CHAPTER 5: WATER SUPPLY AND DEMAND FORECAST

5.1 Introduction

This Chapter describes the water supply and demand forecast prepared for this first legislative report under the Columbia River Water Management Program. The forecast uses the data compiled and described in Chapters 3 and 4. The approach used for the forecast is not analytically sophisticated and, ultimately, additional work at both the inventory level and the forecasting level is needed. However, there are some meaningful observations that can be made with respect to forecasting demand on the Columbia River, and there are decisions to be made by Ecology and other stakeholders in the basin regarding how to further develop forecasting capabilities in the future and then act on them.

By describing and comparing these quantities, an initial understanding of Ecology's ability to issue new water rights for the Columbia River can be developed.

The initial water supply and demand forecast was carried out in two formats or "tiers":

1. The first tier demand forecast (described in Section 5.2) is based solely on water right applications on file in Ecology's WRTS database. It includes a summary of water right applications and the water use associated with those applications. The quantity of water in applications is then compared with the potential quantity of water conservation and the potential quantity of water in new storage projects described in Chapter 4.
2. The second tier demand forecast (described in Section 5.3) is based on projections of estimated actual water use. This projection focuses more on "wet" water. It includes the following:
   - Two projections of domestic water use: one based on OFM population estimates coupled with estimated per capita water use calculated using DOH data; and a second based on a projection of USGS year 2000 water use inventory of domestic use.
   - Two projections of agricultural water use: one based on the agricultural crop projections provide by Washington State University (WSU) for this report; and a second based on a projection of USGS year 2000 water use inventory of agricultural water use.

Both the first tier and second tier forecasts have limitations in their approach that will require future refinement to improve and quantify their accuracy. These limitations could not be eliminated in the short time available to produce the report. However, for the purposes of this first legislative report, the two tiers are illustrative of potential future water demand and issues related to water supply on the Columbia River.

Because of the recognized uncertainty in this forecast, the latter portions of this Chapter describe approaches to more sophisticated supply and demand forecasting, and describe the types of decisions and collaboration that will be necessary for Ecology to develop a more robust forecasting system in the future. We recognize that understanding and describing limits of the

forecast model is an extremely important element in any exercise of this kind.

5.2 First Tier Water Demand Forecast

The first tier water demand forecast is based on water right applications only. Although the degree to which pending water right applications represent a real water demand is subject to some uncertainty, Ecology is obligated to evaluate these applications and make a determination. Therefore no consideration is made in the forecast as to the validity of the applications.

The water right applications on file in Ecology's WRTS database are not complete in the reporting of instantaneous water requested (Q_i), annual volume of water requested (Q_a), or acres to be irrigated (for irrigation applications). The most common field that is not reported is the annual volume of water (Q_a), and about 60% of the records do not report a Q_a request. Most of the applications report a Q_i, and most of the agricultural applications designate an irrigated acreage. A total of 454 applications for surface water and ground water are on file. Figure 5-1 shows the distribution of water right applications on a map. The water right application data were provided by Ecology based on a query of the WRTS database in July 2006 (Ecology, pers. comm., 2006a). Appendix D explains the method and assumptions behind the analysis of the water right applications.

There are an additional 378 water right transfer applications on file.

5.2.1 Irrigation

Table 5-1 shows that there are a total of 195 new water right applications with an irrigation purpose of use, totaling 57,534 acres. There is not consistent reporting of both Q_i and Q_a. However, nearly all of these applications have reported acres irrigated. Therefore, a calculation of irrigation water use associated with these applications was made using an annual water duty (i.e. an annual volume of water per acre). For ground water applications that reported both acreage and Q_a, the average annual duty applied for is 3.41 AF per acre. For surface water, the average annual duty applied for is 3.82 AF per acre. Using these water duties, the total annual demand for agriculture based on water right applications is estimated at 211,323 AF.

The requested acreage (57,534 acres) is a very small proportion of the estimated total irrigated acreage in the Columbia Basin, and the water duty requested is consistent with typical irrigation requirements in Washington.

5.2.2 Domestic

Table 5-2 shows that there are a total of 214 domestic water right applications in the Management Zone, totaling 242 cfs. On an annualized basis, 242 cfs is equivalent to an annual water use of about 86,849 AF. This volume is calculated assuming continuous use of Q_i, which is then reduced by a factor of 2 (e.g. 50%). This assumption means that 242 cfs is equivalent to a peak-day requirement for domestic water supply and that a peaking factor of 2 is appropriate to convert peak day to annual use. Based on Washington Department of

Health guidance (DOH, 2002; DOH, 2005), this peaking factor is reasonable. The accuracy of the 242 cfs Q_i reported in the applications is not known.

Assuming a per capita water usage of 170 gallons per day per person (see Chapter 4), 86,849 AF of annual water use is equivalent to a population of just over 450,000 people.

5.2.3 Commercial/Industrial

Table 5-3 shows that there are 36 water right applications with a commercial/industrial purpose of use, totaling 230 cfs. Similar to domestic demand, the annual demand would be equivalent to 82,237 AF annually, using the same peaking factor assumption. Peaking factors for commercial and industrial use could be lower since the water is often used on a more continuous basis, so the total annual demand associated with 230 cfs of commercial/industrial Q_i may be underestimated.

5.2.4 Environment and Wildlife

Table 5-4 shows that there are 6 water right applications with an environment and wildlife purpose of use, totaling 16 cfs. The annual demand is equivalent to 12,181 AF annually if used continuously. If these applications are intended for summer instream flow purposes, annual use would be lower.

5.2.5 Undefined

Table 5-5 shows that there are 4 water right applications with an undefined purpose of use, totaling 2,211 AF annually.

5.2.6 Total Demand Based on Water Right Applications

The estimated total demand for water based on water right applications is summarized on Figure 5-2 by County. The demand applies only to water right applications within the 1-mile Management Zone. In total, there is 394,801 acre-feet per year of water requested in water right applications, using the assumptions described above. About 56% of that demand is associated with agriculture, 23% for domestic and 21% for commercial and industrial purposed of use. Benton County has the largest volume of water in applications, followed by Grant, Douglas, and Okanogan Counties. Benton, Grant, and Franklin counties have the highest irrigation demand, while Benton, Okanogan, and Walla Walla counties have the highest domestic demand.

The estimated monthly demand for water based on water right application amounts is shown on Figure 5-3 and Table 5-6, based on the typical monthly demand profiles (i.e. shaping factor) described in Chapter 4 to convert an annual demand to a series of monthly demands. The maximum summer demand (June, July, and August) is between about 70,000 and 90,000 AF per month, which is equivalent to between 1,200 and 1,500 cfs.

5.2.7 Comparison to Conservation Potential

5.2.7.1 Agriculture

Agricultural water demand associated with water right applications in the Management Zone are estimated at about 211,323 AF, and interruptible

agricultural water rights constitute at least an additional 163,000 AF (see Chapter 4). Peak monthly demand associated with new water right applications is in the range of 70,000 to 90,000 AF. Potential total conservation amounts are currently estimated at 970,065 AF (see Chapter 4). While the annual volume of potential conservation relative to pending water right applications is encouraging, there are four important considerations:

1. Only a portion of the annual conservation amount will accrue directly to the Columbia River. As described in Chapter 4, the proportion of conserved water that would accrue to the Columbia River cannot be determined accurately with available data. Some of the projects identified may result in a high proportion of accrual while others may be very low or negligible because the savings are largely non-consumptive. In aggregate, the proportion of accrual could be in the range of 5 to 20% on an aggregate basis.
2. The total annual amount of conservation is distributed on a monthly basis, and it is this instantaneous amount of conserved water that would need to be "credited" during the peak irrigation season to offset new water rights. Using crop irrigation requirements as a guide (i.e. the shaping factor described in Chapter 4), less than 30% of the potential annual conservation would be returned during July. After factoring out potential non-consumptive savings described above, this leaves less potential conservation accrual during the peak irrigation season.
3. As described in Chapter 4, the time lag between a point of withdrawal or conservation and return flow to the Columbia River creates a complex time-varying relationship for determining the benefits of conservation to streamflows. This could further reduce the amount of consumptive water conservation savings that would offset new demands during the peak irrigation season, but may increase the offset during the late summer and early fall.
4. Finally, it is possible that some of the conserved water would already be committed to other uses. This would be most relevant to conservation projects in tributary basins that are located farther away from the Columbia River.

Although the appropriate factors to determine what portion of conservation savings actually accrue to the Columbia are not well defined in aggregate, it is possible that conservation savings could become a basis for processing certain water rights. Further characterization of specific conservation projects (or groups of projects) in conjunction with specific water right requests will be necessary to determine whether conserved water will meet the requirements of ESSHB 2860 and can be used to offset or mitigate for new water right applications.

Ultimately, Ecology will strive to identify and evaluate conservation projects, or design enhancements to projects already identified, that will increase the accrual of water to the Columbia River as a way to address the existing demand for irrigation water rights.

5.2.7.2 Residential

Residential water right applications total 242 cfs or an estimated 86,849 AFY. This amount could support an additional population of 450,000 people, assuming 170 gpd per person. Providing water for new population can be considered in two ways:

1. A portion of the new population associated with these water right applications could possibly be served through municipal

conservation, reuse, or ASR, which could "maximize" the capacity of existing rights to meet new demands. This is essentially new population that may not require new water rights.

2. Some portion of the growth served through new water rights could also be permitted through "credits" from new conservation and wastewater treatment plant return flows. This is essentially new water right capacity that is "conditioned" on conservation commitments and recognition of actual consumptive use.

Similar to irrigation conservation, the appropriate factors and methodology for assigning appropriate conservation to potential new population and/or new water right needs is not well defined. An analysis of existing water rights (both perfected and inchoate) would be necessary to determine whether conservation and existing water rights could support the new demand expressed in water right applications. However, if the 1,000,000 people in the Columbia Basin reduced annual per capita demand by 10%, about 19,300 AF of water would become "available", which could support new growth of about 110,000 people. Therefore, it does not appear that conserved water alone would support the projected growth forecast in the pending water right applications. Also similar to irrigation conservation, the instantaneous amount of conserved water that would need to be "credited" during the peak summer months to offset new water rights could be problematic because consumptive use during the summer is higher and not offset by return flows from wastewater treatment plants.

However, it is very possible that individual conservation projects and water right applications could be matched such that conservation savings could become a basis for processing certain water rights. In particular, use of reclaimed water or aquifer storage during the summer months has the greatest potential to actually replace new summer demands (as opposed to simply reducing them), thereby allowing for population growth without new demands on the Columbia River.

5.2.8 Comparison to Storage Potential

The four potential large federal off-channel storage projects on the mainstem Columbia (See Chapter 4) each exceed 1,000,000 AF in capacity. Black Rock Reservoir and Wymer/Yakima Pumpback are two additional potential large federal tributary storage projects in excess of 1,000,000 AF designed to alleviate flows and irrigation demand in the Yakima Basin. Any one of these large storage projects could potentially provide a significant portion of the water right requests within the Management Zone. However, the potential apportionment of various "pieces" of this new storage to existing interruptible rights, new water right applications, instream flows, or other beneficial uses will require further analysis and collaboration with the Bureau of Reclamation.

There is insufficient detail at this time to compare projected storage volumes from smaller water storage projects identified through watershed planning efforts or other local planning documents.

5.2.9 Comparison to Supply

Comparing the available flow volume estimates from BPA's Hyd-Sim model which account for BiOp flow objectives (Reclamation, 2006d) described in Chapter 3 and the first tier demand forecast of 394,801 AF indicates that future out-of-stream demands would use 2% to 42% of the available flow volume estimate. This comparison does not account for the variability in supply and demand throughout the year. In an average year, there is no flow available in August above the BiOp flow targets (Reclamation, 2006d). In a minimum year, there is only flow available above the BiOp targets in October (Reclamation, 2006d).

5.3 Second Tier Water Demand Forecast

The second tier water demand forecast is based on estimated actual water use, using water use data compiled in Chapter 4, projected to the year 2025. The second tier forecast looks at water demand based on historical water use in the Columbia System, rather than the allocable or pending water rights in the system. The factors used to project future water use are very generalized aggregate estimates, and have not been "built" from an analysis of the many potentially underlying variables that affect the demand for water. More sophisticated methods of incorporating multiple factors into an aggregate estimate exist, but could not be developed in the short time frame for this project. However, the generalized forecast described below is useful for this first legislative report in that it provides an initial order of magnitude estimate of water quantities. The second tier forecast focuses on the two principal sectors of water use in the region: municipal supply (both domestic and commercial/industrial) and irrigated agriculture. USGS data on water use from the year 2000 and more recent inventory data compiled for this report are used in the analysis.

5.3.1 Agricultural Sector – WSU Survey

Future irrigation water demand is ultimately related to changes in the total crop acreage, crop type and distribution, and the irrigation profile for various crops. Ecology, through a Memorandum of Understanding, asked researchers at Washington State University (WSU) to perform two complementary analyses on crop production and water use in the Washington State portion of the Columbia River Basin (Wandschneider, et al., 2006). A survey was developed to solicit expert opinions about future crop production and water use for major crops. In addition, an econometric forecasting model was developed and applied to U.S. Department of Agriculture (USDA) National Agricultural Statistics Service data on production and acreage. The two analyses are meant to be interpreted together to obtain a forecast of crop production and water use. Details of the survey results are provided in Appendix D. The important observations from the analyses are summarized below.

5.3.1.1 Agricultural Sector Survey Results

The survey participants comprised representatives of commodity organizations (potatoes, apples, wheat, cattle), government agencies (Farm Service administration, USDA, Natural Resource and Conservation Service

(NRCS)), one processing/distribution association, two irrigation districts, one conservation district, one irrigators association, and three private agricultural firms. The results of the survey indicate that participants believe:

- increases in water demand for wine grapes will occur;
- an increase in water demand for cattle producers (through increases in water demands for processing and irrigated pasture) will occur;
- water demand for potatoes will remain stable; however, a desire to open new lands is expressed to keep yields high; and
- water demand for apples and other tree fruit will remain stable.

Tree fruit growers expressed a concern with the effect of droughts on production. The water demand for wheat is not anticipated to change, although most wheat is dryland farmed anyway.

5.3.1.2 Econometric Forecasting Results

The econometric forecast prepared by WSU uses statistical methods and historical data from the top twenty-five crops to determine crop production trends on a County-wide and regional basis. The top twenty-five crops account for over 95% of farm-gate revenue in the Columbia River Basin. Historical data were taken from 1981-2004 for most crops. Of the twenty-five crops used, silage corn, bluegrass seed, onions, peppermint, potatoes, sweet corn, cherries, and grapes show a visible positive trend in historic production and acreage planted. Pears and hay show a weak positive time trend. Asparagus, barley, and carrots show a visible negative trend, and apricots show a weak negative time trend. The other twelve crops (alfalfa, grain corn, dry beans, green peas, hay, spearmint, wheat, hops, dry peas, lentils, peaches, and apples) were not found to have a significant positive or negative trend. These trends were used by WSU to forecast future crop production using Vector Autoregression (VAR) analysis. The forecast accounts for typical factors that affect crop production if those factors have been present in the sample period. For example, weather and market cycles and trends from 1981-2004 are taken into account using this forecast system. However, because the forecast relies solely on historical data, any factors that affect crop production that have not occurred in the sample period would not be included in the forecast. New technologies or market changes that significantly change crop production compared to the sample period cannot be predicted by this forecast method.

The results of the predicted future agricultural production and acreage for the various crop types are presented in Appendix D. Forecasts for some crops, such as wine grapes, were not made because stable relationships between variables in the VAR equations used did not exist for the crop. Stability of an estimated VAR is required in order to generate reasonable (unbiased and consistent) forecasts. Otherwise, forecasts tend to “explode” in unreasonable ways as predictions are forecasted into the future. For County-level regressions, stable VARs are rarely found for more than four of the important crops.

Table 5-7 provides a short description of the crops with forecasts and the estimated increase or decrease in acreage or production of each. Figure 5-4 shows the projected total crop

acreage for Counties in the Columbia River Basin. The expected trend in total crop acreage shows a stable pattern with no significant increase or decrease in acreage. At the 95% confidence level, an increase of nearly one-million acres of agricultural land is possible; or a decrease of about 750,000 acres is possible. The figure shows the expected trend and bounding trends at a 95% confidence interval. The total crop acreage shown on Figure 5-4 includes dryland wheat farming.

5.3.1.3 Conclusions about Future Water Demand in the Agricultural Sector

The results of the WSU study show little or no change in expected crop acreage in the Columbia River Basin. However, the study could not forecast acreage for a few important crops such as wine grapes and alfalfa. The study acknowledges various necessary limitations in approach, and presents the possibility of both an increase or a decrease in crop acreage. In terms of potential water demand, the lack of an increase in acreage and overall stability in the crop patterns would suggest that, in aggregate, the demand for irrigation water should remain relatively constant with no significant new demand. However, no definite conclusions could be made regarding the need for additional water based solely on this report.

5.3.2 Agricultural Sector – USGS Water Use

It was not possible to develop a sophisticated analysis of growth and validate potential growth in agricultural water use.

- As noted above, the WSU study was based on a total current crop acreage (both irrigated and non-irrigated) for the entire Columbia Basin of around 3,200,000 acres.
- The year 2000 total agricultural water use in Washington counties in the Columbia Basin was estimated at over 3,200,000 AF per year (Lane, 2004). At an average duty of 3.5 feet per year, this is equivalent to 1,156,000 irrigated acres.
- The WSU study indicated that total crop acreage over the next 20 years will remain stable, although increases or decreases of up to 750,000 acres are possible.
- Water right applications suggest an increase by about 60,000 acres.
- The general “mood” of the WSU survey results was for a stable or declining agricultural demand.
- If the Columbia Basin project were completed to its full capacity, an additional 400,000 of irrigated lands could be brought into production;
- Complete conversion of irrigated lands in the Odessa Subarea from ground water to surface water would put 170,000 acres of land on a Columbia River water supply.

Given the wide range in potential irrigation demands, a simple projection of irrigation water use to the year 2025 was made for a range of possible demands. Increases in future demand for irrigation water (if they occur) will represent a combination of additional irrigated acres, a transition to more water intensive crops, or a need for more water in response to higher temperatures and longer growing seasons because of climate change. However, it was not possible to develop a more sophisticated approach and validate the estimated growth rate with the inventory data and time available for the initial forecast. Factors related to

conservation, agricultural economics, and climatic factors are not incorporated in this projection of water demand. With additional time for analysis, future forecasts can examine the more detailed relationships between agricultural water demand and these other factors.

Figure 5-5 shows the range of potential growth in irrigation water demand at the year 2025 based on existing information. The figure shows the annual change in irrigation demand as a percent on the x-axis, and the additional demand for water in the year 2025 on the y-axis. A second y-axis is shown on the left side of the figure that shows equivalent additional irrigated acres. The irrigation demand assumes a water duty of 3.5 AF per acre, and the irrigated acreage increase assumes a current level of irrigated land at 1,156,000 acres. Figure 5-5 also shows the volume of saved water from currently identified agricultural conservation projects (see Chapter 4). There are several discussion points related to this figure:

1. The 57,354 acres of new irrigation water right applications are equivalent to an annual growth rate of about 0.35% per year or a 9% total increase in irrigated area by the year 2025.
2. By contrast, a 15% total increase in irrigated acreage by the year 2025 (0.6% per year) would bring an equivalent 95,000 acres of irrigated land into production.
3. If agriculture were to grow to the WSU high projection, and the entire Columbia Basin Project was brought into production, and the Odessa Subarea was completely converted to surface water, new irrigation demands could approach or exceed 2 million acre feet per year.

Table 5-8 shows the projected increase in water use based on year 2000 USGS estimate and the optimistic assumption that irrigation water use will increase by 15% by the year 2025.

5.3.3 Municipal Sector (Domestic and Commercial/Industrial)

Future domestic water demand is ultimately related to the increase in population for the region. The economic factors that affect population growth are not incorporated in this analysis. The two domestic water demand projections provided below are based on a fundamental assumption that the population forecasts provided by OFM are a realistic basis for projecting water demand. Offsetting factors related to municipal conservation requirements, water reuse or land use constraints are not incorporated in this projection of water demand. With additional time for analysis, future forecasts can examine the more detailed relationships between domestic water demand and other factors.

The OFM moderate forecast for population growth indicates that, over the next 20 years, population at a County level will increase from less than 5% to over 30% (Figure 5-6). These growth rates can be used in two ways:

- On average, 20-year population growth for all counties in the Columbia Basin is projected to be about 20%, or an additional 350,000 people. If only Counties that lie adjacent to the Management Zone are considered, the projected population increase is lower, on the order of 157,000 people. At an average per capita water use rate (170 gpd per person), these populations are equivalent to 67,400 AF per year (all

counties) and 29,600 AF per year (counties adjacent to Columbia River).

- Applying the County growth rates to the year 2000 USGS water use survey estimate of domestic water use (both public supply and self supplied) results in a similar water demand: about 52,500 AFY (all counties) and 18,800 AFY (counties adjacent to Columbia River).

Additional commercial/industrial water demand in 2025 was assumed to grow at the same rate as the growth in population. The economic factors that affect commercial/industrial growth are not incorporated in this analysis and offsetting factors related to conservation requirements, water reuse or land use constraints are not incorporated. With additional time for analysis, future forecasts can examine the more detailed relationships between commercial/industrial water demand and other factors. A commercial/industrial water demand of about 42,000 AFY (all counties) and 28,400 AFY (counties adjacent to Columbia River) is projected assuming that this sector grows at a similar rate to population growth. A lower commercial/industrial growth rate might be more realistic, but the higher rate is used for comparison to water right applications.

Table 5-8 shows the projected increase in water use based on year 2000 USGS estimate and the assumption that domestic and commercial water use will increase by 20% by the year 2025.

5.3.4 Comparison of First Tier and Second Tier Demand Projections

In general, it appears that the total demand for water expressed in the existing water right applications exceeds the total demand for water that is likely to occur based on simplistic projection methodologies. Table 5-9 indicates that:

- The first tier water demand forecast for irrigation water based on water right applications in the Management Zone (211,000 AF) is greater than the expected basin-wide irrigation demand based on the second tier WSU projection (zero), but less than more optimistic projections that are possible.
- The first tier water demand forecast for domestic water based on water right applications (86,849 AF) in the Management Zone is greater than the estimated range of domestic water demand both basin-wide and for Counties adjacent to the Columbia River.
- The first tier water demand forecast for commercial industrial water based on water right applications (82,237 AF) in the Management Zone is greater than the estimated range of domestic water demand both basin-wide (42,000 AF) and for Counties adjacent to the Columbia River (28,400 AF).

Figure 5-7 shows the monthly demand profile based on both the current water right applications and the projections described above. The demand profile is based on the shaping factor described in Chapter 4 and the profile uses an optimistic increase in future agricultural demand of 15% at the year 2025 (see Figure 5-5). Figure 5-7 shows that total demand during July could exceed 2,500 cfs under an optimistic irrigated lands projection, but is on the order of 1,500 cfs based on water right applications. This equivalent flow rate does not compensate for return flows from municipal wastewater plants or from irrigation return flows and therefore represents a worst case monthly demand on the Columbia River.

In relation to the goals of the Columbia River Management Program, there are two relevant considerations:

1. First, although there is a discrepancy between water right applications and potential future demand, this does not mean that individual water right applications are not valid or that future total water use will not approach the quantities currently requested in applications. In the case of irrigated agricultural demand, actual demand for Columbia River water could exceed what is current in applications, particularly if the Columbia Basin Project (CBP) is developed further. A more detailed evaluation of individual water right requests and more sophisticated demand projection methodology is necessary to address individual situations and to factor in issues such as the CBP.
2. Second, the estimated future water (both water right applications and expected levels of use) is conservative (i.e., high) and reasonably close to the conservation savings currently identified in the basin. This, coupled with the possibility of additional storage in the basin and identification of additional conservation projects, suggests that actual future demands for water can be accommodated in large part through the Management Program's current strategy of conservation and storage.

5.3.5 Comparisons to Existing Water Rights and Existing Storage

One final consideration is the ability of existing water rights and storage to accommodate future demand. Existing water right capacity, defined as the difference between current water use and existing water rights, is a consideration in evaluating water demand forecast at a basin scale. The degree to which existing water rights can satisfy future changes in the amount and distribution of water demand is a very complex issue. The implication of existing water right capacity on decisions regarding permit applications was acknowledged in the National Academy of Sciences study (National Research Council, 2004):

"For a given permit application, whether one looks to upstream or downstream rights, it would be incorrect to assume that present flows in the mainstem accurately reflect current legal allocations".

It is also incorrect to assume that all documented water rights are valid and the potential relinquishment of many of these rights due to non-use needs to be considered. In effect, there is currently not an accurate picture of legal entitlements to water from the Columbia River and there will likely not be one in the immediate future. Although simple comparisons between projected water use and existing water right capacity are not valid in a strict sense, the total existing quantity of non-hydroelectric water rights and existing non-hydroelectric storage in the basin is much larger than the estimated use. While there are many factors that would tend to reduce the amount of this existing capacity to meet future needs, it is likely that there is some capacity in existing water rights and storage to meet future demand.

The ability to "optimize" these existing rights and storage volumes can be accomplished through a number of institutional and technical approaches. Engineering optimization of conveyance and storage systems is one way to optimize the use of existing rights, moving water from areas where valid "excess" water rights exist to areas where water is needed. Water

banks, water trusts, and water reuse are other options, and Appendix D contains a more detailed summary of these mechanisms. In order to facilitate these optimization strategies, Washington water law requires that any water rights associated with the strategy be subject to an analysis of beneficial use. This includes an assessment of the quantity, place, and purpose of use over the past five years and a relinquishment of rights that have not been put to beneficial use over that time period. This has been a significant impediment to implementation of these water optimization strategies.

5.4 Conclusions

Based on the available information, the most important conclusion is that the future balance between water supply and water demand in the Columbia River is not yet well understood. Demand is likely to increase and supply is likely to decrease, but a variety of future scenarios exist regarding the details of this future water balance. Additional work at both an inventory and forecasting level is necessary to refine the analysis presented in this report.

However, it is also likely that the demand for water currently expressed in existing water right applications is representative of the demand for water in the future and efforts to plan for this level of growth in water demand should accommodate the objectives for the initial planning cycle of the Columbia River Management Program. At this initial stage of the development of the Management Program, planning for a water demand that represents a mid-point between the lower bounds (i.e. zero new demand) and upper bounds (>1 MAF of new demand) is reasonable. Planning for water use in this range is also consistent with what is known about existing applications and other water supply problems that are known to exist adjacent to the Columbia within Washington State.

Finally, the magnitude of water conservation and storage volumes currently under consideration on or adjacent to the Columbia River is large and, if developed, could improve water supplies for all beneficial uses, including streamflows. Whether this conservation will ultimately accrue to the Columbia River is subject to some uncertainty and must be evaluated on a case-by-case basis. The key will be to accurately understand the volume of water that accrues to the Columbia River, particularly in the months of July and August when flow and temperature concerns can be particularly acute. In this regard, storage may provide more certainty than conservation, since it can be better defined and measured on a larger scale.

Over the long-term, the focus on conservation and storage as management tools to create a sustainable balance between water supply and demand should be successful, both on a case-by-case basis and in aggregate as more refined analyses are developed to document and track the water balance in the Columbia River. As Ecology develops capacity over time, future legislative reports will provide more specific examples of individual projects and a more robust assessment of aggregate performance. Further stakeholder outreach will allow for improved collaboration on specific technical issues or other factors that affect the performance of the program.

TABLES

Table 5-1. New Water Right Applications Within the Management Zone[1], Designated Agriculture[2]

County	Ground Water						Surface Water					
	No. Records		Acres Irrigated		Q_a[3] (AF)		No. Records		Acres Irrigated		Q_a[4] (AF)	
	N	C	N	C	N	C	N	C	N	C	N	C
Benton	15	4	3,600	2,010	12,276	6,854	22	8	14,313	11,616	54,676	44,373
Chelan	7	4	144	159	491	542	11	5	485	294	1,853	1,123
Douglas	14	26	1,231	1,856	4,198	6,329	22	22	4,326	1,448	16,525	5,531
Ferry	NA	NA	NA	NA	0	0	5	2	205	140	783	535
Franklin	11	11	5,442	1,918	18,557	6,540	9	7	3,145	4,644	12,014	17,740
Grant	17	15	4,470	716	15,243	2,442	1	NA	10,000	NA	38,200	0
Kittitas	2	4	140	440	477	1,500	4	NA	0	NA	0	0
Klickitat	7	3	1,495	56	5,098	191	6	NA	1,957	NA	7,476	0
Lincoln	1	NA	130	NA	443	0	NA	NA	NA	NA	0	0
Okanogan	9	9	471	532	1,606	1,814	10	12	2,209	458	8,438	1,750
Skamania	2	NA	23	NA	78	0	3	NA	25	NA	96	0
Stevens	NA	NA	NA	NA	0	0	3	14	145	145	554	554
Walla Walla	8	3	1,803	370	6,148	1,262	6	7	1,595	3,026	6,093	11,559
Yakima	NA	NA	NA	NA	0	0	NA	NA	NA	NA	0	0
Subtotals:	**93**	**79**	**18,949**	**8,057**	**64,616**	**27,474**	**102**	**77**	**38,405**	**21,771**	**146,707**	**83,165**
Total	**172**		**27,006**		**92,090**		**179**		**60,176**		**229,872**	

NOTES

Abbreviations: No.: Number; Q_a: annual quantity; AF: acre-feet; NA: Not Applicable; N: New Applications; and, C: Change Applications, Change Permits and Change ROE.

[1] Washington State Water Rights Tracking System (WRTS). Excerpt of water rights and applications within the 1 mile management zone. Provided by Ecology August 2, 2006.

[2] Agriculture incorporates the following uses: DY, FP, IR, ST.

[3] Q_a for ground water right applications is calculated by multiplying the acres irrigated by 3.41. (Average water duty for applications that specify Q_a and acres).

[4] Q_a for surface water right applications is calculated by multiplying the acres irrigated by 3.82. (Average water duty for applications that specify Q_a and acres).

Table 5-2. New Water Right Applications Within the Management Zone[1], Designated Domestic[2]

County	Ground Water						Surface Water					
	No. Records		Q_i[3] (cfs)		Q_a[4] (AF)		No. Records		Q_i[3] (cfs)		Q_a[4] (AF)	
	N	C	N	C	N	C	N	C	N	C	N	C
Benton	11	4	13	10	4,731	2,454	NA	3	NA	1,571	NA	23,544
Chelan	13	11	12	10	4,427	1,003	6	6	21	25	7,694	2,262
Douglas	33	16	40	15	14,650	1,776	9	7	3	105	1,044	653
Ferry	2	NA	0	NA	313	NA	NA	6	NA	136	NA	NA
Franklin	11	4	10	6	3,467	222	NA	NA	NA	NA	NA	NA
Grant	22	22	41	9	14,778	3,061	NA	1	NA	0	NA	0
Kittitas	1	NA	1	NA	484	NA	NA	NA	NA	NA	NA	NA
Klickitat	12	4	19	4	5,352	944	2	2	6	35	2,533	8,528
Lincoln	18	2	17	2	6,087	72	5	1	0	0	299	0
Okanogan	36	5	19	4	6,732	683	NA	2	NA	1	NA	218
Skamania	1	1	0	0	57	2	3	NA	0	NA	22	NA
Stevens	9	NA	11	NA	3,860	NA	14	4	3	0	1,043	NA
Walla Walla	6	7	26	3	9,281	387	NA	NA	NA	NA	NA	NA
Yakima	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Subtotals:	**175**	**76**	**209**	**63**	**74,216**	**10,602**	**39**	**32**	**33**	**1,873**	**12,634**	**35,204**
Total	**251**		**272**		**84,818**		**71**		**1,906**		**47,837**	

NOTES

Abbreviations: No.: Number; Q_a: annual quantity; Q_i: instantaneous quantity; AF: acre-feet; N: New Applications; C: Change Applications, Change Permits and Change ROE; NA: Not Applicable; CFS: cubic feet per second; and, GPM: gallons per minute.

[1] Washington State Water Rights Tracking System (WRTS). Excerpt of water rights and applications within the 1 mile management zone. Provided by Ecology August 2, 2006.

[2] Domestic incorporates the following uses: DG, DM, DS, HE, MU, RE

[3] Q_i for water right applications is converted from GPM to CFS if reported in GPM (1 GPM = 0.002228 CFS).

[4] Q_a for water rights applications is calculated from Q_i IF no Q_a is provided. Calculation is based on continuous use, divided by 2 (see text for explanation).

Table 5-3. New Water Right Applications Within the Management Zone[1], Designated Commercial and Industrial[2]

County	Ground Water						Surface Water					
	No. Records		Q_i[3] (cfs)		Q_a[4] (AF)		No. Records		Q_i[3] (cfs)		Q_a[4] (AF)	
	N	C	N	C	N	C	N	C	N	C	N	C
Benton	8	3	15	1	5,278	295	6	3	98	661	35,586	1,637
Chelan	1	1	0	0	1	160	NA	6	NA	52	NA	15,561
Douglas	1	3	4	0	1,614	94	NA	1	NA	3	NA	688
Ferry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Franklin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Grant	1	1	5	5	1,937	600	NA	NA	NA	NA	NA	NA
Kittitas	1	NA	0	NA	73	NA	NA	NA	NA	NA	NA	NA
Klickitat	5	1	11	1	3,874	400	1	1	1	35	362	8,524
Lincoln	2	NA	7	NA	2,421	NA	NA	NA	NA	NA	NA	NA
Okanogan	NA	NA	NA	NA	NA	NA	1	NA	54	NA	19,405	NA
Skamania	3	NA	6	NA	1,481	NA	NA	NA	NA	NA	NA	NA
Stevens	NA	NA	NA	NA	NA	NA	1	NA	0	NA	22	NA
Walla Walla	4	6	9	9	2,941	2,016	1	NA	20	NA	7,245	NA
Yakima	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Subtotals:	**26**	**15**	**57**	**16**	**19,619**	**3,565**	**10**	**11**	**173**	**751**	**62,618**	**26,410**
Total	**41**		**73**		**23,184**		**21**		**924**		**89,028**	

NOTES

Abbreviations: No.: Number; Q_a: annual quantity; Q_i: instantaneous quantity; AF: acre-feet; N: New Applications; C: Change Applications, Change Permits and Change ROE; NA: Not Applicable; CFS: cubic feet per second; and, GPM: gallons per minute.

[1] Washington State Water Rights Tracking System (WRTS). Excerpt of water rights and applications within the 1 mile management zone. Provided by Ecology August 2, 2006.

[2] Commercial and Industrial incorporates the following uses: CI, CO, HW, MI, RW

[3] Q_i for water right applications is converted from GPM to CFS if reported in GPM (1 GPM = 0.002228 CFS).

[4] Q_a for water rights applications is calculated from Q_i IF no Q_a is provided. Calculation is based on continuous use, divided by 2 (see text for explanation).

Table 5-4. New Water Right Applications Within the Management Zone[1], Designated Environment and Wildlife[2]

County	Ground Water						Surface Water					
	No. Records		Q_i[3] (AF)		Q_a[4] (AF)		No. Records		Q_i[3] (AF)		Q_a[4] (AF)	
	N	C	N	C	N	C	N	C	N	C	N	C
Benton	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chelan	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Douglas	1	NA	4	NA	2,905	NA	NA	1	NA	0	NA	80
Ferry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Franklin	NA	NA	NA	NA	NA	NA	1	NA	10	NA	7,245	NA
Grant	1	NA	2	NA	1,614	NA	NA	NA	NA	NA	NA	NA
Kittitas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Klickitat	NA	NA	NA	NA	NA	NA	1	NA	0	NA	14	NA
Lincoln	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Okanogan	1	NA	0	NA	323	NA	NA	NA	NA	NA	NA	NA
Skamania	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Stevens	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Walla Walla	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Yakima	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Subtotals:	**3**	**0**	**6**	**0**	**4,842**	**0**	**2**	**1**	**10**	**0**	**7,259**	**80**
Total	**3**		**6**		**4,842**		**3**		**10**		**7,339**	

NOTES

Abbreviations: No.: Number; Q_a: annual quantity; Q_i: instantaneous quantity; AF: acre-feet; N: New Applications; C: Change Applications, Change Permits and Change ROE; NA: Not Applicable; CFS: cubic feet per second; and, GPM: gallons per minute.

[1] Washington State Water Rights Tracking System (WRTS). Excerpt of water rights and applications within the 1 mile management zone. Provided by Ecology August 2, 2006.

[2] Environment and Wildlife incorporates the following uses: EN, FR, FS, WL

[3] Q_i for water right applications is converted from GPM to CFS if reported in GPM (1 GPM = 0.002228 CFS).

[4] Q_a for water rights applications is calculated from Q_i IF no Q_a is provided. Assumes water is used continuously.

Table 5-5. New Water Right Applications Within the Management Zone[1], Designated Undefined Use[2]

County	Ground Water						Surface Water					
	No. Records		Q_i[3] (AF)		Q_a[4] (AF)		No. Records		Q_i[3] (AF)		Q_a[4] (AF)	
	N	C	N	C	N	C	N	C	N	C	N	C
Benton	NA	15	NA	2	NA	364	NA	18	NA	854	NA	190,146
Chelan	NA	6	NA	2	NA	270	NA	6	NA	0	NA	0
Douglas	1	3	2	1	1,114	280	1	4	0	0	161	0
Ferry	NA	NA	NA	NA	NA	NA	NA	5	NA	0	NA	0
Franklin	NA	5	NA	29	NA	5,393	NA	NA	NA	NA	NA	NA
Grant	1	NA	1	NA	775	NA	NA	NA	NA	NA	NA	NA
Kittitas	1	NA	0	NA	161	NA	NA	NA	NA	NA	NA	NA
Klickitat	NA	3	NA	2	NA	1,440	NA	6	NA	36	NA	17,138
Lincoln	NA	1	NA	2	NA	839	NA	1	NA	0	NA	0
Okanogan	NA	NA	NA	NA	NA	NA	NA	2	NA	12	NA	3,098
Skamania	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Stevens	NA	3	NA	5	NA	3,776	NA	7	NA	2	NA	1,449
Walla Walla	NA	1	NA	3	NA	744	NA	1	NA	225	NA	43,704
Yakima	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Subtotals:	**3**	**37**	**3**	**46**	**2,050**	**13,106**	**1**	**50**	**0**	**1,129**	**161**	**255,535**
Total	**40**		**49**		**15,156**		**51**		**1,129**		**255,696**	

NOTES

Abbreviations: No.: Number; Q_a: annual quantity; Q_i: instantaneous quantity; AF: acre-feet; N: New Applications; C: Change Applications, Change Permits and Change ROE; NA: Not Applicable; CFS: cubic feet per second; and, GPM: gallons per minute.

[1] Washington State Water Rights Tracking System (WRTS). Excerpt of water rights and applications within the 1 mile management zone. Provided by Ecology August 2, 2006.

[2] Primary use is undefined or unrecognized (non-standard) use code.

[3] Q_i for water right applications is converted from GPM to CFS if reported in GPM (1 GPM = 0.002228 CFS).

[4] Q_a for water rights applications is calculated from Q_i IF no Q_a is provided. Assumes water is used continuously.

Table 5-6. Tier 1 Monthly Water Use Forecast[1]

County	Total Water Right Applications (AF)	Projected Monthly Increase (2000-2025) in Total Water Use (AF)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adams	-	-	-	-	-	-	-	-	-	-	-	-	-
Asotin	-	-	-	-	-	-	-	-	-	-	-	-	-
Benton	112,547	1,824	1,824	1,824	4,037	11,650	20,165	26,802	22,774	14,037	3,963	1,824	1,824
Chelan	14,466	485	485	485	668	1,460	2,285	2,780	2,639	1,544	665	485	485
Columbia	-	-	-	-	-	-	-	-	-	-	-	-	-
Douglas	39,306	743	743	743	1,473	4,053	6,912	9,078	7,831	4,792	1,450	743	743
Ferry	1,096	13	13	13	36	114	203	275	228	142	35	13	13
Franklin	34,038	139	139	139	976	3,584	6,604	9,201	7,362	4,674	942	139	139
Garfield	-	-	-	-	-	-	-	-	-	-	-	-	-
Grant	70,933	700	700	700	2,277	7,409	13,260	18,086	14,870	9,314	2,218	700	700
Kittitas	1,195	29	29	29	48	122	203	260	231	139	48	29	29
Klickitat	24,695	485	485	485	936	2,544	4,321	5,656	4,900	2,992	922	485	485
Lincoln	9,250	352	352	352	452	928	1,409	1,666	1,639	943	451	352	352
Okanogan	36,180	1,045	1,045	1,045	1,570	3,677	5,919	7,398	6,793	4,035	1,559	1,045	1,045
Pend Oreille	-	-	-	-	-	-	-	-	-	-	-	-	-
Skamania	1,733	62	62	62	82	174	268	322	311	180	82	62	62
Spokane	-	-	-	-	-	-	-	-	-	-	-	-	-
Stevens	5,479	197	197	197	261	551	849	1,018	984	571	260	197	197
Walla Walla	31,708	779	779	779	1,295	3,243	5,356	6,848	6,112	3,679	1,281	779	779
Whitman	-	-	-	-	-	-	-	-	-	-	-	-	-
Yakima	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**382,621**	**6,852**	**6,852**	**6,852**	**14,111**	**39,511**	**67,754**	**89,389**	**76,674**	**47,044**	**13,878**	**6,852**	**6,852**

NOTES

Abbreviations: AF: acre-feet; -: Not applicable; WR Apps; water right applications

[1] Only includes counties strictly within the 1-mile management zone (excludes Adams, Asotin, Columbia, Garfield, Spokane, and Whitman).

Table 5-7. Forecasted Growth in Crops[1]

Crop	Forecasted Growth in Acreage or Production (2005 to 2025)
Barley	+38,600 acres
Dry Beans	-6,500 acres
Hay	-5,000 acres
Potatoes	-19,300 acres
Wheat	-101,500 acres
Grain Corn	-2,700 acres
Sweet Corn	-7,600 acres
Bluegrass Seed	-1,400 acres
Alfalfa Seed	-2,700 acres
Green Peas	+170 acres
Silage Corn	+5,850 acres
Peppermint	-2,600 acres
Apples	No change
Pears	-11,000 tons

NOTES

[1] Reference: Wandschneider, Philip, et al. 2006. Crop Production and Water Use Forecasts for the State of Washington Based on Econometric Estimation and Expert Opinion. School of Economic Sciences, Washington State University. September 2006.

Table 5-8. Tier 2 Annual Water Use Forecast

County	Estimated Water Use (2000)						Projected Change in Use (2000 - 2025)[1]					
	Domestic (public supplied) (AF/yr)	Domestic (self-supplied) (AF/yr)	Crop Irrigation (AF/yr)	Golf Course Irrigation (AF/yr)	Indust-rial (AF/yr)	County Total (AF/yr)	Domestic (public supplied) (AF/yr)	Domestic (self-supplied) (AF/yr)	Crop Irrigation (AF/yr)	Golf Course Irrigation (AF/yr)	Industrial (AF/yr)	County Total (AF/yr)
Adams	2,780	1,468	209,610	123	2,500	216,481	580	306	31,442	12	522	32,862
Asotin	4,125	235	224	123	0	4,707	676	38	34	12	NA	760
Benton	14,684	3,721	265,656	1,311	84,180	369,552	2,645	670	39,848	131	15,165	58,461
Chelan	6,580	2,242	56,382	818	16,253	82,275	1,403	478	8,457	82	3,466	13,887
Columbia	583	247	4831	56	90	5807	25	11	725	6	4	770
Douglas	3,497	594	27,462	347	3,744	35,644	824	140	4,119	35	882	5,999
Ferry	404	740	5033	45	325	6547	85	156	755	5	68	1,069
Franklin	9,079	2,477	489,838	191	1,962	503,547	2,152	587	73,476	19	465	76,699
Garfield	314	168	572	45	11	1110	34	18	86	5	1	144
Grant	11,075	5,941	1,042,446	2,287	3,598	1,065,347	1,801	966	156,367	229	585	159,947
Kittitas	7,342	1,558	223,061	516	1,580	234,057	1,616	343	33,459	52	348	35,818
Klickitat	2,320	1,054	29,704	146	3,116	36,340	495	225	4,456	15	665	5,855
Lincoln	1,334	706	40,241	202	11	42,494	282	149	6,036	20	2	6,490
Okanogan	4,551	4,192	81,378	370	4,237	94,728	732	675	12,207	37	682	14,333
Pend Oreille	594	785	829	0	1031	3239	142	188	124	NA	246	700
Skamania	628	460	280	235	12666	14269	119	87	42	24	2,395	2,666
Spokane	88,552	13,115	10,268	1,580	48,423	161,938	19,009	2,815	1,540	158	10,394	33,917
Stevens	2,858	2,074	10,682	146	135	15,895	979	711	1,602	15	46	3,353
Walla Walla	6,053	1,188	138,993	258	18,271	164,763	873	171	20,849	26	2,634	24,553
Whitman	3,632	1,009	3,139	90	0	7,870	357	99	471	9	NA	936
Yakima	28,807	14,236	637,798	1,424	7,297	689,562	5,912	2,922	95,670	142	1,498	106,143
Total	**199,792**	**58,210**	**3,278,427**	**10,313**	**209,430**	**3,756,172**	**40,742**	**11,756**	**491,764**	**1,031**	**40,070**	**585,363**
Total Mgmt Zone Only	**68,219**	**26,264**	**2,202,375**	**6,749**	**148,609**	**2,452,216**	**13,568**	**5,239**	**330,356**	**675**	**27,129**	**376,968**

See notes on next page.

NOTES

Abbreviations: NA: Not applicable; Mgmt: Management

[1] Domestic and industrial change in use based on medium forecast population growth (OFM, 2006). Agricultural change in use based on a 0.15% total increase in agricultural water use at 2025. See Section 5.3.2 for a detailed discussion.

Table 5-9. Comparison of First and Second Tier Demand Forecasts

Purpose of Use	First Tier Forecast (Water Right Applications)[1]		
	Q_a (AF)	Additional Irrigated Acres	Population Increase
Agriculture	211,323	57,534	NA
Domestic	86,849 [2]	NA	450,000 [3]
Commercial	82,237	NA	NA
Undefined	14,392	NA	NA
Total	**394,801**		

NOTES
Abbreviations: AF: acre-feet; cfs: cubic feet per second; NA: Not applicable
[1] Includes water rights in Management Zone only.
[2] Assumes continuous use of requested Q_i with a 50% reduction for peaking factor
[3] Population calculated based on a per capita use of 170 gallons per day per person.

Purpose of Use	Second Tier Forecast (Water Use Projection)[1]		
	Q_a (AF)	Irrigated Acres	Population Increase
Agriculture	0[2] – 330,000[3]	0[2] – 95,000[3]	NA
Domestic	29,600[4] - 67,400[5]	NA	157,500[4] -350,000[5]
Commercial	28,400[4] - 42,000[5]	NA	NA
Total	**58,000 - 439,400**		

NOTES
Abbreviations: AF: acre-feet; cfs: cubic feet per second; NA: Not applicable
[1] Based on projection of USGS 2000 Water Use estimate to the year 2025.
[2] Projection based on WSU expected growth in crop acreage.
[3] Projection based on 15% growth in irrigated acreage by the year 2025 at 3.5 AF per acre water duty.
(Note: WSU high estimate in projected acreage is 750,000 acres).
[4] Projection based on OFM medium growth in population (Management Zone Only).
[5] Projection based on OFM medium growth in population (All Counties).

FIGURES