted Water Bodies as Identified by ODEQ 303(d) List

Subbasin	Stream Segment/ Water Body	Parameter	Control Points Influencing
Coast Fork	Row River, mouth to Dorena Coast Fork, mouth to Cottage Grove Cottage Grove Reservoir	Temperature – summer Temperature – summer Bacteria – summer Bacteria – FWS Mercury – tissue/water	550 flow 530/575 flow 530 depth
Lower Willamette	Willamette, mouth to Willamette Falls	Temperature – summer Bacteria – FWS Fish deformities	Portland/Oregon City flow
McKenzie	Blue River, mouth to reservoir McKenzie, mouth to Ritchie Cr McKenzie, Ritchie Cr to South Fork South Fork, mouth to Cougar Reservoir	Temperature – summer Temperature – summer Temp, bull trout, summer Temp, bull trout, summer	622 flow 625 flow 625 flow 594 flow
Middle Fork	Mouth to Dexter Reservoir	Temperature - summer	520/490 flow
Middle Willamette	Willamette, Willamette Falls to Santiam River	Temperature – summer Bacteria – FWS Fish deformities	Wilsonville 910 flow
Santiam	Santiam, mouth to North/South Forks North Santiam, mouth to Little North South Santiam, mouth to McDowell Cr (between Waterloo and Sweet Home)	Temperature – summer Temperature – summer Temperature – summer Bacteria - annual	890 flow 830 flow 875 flow
Upper Willamette	Coyote Cr, mouth to headwaters Fern Ridge Reservoir Long Tom, mouth to Fern Ridge Willamette, Santiam to Calapooia Willamette, Santiam to Long Tom Willamette, Santiam to Coast/Mid Forks	Dissolved oxygen: May-Oct Bacteria – annual Turbidity, Bacteria – FWS Temperature – summer Bacteria – FWS Fish deformities Bacteria – FWS Temperature - summer	680 flow 680 depth 680/700 flow 740 flow 740 flow 740/660/580 flow

Sources: ODEQ and Corps of Engineers

The model will give a quantitative measure of the impacts for a limited number of parameters. The model only considers the mainstem Willamette so the major tributaries will only be screened for flow deviations. It is likely that the analysis with the model will only show limited impacts in the main stem unless flows are significantly altered. The opportunity to affect water quality by changing flows is probably more significant in the major tributaries directly downstream of the projects. In future studies, it will be helpful if water quality models are developed for each subbasin so quantifiable metrics can be used to assess water quality impacts of different scenarios.

Tradeoffs. Possible tradeoffs will focus on downstream uses for water quality versus reservoir uses. Increasing downstream flows to maintain water quality because of increasing out of stream uses will adversely impact reservoir recreation and potentially habitat. Other possible tradeoffs are to limit the out of stream uses so the state's water quality objectives can be met without increasing flows from storage. Irrigation and municipal users could be adversely impacted in this case. Tradeoffs between subbasins could be considered, although sacrificing water quality in one subbasin to benefit another would be a difficult choice to make.

Reservoir Recreation Planning Objectives

- Operate the Willamette Basin system to ensure that, with the exception of critical water years, during the peak summer recreation season from Memorial Day through Labor Day, pool elevations in the highest priority recreation reservoirs, Fern Ridge, Detroit and Foster lakes, remain within the optimum range, and that other important recreation reservoirs, including Cottage Grove, Dorena, Green Peter and Fall Creek are retained within an acceptable range for water-related recreation activities, including boating, water skiing, fishing and swimming.

Performance Measures. As shown in table 9, criteria have been developed correlating the relative recreational suitability of each Willamette reservoir at varying conservation pool elevations. The criteria are based principally on the usability of facilities such as boat ramps, boat docks and swimming beaches at different lake elevations, as well as on considerations for impacts of drawdown on general lake access and aesthetics.

Table 9. Recreational Suitability of Willamette Reservoirs by Pool Elevations

Reservoirs	Optimum Recreation Conditions	Acceptable Recreation Conditions	Poor Recreation Conditions	Below Minimal Recreation Pool
Detroit	1563.5 - 1558.5	1558.5 - 1546.0	1546.0 - 1533.0	< 1533.0
Green Peter	1010.0 - 1005.0	1005.0 - 992.0	992.0 - 985.0	< 985.0
Foster	637.0 - 632.0	632.0 - 627.0	627.0 - 613.0	< 613.0
Cougar	1690.0 - 1685.0	1685.0 - 1675.0	1675.0 - 1638.0	< 1638.0
Blue River	1350.0 - 1345.0	1345.0 - 1335.0	1335.0 - 1298.0	< 1298.0
Fall Creek	830.0 - 827.0	827.0 - 822.0	822.0 - 692.0	< 692.0
Hills Creek	1541.0 - 1536.0	1536.0 - 1516.0	1516.0 - 1444.0	< 1444.0
Lookout Point	926.0 - 921.0	921.0 - 914.0	914.0 - 820.0	< 820.0
Dorena	832.0 - 829.0	829.0 - 827.0	827.0 - 768.0	< 768.0
Cottage Grove	790.0 - 787.0	787.0 - 781.0	781.0 - 748.0	< 748.0
Fern Ridge	373.5 - 372.5	372.5 - 371.0	371.0 - 367.0	< 367.0
Dexter	690.0 - 695.0	690.0 - 695.0	< 695.0	< 695.0

Note: elevations in feet National Geodetic Vertical Datum (NGVD)

Priorities. The planning objective reflects the current priority for reservoir recreation in the basin. This priority has evolved in which those reservoirs with the highest recreation demand (Fern Ridge, Detroit, Foster) are held as high as possible until the end of the conservation season (usually after Labor Day). Lower priority lakes are drawn down earlier to meet in-stream flow requirements. Also, there is strong and vocal support for maintaining the recreational viability at Fern Ridge, Foster, and Detroit from the Eugene-Springfield, Sweet Home-Foster-Lebanon-Albany, and the Detroit-Idanha-Mill City communities, respectively. These local interests believe that continued recreation use is important for the economic vitality and quality of life of their communities. This was reflected in the public comments received at the phase one and two public workshops.

Reservoir Recreation Planning Objectives (continued)

Risks and Uncertainties. It is believed that for the initial screening level analysis, the performance measures allow adequate certainty for comparing alternative scenarios to evaluate their relative impacts on reservoir recreation across the system during the peak summer recreation season. The screening level performance measures can be used to do a comparison (ranking) of the relative suitability of the scenarios for recreation and will also allow some simple tradeoff analysis. They will not provide any estimates of recreational output. However, the ranges are not based on any actual observed or reported recreational behavior and cannot be used to develop any correlation to visitation or consumer surplus values. Therefore, no estimates of recreational outputs will be possible during the initial screening phase.

For the final evaluation phase, these screening level metrics will be replaced by the more detailed travel cost model. The travel cost model estimates annual visitor use, consumer surplus, and regional expenditures for each lake under each scenario.

The major risk associated with the screening level performance measure is that the criteria for determining the relative suitability of the various reservoir operating ranges for recreation were developed solely on the professional judgement of technical team members based on an evaluation of the usability of existing recreational facilities, access to shoreline, and aesthetics at different pool elevations. Some uncertainty exists as to whether or not they accurately reflect visitation and use of the reservoirs.

Tradeoffs. Drawdown of the reservoirs for downstream requirements has a direct impact on the recreational suitability of the reservoirs. Ultimately, the study will need to capture cost of drawdown to recreation and other reservoir uses and compare it to the benefits gained by downstream uses. This includes a possible tradeoff between reservoir recreation and downstream recreation. For example, would recreation benefits be greater for maintaining pool elevations in Green Peter or providing increased flows in the South Santiam River below Foster. It is possible that higher total project benefits can be gained by maintaining reservoir pools for recreation than meeting other downstream purposes.

Along those lines, there is a direct tradeoff between maintaining pool elevations in the higher priority recreation lakes while "sacrificing" the recreational suitability of other lakes. It has been assumed that greater project benefits are gained by maintaining Detroit, Fern Ridge, and Foster Lakes near optimum pool elevations for recreation while drawing down other reservoirs. Perhaps greater total benefits can be obtained by drawing down the projects proportionally and thereby maintaining all or most of them within the acceptable range for recreation. The study should attempt to verify that this existing tradeoff, and established priority of drawdown, is appropriate.

Downstream Recreation Planning Objectives

- Operate the Willamette Basin System to provide downstream releases that fall within the target flow ranges for river-based recreation activities, particularly fishing, drift boating, canoeing, kayaking, and rafting.

Performance Measures. The following metric will be used to evaluate the relative effectiveness of alternative scenarios in meeting the downstream recreation objective:

The number of days (or weeks depending on the model time step) during the peak recreation season in which average daily flows fall within the target range of flows for tributary streams downstream of the Willamette reservoir projects.

Target flow ranges have been identified by different user groups and/or managing entities for different activities and use seasons on downstream river reaches, as shown in table 10.

Priorities. For this study, no attempt has been made to prioritize the relative recreation values of the downstream river reaches. The 1986 Pacific Northwest Rivers Study assessed the importance of most river reaches in the Willamette Basin (except the Long Tom River below Fern Ridge) for a variety of fish, wildlife, recreational, and cultural resource values. The river reaches achieved an overall rating of wither outstanding or substantial.

Risks and Uncertainties. While the timing and volume of flow released from the projects may be important to downstream river recreation, this relationship is uncertain and has been difficult to quantify. Studies by the Eugene Water and Electric Board on the McKenzie River concluded that no statistically significant relationship exists between the amount of visitation and flow. Also, the desired timing and flow volume varies considerably between activities; for example, good conditions for anglers and drift boaters are not necessarily good for whitewater enthusiasts. One important assumption that will be tested in the study is that reservoir operations do not have a significant impact on recreational use of the mainstem Willamette River below the confluence of its major tributaries.

Tradeoffs. Drawdown of the reservoirs to release water for downstream water uses has a direct impact on the recreational suitability of the reservoirs. Ultimately, the study will need to capture the cost of releasing water (reservoir drawdown) to reservoir recreation and other uses and compare it to the benefits gained by downstream water uses. This includes a possible tradeoff between reservoir recreation and downstream recreation. It is possible that higher total project benefits can be gained by providing improved downstream recreation conditions than maintaining reservoir pool elevations.

Table 10. Downstream Recreation Flow Targets

River Reach	Target Activities	Recommended Flow	Peak Season	Source	Comments
North Santiam River below Detroit Dam	Angling for steelhead, salmon, and trout	1,000-1,200 cfs (900 cfs during low water year)	June 1 thru August 15	Oregon Water Resources Department, 1990, *Draft Reservoir Coordination Discussion Paper.*	These target flow provide adequate river levels for boating and keeping fish accessible to anglers during peak season.
	Whitewater boating	2,000 - 3,200 cfs	Year-round	Willamette Canoe & Kayak Club, 1994, *Soggy Sneakers; A Guide to Oregon Rivers* (3rd edition).	Stream class varies by flow.
	Drift boating	1,160 cfs minimum flows	Summer	Oregon Department of Fish and Wildlife, 1996, *Development and Application of Oregon Method for Fish Flows: New Approach for Larger Rivers.*	Based on criteria of 50% of riffles maintain a minimum of 0.4 meters depth with contiguous section comprising 25% of riffle across shallowest section. Current summer minimum flows (650 cfs) create difficult passage for driftboats.
Middle Santiam River between Green Peter Dam and Foster Lake	Whitewater boating	2,000 – 4,000 cfs	Summer	Willamette Canoe & Kayak Club, 1994, *Soggy Sneakers, A Guide to Oregon Rivers* (3rd edition).	This reach offers some of the best whitewater in the mid-Willamette River in summer due to powerhouse releases. Cold water and rapid fluctuations are hazards.
South Santiam River below Foster Dam	Angling for steelhead, Salmon, and trout	1,000 cfs minimum releases from Foster Dam (800 cfs minimum for low water years)	June 1 thru August 15	Oregon Water Resources Department, 1990, *Draft Reservoir Coordination Discussion Paper.*	Peak use period is June-July. Studies show angling success 3 times greater at 800 cfs compared to 700 cfs. These flows may conflict with ability to maintain Green Peter reservoir recreation.
	Whitewater boating	1,500 - 3,000 cfs (class 2) 900 cfs (class 1)	Year-round	Willamette Canoe & Kayak Club, 1994, *Soggy Sneakers; A Guide to Oregon Rivers* (3rd edition).	Stream class varies by flow.
	Drift boating	750 - 800 cfs minimum flows	Summer	Oregon Department of Fish and Wildlife, 1996, *Development and Application of Oregon Method for Fish Flows: New Approach for Larger Rivers.*	Based on criteria of 50% of riffles maintain a minimum of 0.4 meters depth with contiguous section comprising 25% of riffle across shallowest section. Current summer minimum flows (650 cfs) create difficult passage for driftboats.

Table 10 (continued). Downstream Recreation Flow Targets

River Reach	Target Activities	Recommended Flow	Peak Season	Source	Comments
South Fork McKenzie River below Cougar	Drift boating (boat angling)	400 cfs minimum 500 cfs minimum 400 cfs minimum 250 cfs minimum 500 cfs minimum 400 cfs minimum	1 Jan - 15 Apr 15 Apr - 15 Jun 15 Jun - 1 Jul 1 Jul - 15 Aug 15 Aug - 30 Oct 1 Nov - 31 Dec	Oregon Water Resources Department. 1991. *Upper Willamette Basin State Scenic Waterways Flow Needs Assessment*	Assessment identifies flow requirements needed to support scenic waterway uses. Objective in identifying recreational flows was to preserve existing range of major uses. S. Fork recreation targets based principally on drift boat requirements.
McKenzie River mainstem below South. Fork confluence	Drift boating & angling	400 cfs minimum flows with minimal daily fluctuation	Summer months	Oregon Water Resources Department, 1990. *Draft Reservoir Coordination Discussion Paper*	The McKenzie R. is a prime trout stream heavily used for fishing and drift boating. Water released from reservoirs is too cold for fish growth. Stream flow fluctuations present boating safety concerns and negatively impact recreational activities.
	All activities	2,000 - 3,000 cfs upstream Leaburg Dam 700 – 800 cfs downstream Leaburg Dam	Not specified, but peak angling season is May	Eugene Water and Electric Board. 1991. *Recreation Visitor Use Study of the McKenzie River, Oregon*	Survey respondents asked if they would have preferred higher, the same, or lower flows than today. Data suggests that for anglers, flow levels do not have a strong effect on overall quality ratings.
	Whitewater boating.	700 - 2,000 cfs (for reach from Paradise Rock to Finn Rock, the first below Cougar). 900 - 3,000 cfs (for the reach from Finn Rock to Leaburg Dam, most popular on the river)	Year-round; peak use period is summer	Willamette Canoe & Kayak Club, 1994, *Soggy Sneakers; A guide to Oregon Rivers* (3rd edition)	Stream class varies by flow.

Table 10 (continued). Downstream Recreation Flow Targets

River Reach	Target Activities	Recommended Flow	Peak Season	Source	Comments
Blue River below Blue River Dam	Not specified	**50 cfs minimum flow**	Not specified	Oregon Water Resources Department, 1990. *Draft Reservoir Coordination Discussion Paper.*	Per ODFW. Minimum flows required to maintain fish life in Blue river from the dam to the mouth.
Middle Fork Willamette between Hills Creek Dam and Lookout Point Lake	Drift boating & angling	**400 - 500 cfs minimum releases Hills Creek Dam**	Not specified	Oregon Water Resources Department, 1990. *Draft Reservoir Coordination Discussion Paper.*	Per ODFW. These minimum flows are required to maintain a wild trout fishery.
	Whitewater boating		Year-round; considered a good Fall run as flows from Hills Creek are released.	Willamette Canoe & Kayak Club, 1994, *Soggy Sneakers; A Guide to Oregon Rivers* (3rd edition).	Stream class varies by flow.
	Drift boating	**1,000 cfs minimum flows**	Summer	Oregon Department of Fish and Wildlife, 1996.. *Development and Application of Oregon Method for Fish Flows: New Approach for Larger Rivers.*	Survey conducted at 1,000 cfs. Flows adequate for boat passage. Survey needs to be conducted at minimum summer flow period of 350 cfs.
Middle Fork Willamette below Dexter Dam	Fishing	**1,500 - 2,500 cfs releases from Dexter Dam**	May thru August	Oregon Water Resources Department, 1990. *Draft Reservoir Coordination Discussion Paper.*	Per ODFW. These flows best accommodate boat angling during the peak fishing period for summer steelhead and spring Chinook. Flows above 3,000 and below 1,000 cfs make river conditions difficult.
	Whitewater boating.	2,000 cfs	Year-round	Willamette Canoe & Kayak Club, 1994, *Soggy Sneakers; A guide to Oregon Rivers* (3rd edition).	Stream class varies by flow.
Coast Fork Willamette River below Cottage Grove Dam	Not specified Whitewater boating	**Not specified** 1,000 cfs	Late fall, winter & early spring	Oregon Water Resources Department, 1990. *Draft Reservoir Coordination Discussion Paper.* Willamette Canoe & Kayak Club, 1994, *Soggy Sneakers; A guide to Oregon Rivers* (3rd edition).	Releases for Eugene target flows seem to support limited recreational use of this reach. Stream class varies by flow.
Row River below Dorena Dam	Whitewater boating	300 - 1,000 cfs	Late fall, winter & early spring	Willamette Canoe & Kayak Club, 1994, *Soggy Sneakers; A guide to Oregon Rivers* (3rd edition).	Stream class varies by flow.

Reservoir and Downstream Aquatic Habitat Planning Objectives

- Determine the most effective operating scenario for the Willamette reservoir projects to assure that pool levels and discharges downstream during the conservation season optimize habitat for a diversity of in-reservoir and downstream aquatic species including upstream and downstream migrants. Anadromous and ESA-listed fish species will be given the highest priority.

Blue River Lake

Scenario Development. Maintain a maximum reservoir elevation of 1280 from mid-July through August. Determine the presence and availability of reservoir contour data to allow definition of the most appropriate draw down measures for revegetation of flats and other potentially important habitat sites.

Performance Measures. Estimate the amount of new vegetative growth on previously unexposed flats (area just below full pool elevation); analyze length/weight characteristics and age class distribution of resident fish species for comparison with existing information.

Priorities. Increase the presence and availability of vegetation on gradually sloping shorelines and flats in the upper pool to provide enhanced biological diversity and production.

Risks and Uncertainties. The relationship between the extent, duration and periodicity of drawdowns and inundations and resultant beneficial biological productivity is not clear. Reservoir contour maps would allow more accurate determination of pool levels that would accommodate the multiplicity of uses this reservoir could support. The continued release of hatchery rainbow trout versus management for natural production of native species should be reevaluated.

Tradeoffs. Lowering of the pool earlier in the summer will help an experimental stand of exotic, bald cypress trees and willows on the upper slopes of the reservoir shoreline. Continued operations as have been experienced the last two years (full pool through August) puts this vegetation at risk. This action will have some negative effect on some of the varied recreation opportunities at the lake. Modification of Blue River reservoir operation will affect downstream flows and pool elevations at one or more Willamette projects during the summer mainstem Willamette flow augmentation period.

Cougar Lake

Scenario Development. Provide a minimum flow of 400 cfs below the dam from June 1st through August and a maximum of 400 cfs from September 1 to 30. The ODFW recommends a discharge of 400 cfs in summer (less in drought years with agency coordination) below the dam for salmon spawning and to insure that the South Fork side channel, just downstream of the dam, remains watered up during the summer and fall providing rearing habitat for salmonids and other resident species. The ODFW suggests that the reservoir be held at or below elevation 1675 from mid-July through August.

Performance Measures. Estimate the amount of new vegetative growth on previously unexposed flats (area just below full pool elevation); analyze length/weight characteristics and age class distribution of resident fish species for comparison with existing information. Monitor South Fork, side channel and associated ponds for presence of year round fish presence and fish habitat.

Reservoir and Downstream Aquatic Habitat Planning Objectives (continued)

Priorities. Manage discharge during salmon spawning period to minimize dewatering of salmon redds after egg deposition. Increase the presence and availability of vegetation on gradually sloping shorelines and flats in the upper pool to provide enhanced biological diversity and production. Keep the South Fork side channel and associated ponds watered up and accessible to rearing salmonids and bull trout. Determine the presence and availability of reservoir contour data to allow definition of the most appropriate draw down measures for revegetation of flats and other potentially important habitat sites.

Risks and Uncertainties. Because of the recent ESA-listing of steelhead and spring Chinook in the Willamette Basin, the scope of changes to project operations needed for recovery of naturally reproducing fish above and below the dam is unknown at this time.

Tradeoffs. Modification of reservoir operation will affect downstream flows and pool elevations at one or more Willamette projects during the summer mainstem Willamette flow augmentation period. Boat ramps extend to elevation 1635, well below the requested pool drawdown for July and August. Drawdown of the pool to enhance vegetative cover in specific shoreline areas will degrade some of the recreational activities at Cougar.

Lookout Point/Dexter Lakes

Scenario Development. Attempt to maintain Lookout Point Lake elevation between 920 and 926 from May through Mid July; Hills Creek Reservoir would provide the additional flow needed. Maintain and maximize releases from Dexter at 1,500 to 2,000 cfs during Chinook spawning (September and October).

Performance Measures. Estimate the amount of new vegetative growth on previously unexposed flats (area just below full pool elevation); analyze length/weight characteristics and age class distribution of resident fish species for comparison with existing information. Monitor for Oregon chub presence and use of habitat.

Priorities. Manage discharges at Lookout Point/Dexter to sustain/enhance spring Chinook fishery in Middle Fork Willamette. Increase the presence and availability of emergent vegetation on gradually sloping shorelines and flats in the upper pool elevations to provide enhanced biological diversity and production. Define the most appropriate draw down measures for revegetation of flats and other potentially important habitat sites by generating/accessing reservoir contour maps.

Risks and Uncertainties. Because of the recent ESA-listing of steelhead and spring Chinook in the Willamette Basin, the scope of changes to project operations needed for recovery of naturally reproducing fish above and below the dam is unknown at this time. Increased abundance of vegetation in the upper elevations of the reservoir would probably not result in favorable conditions for Oregon chub because of an array of exotic warm water game fish present. The relationship between the extent, duration and periodicity of the drawdowns and inundations and resultant beneficial biological productivity is not clear. Contour analysis of the reservoir would allow more accurate determination of pool levels that would best accommodate the multiplicity of uses this reservoir could support.

Reservoir and Downstream Aquatic Habitat Planning Objectives (continued)

Tradeoffs. Modification of Lookout Point Reservoir operations will affect downstream flows and pool elevations at one or more Willamette projects during the summer mainstem Willamette flow augmentation period. A low-water boat ramp affords access to the reservoir for boaters year round.

Fall Creek Lake

Scenario Development. Continue to drawdown Fall Creek in July to arrive at lower pool elevations and discharges during the downstream migration of spring Chinook. Survival of passage through the regulating outlets has shown a positive correlation with reduced discharge and head conditions. Minimum flows and pulsed discharges (50 to 150 cfs discharges during summer upstream salmon migrations) need to be confirmed as mandatory in any low water year.

Performance Measures. Estimate the amount of new vegetative growth on previously unexposed flats (area just below full pool elevation); analyze length/weight characteristics and age class distribution of resident fish species for comparison with existing information. Continue to monitor adult salmon returns to the adult trap at Fall Creek to evaluate effectiveness of mitigation efforts. Periodically estimate the survival to the smolt stage for reservoir reared Chinook. Periodically estimate abundance of largemouth bass and other piscivorous exotic fish in the reservoir.

Priorities. Meet mitigation responsibility of 450 adult Chinook salmon escapement to the Fall Creek fish facility. Monitor and control bass population in reservoir as necessary to minimize conflicts with salmon mitigation responsibilities.

Risks and Uncertainties. Because of the recent ESA-listing of steelhead and spring Chinook in the Willamette Basin, the scope of changes to project operations needed for recovery of naturally reproducing fish above and below the dam is unknown at this time. The relationship between the extent, duration and periodicity of the drawdowns and inundations and resultant beneficial biological productivity is not clear. Contour analysis of the reservoir would allow more accurate determination of pool levels that would best accommodate the multiplicity of uses this reservoir could support. Impact of largemouth bass predation on Chinook rearing in the reservoir and resultant effects on mitigation responsibilities is not clear.

Tradeoffs. Modification of Fall Creek Reservoir operations will affect downstream flows and pool elevations at one or more Willamette projects during the summer mainstem Willamette flow augmentation period. Proliferation of largemouth bass in Fall Creek Lake may affect success of mitigation efforts for spring Chinook. Attraction flows for spring Chinook during summer periods especially in low flow years will have an impact on pool levels; however, reductions in pool levels prior to Chinook outmigration have been shown to be beneficial to survival of passage through the facility.

Hills Creek Lake

Scenario Development. Attempt to maintain flows at a minimum of 450 cfs throughout the conservation season (April through September). Maintain full pool late April through mid-July then gradually draw the pool down to elevation 1526 by September 1st. This may be difficult if discharges are used to maintain Lookout Point pool elevation for Oregon chub spawning.

Reservoir and Downstream Aquatic Habitat Planning Objectives (continued)

Performance Measures. Estimate the amount of new vegetative growth on previously unexposed flats (area just below full pool elevation), analyze length/weight characteristics and age class distribution of resident fish species for comparison with existing information. Assess productivity of fishery in middle fork reach between Hills Creek and Lookout Point reservoirs. Assess productivity of fish species (rainbow, cutthroat and bull trout if present) in reservoir resulting from modified pool level actions.

Priorities. Attempt to maintain flows in the middle fork reach between Hills Creek and Lookout Point reservoirs at a minimum of 450 cfs throughout the conservation season (April through September) to maintain important fish habitat. Maintain full pool (elevation 1541) from late April through mid-July then gradually draw the pool down to elevation 1526 by September 1st. This will increase the presence and availability of emergent vegetation on gradually sloping shorelines and flats in the upper pool elevations and provide enhanced biological diversity and production. This may be difficult if discharges are used to maintain Lookout Point pool elevation for Oregon chub spawning. Again, the most appropriate draw down measures for revegetation of flats and other potentially important habitat sites should be defined by generating/accessing contour maps. Also, attempt to ramp down flows instead of stepping down whenever possible.

Risks and Uncertainties. Because of the recent ESA-listing of steelhead and spring Chinook in the Willamette Basin, the scope of changes to project operations needed for recovery of naturally reproducing fish above and below the dam is unknown at this time. The relationship between the extent, duration and periodicity of the drawdowns and inundations and resultant beneficial biological productivity is not clear. Development of contour maps will allow finer adjustment of recommended pool level. Reintroduction of bull trout into habitats above Hills Creek Dam could have impact on operation of the reservoir. The last bull trout seen at Hills Creek Reservoir was documented in a photo by an angler; no landings have been reported since, nor has the ODFW observed any bull trout in their monitoring and search efforts.

Tradeoffs. Modification of Hills Creek Reservoir operations will affect downstream flows and pool elevations at one or more Willamette projects during the summer mainstem Willamette flow augmentation period. Maintaining full pool from late April through mid-July would be difficult if discharges are keyed to maintaining Lookout Point at constant elevation during Oregon chub spawning period.

Detroit and Big Cliff Lakes

Scenario Development. Maintain a minimum flow of 1,000 to 1200cfs below Big Cliff from June 1 to August 15.

Performance Measures. Determine effectiveness of increased discharges on downstream fishery. Determine relative success of steelhead and salmon downstream spawning resulting from stabilized discharges during and after those activities.

Priorities. Provide flows of 1,000 to 1,200 cfs below big Cliff from June 1 to August 15 to support the fishery below Big Cliff which is excellent for steelhead and salmon and trout angling. To aid in boat planting of trout, the ODFW requests 4 to 5 hours of flows between 1,500 to 1,800 cfs below Big Cliff Dam in late May, mid-June, and early July. Maintain stable and constant flows in April and May during steelhead spawning, and then in September and October when salmon are spawning. Stable and constant flows would prevent dewatering of redds.

Reservoir and Downstream Aquatic Habitat Planning Objectives (continued)

Find ways to reduce fall water temperatures in the North Santiam below Big Cliff Dam. Accelerated incubation times, similar to the problems on the South Fork McKenzie below Cougar, should be studied. Need to stabilize flows in the Santiam when operating the Minto fish facility. At times flows are too high to trap or depth of water at the facility is too deep to accommodate fish collection activities. Operation of the facility for a longer period of time to allow the ODFW to recycle more summer steelhead downstream should be considered.

Risks and Uncertainties. Because of the recent ESA-listing of steelhead and spring Chinook in the Willamette Basin, the scope of changes to project operations needed for recovery of naturally reproducing fish above and below the dam is unknown at this time.

Tradeoffs. Modification of Detroit Reservoir operations will affect downstream flows and pool elevations at one or more Willamette projects during the summer mainstem Willamette flow augmentation period. An alternative to stabilizing flows at the Minto fish trap would be to redesign the facility to accommodate trapping operations under fluctuating flow conditions.

Green Peter/Foster Lakes

Scenario Development. Maintain flow at 800 cfs below Foster from June 1 to July 31 for enhancing fisheries success; continue lowered pool level operations (elevation 614) and shallow spill discharges during the period April 15 to May 20 for enhanced downstream migrant passage and survival at Foster.

Performance Measures. Continue to monitor and pass adult, winter steelhead at Foster Dam. Adult returns provide some measure of effectiveness of the special spill operations conducted at Foster each spring for downstream migrating winter steelhead.

Priorities. Continue special drawdown and surface spill operations for enhanced survival of downstream migrant winter steelhead. Determine impact of night spills at Foster on summer steelhead angling success downstream of the dam. These spills are part of an action at the Willamette projects to limit generation of electricity at night to maximize electricity generation at Columbia River projects. This added power generation on the Columbia helps reduce nitrogen saturation conditions during downstream migrations of salmon and steelhead. Continue to discharge a minimum of 800 cfs at Foster June 1 to July 31 for enhanced fishery success with the understanding that these flows may need to be reduced during low flow, dry years.

Risks and Uncertainties. Because of the recent ESA-listing of steelhead and spring Chinook in the Willamette Basin, the scope of changes to project operations needed for recovery of naturally reproducing fish above and below the dam is unknown at this time.

Tradeoffs. Terminating night spill operations at Foster/Green Peter would have negligible impact on Columbia River nitrogen saturation problems. The 800 cfs discharges at Foster will have an undetermined minimal impact on some recreation activities at Green Peter, especially in low flow years. Continuing the special drawdown and spill operations at Foster in April and May has some impact on recreation activities at both projects. The drawdown of Foster during April and May to enhance steelhead passage at Foster has an impact on some forms of recreation at Foster and Green Peter especially in low flow years.

Reservoir and Downstream Aquatic Habitat Planning Objectives (continued)

Cottage Grove and Dorena Lakes

Scenario Development. Maintain normal reservoir operations and drawdown procedures; increased flow during water quality limited periods should be considered. Reduce levels of mercury in and upstream of Cottage Grove Reservoir.

Performance Measures. Determine if increased discharges can reduce temperature and alter coliform concentrations in the Coast Fork of the Willamette during water quality limited periods. Monitor levels of mercury entering the reservoir and in large mouth bass which inhabit the reservoir.

Priorities. Maintain reservoir operations with the exception of increasing discharges to improve water quality downstream during water quality limited periods.

Risks and Uncertainties. It is not clear as to what actions are necessary to reduce existing levels of mercury present in the substrate at Cottage Grove Reservoir. Remediation of one identified source upstream of the reservoir (abandoned mine tailings) needs to be accomplished. More information is needed regarding the level and duration of discharges needed to improve water quality in streams below Dorena and Cottage Grove.

Tradeoffs. Additional releases of water from Cottage Grove and Dorena during low flow periods will affect the pool levels and impact quality of reservoir recreation to some degree. Modification of Cottage Grove and Dorena discharges to alter downstream water quality will have some effect on discharges and pool elevations at one or more Willamette projects during the summer mainstem Willamette flow augmentation period.

Fern Ridge Lake

Scenario Development. Maintain normal reservoir operations and drawdown procedures, except in low flow dry years; increase discharges into the Long Tom to improve water quality. The ODEQ lists the Long Tom as water quality limited both for temperature in summer and fecal coliform fall through spring.

Performance Measures. Determine if increased discharges from Fern Ridge can reduce temperature and alter coliform concentrations in the Long Tom during water quality limited periods. Assess the impact of higher flows in the Long Tom on a small population of Willamette cutthroat trout present in this stream.

Priorities. Maintain normal reservoir operations and drawdown procedures, except in low flow dry years. Increase discharges into the Long Tom to improve water quality and Willamette cutthroat trout habitat in the Long Tom.

Risks and Uncertainties. Improvement of water quality in the Long Tom may be accomplished by several means, increased flows being possibly only one of several.

Tradeoffs. The ODEQ lists the Long Tom as water quality limited both for summer water temperature and fecal coliform during fall through spring. Increased discharges during water quality limited periods will impact some forms of recreation in the reservoir because of lowered pool elevation.

Wildlife and Reservoir Wetland Planning Objectives

- Operate Corps reservoirs during conservation season o maintain and/or improve existing wildlife and wetlands habitat potential surrounding Corps reservoirs and downstream. Habitat for threatened, endangered, and unique species will be given the highest priority.

Performance Measures. For the purpose of screening alternatives, the metrics to be used to evaluate the relative effectiveness of alternatives in meeting the reservoir wildlife objectives will be pool elevation (feet) and deviation from current operations under a drawdown or other scenario; the number of days or percent of conservation season that the reservoir is maintained at a stable elevation (expressed as a number or percentage); the timing of drawdown (month) during the conservation season; and the number of acres of habitat affected (either inundated or dewatered) by each operational scenario. Table 11 displays how preliminary criteria correlate with relative wildlife habitat suitability for each reservoir at varying operating ranges.

Table 11. Relative Wildlife Suitability of Operating Ranges (elevations in feet, NGVD)

Storage Reservoirs	Optimum Wildlife Conditions	Beneficial Wildlife Conditions	Acceptable Wildlife Conditions
Fern Ridge	372 Apr 15-Sep 30	372 Apr 15-Sep 30	372 Apr 15-Sep 30
Green Peter	995 May 30-Aug 30	995 May 30-Aug 30	1000 Apr 30-Aug 30
Foster	622 May 30-Sep 30	622 May 30-Sep 30	622 May 30-Sep 30
Blue River	1330 May 15-Sep 30	Current operations	Current operations
Cougar	Current operations	Current operations	Current operations
Detroit/Big Cliff	Current operations	Current operations	Current operations
Hills Creek	Current operations	Current operations	Current operations
Cottage Grove	Current operations	Current operations	Current operations
Dorena	Current operations	Current operations	Current operations
Lookout Point	885 Apr 1-Jul 30	890 Apr 1-Jul 30	900 Apr 1-Jul 30
Fall Creek	820 Apr 15-Aug 15	820 Apr 15-Aug 15	820 Apr 1-Aug 15

Fern Ridge Lake

Priorities. The Long Tom River is water quality limited for fecal coliform from fall through spring and for temperature during the summer. Increase downstream flows to improve water quality during quality-limited periods. Increase buffer between wildlife and adjacent land development by increasing the width of the wetland fringe. Increase wetland habitat by increasing depth of the wetland fringe. Maintain project operations that sustain unique, rare, threatened, or endangered species including but not limited to *Deschampsia* plant community, western pond turtle, and bald eagle. Maintain open water and emergent habitat for nesting and wintering waterfowl, in support of the Fern Ridge Waterfowl Management Area (ODFW).

Risks and Uncertainties. Long term effects of project operations on species composition and cover of emergent (*Phalaris*, *Typha*, *Scirpus*), moist soil, and wet prairie (*Deschampsia*) vegetation are unclear. Difficulty in measuring habitat changes resulting from operational changes with the reservoir and downstream. Difficulty in measuring species-specific responses to changes in habitat or forage availability resulting from operational changes.

Wildlife and Reservoir Wetland Planning Objectives (continued)

Tradeoffs. Increased discharge during water quality limited periods limits production potential of wildlife by limiting vegetative productivity which might benefit more from operation of the reservoir at stable pool elevation. Current operations do maintain a stable pool elevation which contributes to establishment of emergent and riparian vegetation along the lake margin.

Green Peter Lake

Priorities. Restore riverine riparian habitat along the Quartzville arm. Maintain moist soil vegetation complex in the upper reservoir to sustain elk foraging. Increased vegetation at Green Peter Peninsula may enhance spawning habitat. Maintain project operations that sustain rare, unique, threatened, and/or endangered species including but not limited to bald eagle and osprey nesting and foraging.

Risks and Uncertainties. Long term effects of project operations on species composition and cover of emergent vegetation. Difficulty in measuring habitat changes resulting from operational changes with the reservoir and downstream. Effects of lowered pool on bald eagle foraging.

Tradeoffs. Maintenance of flows for downstream fisheries. Variability in the surface water elevation of the reservoir and moderate topographic gradient limits colonization potential of vegetation (e.g., emergent, riparian) along much of the reservoir margin.

Foster Lake

Priorities. Mudflats in the upper Foster Reservoir, e.g., Newhouse Peninsula, sustain a resident fishery and may contribute to forage base for bald eagles. Restore riverine habitat along upper SF Santiam to restore yellow-legged frog breeding habitat. Maintain project operations which sustain rare, unique, threatened, and endangered species including but not limited to Harlequin duck, western pond turtle, bald eagle, and yellow-legged frog.

Risks and Uncertainties. The potential for long term benefits of project operations on species composition and cover of emergent vegetation at Newhouse Peninsula and riverine restoration along the SF Santiam are poorly understood. Difficulty in measuring habitat changes resulting from operational changes with the reservoir and downstream. Effects of lowered pool on bald eagle foraging.

Tradeoffs. Current operations do not maintain a stable pool elevation, which would contribute to establishment of emergent and riparian vegetation on large flats below the pool. As a consequence, resident fisheries and other species that rely on emergent habitats or their resources may be limited. Current operations limit potential for development of emergent habitat at Newhouse Peninsula and colonization of riparian vegetation along the Middle Fork Santiam River. As a consequence of operations for fisheries and recreation a historic yellow-legged frog breeding site is limited in the potential for recovery.

Blue River Lake

Priorities. Maintain project operations that sustain rare, unique, threatened, and endangered species including but not limited to bald eagle and Harlequin duck. Maintain the flats supporting species tolerant of inundation including willow and a unique bald cypress stand.

Wildlife and Reservoir Wetland Planning Objectives (continued)

Risks and Uncertainties. Long term effects of project operations on species composition and cover of vegetation on flats below the pool. Difficulty in measuring habitat changes resulting from operational changes with the reservoir and downstream. Effects of lowered pool on bald eagle foraging.

Tradeoffs. Current operations for recreation may affect a unique bald cypress wetland forest habitat and stands of willow which tolerate inundation. Thus, reducing vegetation species diversity.

Cougar Lake

Priorities. Potential Wild and Scenic designation of the South Fork McKenzie River. Maintain flows for management of downstream habitat in slough and backwater channels. Maintain project operations which sustain rare, unique, threatened, and endangered species including but not limited to bull trout, bald eagle, and Harelquin duck.

Risks and Uncertainties. Long term effects of project operations on species composition and cover of vegetation along the reservoir margin is unclear. Difficulty in measuring habitat changes resulting from operational changes with the reservoir and downstream. Lack of adequate topographic information for the project limits predictive capability for assessing affects from change in operations.

Tradeoffs. Drawdown for fisheries management may improve habitat potential along the reservoir margins.

Detroit and Big Cliff Lakes

Priorities. Maintain project operations that sustain rare, unique, threatened, and endangered species including but not limited to bald eagles.

Risks and Uncertainties. Long term effects of project operations on species composition and cover of vegetation in the reservoir is unclear. Difficulty in measuring habitat changes resulting from operational changes with the reservoir and downstream.

Tradeoffs. Current operations for fisheries and recreation limits the potential for habitat development for wildlife.

Cottage Grove and Dorena Lakes

Priorities. The Row River is water quality limited for temperature and the Coast Fork is water quality limited for temperature and fecal coliform. Increase downstream flows to improve water quality during quality-limited periods in the Row River and Coast Fork Willamette. Habitat management for pond turtles downstream of the project. Manage Coast Fork and Row River flows to enhance western pond turtle populations in both rivers. Maintain project operations that sustain rare, unique, threatened, and endangered species including but not limited to bald eagles, wood ducks, and pond turtles.

Wildlife and Reservoir Wetland Planning Objectives (continued)

Risks and Uncertainties. Long term effects of project operations on species composition and cover of vegetation in the upper reservoir is poorly understood. Changes in water quality under varying discharge scenarios and correlation of operation and associated downstream effects on water quality and habitat suitability for pond turtles, bald eagles, and other species are poorly understood. Effects of operational changes on resident pair of bald eagles.

Tradeoffs. Current operations accommodate proliferation of extensive monotypic stands of reed canarygrass. Emergent habitats generally benefit the bass fishery; however, these stands are limited in vegetative diversity and as a consequence limit wildlife species diversity in the upper reservoir.

Lookout Point Lake

Priorities. Provide flow for downstream releases to provide slough and backwater habitat in Elijah Bristow State Park for western pond turtles and Oregon chub. Reservoir management to improve habitat for chub in Hazel Arm. Maintenance of moist soil vegetation complex in the upper reservoir. Management of backwater areas to improve habitat for pond turtles. Maintain project operations that sustain rare, unique, threatened, and endangered species including but not limited to bald eagles, elk, and pond turtles.

Risks and Uncertainties. Long term effects of project operations on downstream slough and backwater areas is poorly understood. Probability of improving habitat conditions for chub and other rare, threatened, or endangered species is not well understood. Habitat potential at Arrmett and Hampton Flats to sustain moist soil vegetation under a "shallow" operational scenario is unclear. Potential to restore riverine condition and the floodplain dynamic along Hazel Creek, Rolling Riffle Creek, and School Creek under a drawdown scenario is poorly understood. Potential for benefit to western pond turtles and Oregon chub from maintaining an elevated and stable pool is poorly understood.

Tradeoffs. Off-road vehicle use of upper reservoir limits use of habitat for several wildlife species. Historically, this area supported a vigorous population of pond turtles. Current operations do not enhance habitat conditions for this species.

Fall Creek Lake

Priorities. Promote vegetative growth on large flats at Winberry and Fall Creek flats. Flow management to maintain spawning habitat for chub. Maintain project operations which sustain rare, unique, threatened, and endangered species including but not limited to bald eagles and western pond turtles.

Risks and Uncertainties. Long term effects of project operations on species composition and cover of vegetation in mudflats of the upper reservoir is poorly understood.

Tradeoffs. Drawdown to facilitate smolt outmigration. Rainbow and cutthroat trout habitat management within, upstream, and downstream of the Fall Creek project. Current operations do not maintain a stable pool elevation that would contribute to establishment of emergent vegetation in the upper reservoir in areas such as Winberry Flats and Fall Creek Flats, and dewatered coves that support western pond turtles early in the summer.

Wildlife and Reservoir Wetland Planning Objectives (continued)

Hills Creek Lake

Priorities. Maintain project operations that sustain rare, unique, threatened, and endangered species including but not limited to bald eagles, western pond turtles, and peregrine falcons. Maintain riverine habitat along the Middle Fork between Hills Creek and Lookout Point. Vegetation management along the reservoir margin and upper flats.

Risks and Uncertainties. Long term effects of project operations on species composition and cover of vegetation along the reservoir margin is poorly understood. Effects of operations on foraging success of bald eagles.

Tradeoffs. Current operations to maintain the reservoir elevation at Lookout Point to sustain chub spawning do not accommodate stable pool operations that would benefit development of emergent and riparian habitat along the reservoir margin.

Floodplain Management Planning Objectives

- Operate the Willamette reservoirs during the conservation season to maintain and/or improve existing floodplain management objectives.

Hydropower Planning Objectives

- Operate the Willamette power projects during the conservation season to maintain power production.

Navigation Planning Objectives

- Maintain established navigation target flow levels at Albany and Salem.

Cultural Resources Planning Objectives

- Maintain and enhance the ongoing protection and preservation measures, which ensure statutory compliance with federal and state historic preservation laws and Native American coordination policies.

5.2. Hydrology and Hydraulics

5.2.1. WILMA Model Development

The Corps and the OWRD contracted with the University of Washington's Department of Civil Engineering to model the operation of the Willamette River system. A simulation model was sought that could more easily demonstrate tradeoffs between the various uses of stored water. A Willamette system model (WILMA) was developed by the University of Washington that emulates the flow of water from the headwaters of the Willamette system down to Albany. The model was constructed to perform at a weekly time-step and mimicked the operating rules for reservoir releases practiced by the Corps. WILMA provided a user interface, including control panels, a model map, and a results section to facilitate the operation of the model. All reservoirs, withdrawal points, and in-stream flows were incorporated into the WILMA model. This model was used to develop the initial alternative scenarios for the study.

5.2.2. HEC-5 Model Development

A HEC-5 reservoir regulation model that uses a monthly flow time step was developed for the earlier reconnaissance study. This initial HEC-5 model has been updated to utilize daily flows to provide a more detailed analysis for the base condition and to evaluate the effects of the final alternative scenarios. A data base of daily data was assembled for the updated model, and included developing observed or estimated data for historical inflow to the reservoirs, flows for control points in the system, evaporation and rainfall for each reservoir, and data for discontinued gages. Also, a control point was added to the model for the lower basin at Portland. Completing this effort also included modifying the water control diagram information in the earlier model, incorporating stream travel times, and verifying the drawdown priority simulation in the model.

5.3. Public Involvement

5.3.1. Phase One Public Outreach

Between December 1996 and April 1997, the Corps and OWRD conducted the first phase of a public involvement campaign for the reservoir study. The outreach effort was intended to elicit comments about the study issues early in the process, and to educate the general public and key audiences about the study process and purpose. The consultant team of Tashman Johnson LLC, Claire Levine Writing & Research, Summit Design, and Strategic Resources LLC was used to conduct the outreach effort. The consulting team provided a report, *Final Report: Willamette Basin Reservoir Study Public Involvement Effort* which is summarized below (OWRD, 1997).

The sponsoring agencies entered the public involvement process with the following goals:

- Capturing the range of public issues from as broad a group of participants as possible.
- Creating confidence in the openness and technical validity of the process.
- Educating the public-at-large and decision-makers about water resource issues.

- Obtaining useful, reasoned information and creating a mechanism for future communications with individuals and groups.
- Meeting scoping requirements of the National Environmental Policy Act.
- Establishing realistic citizen expectations about the study scope and outcomes.

The main objective of the outreach process was to conduct public workshops at several locations throughout the Willamette Basin. Other activities were designed to inform people about the study generally and the workshops specifically, and to encourage participation. In early December 1996, a brochure was mailed that contained a general description of the study as well as a questionnaire asking for names for the mailing list. A second brochure mailed in March contained the dates and places of the three workshops. Information was prepared for dissemination to more than 110 media outlets throughout the basin. Elements included a press release; a calendar notice; fact sheets about the study and water issues; a map; and background information. Corps and OWRD staff also met with editors at the Salem, Albany, Corvallis, and Eugene newspapers.

Evening workshops on March 31, April 1 and April 2 in Tualatin, Albany and Springfield, respectively. Members of the public were invited to visit different stations providing information about the study and the EIS process; flood control and dam operations; fish and wildlife; water quality; out-of-stream uses; and recreation. Each issue station contained a display board listing the planning objectives and a two-page explanation of the particular issue that described history, current uses and tradeoffs. Each station held signs listing four questions designed to elicit comments about the study objectives and issues of concern to participants.

Other written material available at the workshops included a brochure generally describing the study, a discussion of the planning objectives, and a comment response form asking input on the substance of the study as well as an evaluation of the workshops. The workshops gave people the opportunity to speak with staff from a variety of agencies, including the Corps, OWRD, the Oregon Department of Fish and Wildlife (ODFW), ODEQ, various cities and special districts, and the USBR. Individuals affiliated with various stakeholder groups represented on the Technical Workgroup also staffed the stations and were available to talk with the public. Most workshop participants fell into three categories: recreational users, agricultural interests, and people concerned about environmental preservation. The comments, written and submitted by participants or recorded by staff, generally corresponded to these three interest areas. The principal themes of the comments are as follows.

- Sustain reservoir levels for recreational users. Reasons cited included the economy of communities near the reservoirs, boater safety and access to fishing.
- Assure water for irrigation. Build smaller, more accessible storage units rather than large dams; explore aquifer storage; or increase storage capacity at existing reservoirs.
- Protect water quality and fish and wildlife habitat; reduce erosion.
- Control growth. A number of comments referred to redistribution of population, discouraging people from moving to the basin or limiting industry.
- Support the functions of floodplains and wetlands.

A number of people attended specifically to express concern about recent news articles on a proposed reauthorization of three new dams on the river system. Corps staff also entertained a variety of questions about dam operations and flood control generally. About 100 people attended the workshops, with the highest attendance in Albany and the lowest attendance in Tualatin. Twenty-eight participants filled out evaluation forms of the workshops. They were asked to rate the workshops on usefulness, with "1" being very useful and "5" not at all useful. Four people rated the workshops very useful, two people rated them not at all useful, one person marked "don't know," and the rest were divided fairly evenly through the other ratings.

5.3.2. Phase Two Public Outreach

A second phase of public workshops were held in April 1998 in Salem, Portland, Albany and Eugene. A report, *Willamette River Basin Reservoir Study, Results of Public Workshops*, was prepared by the consultant assisting with the public outreach, Cogan Owens Cogan, LLC (OWRD, May 1998). For the workshop discussions, four initial alternative scenarios or emphasis areas were developed by the Corps, OWRD, and Technical Workgroup describing possible future allocations of water for various purposes. The four emphasis areas included meeting out of stream demands, improving recreational conditions, improving fish and wildlife habitat, and meeting multiple objectives. The WILMA model was used to develop the initial alternative scenarios for the workshops. The model provided the information necessary to investigate basic system configuration and explore system impacts and tradeoffs of altered or changed demands resulting from the initial scenarios. Two levels of future out of stream demands were modeled for each emphasis area: a low demand level that estimated the amount of stored water needed to meet demands by the year 2020 (171,400 acre-feet) and a high demand level that estimated the stored water needed to meet demands by the year 2050 (712,000 acre-feet).

More than 170 people participated in the four workshops. Participants were asked to consider and comment on the four emphasis areas. Workshop attendees participated in small group discussions and were asked to consider and comment on the following two questions. A third, optional question was posed to the groups if there was extra time regarding priorities for the reservoir system.

- What are the advantages and disadvantages of the emphasis area?
- What factors or changes are necessary to make the emphasis area work?

Comments from the small group discussions were compiled for each emphasis area. The following pages provide the information given to workshop participants for each emphasis area based on WILMA model results, followed by answers mentioned more than once and in order of the number of times it was mentioned in the group discussions. Additional input and comments from the workshops can be found in *Willamette River Basin Reservoir Study, Results of Public Workshops* (OWRD, May 1998).

Emphasis Area A: Meeting Out of Stream Demands

Purpose

To provide sufficient stored water to meet increasing needs for irrigation, municipal and industrial uses. Flows in the Willamette River at Salem increase by 300 cfs during the summer months to meet ODEQ's water quality recommendations for the Newberg reach. Although other uses would continue to be supported, out of stream uses would take precedence in project operations.

Tradeoffs

- Provides between 171,400 acre-feet and 712,000 acre-feet of storage for new out of stream uses.
- Only slight water quality impacts at low demand level. At high demands, the benefits from increased flows at Salem are reduced and the potential for water quality problems on some tributaries increases.
- No significant impact on fisheries at low demand level. At high demands, increased flows on the North Santiam River may benefit fisheries while flow reductions on the Coast Fork Willamette and Row Rivers may have negative fisheries impacts.
- Only minor impacts on reservoir recreation at low demands. At high demand levels, small impacts on recreation at Detroit, Foster, and Fern Ridge may occur, with generally poorer conditions at all other reservoirs.
- No significant impact on river recreation at low demand levels. River recreation may improve on the North Fork Santiam, McKenzie and Middle Fork Willamette Rivers as flows are increased to meet higher out of stream demands.

Responses for Advantages of the Out of Stream Demand Emphasis Area

- Good for agriculture and other related issues; more flexibility for marginal land.
- Help for industrial uses; encourage business
- Water quality
- Aid municipalities
- Meet upstream needs in North Santiam more frequently; including recreation.
- Releases provide reach (tributary) benefits; additional fish and wildlife habitat.
- Continued economic development; greater stability.
- Improved in-stream recreation; fish and wildlife benefits downstream.
- Increased capacity; flood control space
- Better estimate of out of stream water demand/use.

Responses for Disadvantages of the Out of Stream Demand Emphasis Area

- Recreation will suffer; less water in the lakes.
- Minimum flows at Salem and Albany not met (water quality).
- Does not encourage water conservation.
- Lacks flexibility. There is not enough water for everything.
- Changes allocation from agriculture; EFU zoned lands to keep in production.
- Negative effect on growth especially on communities next to the reservoirs.

Emphasis Area A: Meeting Out of Stream Demands (continued)

- Unknowns. For example, will 7Q10s remain reliable?
- No guarantees for loss of groundwater, well levels.
- Supply. Need to plan for the next generation, not just the next 20 years.

Proposed Changes to Make the Out of Stream Demand Emphasis Area Work

- Consider conservation for all uses and users.
- Be more flexible in conservation.
- Maintain agricultural water supply without seriously degrading other values.
- Sustain the water quality of rivers.
- Develop better management of releases.
- Coordinate discharges with point of withdrawal to maximize other benefits.
- Consider hydraulically connected sources and river wells.
- Undertake more study.
- Consider industry.
- More storage needed.
- Don't sacrifice wild fish.
- Consider efficient use of water with accountability.
- Maintain water quality.
- Reduce the amount of water for agriculture.
- Extend boat ramps so that recreational needs are met.
- Develop optimum levels as a threshold for recreation.
- Increase flows to raise water elevation.
- Control population.
- Prioritize the industrial component of demand.
- Look for greater efficiencies and technologies to extend resources.
- Municipal water for people and livelihood.
- Relative balance between stored water and in-stream uses.
- Place a priority on meeting water quality standards.
- Ability to transfer between in and out of stream uses as needed.
- Earlier water release.
- Account for beneficial non-consumptive releases (cost to run water down the Mill Race, etc).

Emphasis Area B: Improving Recreational Conditions

Purpose

To improve reservoir recreation, Fern Ridge, Detroit and Foster are held at optimum pool levels for as long as possible in the summer months. Maintaining at least acceptable recreational conditions is the goal of project operations at Green Peter, Cougar, Hills Creek, Dorena and Fall Creek. Although other uses would continue to be supported, retaining water in the reservoirs would take precedence.

Tradeoffs

- Provides between 171,400 acre-feet and 670,000 acre-feet of storage for new out of stream uses. Maximum demands are limited in some years.
- Even at low demands, the potential for water quality problems in the Willamette River near Albany and in the Santiam, Coast Fork Willamette, and Long Tom systems is significant. At high demand levels, water quality in the Willamette River below Albany and in most of the tributaries may be severely degraded.
- Small improvements occur in fish and wildlife habitat at Fern Ridge and below Blue River and Big Cliff with some habitat loss at Foster under both demand levels.
- At low demand levels, small improvements in recreational conditions occur at Foster, Detroit, Fern Ridge, Green Peter, Fall Creek, Dorena, and Cottage Grove. Slightly to moderately poorer recreational opportunities occur at Lookout Point, Cougar, Blue River, and Hills Creek. At high demand levels, there are small improvements at Detroit and Foster, and Fern Ridge shows little change from current operations. Conditions at all other reservoirs are slightly to moderately poorer.
- Small potential benefit for river recreation occurs at low demand levels. Increased flowes in the North Santiam River may provide benefits while flow reductions may impact recreation on the South Santiam River at high demand levels.

Responses for Advantages of the Improving Recreational Conditions Emphasis Area

- Recreation, social values. Fern Ridge specifically mentioned.
- Economic benefits for local towns. State benefits, government revenue from camping and rural development.
- Fish and wildlife benefits. System allows migrating fish to reach spawning areas, benefits for endangered and declining species.
- Aesthetics
- Fisheries
- Greater flexibility to accommodate the Endangered Species Act, and water quality issues. Enhanced ecosystem resilience. Most closely mimics natural condition.
- Improved safety.

Responses for Disadvantages of the Improving Recreational Conditions Emphasis Area

- Reservoir recreation vs. downstream uses; whitewater on Willamette, for example. Not a holistic approach if not considering downstream uses.
- Fish and wildlife habitat; conflicting resource management pitting one species vs. another, or fish vs. wildlife. Impacts on migration.

Emphasis Area B: Improving Recreational Conditions (continued)

- Impacts on water quality; antiquated sewer systems impacts.
- Decreased flexibility in the system.
- Overuse by boats/humans; increases in death and injury.
- Loss of new agricultural business.
- Effect on industrial base.
- Negative economic impact on "non-optimum" reservoirs such as Fern Ridge.
- More people leads to greater nonpoint source pollution.
- Impact on municipal drinking water; limits expansion by cities.
- Unknown net effects; not comprehensive enough.

Proposed Changes to Make the Improving Recreational Conditions Emphasis Area Work
- Rely on natural flows to Foster and reduce draw downs from Green Peter.
- Consider the loss of recreation (loss of certainty).
- Add more reservoirs.
- Develop more requirements for water uses.
- Establish criteria to prioritize uses.
- Improve fish passage.
- Redesign reservoirs.
- Create better access to Green Peter reservoir.
- Limit recreational use during dry years.
- Improve conservation and efficient uses of water.
- Use some reservoirs for recreation, others for downstream needs.
- Develop low water recreational facilities.
- Use Detroit for in-stream flows because can still be at an acceptable level.
- Create four tiers for types of recreation activities and sensitivity to reservoir drawdown.
- Base discharges for water quality on science.
- Balance all uses.
- Limit recreation.
- Lower water levels for juvenile salmon.
- Coordinate migration with wetlands.
- Increase monitoring of affects of control and uses.
- Consider using Willamette water to augment Long Tom.
- Water temperature = variable water intakes.
- Consider mitigation for lost recreational opportunities.
- Compare wildlife habitat in reservoir vs. downstream.
- Look at the big picture.

Emphasis Area C: Improving Fish and Wildlife Habitat

Purpose

To improve habitat at reservoirs and downstream conditions. Operational changes include spring flow increases in the Willamette River to aid salmon migration and increasing releases or reducing flow fluctuations below Cottage Grove, Dorena, Big Cliff, and Foster. Emergent wetlands are created at Blue River, Lookout Point, and Fall Creek by stabilizing reservoir elevations and limiting filling. While other uses will continue to be supported, improving fish and wildlife conditions take precedence.

Tradeoffs

- Provides between 171,400 acre-feet and 712,000 acre-feet of storage for new out of stream uses.
- The potential for water quality problems in the Willamette River near Albany and on some tributaries increases as out of stream demands increase.
- Small impacts on recreation at Detroit, Cottage Grove, and Dorena occur at both demand levels. Fern Ridge, Foster, Fall Creek, Lookout Point, Blue River, Cougar, and Hills Creek may have poorer recreational conditions.
- Habitat conditions at Lookout Point, Fall Creek, Fern Ridge, and Foster reservoirs improve under both demand levels. Increased flows in the Willamette River, the North and South Santiam Rivers, and on the Coast and Middle Fork of the Willamette River benefit fish under both demand levels.
- River recreation on the Middle Fork Willamette and McKenzie Rivers may benefit from increased flows at higher demand levels.

Responses for Advantages of the Fish and Wildlife Emphasis Area

- Economic values, including downstream recreation and fishing opportunities. Specifically salmon and steelhead fishing, tourism.
- Preserving fish and wildlife habitat, especially for threatened and endangered species. Specific mentions include fall fish and reducing federal intervention.
- Increasing species diversity for fish & wildlife and ecosystem resilience. Assist in steelhead (smolt) migration.
- Water quantity releases provides better water quality; mimic natural flow conditions (spring flush); improve flow consistency; benefit migration.
- Riparian vegetation and resultant improvements in water quality. Specifically, for the lower McKenzie and the entire Willamette River system.
- Use of wetlands, store and release water naturally.
- Maintain local control, social health.

Responses for Disadvantages of the Fish and Wildlife Emphasis Area

- Effect on boating recreation. Concerns about local economic impacts and the loss of revenue to state agencies. Loss of value to property owners.
- Negative effect on water quality.
- Disconnect between water quality and habitat.

Emphasis Area C: Improving Fish and Wildlife Habitat (continued)

- Effect on fish and wildlife (e.g., eagles).
- Impact on tributaries and side channel habitat.
- Unknown factors.
- Misconceptions about how much we can control the system.
- Restrictions on downstream out-of-stream uses.

Proposed Changes to Make the Fish and Wildlife Emphasis Area Work

- Be willing to give up/compromise.
- Humans vs. wildlife.
- Conflict between wetlands and fisheries and the value of fisheries.
- Potential downstream habitat protection.
- Utilize a holistic issue focus rather than a single issue.
- Plan on sustainability.
- Provide more education for urbanites.
- Do not overlook water quality issues when considering migration/flows (e.g., temperatures below dams).
- Addressing water quality may have more effect than changing migrations.
- Consider impacts (including developmental stress) of non-natural migrations.
- Consider water quality impacts on local entities rather than mitigating by extra water.
- Address non-structural benefits.
- Consider economic impact to lake area.
- Evaluate effect on wildlife other than fisheries
- Clean up the river – higher water quality.
- Consider use of low flush toilets.
- Increase storage and maximize current reservoirs.
- Study more consistent flows than current open/close method.
- Consider lower releases for downstream habitat in summer.
- Build beyond the rule curve limit for potential benefits.

Emphasis Area D: Meeting Multiple Objectives

Purpose

To balance competing demands for in-stream flows, out of stream needs, and reservoir uses. Recreational priorities at Detroit and Fern Ridge are retained at acceptable levels. Operational changes limit reservoir fluctuations at some projects to improve fish and wildlife habitat. Flows in the Willamette River increase by 300 cfs for water quality. Future out of stream demands are limited to 499,000 acre-feet. Operational decisions are based on achieving and maintaining a balance of objectives.

Tradeoffs

- Provides between 171,400 acre-feet and 499,000 acre-feet of storage for out of stream uses.
- The potential for water quality problems in the Willamette River near Albany and on some tributaries increases as out of stream demands increase.
- Slight to moderate impacts on recreation at Cottage Grove, Dorena, Foster, and Fern Ridge occur at both demand levels. Recreational conditions at Lookout Point, Blue River, Cougar and Hills Creek may be poorer.
- Improved fish and wildlife habitat conditions occur at Blue River, Detroit, Foster and Lookout Point under both demand levels. At high demand levels, habitat may be reduced at Cottage Grove, Dorena, and Fall Creek.
- River recreation on the North Santiam, South Santiam, and Middle Fork Willamette Rivers may be affected by flow reductions at higher demand levels.

Responses for Advantages of the Meeting Multiple Objectives Emphasis Area

- Makes everybody happy.
- During a drought or a peak year, assumes all will suffer or benefit equally. There do not appear to be losers.
- Better water quality.
- Better control over the system, more flexibility.
- Maintaining multiple species.
- Shared cost.
- Provides substantial out of stream demands.
- Economic benefits.
- More water available for municipal needs.
- Future demand will drive research and development (technical) to better meet future needs.
- Education
- Additional storage (Big Cliff on North Santiam)
- Increased land value and agricultural production.
- Increased flows and habitat in upper reaches.
- Forces conservation.

Responses for Disadvantages of the Meeting Multiple Objectives Emphasis Area

- Impacts on in-stream demands, fish & wildlife, threatened/endangered species, water quality.
- Limits on future agricultural needs.
- Limits on future municipal uses.

Emphasis Area D: Meeting Multiple Objectives (continued)

- Limits on recreational uses.
- Uneven allocation system; particularly during dry months.
- Loss of flexibility for meeting emerging needs.
- Makes everyone "mad."
- Economic disadvantage to dischargers with water quality permits.
- Decreases incentive to search for sustainable alternatives, improving practices.
- Failure to prioritize.
- Doesn't address need for more storage.
- Some economic sectors hurt more than others.
- Greater drawdown on certain reservoirs.
- Is existing groundwater affected?
- Impact on Fern Ridge, Veneta.
- Need more zoning standards to make emphasis area work.

Proposed Changes to Make the Meeting Multiple Objectives Emphasis Area Work

- Consider water conservation and reuse in the study; may be a significant change.
- Need more water; look for alternative sources.
- Prioritize uses (consider drought efforts; develop mechanisms to differentiate between uses).
- Education
- Make water quality a priority.
- Population and sprawl control; need zoning laws.
- Keep scientific track of water quality.
- Reduce pollution.
- Optimize scheduling of uses with seasonal variations (pay attention to anadromous fish needs).
- Keep track of pollution
- Lessen impacts on groundwater.
- Renovate recreational facilities.
- Satisfy everyone's concerns, including Department of Fish and Wildlife
- Don't over allocate resources.
- Hold more local meetings to get input on priorities.
- Consider modifications in reservoirs/dams.
- Improve technology
- De-emphasize Detroit for recreation.
- Shift recreational opportunities to lower basin.
- Consider where most people receive the most benefits.
- Create a market for water.
- Designate one central authority for decision making.
- More documentation necessary to assure fishery needs are being met.
- Emerald Canal – assure availability of water connection to Long Tom from Eugene millrace.
- Revisit allocations periodically; be open for change.
- Consider a holistic approach; water is not answer to all problems.
- Value of water should be higher.
- Concern regarding National Marine Fisheries Service vs. local control.
- Downstream impacts and sedimentation need improvements.

Participants also were asked to complete a survey about water allocations during dry or drought water years. One hundred and twenty-eight responses were received. A summary of observations and responses follow.

- Respondents generally agreed that in dry years, protecting fish and water quality should take precedence over other uses. They concur that at least minimum stream flows be maintained for fish and water quality. Most (71 percent) did not agree that all water uses should be given equal priority, or that irrigation or industries should be supplied with water even if it hurts fish and water quality.
- Respondents were divided on whether water quality should have priority over all other uses and if industries should reduce pollution to make water available for recreation, irrigation, and water quality; slightly more people agree than disagree with these strategies.
- Respondents nearly unanimously agreed that people should reduce outdoor water usage in dry years; and most agreed that farmers also should reduce irrigation in dry years.
- When given a choice, most respondents recommend drawing from multiple lakes as opposed to a single lake to ensure adequate water supply for rivers during dry years, although others were unsure about this issue.
- Participants ranked water uses in this priority order (average rank on a 1 to 9 scale, with 9 being the highest priority):

    1. Minimum flows for water quality (6.32)
    2. Community drinking water (6.23)
    3. Minimum flows for fish (5.96)
    4. Wildlife (5.31)
    5. Irrigated agriculture (5.15)
    6. Industry water (4.20)
    7. Hydropower (4.18)
    8. Reservoir recreation (3.86)
    9. River recreation (3.68)

Additional suggestions for dealing with dry water years cited more than once, in priority order, included:

- Promote conservation and reuse. Emphasize conservation and reuse among all groups of water users during all years.
- Increase education. Improve education about conservation needs, limits on the supply of water and other issues.
- Improve planning. Develop a consistent, objective plan and procedures for water use during dry years. To promote conservation, make dry-year planning the norm instead of the exception.

5.4. Fish and Wildlife Studies

The existing and base conditions for fish and wildlife in the Willamette study area are discussed in detail in the report, *Criteria and Discussion of Existing and Base Conditions for the Willamette Basin Reservoir Study* (Corps, January 2000). Also, an initial alternative scenario for fish and wildlife was developed by the Technical Workgroup for the April 1998 public workshops, as described in the previous section of this report.

A series of fish operating alternatives were developed in the spring of 1999 in an attempt to address ESA requirements. These alternatives are called F1a-c, F2, F3, and F4 and are described below. Only alternatives F1a-c and F2 will be carried forward for additional consideration during formulation of final alternative scenarios for the study. The HEC-5 model results for alternatives F1a-c and F2 are discussed in Section 6.3 of this report.

5.4.1. Fish Operating Alternative F1

This alternative considers establishing flow requirements on the mainstem Willamette River at Salem based on ODFW flow recommendations for winter steelhead juvenile outmigration which occurs during April and May. Currently, the reservoir system is managed to provide the following target flows at Salem:

April 15-30	16,500 cfs
May 1-15	11,500 cfs
May 16-30	8,500 cfs

This alternative also increases downstream releases from Cougar Dam to 400 cfs year round. It results in a decrease in reservoir elevations in average and low water years. There is a need to select which reservoirs would be used to meet the increased flow requirements. There are three sub-alternatives under consideration, F1a, F1b, and F1c, and their criteria are shown in table 12.

Table 12. Target Flows at Salem for Fish Operating Alternative F1a-c

Time Period	Alternative F1a Flows to produce 4,000 recruits @ 50% probability	Alternative F1b Flows to produce 4,000 recruits @ 95% probability	Alternative F1c Flows to produce 8,000 recruits @ 50% probability
April 15-30	16,350 cfs	19,200 cfs	25,350 cfs
May 1-15	11,450 cfs	16,450 cfs	27,300 cfs
May 16-31	8,325 cfs	13,300 cfs	24,400 cfs

Source: Corps, NMFS, ODFW, USFWS

5.4.2. Fish Operating Alternative F2

This alternative attempts to produce natural flows from April through May from the Detroit, Lookout Point/Hills Creek, Green Peter/Foster, and Cougar projects. It would essentially stop filling from these tributaries (or in other words, inflow into the projects would be passed downstream and not stored) after April 15 to the end of May as long as adequate flows are stored to provide water quality flows throughout the summer months. Storage at these projects would only occur when flows are above bankfull or some recommended maximum flow. The flow from the main fish passage tributaries would be used to meet target flows at Salem. Using these projects is based on the assumption that these tributaries have the most potential for adult spring Chinook and steelhead.

5.4.3. Fish Operating Alternative F3

This alternative is no longer under consideration. It combined alternatives F1 and F2 by using the flow objectives described for F1 and using the inflow equals outflow condition described in F2 for Detroit, Lookout Point/Hills Creek, Green Peter/Foster, and Cougar from April 15 to May 31.

5.4.4. Fish Operating Alternative F4

This alternative is no longer under consideration. It considered operating the Cougar and Blue River projects at minimum flood control pool elevations year round, except to control flood events. Its purpose was to mimic natural flows and provide temperature control.

5.5. Recreation Surveys and Model Development

The future condition measures of recreation, such as visitation, national benefits, regional economic impacts were developed through development of a number of models. The visitation model for Willamette Basin shows how recreation visits change as a function of operations such as water levels and facilities, as well as population and costs. Developing the visitation model required obtaining baseline visitation information for all reservoir and river recreation sites and determining how visitation changed over a range of conditions by looking at historic visitation data.

To evaluate the demand and value of recreation at Corps reservoirs, a Regional Recreation Demand Model (RRDM) was developed. The RRDM used visitation, natural resources, and water level data to develop a model of recreation demand and NED benefits. These benefits are contributions to the welfare of the nation, and are defined as the public's willingness to pay to visit Corps projects in excess of actual costs (such as entrance fees).

Rather than the national perspective, local businesses dependent on sales of gas, food, and licenses want to know the impacts on the local economy caused by changes in recreation visitation due to such factors as water management or facility development. These local or regional economic impacts include changes in local spending, income, and jobs and are known as Regional Economic Development (RED) benefits. Beginning in 1992, the Corps has collected expenditure information from reservoir visitors and developed a model that estimates jobs, income, and sales for the areas around reservoirs.

The attractiveness of reservoirs (water levels, facilities, fishing quality) determines the recreational visitation to the projects. The impact on visitation caused by the way the reservoirs are operated is of major concern when considering operational changes. Once visitation under a new operating scheme is known, the NED and RED impacts can be determined. Reservoir management affects recreation not only at Corps projects but also downstream from the reservoirs. High downstream flows may result in dangerous conditions for canoeing, kayaking, and fishing whereas low flows may be inadequate to float a boat or support fish spawning. Evaluation of downstream visitation and economic effects are also important in development water management plans.

5.5.1. Baseline Visitation – Oregon Lakes and Rivers Recreation Survey

A general population survey was undertaken after the recreation season in 1996 to provide a baseline for visitation, identify how far visitors travel to use Willamette projects, and collect information on the spending by recreation visitors. A telephone survey using random digit dialing for households within 150 miles of Willamette reservoirs was used to contact 1,920 households in 33 counties in Oregon, southeastern Washington and northern California. If a project had been visited, they were asked to participate in a mailed survey to obtain visitation information for specific reservoir projects and river reaches. The mailed survey asked for information on numbers of visits to specific reservoirs and river reaches, recreation activities participated in, and length of recreation visits. The mailed survey included an expenditures worksheet to obtain expenditure information on food, gas, lodging and other expenses related to recreation trip (not durable goods, such as boats that are intended for multiple trips. A total of 1,058 surveys were mailed and 603 useable surveys returned for a 59 percent response rate.

Extrapolations of the survey results were performed to estimate 1996 visitation to all 18 study sites. The extrapolations were adjusted for non-response bias and outliers. The 1996 visitation estimate for all study sites was 6.47 million day use recreation days and 2.67 million overnight use recreation days. The estimates indicated that about half of all visitation (51 percent of day use and 35 percent of overnight use) occurred at the river sites. Therefore, the river sites were considered to be an important part of the study and an estimate was made of the response of river visitation to in-stream flows.

5.5.2. Reservoir Visitation Model

The *Oregon Lakes and Rivers Survey* only provided detailed visitation data for 1996. The water levels in 1996 at the reservoirs were near optimal for recreation. The lack of variation in water levels suggested that a valid model to predict the response of visitation to water level changes could not be estimated. Since a main objective of the study is to estimate how visitation is affected by water levels, another approach was required. Historical visitation models were proposed to predict monthly reservoir day use and overnight visitation and river visits as a function of relevant variables (water levels, facilities, weather conditions, population, and substitutes). While the Corps keeps monthly visitation data (day and overnight use) for its recreation areas, many camping and some day use areas at the reservoirs are managed by the Forest Service. Oregon State Parks operates Detroit Lake State Park, ten state parks on the river stretches, and numerous boat ramps and access points along the rivers. The completeness and availability of visitation and facility data varied through years and across agencies. Monthly visitation data for the Corps were available from 1984 to 1995.

Discussions of Willamette recreation patterns identified an additional potential determinant of recreation – weather. While water levels are important, it was suggested that occurrence of days that are dry and warm enough for water contact recreation were an important determinant of recreation. In developing the Willamette Basin model, variables for both average monthly temperature and monthly precipitation were initially included using 12 years of hydrologic and visitation data.

A number of variables were used as predictors to predict monthly visitation for the recreation season, which occurs from May through September. The predictor variables initially used to test significance for visitation prediction included water levels, facilities, weather variables, and population. The day use historical visitation model explains 74 percent of the variation in visitation while the overnight use model explains 45 percent of visitation variation. In both models, reservoir water levels had a significant impact on visitation. While visitation increases with temperature, precipitation was not an important explanatory variable. The water levels at substitute reservoirs were also found to be important in explaining visitation.

The reservoir historical visitation models are used to predict visitation at each project under the water management scenarios as described below. The inputs are the monthly water levels defined by the scenarios. Monthly averages are used for the weather variables. Another application of the models, not reported on here, is to develop visitation forecasts based on population projections.

5.5.3. River Visitation Model

A survey of river recreation literature was performed to determine the response of river visitation to water levels. The literature suggests that there in not a single optimal flow, but rather a range of flows over which conditions are optimal for a particular type of recreation, such as fishing or whitewater boating. Below this plateau, there is a minimal flow below which flow is too low for recreation and a higher flow where conditions are too swift or deep for recreation. Also, in order to estimate the critical flow levels, a mail survey of river recreation experts was conducted. Phone calls were made to local river guides and outfitters. Those that were knowledgeable about flow levels on the study river stretches were sent a mail survey. Separate surveys were created dealing with each river stretch and three activities: fishing, whitewater boating, and non-specialized day use recreation such as sightseeing. Respondents were sent the survey for the river stretches and activities they were most familiar with. In the survey, respondents were asked to identify critical flow values and the importance of river flows on visitation levels.

A total of 66 completed surveys were returned. Nearly all respondents indicated that flows were the most important or a very important factor in determining fishing and whitewater boating visitation. Most respondents (63 percent) indicated that flows were "an unimportant factor" with respect to non-specialized river recreation. Therefore, it was assumed that non-specialized visitation did not vary with in-stream flows. For each river reach-activity combination, the four critical flow levels were determined by either averaging flows from the appropriate surveys or using flow estimates from models developed using all surveys. The models were used to develop predictions for a few river-activity combinations where no surveys were returned.

5.5.4. National Economic Benefits

Travel costs models, using the cost of travel and time as measure of willingness to pay for recreation, were developed to estimate economic benefits. Four separate TCMs were estimated including day use and overnight use as well as reservoir and river visitation. The

TCMs estimate visitation from origin zones (normally counties) to each recreation site as a function of the required travel costs (including an estimate of the value of travel time), zonal demographics (income, average income, and average age), site facilities, and available substitutes. The *Oregon Lakes and Rivers Survey* provided data on the geographic distribution of visitors to each site.

The TCMs estimate average willingness to pay per recreation day for day users and overnight users to each site. The average willingness to pay benefit estimates obtained from the travel cost models are multiplied by the visitation predictions from the visitation models. For the reservoirs, the average economic benefit for day use was $2.40 per recreation day (1996 dollars), ranging from $1.35 at Fern Ridge Lake to $3.14 at Detroit Lake. Average overnight benefits averaged $5.19 per recreation day, ranging from $3.43 at Fall Creek Lake to $11.17 at Detroit Lake. The average benefits for day use visitation on the river reaches were $3.86 per recreation day, ranging from $1.39 for the Willamette River mainstem to $6.41 for the North Santiam River downstream of Detroit. For overnight visits to the rivers, the average benefit was $2.53 per recreation day, ranging from $1.71 on the Willamette River mainstem to $3.50 on the McKenzie River.

5.5.5. Regional Economic Impacts

The importance of recreation expenditures for local and regional economies amplifies the impact of any change in recreation opportunities, such as changes in reservoir operations and river flow levels. Visitor expenditure data on three Willamette lakes (Fern Ridge, Cottage Grove, Fall Creek) were part of 12 projects used to develop spending profiles for Corps' recreation visitors. However, these profiles did not provide any information on the expenditures of visitors to other Willamette lakes or any of the river stretches. Expenditure questions were included in the *Oregon Lakes and Rivers Survey* to provide more detailed and up-to-date information on visitor expenditures. Survey respondents were asked to provide a detailed list of their expenditures for their most recent trip to one of the 18 study sites. The responses were used to develop four average expenditure profiles (day use river visitors, overnight river visitors, day use reservoir visitors, and overnight reservoir visitors). Average expenditures per recreation day ranged from $17.36 for overnight reservoir visitors to $26.29 for day use river visitors.

As the visitation and expenditure surveys were being analyzed the latest economic impact tool became available, *Estimating the Local Economic Impacts of Recreation at Corps of Engineers Projects 1996* (Propst et al., 1998). This tool provides a model that estimates jobs, income, and total sales for the region around a project, using expenditure and visitation estimates. In this case the estimates from the visitation models were used. The model considers the multiplier effect of local spending in that the money spent in the area will increase local income, which results in further increases in spending and income. The inputs into the model included the average expenditure profiles and visitation estimates. The outputs included the estimated number of local jobs generated, the total local spending, and the increase in local income associated with recreation expenditures.

5.5.6. Modeling of Alternative Scenarios

For each alternative scenario, operating criteria will be input into the HEC-5 model to produce reservoir levels, and precipitation and reservoir inflows will be used to produce water level estimates for input into the visitation models. Results will be compared to the base condition to evaluate the impact or effect of the alternative in meeting the evaluation criteria for recreation. Evaluation criteria for recreation include visitation, NED benefits, and RED benefits such as local sales, income, and jobs caused by recreation expenditures.

During the summer of 1999, the NMFS and the ODFW developed minimum flow criteria for the Willamette River for salmon and steelhead recovery. The criteria increased flows in the river to improve in-river habitat conditions during downstream migration of juvenile steelhead during April and May and upstream migration of adult Chinook salmon in June. Table 13 shows the flow criteria at Salem for the base condition and for this fish flow alternative. Hydrologic models were used to produce the reservoir and river levels resulting from the fish flow alternative for 1991 to 1994. The water levels were used in the recreation visitation models to estimate recreation visits. The estimated visits then were used in the economic benefits and regional economic models to estimate economic benefits and local sales, income and jobs. Model results for visitation, economic benefits, and economic impact projections for the base condition and the fish flow alternative for 1991 to 1994 are shown in table 14.

Table 13. Flow Criteria for the Base and Fish Flow Alternative at Salem

Time Period	Base Condition (cfs)	Fish Alternative (cfs)
April 1-15	6,000	21,500
April 16-30	6,000	18,500
May 1-15	6,000	15,000
May 16-31	6,000	15,000
June 1-15	6,000	12,500
June 16-30	6,000	8,500
July	6,000	6,000
August	6,000	6,000
September	6,500	6,500

Source: Corps, NMFS, ODFW

For the 1936 to 1994 flow record at Salem, 1991 was generally a normal water year (93 percent of average), 1992 a low water year (57 percent of average), 1993 a high water year (129 percent of average), and 1994 a low water year (62 percent of average).

For 1991, the analysis shows that the fish flow alternative produces a total of 4.64 million recreation days at the reservoirs and 3.88 million recreation days on the river reaches. This totals 8.5 million recreation days and is 420,000 more than the base condition, which is a 4 percent increase for reservoirs and a 7 percent increase for river reaches. This level of visitation for the fish flow alternative produces increases in all of the economic measures.

Table 14. Recreation Model Results, Base Condition and Fish Flow Alternative

Evaluation Criteria	Site Type	1991			1992			1993			1994		
		Base	Fish Alt.	Change	Base	Fish Alt.	Change	Base	Fish Alt.	Change	Base	Fish Alt.	Change
Total Estimated Visitation (millions of recreation days)	Reservoirs	4.48	4.64	0.16	3.97	3.24	-0.73	4.47	4.74	0.27	4.23	3.46	-0.77
	Rivers	3.62	3.88	0.26	3.13	3.38	0.25	3.64	3.82	0.18	3.6	3.68	0.08
	Total	8.1	8.52	0.42	7.1	6.62	-0.48	8.11	8.56	0.45	7.83	7.14	-0.69
Total Economic Value (NED benefits in $ millions)	Reservoirs	20.96	21.57	0.61	18.5	13.05	-5.45	20.98	22.02	1.04	19.85	13.62	-6.23
	Rivers	9.25	10.09	0.84	7.84	8.81	0.97	9.21	9.56	0.35	9.36	9.58	0.22
	Total	30.21	31.66	1.45	26.34	21.86	-4.48	30.19	31.58	1.39	29.21	23.2	-6.01
Total Local Sales (in $ millions)	Reservoirs	64.16	66.65	2.49	57.42	48.23	-9.19	64.05	67.89	3.84	61.04	51.62	-9.42
	Rivers	55.58	59.83	4.25	48.68	52.49	3.81	54.66	56.63	1.97	56.56	57.45	0.89
	Total	119.74	126.48	6.74	106.1	100.72	-5.38	118.71	124.52	5.81	117.6	109.07	-8.53
Total Local Income (in $ millions)	Reservoirs	36.72	38.14	1.42	32.86	27.6	-5.26	36.66	38.85	2.19	34.93	29.54	-5.39
	Rivers	31.81	34.24	2.43	27.86	30.04	2.18	31.28	32.41	1.13	32.37	32.88	0.51
	Total	68.53	72.38	3.85	60.72	57.64	-3.08	67.94	71.26	3.32	67.3	62.42	-4.88
Total Local Jobs (full time equivalents)	Reservoirs	1,822	1,892	70	1,633	1,369	-264	1,819	1,928	109	1,735	1,467	-268
	Rivers	1,575	1,699	124	1,380	1,491	111	1,554	1,607	53	1,607	1,632	25
	Total	3,397	3,591	194	3,013	2,860	-153	3,373	3,535	162	3,342	3,099	-243

Source: Corps of Engineers, Waterways Experiment Station

Total economic benefits (NED benefits) were $31.66 million for the fish flow alternative, an increase of $1.45 million over the base condition. The economic impacts to local economies as measured by local sales, income and jobs increased by $6.74 million, $3.85 million, and by 194 jobs, respectively. Similarly, the 1993 analysis shows an increase in all of the economic measures. Both 1991 and 1993 were normal to above normal water years in the Willamette Basin.

Conversely, 1992 and 1994 were low water years in the basin. April and May are months when inflows into the reservoirs are being stored to fill them to their summer conservation pool elevations. As shown in tables 13 and 14, meeting the higher flows at Salem specified in the fish flow alternative likely prevents filling some or all of the reservoirs. Also, meeting the higher June flow targets at Salem likely results in drawing down some of the reservoirs earlier than under the base condition.

The analysis for 1992 and 1994 in table 14 shows that increasing the flow requirements at Salem for the fish flow alternative generally causes a reduction in visitation, NED benefits, and local economic measures. This impact is especially adverse for reservoir recreation. There may be a substitution effect during low water years because while the increased flows for fish reduce water levels in the reservoirs, higher reservoir outflows make downstream river reaches more accessible and attractive for recreation.

5.6. Water Quality

A modeling analysis was performed to estimate the minimum Willamette River flow rate at which water quality standards for dissolved oxygen and action levels for algae would be met (Bloom, 1998). The analysis was performed using a QUAL2E model of the Willamette River. Current dissolved oxygen standards for the Willamette River became effective on July 1, 1996 (Bloom, 1998). The reach of the Willamette River above Corvallis (river mile 131) has been identified as providing for cold-water aquatic life, while the reach below Corvallis has been identified as providing for cool-water aquatic life. For the cold-water reach, the 30-day average dissolved oxygen concentration must be no less than 8.0 milligrams per liter (mg/l). For the cool-water reach, the 30-day average dissolved oxygen concentration must be no less than 6.5 mg/l. For algae, a 15 micrograms per liter action level for chlorophyll *a* applies. Modeling indicates that Willamette River flow rates of 6,200 cfs ± 5 percent at Salem and 7,865 cfs ± 5 percent at Portland are needed to meet water quality standards for dissolved oxygen and action levels for algae (Bloom, 1998).

A modeling analysis also was performed to evaluate the sensitivity of Willamette River temperature to river flow rate (Bloom, 1997). The analysis was performed using a QUAL2E model of the Willamette River, and both steady state and dynamic simulations were performed for reduced flows. The modeling indicates that a 20 percent reduction in flow would produce roughly a 0.4 °C or 0.7 °F increase in daily average water temperatures. Also, a 20 percent flow reduction would increase the daily maximum water temperature about 0.7 °C or 1.3 °F (Bloom, 1997). Due to model limitations, however, the sensitivity to flow rate changes may be greater than indicated in the analysis.

5.7. Hydropower Analysis

The existing and base conditions for the Willamette hydropower projects are discussed in detail in the report, *Criteria and Discussion of Existing and Base Conditions for the Willamette Basin Reservoir Study* (Corps, January 2000). The capacity and energy currently produced by the projects are not expected to change in the future. The report also provides the average (1983 to 1995) monthly power generation by project. Once final alternative scenarios are formulated, the NED benefits for the Willamette hydropower system and/or each project will be identified for the base and changed operating condition using a system analysis model called PC-SAM. Projected future hydropower production will be based on the Bonneville Power Administration's energy demand forecasts. The impacts (changes) in hydropower production will be identified and described for each final alternative scenario.

6. INTERIM STUDY ACTIVITIES

While completion of the study has been delayed, work efforts on a number of ongoing interim activities has continued and are summarized below.

6.1. Existing and Base Conditions Report

An initial report, *Criteria and Discussion of Existing and Base Conditions for the Willamette Basin Reservoir Study* was completed in July 1997. This report was updated in September 1999 to consider changed conditions that have occurred since that time, including the recent ESA-listing of fish species in the basin. Estimates for irrigation, municipal, and industrial water demands also were updated, as well as economic information for the basin. The discussion for recreation was expanded to reflect work completed to date by the Corps Waterways Experiment Station.

6.2. Water Supply Policy Issue Paper

An issue paper was prepared in May 1999 that reviews Corps planning and policy guidance, including previous discussion papers addressing similar topics, pertaining to potential policy issues for the recommendations that the study may make to Congress. The issue paper is currently being used to coordinate and discuss policy issues with Corps Headquarters staff for resolution prior to writing the draft feasibility report. A summary of the recommendations for each issue discussed in the document is described below.

6.2.1. Originally Authorized Project Purposes

From the language and quantified benefit estimates presented in the authorizing documents for the Willamette projects, it appears clear and well documented that Congress originally authorized the projects for all the following purposes: flood control, drainage, navigation, power, irrigation, water supply, flow augmentation for pollution abatement and improved fishery conditions, and recreation at the reservoirs and downstream. The authorizing documents include water supply as an authorized purpose and, in fact, pre-date the Water Supply Act of 1958. This would lead to recognizing that water supply is among the originally authorized purposes of the Willamette reservoir projects.

The feasibility study is not proposing to add or delete project purposes to those originally authorized by Congress. Flood control was the major use and focus at the time of authorization of the reservoir system, and dedicating the conservation storage to the various authorized purposes was not. The feasibility study is reviewing all benefit categories and may propose operational changes as well as an initial allocation of the existing conservation storage among the original authorized purposes to meet the future water needs in the Willamette Valley. In addition, an inherent priority for the originally authorized purposes appears specified in the authorizing documents in that flood control and drainage were considered primary, and all other authorized purposes considered as secondary, and more importantly, equal in their application during the conservation season.

6.2.2. Future Water Needs and Sponsorship Requirements

The sponsorship requirements associated with the increased use of conservation storage in the Willamette reservoirs to meet current and anticipated future water needs in the basin are discussed below with respect to irrigation, fish, water quality, recreation, and water supply. The major benefit to the Nation would be the reimbursement of the original federal investment, as well as annual operation and maintenance costs, for the acquisition of conservation storage in the Willamette reservoirs.

Irrigation. The USBR administers the water service contracts for irrigators using conservation storage from the Willamette projects. The cost per acre-foot of this storage is based on the original cost of the projects with no escalation of original costs to current price levels or interest, plus an administrative fee. As of April 1999, the Bureau charges a base price of $8 per acre-foot of water plus and administrative/processing fee of $100. The sponsorship and cost-sharing requirements for agricultural crop irrigation are clearly established and will not be changed.

Fish. In March 1999, steelhead and Chinook salmon were listed for the upper Willamette Basin as threatened species under the ESA. Federal and State fishery agencies and the Corps are in the process of coordinating specific actions relating to increasing releases from the Willamette reservoirs and possibly operational changes with respect to recovery of these species. The Federal Government would be responsible for the costs resulting from Section 7 consultation. Congressional approval would be necessary if the storage reallocated for ESA-listed fish species has a severe effect on other authorized purposes or involves major operational changes.

Water Quality. About 250,000 to 350,000 acre-feet of storage is currently used to meet the minimum flows at Albany and Salem as originally authorized. Original project authorizations also recognized that these flows would also benefit stream conditions by diluting wastes and increasing dissolved oxygen for fish life. Although a navigation channel is no longer maintained upstream of Portland, the originally established minimum flows are maintained for pollution abatement and fishery purposes. The use of storage for water quality purposes above what is currently provided to meet authorized minimum flows at Albany and Salem requires a sponsor to cost-share (purchase) the additional conservation storage from the Corps. For example, storage from the reservoirs could be purchased for water quality purposes by industrial/private providers. Using additional storage solely for water quality purposes was discussed early in the study process; at this time, no demand estimates for the feasibility study are likely to be developed.

Recreation. Recreation demand at the Willamette projects is currently strong. Current operation of many of the projects incorporates this originally authorized purpose. Recreation use of the reservoirs is a by-product of conservation storage. Although the reservoirs are held as high as possible to provide recreation opportunities, in-stream flows take a higher priority. Population growth in the basin will increase recreation demand and many communities have come to rely on the tourism generated by the projects. Dedicating conservation storage at reservoirs important for recreation requires a sponsor to cost-share (purchase) the storage necessary to do so. Dedicating pool elevations solely for recreation was discussed early in the study process; at this time, no demand estimates for the feasibility study are likely to be developed.

Water Supply. Population growth will increase future demands for municipal and industrial water supply in the Willamette Valley. Unexercised water rights and existing facilities improvements will be used to meet near-term increased water supply demands. The use of conservation storage for water supply requires a sponsor to cost-share (purchase) the storage from the Corps. Municipal water providers in the Willamette Valley have yet to contract with the Corps for storage. Their belief is that the price, when using the updated cost of storage method (reallocation) and including facilities costs for diverting, treating, and distributing the water, would be significantly higher than the costs for developing other sources. In addition, this Corps methodology for pricing storage creates a strong sense of inequity when compared to the price of storage charged by the USBR for irrigation.

6.2.3. Cost-sharing Requirements for Water Supply

Discussed below are several issues related to cost-sharing requirements for water supply.

System vs. project pricing of storage due to the system-wide operation of the projects. The Willamette projects are currently operated as a system, which provides the Corps the most flexibility when formulating the annual Willamette Basin release plan. Even though the water may be withdrawn directly downstream of a specific project, it is necessary to coordinate releases elsewhere in the system to meet minimum flow requirements at Albany and Salem. Also, a system-wide pricing concept was forwarded to the Corps Headquarters office (HQUSACE) in conjunction with purchasing surplus water storage from the Willamette reservoir system. The Assistant Secretary of the Army for Civil Works [ASA(CW)] approved the system-wide pricing for surplus water agreements on January 10, 1997. The reservoir study should continue to stress the need for a system-wide operating scheme and utilize a system-wide pricing concept for sponsors willing to purchase conservation storage. By calculating user costs based on the total conservation storage (about 1.6 million acre-feet), operational flexibility of the system is maintained and an equitable price that can be easily administered is established for sponsors.

Immediate vs. future use because future water supply demands are being considered in the reservoir study. It appears clear that the authorizing documents provided for future water supply storage in the Willamette reservoirs. Also, the future demand estimated for the feasibility study would be well below the 30 percent total construction cost limitation of the Water Supply Act of 1958. A request for exception to Corps policy limiting future use storage should be forwarded to HQUSACE for approval.

Derivation of storage costs based on the two alternative approaches.

Approach 1 – Originally Authorized Purposes. The price of water supply storage for originally authorized purposes would be based on the original cost of the storage, instead of the methods required by Engineer Regulation (ER) 1105-2-100 (highest of benefits or revenues foregone, the replacement cost, or the updated cost of storage). This approach would apply to all originally authorized purposes (except irrigation) of the Willamette reservoir system in deriving a cost of storage for sponsors seeking the use of Corps storage to meet current and future water needs. Using original project costs, the cost of storage to be purchased is $189 per acre-foot (cost rounded to nearest dollar). An additional cost of $6.23 per acre-foot is added to include Fiscal Year (FY) 1998 operation, maintenance, repair, replacement and rehabilitation (OMRR&R) costs. Therefore, a water user would be charged $195 per acre-foot of storage purchased from the Willamette reservoir system under Approach 1.

Approach 2 – Reallocation. Corps guidance for reservoir reallocations and associated cost-sharing requirements is found in ER 1105-2-100, dated 28 December 1990 (Section VII of Chapter 4 specifically discusses water supply and was revised on 31 October 1997). As specified in this regulation, the cost of reallocated (permanent) storage in a Corps reservoir to add water supply is the highest of benefits or revenues foregone, the replacement cost, or the updated cost of storage. Added to this annual cost for storage is an estimated annual cost for OMRR&R. The updated cost of storage method provides the highest cost for permanent storage in the Willamette projects. However, this is because inflating the project costs over a +40 year period, as required by Corps policy, distorts the costs so significantly that they become meaningless. Using the updated cost of storage method, the cost of storage to be purchased is $1,508 per acre-foot (February 1999 price level, cost rounded to nearest dollar). An additional cost of $6.23 per acre-foot is added to include FY 1998 OMRR&R costs. Therefore, a water user would be charged $1514 per acre-foot of storage reallocated from the Willamette reservoir system.

In summary, Approach 1 provides a reasonable cost of storage that, when added to the facilities costs for diverting, treating, and distributing the water, would likely make the use of storage in the Willamette reservoirs attractive to many water providers as a future water supply source. Using the updated cost of storage method (Approach 2), the cost of storage combined with facilities costs becomes significantly higher and may preclude the use of Willamette storage by water providers in the basin.

6.2.4. Multiple Benefits from Releasing Stored Water

This concept was included in the Project Study Plan at the request of the sponsor, and resulted from discussions with water providers and their concerns over the high cost of purchasing storage from the Willamette reservoir system. Release of stored water for water supply in the lower end of the basin could have multiple benefits as it travels downstream which may make it possible to share the cost of the storage. For example, if benefits from this water could also be derived for ESA-listed fish species, then it could be argued that environmental restoration cost-sharing (35 percent sponsor/65 percent federal) could be applied to the cost of storage for water providers near the end of the system. While the concept of multiple benefits is an interesting one, fish benefits would need to be quantified, which is a complex and likely impossible task. On the other hand, use of this concept for the feasibility study also could open up the issue so that anyone, anywhere in the system would demand preferential cost-sharing for storage. It is recommended that this complex and possibly inequitable concept not be pursued for the feasibility study.

6.3. HEC-5 Model Results for Fish Operating Alternatives

The Corps has completed some HEC-5 model runs for possible fish operating alternative strategies developed by the agency representatives and study team. The fish operating alternatives under consideration (F1a-c, and F2) were developed to address operating requirements specifically for fish. The model outputs provide information on the ability of the reservoir system to meet different ranges of flow augmentation and other operating criteria for different water years, including wet, average and dry conditions. The HEC-5 model was used to model the fish operating alternatives, F1a-c and F2 using a 59-year period of record of unregulated flows from 1936 to 1994 (see section 5.4 of this report for a description of the fish operating alternatives). Flow and reservoir volume data for water years representing wet, average, and dry conditions are shown in table 15.

Based on this period of record, the HEC-5 model shows that:

- Flow requirements for Alternative F1a can be met 90 to 95 percent of the time
- Flow requirements for Alternative F1b can be met 75 to 85 percent of the time
- Flow requirements for Alternative F1c can be met 45 to 55 percent of the time
- Flow requirements for Alternative F2 can be met 90 to 95 percent of the time

Depending on the flow available, meeting the April to May flow requirements at Salem for alternatives F1b and F1c can cause a drastic drawdown in some the projects, particularly the larger storage projects of Hills Creek, Lookout Point, Cougar, Detroit, and Green Peter. HEC-5 model results for the representative water years are shown in table 16.

Table 15. Flow and Reservoir Volume Data

Water Year	Average Flow Feb-Aug (cfs)	Total Volume	Rank out of 59 years	Percent of Average
1942	16,340	6,873,000	50	74
1950	32,700	13,750,000	1	147
1955	23,860	10,032,000	25	107
1959	19,740	8,299,000	40	89
1970	18,110	7,615,000	45	82
1977	12,670	5,328,000	57	57
1989	21,930	9,222,000	31	99
1991	20,590	8,658,000	35	93
1992	12,720	5,348,000	56	57
1993	28,740	12,086,000	8	129
1994	13,750	5,781,000	55	62

Source: Corps of Engineers, Portland District

Table 16. Model Results for Fish Operating Alternatives (X = criteria met)

1942 – 74 percent of average flows

Criteria	F1-a	F1-b	F1-c	F2
April-May minimum flow at Salem	X	X	2	1
Minimum outflows at the projects	X	X	---	X
July-September minimum at Albany	X	X	---	X
July-September minimum at Salem	X	X	---	X

1. April-May minimum at Salem not required in F2.
2. There is not enough storage in this year to meet Apr-May flows in F1c.

1950 – 147 percent of average flows

Criteria	F1-a	F1-b	F1-c	F2
April-May minimum flow at Salem	X	X	X	1
Minimum outflows at the projects	X	X	X	X
July-September minimum at Albany	X	X	X	X
July-September minimum at Salem	X	X	X	X

1. April-May minimum at Salem not required in F2.

1955 – 107 percent of average flows

Criteria	F1-a	F1-b	F1-c	F2
April-May minimum flow at Salem	X	X	X	1
Minimum outflows at the projects	X	X	X	X
July-September minimum at Albany	X	X	X	X
July-September minimum at Salem	X	X	X	X

1. April-May minimum at Salem not required in F2.

Table 16 (continued). Model Results for Fish Operating Alternatives (X = criteria met)

1959 – 89 percent of average flows

Criteria	F1-a	F1-b	F1-c	F2
April-May minimum flow at Salem	X	X	2	1
Minimum outflows at the projects	X	X	2	X
July-September minimum at Albany	X	X	X	X
July-September minimum at Salem	X	X	X	X

1. April-May minimum at Salem not required in F2.
2. April-May minimum at Salem can be met in this year, but drawdown is dramatic at Hills Creek, Cougar, Blue River, Detroit, and Green Peter. Minimum outflows from these projects may not be met in late summer but minimum July-September flows at Albany and Salem are met.

1970 – 82 percent of average flows

Criteria	F1-a	F1-b	F1-c	F2
April-May minimum flow at Salem	X	X	2	1
Minimum outflows at the projects	X	X	---	X
July-September minimum at Albany	X	X	---	X
July-September minimum at Salem	X	X	---	X

1. April-May minimum at Salem not required in F2.
2. April-May minimum at Salem can be met in this year, but drawdown is dramatic at Hills Creek, Lookout Point, Cougar, Blue River, Detroit, and Green Peter. Minimum outflows from these projects may not be met in late summer. Minimum flows at Albany and Salem are not met most of August.

1977 – 57 percent of average flows

Criteria	F1-a	F1-b	F1-c	F2
April-May minimum flow at Salem	X	X	---	1
Minimum outflows at the projects	X	2	---	X
July-September minimum at Albany	3	X	---	X
July-September minimum at Salem	3	X	---	X

1. April-May minimum at Salem not required in F2.
2. Minimum flows at Hills Creek and Cougar not met in late summer.
3. July-September minimums at Salem and Albany are not met.

1989 – 99 percent of average flows

Criteria	F1-a	F1-b	F1-c	F2
April-May minimum flow at Salem	X	X	2	1
Minimum outflows at the projects	X	X	---	X
July-September minimum at Albany	X	X	X	X
July-September minimum at Salem	X	X	X	X

1. April-May minimum at Salem not required in F2.
2. April-May minimum at Salem can be met in this year, but drawdown is dramatic at Hills Creek, Lookout Point, Fall Creek, Cougar, Blue River, Detroit, and Green Peter. Minimum outflows at Hills Creek and Lookout Point not met in late summer.

Table 16 (continued). Model Results for Fish Operating Alternatives (X = criteria met)

1991 – 93 percent of average flows

Criteria	F1-a	F1-b	F1-c	F2
April-May minimum flow at Salem	X	X	X	1
Minimum outflows at the projects	X	X	X	X
July-September minimum at Albany	X	X	X	X
July-September minimum at Salem	X	X	X	X

1. April-May minimum at Salem not required in F2.
Alternative F1c run for 1991 looks better than for 1989 even though 1991 was a lower overall flow year. This may be due to 1991 having a wet May, so much of the Salem flow requirement could be met with natural flow.

1992 – 57 percent of average flows

Criteria	F1-a	F1-b	F1-c	F2
April-May minimum flow at Salem	X	3	3	1
Minimum outflows at the projects	X	---	---	X
July-September minimum at Albany	2	3	3	---
July-September minimum at Salem	2	3	3	---

1. April-May minimum at Salem not required in F2.
2. Minimums met July-September but system is then out of water in October and flows drop off to minimum of 3,700 cfs at Albany and 4,800 cfs at Salem.
3. Both April & May minimums at Salem and July to September minimums at Albany and Salem cannot be met.

1993 – 129 percent of average flows

Criteria	F1-a	F1-b	F1-c	F2
April-May minimum flow at Salem	X	X	X	1
Minimum outflows at the projects	X	X	X	X
July-September minimum at Albany	X	X	X	X
July-September minimum at Salem	X	X	X	X

1. April-May minimum at Salem not required in F2.

1994 – 62 percent of average flows

Criteria	F1-a	F1-b	F1-c	F2
April-May minimum flow at Salem	X	3	3	1
Minimum outflows at the projects	X	---	---	X
July-September minimum at Albany	2	3	3	---
July-September minimum at Salem	2	3	3	---

1. April-May minimum at Salem not required in F2.
2. Albany flow drops to 4,400 cfs and 4,200 cfs in September/October.
Salem flow drops to 5,400 cfs in both September/October.
3. Both April & May minimums at Salem and July to September minimums at Albany and Salem cannot be met.

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APPENDIX
LISTING OF CONTRIBUTORS AND PARTICIPANTS FOR THE WILLAMETTE RIVER BASIN RESERVOIR STUDY

CONTRIBUTORS

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City of Eugene
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City of Harrisburg
City of Idanha
City of Independence
City of Keizer
City of Lake Oswego
City of Lebanon
City of Milwaukie
City of Monmouth
City of Mt Angel
City of North Plains
City of Oregon City
City of Portland
City of Salem
City of Sherwood
City of Stayton
City of Tigard
City of Tualatin
City of Turner
City of Veneta
City of West Linn
City of Willamina
City of Wilsonville
Damascus Water District
Pope and Talbot
West Slope Water District
Hewlett Packard
Mitsubishi Silicon America
Lyons-Mehama Water District
McMinnville Water & Light
METRO
Mt. Scott Water District
Palatine Hill Water District
Portland Water Bureau
Raleigh Water District
Scravel Hill Water District
South Fork Water Board
Springfield Utility Board
Suburban East Salem Water Dist.
Tualatin Valley Water District
Unified Sewage Agency
Valley View Water District
Assoc. of Clean Water Agencies
Clackamas River Water District
Portland General Electric
Eugene Water & Electric Board
Hillsboro Utilities Commission

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Association of Clean Water Agencies
City of Salem
Lane County Parks
League of Oregon Cities
Oregon Environmental Council
Oregon Farm Bureau
Oregon Dept. of Economic Development
Oregon Dept. of Environmental Quality
Oregon Dept. of Fish & Wildlife
Oregon Trout
Oregon Water Utility Council
Portland Water Bureau
Special Districts Association
Tualatin Valley Water District
Unified Sewage Agency
Water Watch
Oregon Dept. of Agriculture
Oregon Parks and Recreation Dept.
Bureau of Reclamation
U.S. Department of Energy
U.S. Fish & Wildlife Service