RATHDRUM PRAIRIE AQUIFER WATER DEMAND PROJECTIONS

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Executive Summary

Water demand overlying the Rathdrum Prairie Aquifer (the Idaho portion of the Spokane Valley-Rathdrum Prairie Aquifer) was projected for 5-year increments between 2010 and 2060. The projections were made for the Idaho Water Resource Board (IWRB) and the Idaho Department of Water Resources (IDWR) as part of the Idaho Statewide Comprehensive Aquifer Planning and Management Program (CAMP).

Approach

The approach for projecting future water demand consisted of

1. Reviewing historic population growth trends and growth rates;
2. Estimating existing water demand based on community water system data, water right information, USDA crop data, and other information;
3. Reviewing climate projections from the University of Washington Climate Impacts Group relative to the northern Idaho area;
4. Quantifying water conservation potential;
5. Evaluating selected potential water-demand constraints;
6. Projecting future population and employment growth;
7. Projecting future water demand for indoor domestic, municipal, commercial, industrial, and irrigation uses; and
8. Developing "water-demand scenarios" to evaluate possible future water-demand outcomes that take into account various population growth rates, levels of water conservation, and the potential impact of climate variability.

There are two general categories of factors that will shape future water demand: (1) exogenous factors over which local policies have limited influence and (2) local factors over which public policy and private incentives can have substantial influence. Exogenous factors include the strength of the national or global economy and national demographic trends that strongly influence regional population and job growth. Although local governmental policy can have some influence over these factors, the local economy is largely driven by national or global factors. One needs to look only at the recent economic recession to see that some of these national or global factors are difficult to control other local level. Exogenous factors also include potential effects of climate variability, over which local policy-making will have very little direct influence.

In contrast, regional land-use policies, building codes, governmental policies, water delivery pricing, and other local measures can have substantial influence on future water demand. Local and state government, local water purveyors, and area residents have substantial influence over these factors.

Thus, future water-demand scenarios were constructed to reflect the effect of both exogenous (external realm) and local influences (policy realm) on future water use. First, three primary scenarios were developed to reflect three different population growth scenarios: low population growth, medium-level ("baseline") population growth, and high population growth. Then, three sub-scenarios were constructed within each of the population-growth scenarios to reflect various water conservation levels. The three primary population-growth scenarios, each with three water conservation sub-scenarios, result in nine different projections of potential future water demand. Finally, the effects of potential climate variability were illustrated with a scenario representing baseline population growth and moderate water-conservation.

Conclusions

Primary conclusions from this analysis include the following:

1. Water demand by the year 2060 could rise from estimated current withdrawals of approximately 74,000 acre-feet to between 77,000 acre-feet (based on a low population-growth rate of 1.6% per year and aggressive water conservation) and 223,000 acre-feet (based on a higher population growth rate of approximately 3% per year and no water conservation). The Rathdrum Prairie Aquifer area has experienced both of these population-growth rates over multi-year periods in past decades.
2. The most likely 2060 water-demand projection ranges from approximately 101,000 and 163,000 acre-feet, depending on the level of water conservation. This projection is based on a moderate level of population growth (averaging approximately 2.3% per year) over the next 50 years.
3. The *consumptive use* is water lost from the local hydrologic system (i.e., aquifer and Spokane River), mostly through evapotranspiration. The consumptive use is projected to increase from approximately 40,000 acre-feet in 2010 to between 59,000 and 76,000 acre-feet in the year 2060 under moderate population- and employment-growth rates. This range reflects the effects of different water conservation levels.
4. The water use for agricultural irrigation will likely decrease in time as irrigated agricultural land is replaced by more urban and suburban land uses. However, development of new residential and municipal irrigation on land that is currently non-irrigated will likely lead to an overall increase in total irrigation demand.

Population and Employment Projections

5. The Kootenai County population grew from approximately 22,300 people in 1940 to 134,400 people in 2007. Bonner County grew from 15,700 people in 1940 to approximately 41,000 people in 2007.

6. Annual population growth rates in Kootenai County (most of which overlies the Rathdrum Prairie Aquifer) have ranged from 1.6% (between 1980 and 1990) to 5.4% (between 1970 and 1980). The average annual growth rate between 1970 and 2007 was 3.7%.
7. The Rathdrum Prairie Aquifer area population growth is projected to grow from approximately 128,000 people to approximately 400,000 people by the year 2060, reflecting an average growth rate of approximately 2.3% per year. If population growth for the next 50 years is at the same 1.6% annual rate experienced between 1980 and 1990, the 2060 population overlying the aquifer will be approximately 286,000 people. If the population grows at a rate of 3% per year (which is less than the 3.7% annual growth between 1970 and 2007), the 2060 population overlying the Rathdrum Prairie Aquifer will be approximately 581,000 people.
8. Employment over the aquifer area is projected to increase from approximately 53,000 employees in the year 2010 to 183,000 employees in the year 2060. The largest employment sector will likely continue to be wholesale and retail trade.

Existing Water Use

9. Existing water use was estimated with data from 20 community water systems ranging in size from approximately 39 to 46,000 people; these 20 community water systems serve approximately 72% of the total Rathdrum Prairie population. Data from the 20 community water systems were used to extrapolate water use to 70 additional community water systems that serve approximately 19% of the study area population. Estimates of self-supplied domestic water use for the remaining 9% of the population were made based on household domestic use rates estimated from community water system data. Self-supplied industrial water use estimates were based on IDWR water right information. Agricultural water use rates were estimated based on irrigated acreage, USDA crop information, and precipitation-deficit data.
10. Approximately 72,000 acre feet of water were withdrawn annually from the Rathdrum Prairie Aquifer in recent years. Of this, an estimated 34,400 acre-feet were withdrawn by community water systems, 8,800 acre-feet were withdrawn by individual domestic wells, 4,200 acre-feet were withdrawn for self-supplied commercial and industrial uses, and 24,700 acre-feet were used for agricultural irrigation. The estimated aggregate consumptive use (water that is lost from the local hydrologic system) was approximately 38,400 AFA.
11. Approximately 67% of the projected 2010 ground water withdrawals are used for the irrigation of residential, commercial, institutional, and agricultural lands. Other residential uses (14%), commercial, industrial, and institutional uses (14%), and unaccounted water (5%) constitute the balance.

Water Supply Characteristics

12. The Rathdrum Prairie Aquifer, part of the larger Spokane Valley-Rathdrum Prairie Aquifer, consists of unconsolidated sediments that are primarily course-grained sand, gravel, cobbles, and boulders deposited by immense floods.
13. The highly transmissive nature of the Rathdrum Prairie Aquifer means that the impact of water use in one portion of the aquifer will rapidly propagate throughout the entire aquifer.
14. Recharge to the entire Spokane Valley-Rathdrum Prairie Aquifer is approximately 1,000,000 acre feet per year.
15. The existing Rathdrum Prairie Aquifer consumptive water use (consumptive use is a measure of aquifer impact) is approximately 38,000 AFA, or approximately 3.8% of the 1,000,000 acre feet of aggregate Spokane Valley-Rathdrum Prairie Aquifer recharge.
16. It is unlikely that ground water availability in most portions of the Rathdrum Prairie Aquifer will limit future water demand over the next 50 years. A projected consumptive use of approximately 71,000 AFA in the year 2060 (based on medium population and employment growth and medium levels of water conservation) represents only about 7% of the Spokane Valley-Rathdrum Prairie Aquifer recharge (although, recharge rates are not equivalent to water available for use). Given the transmissive nature of the Rathdrum Prairie Aquifer sediments, it is likely that this amount of water could be withdrawn from the aquifer (except for, perhaps, along the basin margins where the aquifer is less thick than in central portions of the Rathdrum Prairie).

Potential Environmental Constraints

17. Aquifer water quality is good in most areas and does not presently pose a constraint on future ground water demand.
18. Future water demand may, however, be limited by the ability to discharge treated municipal effluent.
19. A portion of the Rathdrum Prairie agricultural land will almost certainly be maintained for the land application of treated municipal effluent. Residential or municipal irrigation, to the extent that it occurs on currently non-irrigated land, will contribute to a likely increase in overall irrigation demand.

Climate Variability

20. Annual average temperatures are projected to increase by approximately 3.2°F by 2040 and about 5.3°F by 2080.
21. Evapotranspiration may increase by approximately 6% per degree centigrade over 2010 values. This could lead to potential evapotranspiration increases of

between 12% and 19% by the years 2040 and 2080, respectively. Another study suggests possible potential evapotranspiration increases of 5% to 9% by the year's 2040 and 2080, respectively. Based on these predictions, irrigation demand could increase by 5% to 20% in the next 50 years.

22. For most of the projections in this study, we assumed a 10% increase in future irrigation demand as a result of increased evapotranspiration. However, the effects of a 5% increase and a 20% increase in future irrigation demand were also evaluated for a moderate population-growth and conservation-level, scenario. A 5% increase in irrigation demand would result in an overall water demand that is approximately 3% less than the demand projected based on a 10% increase in irrigation demand. A 20% increase in future irrigation demand would result in an overall aquifer demand that is approximately 6% greater than the demand projected based on a 10% increase in irrigation demand.
23. Annual precipitation may increase by approximately 2.3% by the year 2040, and by approximately 3.8% by the year 2080. The Rathdrum Prairie Aquifer area is expected to become wetter in the fall and winter and dryer in the spring and summer. Additional precipitation, to the extent it occurs in the fall, winter, and spring, will not reduce irrigation demand during summer months.
24. Extreme temperature and precipitation events will likely increase in frequency. Extreme and/or extended drought periods will increase annual irrigation demands.

Water Conservation Potential

25. Aggressive water conservation can help mitigate some of the projected future water use. Aggressive conservation can result in aggregate water demand that is approximately 60% of the non-conservation demand for a given population growth outcome in 2060.
26. Aggressive water conservation could lead to a 52% reduction in per-household domestic water demand by the year 2060 (from 2010 levels).
27. Per-household outdoor residential irrigation use could be reduced by up to approximately 33% from 2010 levels.
28. Commercial and industrial use could likely be reduced by up to approximately 40% over the next 50 years compared to 2010 per-employee use rates.
29. Specific water conservation measures are outlined in the report.
30. Water reuse is a potential method to extend water supply, but does not bear directly on future Rathdrum Prairie water demands or aquifer withdrawals.

Recommendations

1. Develop a comprehensive, consistent system to report, collect, and compile water-use data. Use these data to monitor and report future pumping and consumptive water use.
2. Use spatial data to better define and quantify irrigated areas.
3. Compare future population and employment growth with the population and employment projections made in this study. Modify future water demand projections based on actual population and employment growth numbers.

Acknowledgements

The following companies and individuals contributed to this report:

1. John Church (Idaho Economics) provided historical population data and forecasts of future population, households, and employment growth.
2. Bob Taunton (Taunton consulting) prepared an assessment of the future population patterns and spatial distribution based on interviews with city planning officials, the Kootenai Metropolitan Planning Organization, an environmental representative, a private developer, planning and engineering consultants, and other business interests.
3. AMEC Earth and Environmental (AMEC) collected existing water-use data and prepared sections of this report pertaining to climate variability, water conservation opportunities, and potential water quality and environmental constraints. Individuals contributing to this effort included Chuck Brendecke, Cam Stringer, Adam Johnson, Hanna Sloan, Lee Rozaklis, and Subhrendu Gangopadhyay.
4. SPF Water Engineering, LLC (SPF) prepared estimates of existing water use, developed the water-demand forecasting tool, and projected future water use. Individuals contributing to this effort included Jennifer Sukow, Mike Martin, and Christian Petrich (project manager).
5. The Idaho Department of Water Resources (Helen Harrington, Neeley Miller, and Sandra Thiel) provided general project guidance, study oversight, and report review.
6. Comments from the Rathdrum Prairie CAMP Advisory Committee during discussions on December 18, 2009 and March 5, 2010 help guide some of the assumptions made in the projection of future water demand. Advisory Committee members included Mike Galante, Ron Wilson, Alan Miller, Paul Klatt, Ken Windram, Hal Keever, Kermit Kiebert, Bruce Cyr, Phil Cenera, Michael Neher, Jim Markley, Chris Beck, Todd Tondee, Andy Dunau, Jonathan Mueller, Kevin Lewis, and Al Isaacson.

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1 INTRODUCTION

1.1 Background

The Idaho Statewide Comprehensive Aquifer Planning and Management Program (CAMP) was created to provide the Idaho Water Resource Board (IWRB) and the Idaho Department of Water Resources (IDWR) with information for managing ground and surface water resources into the future. With the CAMP program, IWRB and IDWR seek to avoid future conflicts over water resources, prioritize state investments in water resources, and identify ways of bridging potential gaps between future water needs and available supply[1].

The CAMP program, and the Aquifer Planning and Management Fund that supports the program, were established in 2008 by the Idaho Legislature. Under the CAMP program, water management plans will be developed for 11 Idaho basins in the coming years. A basin plan has been completed for the Eastern Snake Plain Aquifer; basin plans for the Rathdrum Prairie Aquifer and the Treasure Valley aquifer system were initiated in 2009.

Projecting future water demand is an integral part of the Rathdrum Prairie CAMP process. The sufficiency of existing water resources cannot be determined without understanding the potential magnitude of future water demand.

This report provides projections of Rathdrum Prairie water demand over the next 50 years. The water-demand study was conducted for (and funded by) the IWRB as part of the Rathdrum Prairie CAMP process. The study was conducted by SPF Water Engineering, LLC (SPF), AMEC Earth and Environmental (AMEC), Idaho Economics (John Church), and Taunton Consulting (Taunton), with guidance from the IWRB, IDWR, and the Rathdrum Prairie CAMP Advisory Committee.

1.2 Purpose and Objectives

The purpose of this study was to provide information needed for the development of Rathdrum Prairie water-resource management plans. The general objective was to project water demand over the next 50 years. Specific objectives included the following:

1. Develop a conceptual framework and methodology for projecting future water demand;
2. Project future population and employment growth (upon which water demand is based);

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[1] http://www.idwr.idaho.gov/waterboard/WaterPlanning/CAMP/RP_CAMP/RathdrumCAMP.htm, accessed on February 24, 2010

3. Estimate current domestic, commercial, municipal, and industrial (DCMI) and agricultural water use;
4. Describe general water supply characteristics and potential constraints that will influence future water demand patterns;
5. Qualitatively assess the potential effects of conservation and water re-use on future water demands;
6. Develop water demand projections for DCMI and agricultural uses based on current water-use patterns, describe general water-supply characteristics and constraints, and describe potential effects of climate change, conservation, and reuse;
7. Project future water demand in 10-year increments through the year 2060;
8. Prepare water-demand data sets and a forecasting tool (i.e., spreadsheet) for use by IDWR and the IWRB to refine projections as new information becomes available;
9. Prepare a final written report summarizing methodology, water demand projections, and a discussion of factors influencing future water demand; and
10. Present findings to the IWRB, IDWR, Legislature, and Advisory Committee.

1.3 Report Organization

This report presents water-demand projections (and supporting information) for the Rathdrum Prairie Aquifer. The report is organized into the following sections:

Section 1: Introduction

Section 2: Description of study area

Section 3: Approach and methodology

Section 4: Population growth and distribution projections

Section 5: Estimate of existing Rathdrum Prairie water use

Section 6: Water supply characteristics and potential environmental constraints

Section 7: Assessment of water conservation and re-use potential

Section 8: Water demand projections

Section 9: Conclusions and recommendations.

2 DESCRIPTION OF STUDY AREA

2.1 General Description

The Rathdrum Prairie Aquifer area overlies the Idaho portion of the Spokane Valley-Rathdrum Prairie Aquifer (Figure 1). The Idaho portion of the Spokane Valley-Rathdrum Prairie Aquifer (referred to hereinafter for the purposes of this report as the Rathdrum Prairie Aquifer) is present under a large portion of Kootenai County and a relatively small portion of Bonner County. The general aquifer area ranges in elevation from about 2,400 feet in the northern Rathdrum Prairie Aquifer area to about 2,000 feet near State Line, Idaho. The topography ranges from relatively flat farm land to rolling hills with forest cover. In Bonner County the landform becomes more rugged. Most land within the Rathdrum Prairie Aquifer study area is privately owned.

Urban development is concentrated in the southern portion of the aquifer area along Interstate 90 and Highway 95 and includes most of the cities in Kootenai County. The largest cities in the Rathdrum Prairie are Post Falls, Coeur d'Alene, Hayden and Rathdrum (Figure 2). The area between these cities is relatively undeveloped and is characterized by agricultural land and isolated industrial uses.

The primary transportation corridors are Interstate 90 and Highway 95, with secondary corridors being Highways 41, 53 and 54. Several primary rail lines operated by Union Pacific and Burlington Northern traverse the Prairie. The Coeur d'Alene airport is located adjacent to the City of Hayden.

North of Hayden, the land use consists largely of low-density rural residential development, with the exception of the small communities of Spirit Lake, Bayview, and Athol. Several industrial sites and the Silverwood Theme Park are located adjacent to Highway 95.

2.2 Water Use

Water is pumped from the Rathdrum Prairie Aquifer for municipal, commercial, industrial, institutional, and agricultural uses. Community water systems supply most of the potable water, although a substantial amount of water is also self-supplied (e.g., individual wells supply water for rural homes). Municipal water systems in urban areas supply water for irrigation in residential areas. Much of the water serving commercial, institutional, and industrial users is also supplied by municipal water systems, although several large users pump water authorized under individual water rights. Water is drawn from the aquifer to irrigate agricultural crops – consisting primarily of hay, grass seed, and grain crops.

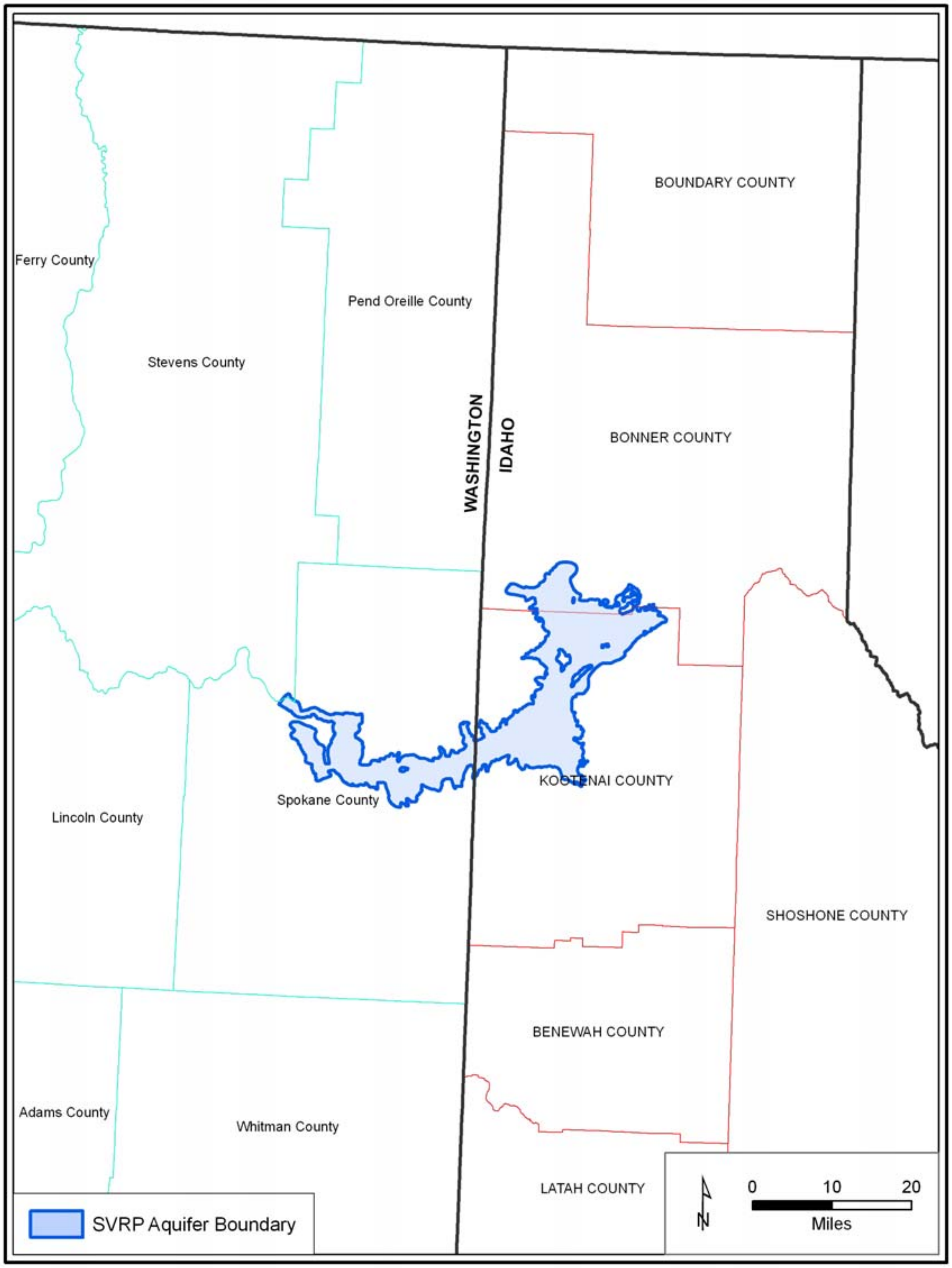

Figure 1. Spokane Valley-Rathdrum Prairie Aquifer.

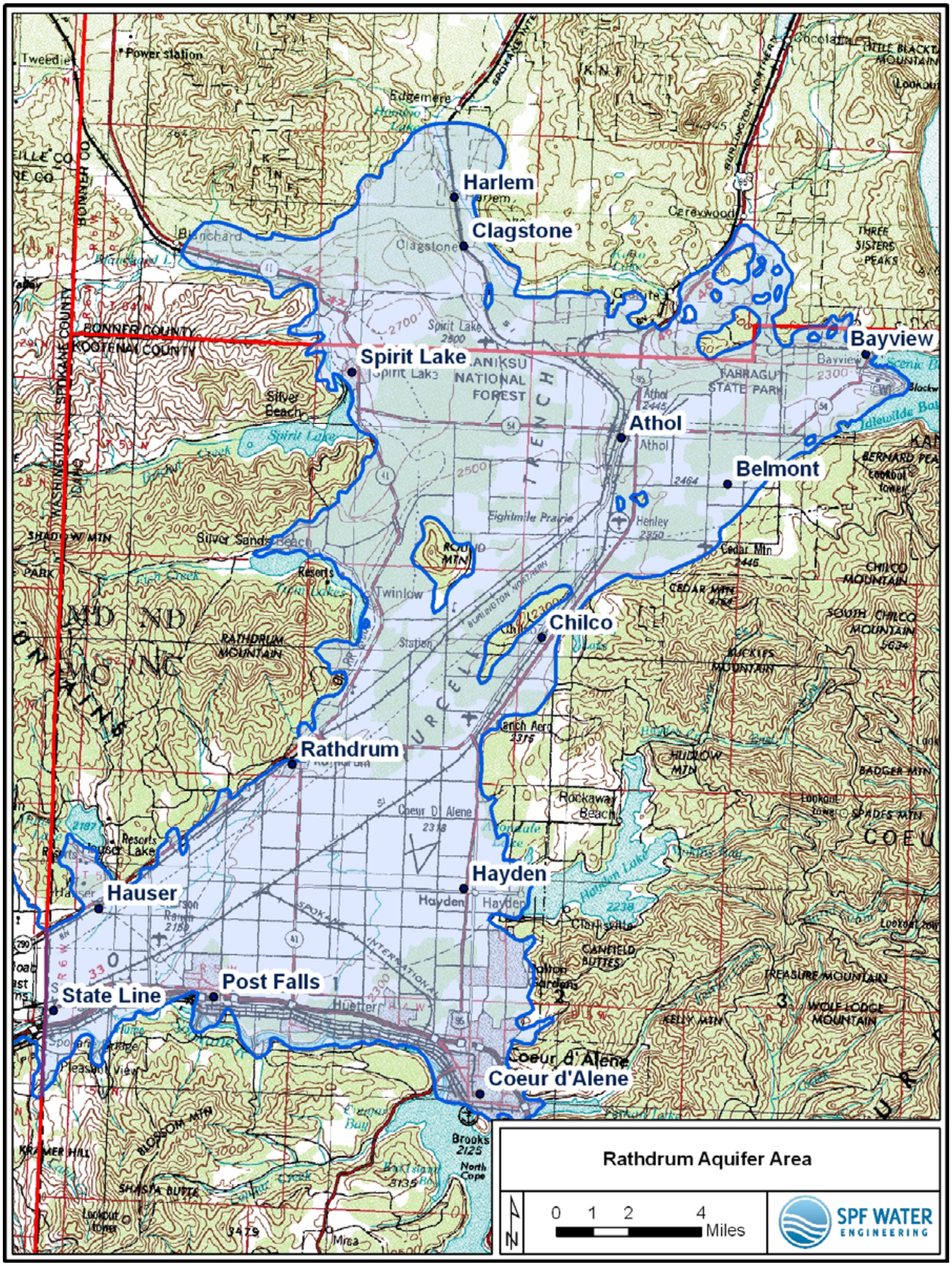

Figure 2. Rathdrum Prairie Aquifer area.

3 APPROACH AND METHODOLOGY

This section outlines the approach and methodology used to project future water use in the Rathdrum Prairie Aquifer area.

3.1 Overview

Our approach for projecting water demand consisted of the following steps:

1. Review historical population growth rates;
2. Estimate current water demand (by sector);
3. Project future population and employment growth;
4. Evaluate the potential impacts of climate variability, water conservation, and potential regulatory constraints on future water demand.
5. Project future domestic, commercial/industrial, and irrigation water demand based on estimates of future population and employment growth and based on existing water use patterns;
6. Adjust the projected future demand based on possible climate variability and water conservation potential; and
7. Develop "scenarios" to describe possible future water-use outcomes.

The methodology for developing water demand projections is summarized in Sections 3.2, 3.3, and 3.4. More detailed descriptions of methodology are provided in subsequent sections.

3.2 Project Future Population, Number of Households, and Employment

Projecting future water use requires forecasts of future population growth, growth in the number of future households, and future employment growth, all of which will influence future water use. A hybrid approach was used to project population and employment growth (Section 4):

1. The Idaho Economic Forecasting Model (developed by John Church, Idaho Economics) was used to forecast population, number of households, and employment to the year 2035. The same model has been used by Mr. Church to make economic projections for all Idaho counties. The model uses national economic components to forecast local economic employment, which, in part, drives local population and household numbers.
2. The national economic projections used in the Idaho Economic Forecasting Model are not available beyond 2035. Thus, the Idaho Economic Forecasting Model was used to project population, households, and employment to the year 2035. A semi-logarithmic

extrapolation (using a combination of actual historic data and projections made with the Idaho Economic Forecasting Model for the years 2009 through 2035) was used to extend the forecasts to the year 2060.

3.3 Estimate Current Water Use

Estimates of current water use (Section 5) formed the foundation for projecting future water use. Current domestic, commercial, industrial, and municipal (DCMI) water use was estimated with data collected from primary municipal providers and other public water systems. Per-employee water use statistics and forecasts of employment by sector were used to project water use for commercial, industrial, and institutional users. Diversion rates and annual volumes authorized under existing water rights were used to estimate water use for large, self-supplied users. Current irrigation use was estimated based on agricultural crop acreage data and precipitation deficit data[2].

3.4 Project Future Water Use

Future water use (Section 8) was projected for three different population-growth scenarios. The three scenarios are based on low, medium, and high population growth projections. Within each of these three scenarios, future water use was projected for three different levels of water conservation (for a total of the nine future water demand scenarios). Future water demand was projected for residential; commercial, industrial, and institutional; and agricultural irrigation uses within each of the nine scenarios.

These scenarios reflect factors over which local policies have (1) minimal influence and (2) substantial influence. Factors over which local policies have minimal influence include national economic trends (that drive local population and employment growth) and climate variability (Section 6.4). Factors over which local policies could have substantial influence include conservation levels, irrigation efficiency, and conservation implementation rates (Section 7).

There is substantial uncertainty in many of the factors influencing future water demand. Nonetheless, the water-demand scenarios illustrate potential outcomes of various external factors and local policy choices. This information lays the foundation for local and regional water-supply planning.

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[2] *Precipitation deficit* is the difference between potential evapotranspiration and the combined amount of precipitation infiltration and water residing in the zone. In essence, precipitation deficit is the net irrigation water requirement. Monthly precipitation deficit data are compiled by the University of Idaho (http://www.kimberly.uidaho.edu/ETIdaho/) for various crop types and based on data collected at various Idaho weather stations.

4 Population Projections and Growth Distribution

4.1 Introduction

A major factor influencing future water use in the Rathdrum Prairie is regional population growth. Despite recent decreases in the population growth rate as a result of a national economic slowdown, we anticipate continued regional population growth because of significant regional attractors:

- Recreational and scenic resources, particularly water, that sets this area apart from many others in the west;
- An attractive resort community in Coeur d'Alene that is the cultural center of the region;
- Regional educational and medical facilities;
- An economy that has successfully transitioned from resource based to diversified services;
- A convenient regional airport is within an hour's drive (in Spokane) and a local commercial airport is near Hayden;
- An adequate supply of developable land; and
- A diversity of residential lifestyle choices.

The following sections (Section 4.2 and 4.3) provide a review of historic population growth, which forms the basis for Rathdrum Prairie population growth projections. Section 4.4 presents a more detailed description of population forecasting methodology, followed by Rathdrum Prairie population projections for the period from 2010 to 2060 (Section 4.5).

4.2 Kootenai and Bonner County Historic Population Trends

The Kootenai County population grew from approximately 22,300 people in 1940 to 134,400[3] in 2007 (Table 1 and Figure 3). Population growth in Kootenai County has substantially exceeded the national population growth rate since the 1970s. Between 1990 and 2000 the total population in the nation increased by 13 percent; the Kootenai County population increased by nearly 56 percent (four times the national growth rate). Kootenai County was the third fastest growing county in Idaho between mid-year 1990 and mid-year 2000 according to the U.S. Census Bureau's estimates. In Idaho, only the populations of Boise and Teton Counties grew at a faster rate (86.9

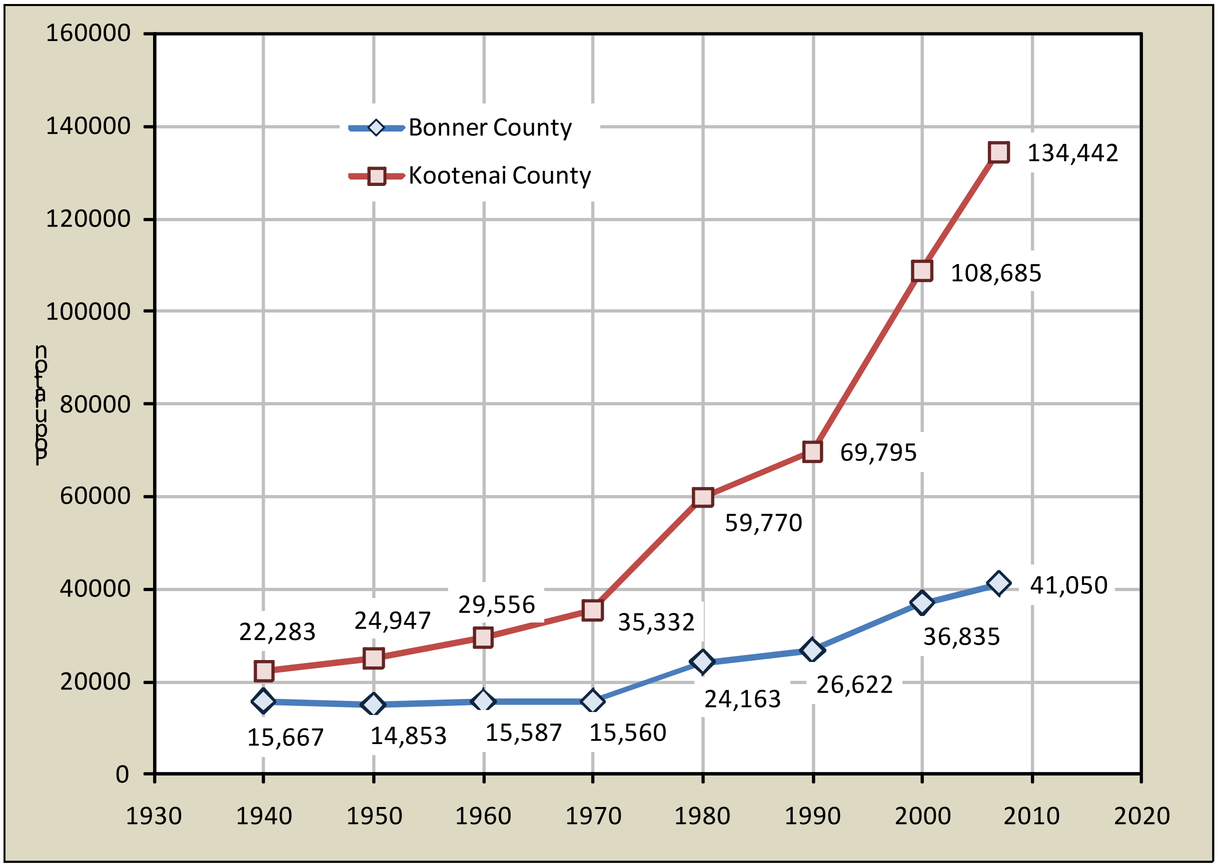
[3] 1940-2000 growth numbers based on U.S. Census annual estimates; 2001-2007 data based on mid-year estimates.

percent and 73.5 percent, respectively) than Kootenai County. By comparison, Ada and Canyon counties were the fourth and fifth fastest growing counties in Idaho (with population gains of 44.9 percent and 45.0 percent, respectively) over the 1990 to 2000 period.

County / City	1940	1950	1960	1970	1980	1990	2000	2007
Bonner County	15,667	14,853	15,587	15,560	24,163	26,622	36,835	41,050
Clark Fork	430	387	452	367	449	448	530	578
Dover					190	294	342	517
East Hope	115	149	154	175	258	215	200	218
Hope	116	111	96	63	106	99	79	86
Kootenai	214	199	180	168	280	327	441	474
Oldtown		358	211	161	257	151	190	207
Ponderay		248	231	275	399	449	638	697
Priest River	1,056	1,592	1,749	1,493	1,639	1,560	1,754	1,909
Sandpoint	4,356	4,265	4,355	4,144	4,460	5,561	6,835	8,216
Balance of Bonner County	9,380	7,544	8,159	8,714	16,125	17,518	25,826	28,148
Kootenai County	22,283	24,947	29,556	35,332	59,770	69,795	108,685	134,442
Athol**	120	226	214	190	312	346	676	688
Coeur d' Alene**	10,049	12,198	14,291	16,228	19,913	24,561	34,514	42,267
Dalton Gardens**			1,083	1,559	1,795	1,951	2,278	2,385
Fernan Lake**			134	179	178	170	186	184
Harrison	362	322	249	249	260	226	267	289
Hauser**		70	127	349	305	380	668	797
Hayden**			901	1,285	2,586	3,744	9,159	12,640
Hayden Lake**		39	247	260	273	338	494	560
Huetter**		84	114	49	65	82	96	97
Post Falls**	843	1,069	1,983	2,371	5,736	7,349	17,247	25,358
Rathdrum**	511	610	710	741	1,369	2,000	4,816	6,613
Spirit Lake**	1,006	823	693	622	834	790	1,376	1,701
State Line**		52	33	22	26	26	28	28
Worley	241	233	241	235	206	182	223	218
Balance of Kootenai County	9,151	9,221	8,536	10,993	25,912	26,506	36,657	40,617

Source: U.S. Census Bureau (www.census.gov).
* Based on mid year estimates.
** Communities overlying Rathdrum Prairie Aquifer.

Table 1. Historic population in Bonner and Kootenai Counties, 1940-2007.



Source: US Census Bureau data

Figure 3. Historical Kootenai and Bonner County population.

Bonner County grew from about 15,700 people in 1940 to about 36,800 in 2000. In the mid-year 1990 to mid-year 2000 period, the county grew by three times that of the national population rate, for a gain of 38.4 percent (Table 2). Over the mid-year 1990 to mid-year 2000 period Kootenai and Bonner counties accounted for 17.5 percent of the State's total population growth.

Population growth depends on changes in three factors; births, deaths, and migration. The difference between births and deaths is the natural increase in population. The natural increase in population has remained fairly steady in Kootenai and Bonner counties in recent years; net in-migration has accounted for most of the population increases in Kootenai and Bonner Counties since 2000.

The Kootenai County population grew at an annual average rate of 3.0 percent per year over the 1980 to 2007 period (Table 3 on page 12). Population in Bonner County increased at an annual average pace of 2.0 percent over the same 27 year period. The 1990s was a decade of particularly strong population growth in Kootenai and Bonner counties when population increased at annual average rates of 4.5 and 3.3 percent per year, respectively. Kootenai and Bonner counties experienced the slowest population growth in the 1980s, when population in the two counties increased at annual average rates of 1.6 percent and 1.0 percent, respectively.

County / City	1970-1980	1980-1990	1990-2000	1970-2007	1980-2007	1990-2007	2000-2007
Bonner County	55%	10%	38%	164%	70%	54%	11%
Clark Fork	22%	0%	18%	57%	29%	29%	9%
Dover		55%	16%		172%	76%	51%
East Hope	47%	-17%	-7%	25%	-16%	1%	9%
Hope	68%	-7%	-20%	37%	-19%	-13%	9%
Kootenai	67%	17%	35%	182%	69%	45%	7%
Oldtown	60%	-41%	26%	29%	-19%	37%	9%
Ponderay	45%	13%	42%	153%	75%	55%	9%
Priest River	10%	-5%	12%	28%	16%	22%	9%
Sandpoint	8%	25%	23%	98%	84%	48%	20%
Balance of Bonner County	85%	9%	47%	223%	75%	61%	9%
Kootenai County	69%	17%	56%	281%	125%	93%	24%
Athol**	64%	11%	95%	262%	121%	99%	2%
Coeur d' Alene**	23%	23%	41%	160%	112%	72%	22%
Dalton Gardens**	15%	9%	17%	53%	33%	22%	5%
Fernan Lake**	-1%	-4%	9%	3%	3%	8%	-1%
Harrison	4%	-13%	18%	16%	11%	28%	8%
Hauser**	-13%	25%	76%	128%	161%	110%	19%
Hayden**	101%	45%	145%	884%	389%	238%	38%
Hayden Lake**	5%	24%	46%	115%	105%	66%	13%
Huetter**	33%	26%	17%	98%	49%	18%	1%
Post Falls**	142%	28%	135%	970%	342%	245%	47%
Rathdrum**	85%	46%	141%	792%	383%	231%	37%
Spirit Lake**	34%	-5%	74%	173%	104%	115%	24%
State Line**	18%	0%	8%	27%	8%	8%	0%
Worley	-12%	-12%	23%	-7%	6%	20%	-2%
Balance of Kootenai County	136%	2%	38%	269%	57%	53%	11%

Source: U.S. Census Bureau (www.census.gov).
* Based on mid year estimates.
** Communities overlying Rathdrum Prairie Aquifer.

Table 2. Historical percentage changes in population.

County / City	1970-1980	1980-1990	1990-2000	2000-2007	1970-2007	1980-2007	1990-2007	2000-2007
Bonner County	4.5%	1.0%	3.3%	1.6%	2.7%	2.0%	2.6%	1.6%
Clark Fork	2.0%	0.0%	1.7%	1.2%	1.2%	0.9%	1.5%	1.2%
Dover		4.5%	1.5%	6.1%		3.8%	3.4%	6.1%
East Hope	4.0%	-1.8%	-0.7%	1.2%	0.6%	-0.6%	0.1%	1.2%
Hope	5.3%	-0.7%	-2.2%	1.2%	0.8%	-0.8%	-0.8%	1.2%
Kootenai	5.2%	1.6%	3.0%	1.0%	2.8%	2.0%	2.2%	1.0%
Oldtown	4.8%	-5.2%	2.3%	1.2%	0.7%	-0.8%	1.9%	1.2%
Ponderay	3.8%	1.2%	3.6%	1.3%	2.5%	2.1%	2.6%	1.3%
Priest River	0.9%	-0.5%	1.2%	1.2%	0.7%	0.6%	1.2%	1.2%
Sandpoint	0.7%	2.2%	2.1%	2.7%	1.9%	2.3%	2.3%	2.7%
Balance of Bonner County	6.3%	0.8%	4.0%	1.2%	3.2%	2.1%	2.8%	1.2%
Kootenai County	5.4%	1.6%	4.5%	3.1%	3.7%	3.0%	3.9%	3.1%
Athol**	5.1%	1.0%	6.9%	0.3%	3.5%	3.0%	4.1%	0.3%
Coeur d' Alene**	2.1%	2.1%	3.5%	2.9%	2.6%	2.8%	3.2%	2.9%
Dalton Gardens**	1.4%	0.8%	1.6%	0.7%	1.2%	1.1%	1.2%	0.7%
Fernan Lake**	-0.1%	-0.5%	0.9%	-0.2%	0.1%	0.1%	0.5%	-0.2%
Harrison	0.4%	-1.4%	1.7%	1.1%	0.4%	0.4%	1.5%	1.1%
Hauser**	-1.3%	2.2%	5.8%	2.6%	2.3%	3.6%	4.5%	2.6%
Hayden**	7.2%	3.8%	9.4%	4.7%	6.4%	6.1%	7.4%	4.7%
Hayden Lake**	0.5%	2.2%	3.9%	1.8%	2.1%	2.7%	3.0%	1.8%
Huetter**	2.9%	2.4%	1.6%	0.1%	1.9%	1.5%	1.0%	0.1%
Post Falls**	9.2%	2.5%	8.9%	5.7%	6.6%	5.7%	7.6%	5.7%
Rathdrum**	6.3%	3.9%	9.2%	4.6%	6.1%	6.0%	7.3%	4.6%
Spirit Lake**	3.0%	-0.5%	5.7%	3.1%	2.8%	2.7%	4.6%	3.1%
State Line**	1.7%	0.0%	0.7%	0.0%	0.7%	0.3%	0.4%	0.0%
Worley	-1.3%	-1.2%	2.1%	-0.3%	-0.2%	0.2%	1.1%	-0.3%
Balance of Kootenai County	9.0%	0.2%	3.3%	1.5%	3.6%	1.7%	2.5%	1.5%

Source: U.S. Census Bureau (www.census.gov).
* Based on mid year estimates.
** Communities overlying Rathdrum Prairie Aquifer.

Table 3. Average annual percentage change in population.

The share of Kootenai County's population residing in unincorporated areas of the county increased from 28.9 percent in 1960 to 33.7 percent in 2000 (Table 4). The population residing in unincorporated areas of Bonner County has increased from a 52.3 percent share in 1960 to a 70.1 percent share at the 2000 Census. Kootenai County's largest city (Coeur d'Alene) has seen its share of the total population in the county decrease from a 48.4 percent share in 1960 to a 31.8 percent share in 2000.

However, the Kootenai County cities of Hayden, Post Falls, and Rathdrum have seen their share of the County's population more than double over the 40 year period from 1960 to 2000.

County / City	1940	1950	1960	1970	1980	1990	2000
Bonner County	15,667	14,853	15,587	15,560	24,163	26,622	36,835
Clark Fork	2.7%	2.6%	2.9%	2.4%	1.9%	1.7%	1.4%
Dover					0.8%	1.1%	0.9%
East Hope	0.7%	1.0%	1.0%	1.1%	1.1%	0.8%	0.5%
Hope	0.7%	0.7%	0.6%	0.4%	0.4%	0.4%	0.2%
Kootenai	1.4%	1.3%	1.2%	1.1%	1.2%	1.2%	1.2%
Oldtown	0.0%	2.4%	1.4%	1.0%	1.1%	0.6%	0.5%
Ponderay	0.0%	1.7%	1.5%	1.8%	1.7%	1.7%	1.7%
Priest River	6.7%	10.7%	11.2%	9.6%	6.8%	5.9%	4.8%
Sandpoint	27.8%	28.7%	27.9%	26.6%	18.5%	20.9%	18.6%
Balance of Bonner County	59.9%	50.8%	52.3%	56.0%	66.7%	65.8%	70.1%
Kootenai County	22,283	24,947	29,556	35,332	59,770	69,795	108,685
Athol**	0.5%	0.9%	0.7%	0.5%	0.5%	0.5%	0.6%
Coeur d' Alene**	45.1%	48.9%	48.4%	45.9%	33.3%	35.2%	31.8%
Dalton Gardens**			3.7%	4.4%	3.0%	2.8%	2.1%
Fernan Lake**			0.5%	0.5%	0.3%	0.2%	0.2%
Harrison	1.6%	1.3%	0.8%	0.7%	0.4%	0.3%	0.2%
Hauser**		0.3%	0.4%	1.0%	0.5%	0.5%	0.6%
Hayden**			3.0%	3.6%	4.3%	5.4%	8.4%
Hayden Lake**		0.2%	0.8%	0.7%	0.5%	0.5%	0.5%
Huetter**		0.3%	0.4%	0.1%	0.1%	0.1%	0.1%
Post Falls**	3.8%	4.3%	6.7%	6.7%	9.6%	10.5%	15.9%
Rathdrum**	2.3%	2.4%	2.4%	2.1%	2.3%	2.9%	4.4%
Spirit Lake**	4.5%	3.3%	2.3%	1.8%	1.4%	1.1%	1.3%
State Line**	0.0%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%
Worley	1.1%	0.9%	0.8%	0.7%	0.3%	0.3%	0.2%
Balance of Kootenai County	41.1%	37.0%	28.9%	31.1%	43.4%	38.0%	33.7%

Source: U.S. Census Bureau (www.census.gov).
* Based on mid year estimates.
** Communities overlying Rathdrum Prairie Aquifer.

Table 4. City populations as a percent of county population.

The City of Coeur d'Alene (and Kootenai County) is a resort area and experiences a significant influx of population during the summer season. It was estimated from the

2000 Census data that Kootenai County had about 3000 housing units (or about 6.4% of the total housing units) being used on a seasonal basis. However, it was estimated that only approximately 2.1% of housing stock used on a seasonal basis overlies the aquifer area; the balance is within the county but outside of the aquifer area.

4.3 Identifying Existing Population Relying on Rathdrum Prairie Aquifer

The Rathdrum Prairie Aquifer provides water for a majority of Kootenai County residents and a relatively small number of Bonner County residents. The population overlying the aquifer includes residents of 12 Kootenai County cities (71,538 people – see Table 4) and portions of the rural population of Bonner and Kootenai County.

Because the Rathdrum Prairie Aquifer study area does not coincide with county boundaries, the current rural population served by the Rathdrum Prairie Aquifer was determined by estimating the rural population of Bonner and Kootenai counties residing over the aquifer using 2000 census data by (1) zip code and (2) census tract and block groups.

4.3.1 Zip Code Analysis

Zip codes generally overlying the aquifer study area are shown in Table 5 and Figure 4. For each zip code, the rural portion of the population residing within the zip code was calculated by deducting the 2000 Census population residing in cities located within the zip code (Table 5). The rural population of zip codes 83814 and 83815, which include Coeur d'Alene, Dalton Gardens, and Fernan Lake, was assumed to be located outside of the aquifer study area. The rural population overlying the study area estimated using zip codes is approximately 27,700 people.

4.3.2 Census Tract and Block Group Analysis

The portion of the rural population of Bonner County located within the study area was estimated from census data available by census tract and block group. Two Bonner County census block groups are mostly overlying the Rathdrum Prairie Aquifer (Figure 5). The 2000 Census population for Census Tract 9507 Block Group 3 and Census Tract 9508 Block Group 3 was 3,099, about 8.4% of the total population of Bonner County at the 2000 Census benchmark. Based on aerial photography, it appears that most, but not all, of the population of these two census tract block groups is located within the aquifer study area. A population of 3,000 was assumed to be a reasonable approximation of the rural Bonner County population located within the aquifer study area.

Zip Code	Cities in Zip Code	2000 Zip Code Population	2000 City Population	2000 Rural Population in Zip Code	2000 Rural Population in Study Area
83801	Athol	4,967	676	4,291	4,291
83803	Bayview (unincorporated)	296	0	296	296
83804	Blanchard (unincorporated)	1,037	0	1,037	1,037
83814	Coeur d' Alene	22,432	34,514	7,733	0
	Fernan Lake		186		
83815	Coeur d' Alene	22,279	34,514		
	Dalton Gardens		2,278		
83835	Hayden	14,776	9,159	5,123	5,123
	Hayden Lake		494		
83854	Hauser	27,385	668	9,346	9,346
	Huetter		96		
	Post Falls		17,247		
	State Line		28		
83858	Rathdrum	10,210	4,816	5,394	5,394
83869	Spirit Lake	3,637	1,376	2,261	2,261
Total Estimated Rural Population in Study Area					27,748

Table 5. 2000 Census data for zip codes overlying the aquifer study area.

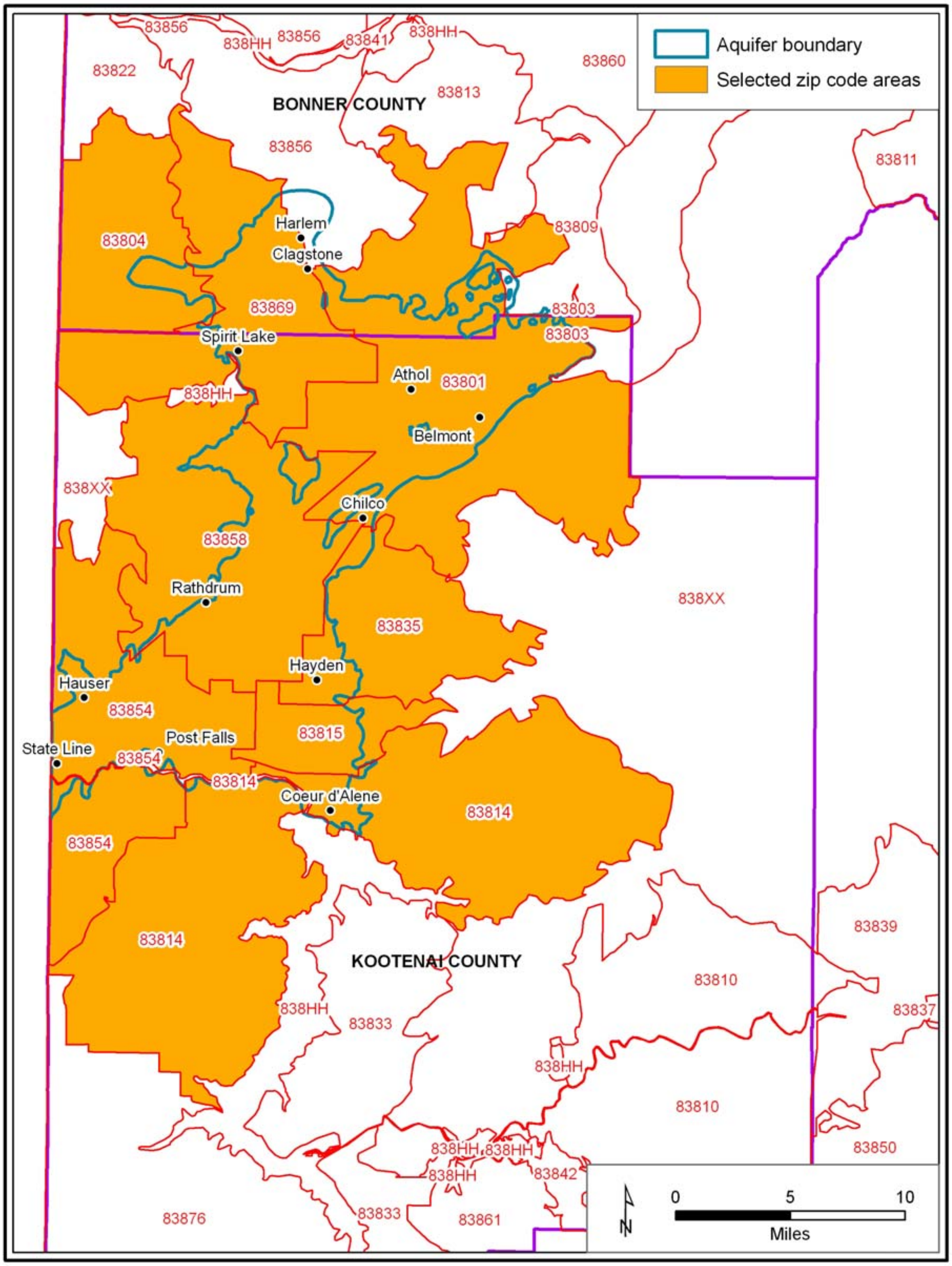


Figure 4. Zip codes overlying aquifer study area.

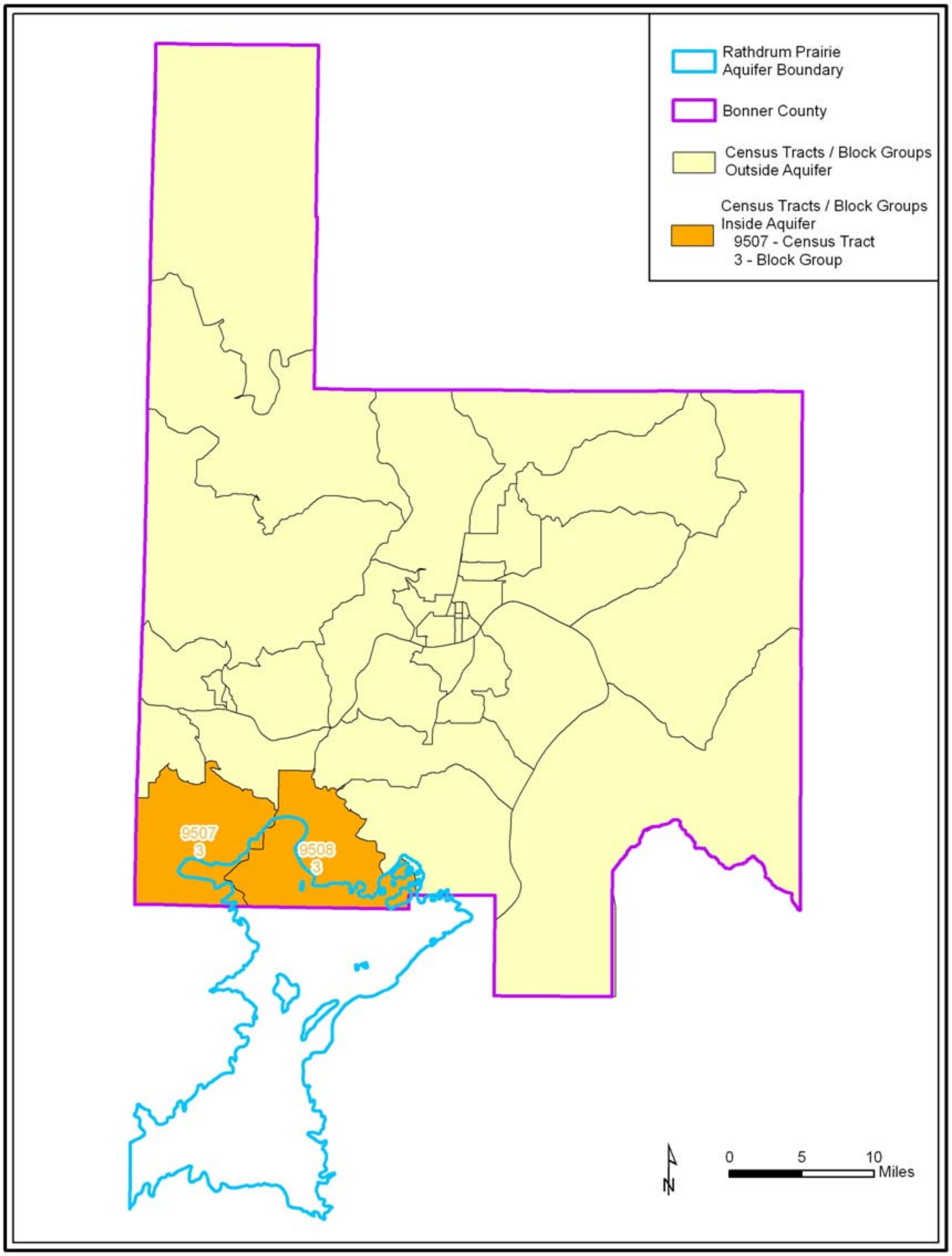


Figure 5. Bonner County census tracts overlying the Rathdrum Prairie Aquifer.

The portion of the rural population of Kootenai County located within the study area was also estimated from census data available by census tract and block group. Because most of the Kootenai County population is located within the aquifer study area, the 2000 Census population outside of the study area was estimated using census tracts and block groups. Census tracts generally not overlying the Rathdrum Prairie Aquifer are located south of the Spokane River and west of Lake Coeur d'Alene (Census Tracts 20 and 21, and Census Tract 4 Block Group 2); east of Lake Coeur d'Alene and eastern Kootenai county east of Hayden Lake Census Tract 19 (Census Tract 18 Block Groups 2 and 3, and Census Tract 17 Block Group 3), and an area of Kootenai County that is generally west of the communities of Hauser and Spirit Lake (Census Tract 3 Block Groups 1 and 4). Census tracts are shown in Figure 6. The 2000 Census population in these areas is shown in Table 6.

Census Tract	Block Group	2000 Census Population
3	1	1,171
3	4	1,863
4	2	1,793
17	3	535
18	2	1,309
18	3	2,669
19		2,857
20		2,841
21		2,086
Total population		17,124
Percentage of Kootenai County population		15.8%
Source: 2000 Census		

Table 6. Kootenai County 2000 census population in areas outside of the Rathdrum Prairie Aquifer.

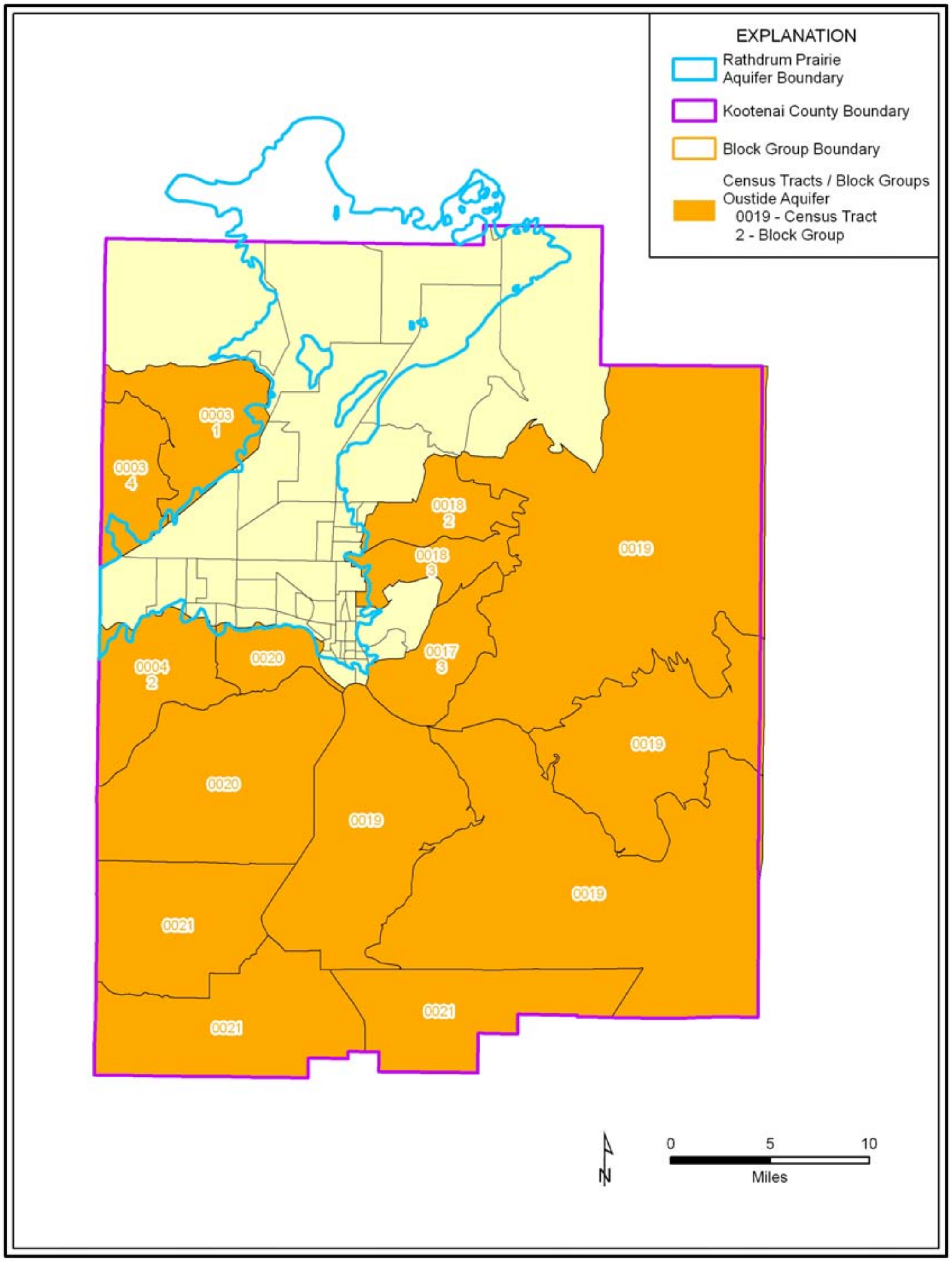


Figure 6. Kootenai County Census tracts generally located outside of aquifer study area.

4.3.3 Summary: Rural Population Overlying Aquifer

Based on the 2000 Census data, 17,124 people in Kootenai County resided in census tracts generally located outside of the boundaries of the Rathdrum Prairie Aquifer. Because of small overlaps with the aquifer study area in populated areas, this number appears to slightly overestimate the population residing outside of the aquifer area.

Comparison with zip code data further suggests that this method slightly overestimates the number of rural residents located outside of the aquifer study area. Based on zip code data and Bonner County census tract data, the estimated rural population of the study area is approximately 27,700 people, of which approximately 3,000 reside in Bonner County and 24,700 reside in Kootenai County. Given a 2000 Census population of 108,685 people in Kootenai County, with 71,538 people residing in cities overlying the aquifer study area, the Kootenai County population outside of aquifer study area was estimated to be approximately 12,500 people.

In summary, the estimated population overlying the aquifer in 2000 was approximately 99,200 people. This represents approximately 88% of the Kootenai County population and 8% of the Bonner County population. It was assumed that these percentages of Kootenai and Bonner County residents overlying the aquifer would continue at the same proportions into the future.

4.4 Population Forecasting Methodology

This section provides information on the methods used in projecting future population growth.

4.4.1 Forecasting Population, Households, and Employment

The Idaho Economic Forecasting Model (Appendix A) was used to forecast future population growth, number of households, and employment through the year 2035. The Idaho Economic Forecasting Model could not be used for forecasting beyond this year because projected national economic data are not available beyond 2035. A semi-logarithmic extrapolation (using a combination of actual historic data and projections made with the Idaho Economic Model for the years 2009 and 2035) was used to extend the forecasts from the year 2035 to 2060.

The Idaho Economic Forecasting Model is a simultaneous-equation model that uses forecasts of national inputs and demands for particular sectors of the Idaho economy having a national or international exposure. For example, the large majority of output from Idaho's electronics firms is not for consumption within Idaho. Rather, these products will be shipped to other areas for consumption and use. For example, production decisions of Idaho's electronics firms often are driven by national product demand. Industries with these characteristics are often called basic industries.

The economic model treats manufacturing, mining, agriculture, and the federal government sectors of the Idaho economy as basic industries. Furthermore, personal income from federal military duty within Idaho is treated as a basic industry, although the jobs are not classified in the state's total employment.

Local-serving industries not having a national profile are referred to as secondary industries. Secondary industries provide products or services only for the local economy. Demand for these products is determined by local economic factors rather than by national economic factors.

The basic industry/secondary industry distinction has blurred in recent years. Idaho's employment in facilities such as the Citibank Credit Facility, Key Bank's consumer loan unit, Direct TV's customer service center, and T-Mobile (all in Boise), would traditionally be classified as local serving, secondary industries. However, Idaho call centers operated by these companies perform a national business activity, very little of which serves local customers. The geographic reach of these call centers extends far beyond Idaho, providing services by interfacing with customers in all parts of U.S. Periodic monitoring of these types of "back-room" facilities and their functions was used to maintain accuracy in the forecast.

The economic model makes a further distinction in attempting to model the factors that affect the location decisions of a firm or industry. Many cost factors are examined when a firm evaluates a location for a plant, such as taxes, energy costs, wages, and labor availability. The model therefore incorporates factors such as wage rates and energy costs that influence these location choices.

4.4.2 Spatial Distribution of Population Growth

This section examines the spatial distribution and density of the projected population growth. Population distribution and density is important because it influences the amount and location of land to be irrigated. For example, residential subdivisions near urban centers with 4 to 5 homes per acre have greater impervious cover (in the form of rooftops, streets, sidewalks, homes, decks, etc.) than rural residential areas. Rural residential areas with 1 home per several acres will have greater amounts of irrigable area and therefore have potential for greater irrigation water use on a per-unit basis.

An evaluation of future spatial population distribution was made based on interviews with city planning officials from Coeur d'Alene, Post Falls, Rathdrum and Hayden; Kootenai County planning staff; Kootenai Metropolitan Planning Organization (KMPO) staff; an environmental representative; a private developer; planning and engineering consultants; and other business interests (see Appendix B) that could provide an historical perspective on the growth patterns and offer a forward-looking view of projected growth. Other sources of information were the comprehensive plans for the various cities on the Rathdrum Prairie and Kootenai County (which is in the final approval stage of a comprehensive plan update); the KMPO 2007-2030 Transportation Plan (currently being completed); and the Rathdrum Prairie Wastewater Master Plan, which was undertaken on behalf of the cities of Hayden, Post Falls, and Rathdrum. These studies provide an insight into future growth patterns in coming decades.

- Existing Cities and Areas of City Impact

  Existing infrastructure (e.g., public water and sewer systems) allows for greater residential density than would otherwise be possible. Infrastructure is present in existing cities. Water and sewer systems will likely extend into Areas of City Impact (ACIs) as cities annex these areas, resulting in denser residential land use than in urban areas.

  Idaho state law allows cities to establish ACIs surrounding their incorporated boundaries with the agreement of the local county. ACIs represent the locations where the cities expect urban growth to occur over a 20 year period through the extension of urban services and annexation. Until annexation, the county continues to be the land-use approving jurisdiction. The cities in the southern portion of the Rathdrum Prairie (Post Falls, Hayden, Rathdrum and Hauser) established ACIs surrounding their cities in the 1990s. In 2004, Kootenai County, Post Falls, Hayden, and Rathdrum entered into a Coordinated Area of City Impact Agreement that established two tiers of land outside each city's boundary.

  The Exclusive Tier reflects the prior ACI. The County committed to apply subdivision and infrastructure standards in this tier identical to that of the adjacent city. These standards include requirements for community water and sewer systems. Beyond the Exclusive Tier, the Agreement established a Shared Tier, which was bounded by the Exclusive Tiers, the Hauser ACI and the Washington State boundary. The Shared Tier is approximately 10,460 acres. The County agreed to not undertake any rezoning of agriculture lands for 5 years in this tier without engaging the affected city.

  The 2004 agreement required the parties to undertake studies related to regional open-space preservation and a wastewater master plan, with the intent that following the studies the parties would enter into negotiations for a long term ACI agreement to supersede the 2004 agreement. In 2008, the cities and the county adopted a resolution ("An Endorsement of Shared Principles and Common Goals for the Rathdrum Prairie") to further their collaborative approach to growth on the Prairie.

- Rathdrum Prairie Wastewater Master Plan

  The need to preserve land for land application of treated municipal wastewater will limit development in some areas. Consequently, new aquifer withdrawals will also be limited in these areas.

  The Rathdrum Prairie Wastewater Master Plan (J-U-B Engineers, 2008) was prepared "to provide technical evaluations, regulatory review, implementation priorities and cost opinions that the cities of Hayden, Post Falls and Rathdrum along with Kootenai County will need to guide long-term wastewater service for the Rathdrum Prairie". A primary driver for the study is the impending revision to water quality standards in the

Spokane River by the state of Washington that would be the most stringent in the country and affect wastewater discharges to the Spokane River in the summer months. The study determined that there is no treatment method capable of treating wastewater to the proposed standard. The recommended solution is treatment of wastewater to the Idaho Department of Environmental Quality (IDEQ) Class A reuse standard for irrigation of crops, trees, parks, schools, golf courses, and open spaces. The Hayden Area Regional Sewer Board currently re-uses wastewater to irrigate crops and poplar trees on 476 acres from June through September and has successfully demonstrated compliance with water quality regulations on the Rathdrum Prairie Aquifer.

The study developed several growth scenarios for the Exclusive Tier and the Shared Tier using equivalent densities of 12 persons per acre and in some key locations 20 persons per acre. Equivalent densities were used rather than attempting to forecast actual land uses over the 11,920 acre study area, which included the Shared Tier area plus 1,460 acres in the Post Falls Exclusive Tier. The study also assumed a 3% growth rate over the build out period. Full build out of all of the study area totaled 339,121 equivalent persons, but when the need to reserve land for reuse was considered, the projected total reduced to 261,576 equivalent persons. With 6,372 acres needed for reuse, only 47% of the Shared Tier would be available for development. The significance of the conclusion is that land application, if adopted by the policy makers, would be a constraint on the spatial pattern of growth, either diverting growth to other locations or increasing the density of residential units on available land.

- <u>KMPO Growth Projections for 2030</u>

Regional transportation plans provide insight into the anticipated spatial distribution and density of population growth. The KMPO, which prepares regional transportation plans for the Kootenai County area, is currently updating the transportation plan and has conducted modeling for population, household growth, and employment growth from 2007 to 2015 and 2030 that is needed to build the travel demand forecast models for the transportation plan. The staff at KMPO worked closely with the local agencies to develop the population forecasts.

Much of the analysis provided by KMPO is by transportation analysis zones (TAZs), which allows for mapping the data on population, households and employment. The TAZ maps provide a comparison of population density and employment density per square mile for the years 2007 and 2030 per square mile. Other mapping shows existing households and employers per acre, and single family and multi-family dwelling units by location.

KMPO mapping (Figure 7) illustrates the existing concentration of population along I-90 and Highway 95 within the city boundaries of Post Falls, Coeur d'Alene, Hayden and Rathdrum. North of Hayden the population and households drop to low densities.

Employment and retail is similarly concentrated in the main transportation corridors and population centers.

The 2030 KMPO population density mapping (Figure 8) shows the anticipated growth in the cities and expansion into their ACIs (Exclusive Tier). Significant population growth is projected at Post Falls and at Hayden, south of the Coeur d'Alene airport along the proposed Huetter Road Corridor, a proposed bypass that would link I-90 to Highway 95 north of Hayden. The 2030 KMPO map also projects rural infill north of Hayden and east of Athol. KMPO also projects employment to continue to grow in the two main transportation corridors as well as in the Post Falls ACI north and south of Interstate 90 and west of Pleasant Valley Road.

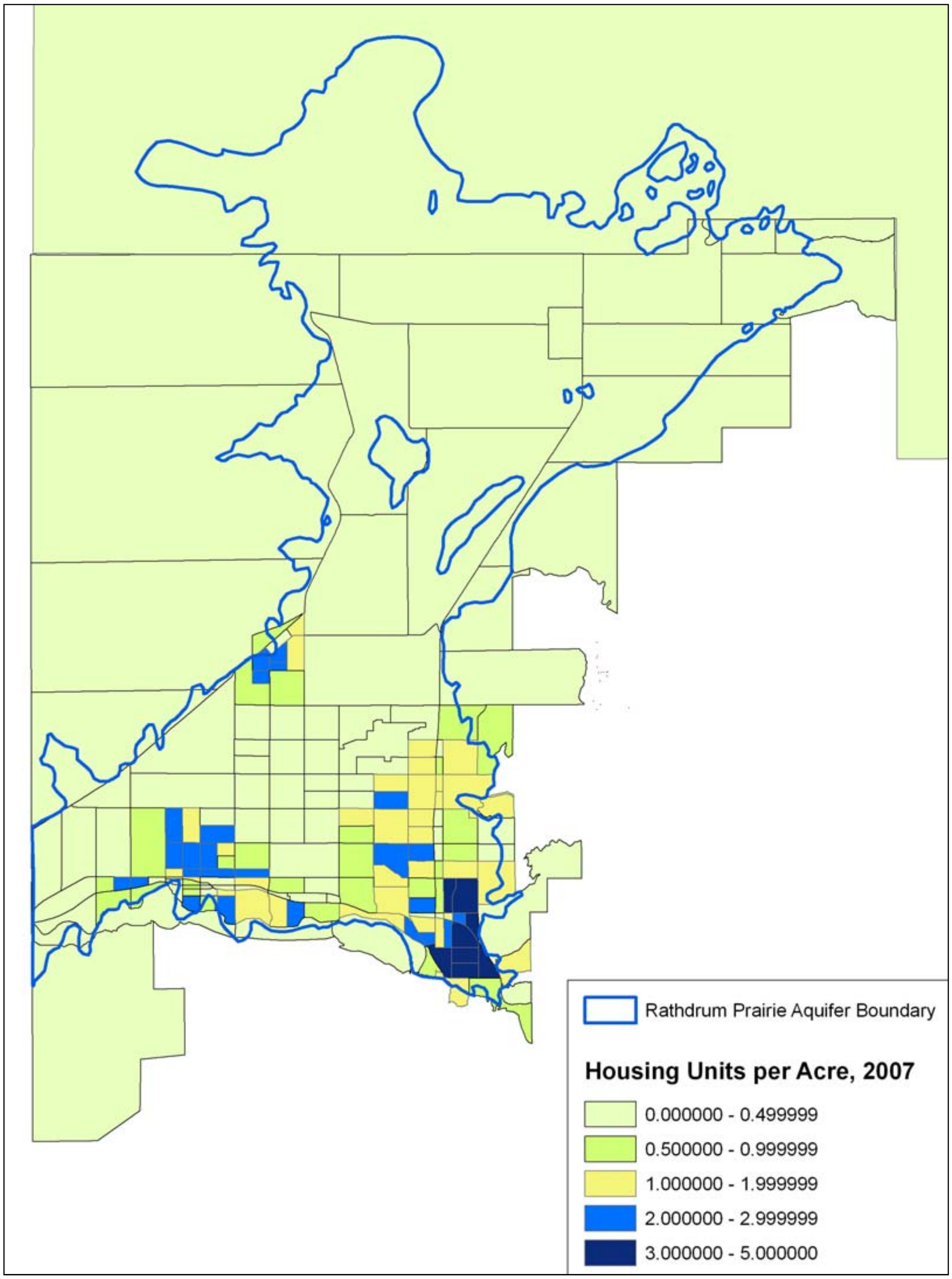
- Kootenai County Comprehensive Plan

The County's comprehensive plan update provides additional insight in the spatial pattern of growth anticipated through 2030. The update of the 1994 Comprehensive Plan began in 2007 and presently is being reviewed chapter by chapter by the Kootenai County Commission. The intent of the plan is to maintain the current 70:30 ratio of rural/urban land uses in the County. The plan envisions directing growth to existing urban places and newly created Rural Dispersed Villages. Bayview on Lake Pend Oreille currently is the only mapped Rural Dispersed Village in the Rathdrum Prairie Aquifer study area.

Planned Communities, a proposed new designation allowing larger self-contained projects, may be located throughout the County. The Planned Community proposal has proven to be controversial with the cities. The size, location, and density of these future planned communities are difficult to predict at this time.

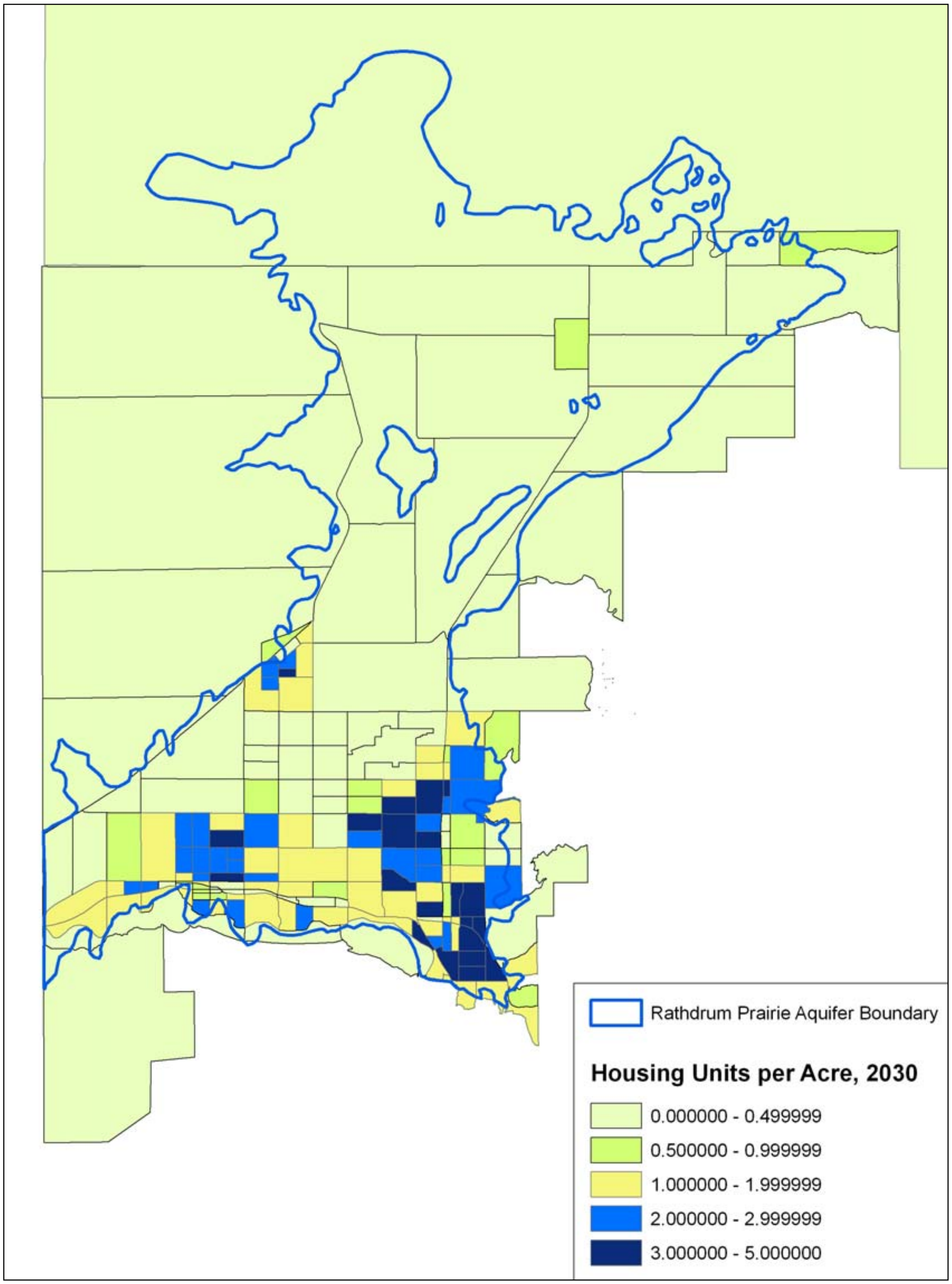
The County's proposed Future Land Use Map reflects the goals and policies of the comprehensive plan. The planners have proposed a number of land use designations that will reflect the opportunities and constraints in the planning area. The map illustrates that urban development will likely be concentrated in the southern portion of the Rathdrum Prairie Aquifer area in the existing cities and ACI's where municipal wastewater treatment is available. Land adjacent to the cities is designated as Urban Reserve to reserve areas for future annexation and urban densities. In the interim Urban Reserve lands have a density of 1 unit/10 acres until such time as annexation and the extension of sewer and water infrastructure have occurred.

North of Hayden and Rathdrum the proposed land use is for larger lot designations. Rural areas will have a density of 1 unit/10-20 acres, and Rural Infill areas will be 1 unit/3-10 acres. Density over the Rathdrum Prairie Aquifer is limited to 1 unit /5 acres minimum without municipal wastewater. Similar designations are located south of the Spokane River, plus an Urban Reserve designation within the Coeur d'Alene ACI west of Highway 95.



Source: KMPO

Figure 7. Housing units per acre, 2007.



Source: KMPO

Figure 8. Housing units per acre, 2030.

- Bonner County Comprehensive Plan

  The Bonner County Projected Land Use Map was adopted in 2005 as part of the comprehensive plan update. The projected land uses are a reflection of resource features in the county. The Rathdrum Prairie Aquifer area extends approximately 10 miles into Bonner County between Highways 41 and 95 and for 1-2 miles east of Highway 95. There are **no** population centers in this part of the county.

  The majority of land is designated as Ag/Forest Land with lot sizes of 10-20 acres. Some lands are designated as Rural Residential with lot sizes of 5-10 acres. Idaho State lands create a checkerboard ownership pattern in the aquifer area.

- Summary of Future Growth Patterns

  The studies undertaken by the cities, Kootenai County, and KMPO provide a guide to the spatial pattern of future growth on the Rathdrum Prairie Aquifer. The county and KMPO mapping are relatively consistent in the future pattern of growth. Over the next 50 years growth will be concentrated in the ACI's of the existing cities south of Highway 53. Planners for the cities of Coeur d'Alene, Hayden, Post Falls and Rathdrum project the focus of development to be the creation of compact, mixed-use communities with average residential densities increasing from 3-4 units/acre to 5-6 units/acre.

  The City of Coeur d'Alene presents a unique situation. With little land available for traditional development within its ACI the city's future growth will shift to infill and redevelopment at higher densities than the other cities. The former mill sites along the Spokane River are envisioned to be a mixed-use neighborhood of housing, commercial and retail services, at a scale and intensity only slightly less than the downtown area. The 160-acre Village at Riverstone, which is under development on a former mill site, is planned for retail, entertainment, hotels, offices, restaurants and residences. Similarly, institutional stakeholders have recently created a concept plan for the Educational Corridor south of the Highway 95 river crossing and west of Northwest Boulevard.

  Part of the Coeur d'Alene ACI includes lands south of the Spokane River and accessed by Highway 95, which offers an opportunity for future development. The City Comprehensive Plan proposes an overall density of one unit/acre with project densities up to 3 units/acre. Similarly, there is an opportunity for lower density development across the Spokane River from Post Falls. Topography and lack of urban infrastructure will limit lot density in this area. Water demand in this area might be supplied from the Rathdrum Prairie Aquifer if included in the City of Coeur d'Alene's municipal service area.

  Highway 53 between the Washington border and Rathdrum, and Highway 41 north of Rathdrum to Spirit Lake, mark the abrupt transition from the relatively flat Prairie landscape to steeper slopes of the Selkirk Mountains. This terrain precludes development except for sparse development with individual water and septic services.

North of Rathdrum and Hayden the land changes from the relatively flat prairie to a rolling forested landscape. Properties generally consist of large rural parcels. Kootenai County compared the settlement pattern for this part of the county from pre-1995 to 2007 and concluded that this area represented the highest rate of building permit activity in the county. The county anticipates further infilling of areas adjacent to Highway 53, and south of Spirit Lake and Athol. Anticipated challenges for development in this area will be the impact of wastewater from individual residences on aquifer water quality, and the cost to develop community level wastewater collection and treatment to meet current and future effluent discharge requirements.

Kootenai County's proposed Planned Community designation, if approved, may encourage the development of a limited number of planned communities in the aquifer area beyond ACI's. Experience from southwest Idaho provides guidance that planned communities, while generally adhering to a very high standard of community development, represent a considerable financial and entitlement risk for developers. The creation of a self-contained community requires significant up-front expenditures for infrastructure and amenities that make financing projects of this scale very difficult. Often, the ability to amortize this investment is subject to negative market cycles. However, given the scenic and recreational amenities of Kootenai County, it is likely that planned communities will be proposed, perhaps as lifestyle, active adult communities catering to primary and second home residents. As it is not the intent of the County to map appropriate locations for planned communities, it is not possible at this time to identify actual locations of future planned communities. However, the ability to assemble large enough acreage in areas where fragmented ownership does not exist would suggest that that Rathdrum Prairie Shared Tier could be a focus.

In summary, although rural infill will continue, the vast majority of residential and employment growth over the Rathdrum Prairie Aquifer will likely occur in established communities and their ACI's because of the availability of municipal services. The development pattern can be expected to follow expected national trends featuring a more compact development form that reflects a diversity of housing options matching forecasted changes in demographics and market preferences.

The precise density distribution for the entire aquifer area is unknown. However, for the purposes of this study, it was assumed based on the information presented about that approximately 70% of the existing housing stock is "high-density" (4 to 5 units per acre)[4], 10% are "medium density" (2 units per acre", and 20% are "low density" (1 unit per one or more acres). It was assumed that new construction over the next 50 years would average about 85% high density, 5% medium density, and 10% low density.

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[4] These values refer to project densities; the overall density with transportation corridors, commercial space, etc. would be less.

The density and general location (within or outside of currently irrigated areas) influence the amount of future water demand. High-density urban areas have less irrigable land than low density rural areas. Rural areas have greater potential for irrigation, although not all rural land is irrigated.

4.5 Population Projections

This section presents population projections from the year 2010 to 2060 in Kootenai and Bonner Counties, followed by a forecast of the future Idaho population using the Rathdrum Prairie Aquifer.

4.5.1 Kootenai County Population Forecast

Our forecast suggests that the population in Kootenai County will reach about 438,000 people in the year 2060 (Table 7). This represents an absolute gain in Kootenai County's population of nearly 296,000 people over the next 50 years and an annual average population growth rate of 2.3 percent per year. Similarly, we project that the number of households will increase from about 57,000 to 181,000 by the year 2060. Non-agricultural employment in Kootenai County is projected to increase to nearly 196,000 in the year 2060, representing an annual average employment increase of about 2.5% per year.

County	Kootenai County			Bonner County		
Year	Population	Households	Nonagricultural Employment	Population	Households	Nonagricultural Employment
2000	109,550	41,370	43,660	37,003	14,750	12,376
2005	128,890	49,052	51,776	39,891	16,303	13,604
2010	142,330	54,551	56,895	42,387	17,751	14,540
2015	158,200	61,067	63,725	45,160	19,403	16,150
2020	179,500	69,787	73,325	49,176	21,240	18,470
2025	202,750	79,398	84,485	53,516	23,200	21,130
2030	227,430	89,712	97,245	58,046	25,377	24,200
2035	255,100	101,367	112,255	62,964	27,762	27,790
2040	285,930	114,458	126,802	69,517	29,283	31,654
2045	319,730	128,944	142,106	76,753	31,761	34,552
2050	356,140	144,707	158,641	84,741	34,416	37,673
2055	395,150	161,773	176,411	93,561	37,147	40,909
2060	438,420	180,857	196,166	103,299	40,095	44,420

Table 7. Kootenai and Bonner County population projections, 2000-2060.

4.5.2 Bonner County Population Forecast

The results of this forecast suggest that the population in Bonner County will reach about 103,000 people in the year 2060 (Table 7). This represents an approximate 1.5% annual average population growth rate over the period 2010 to 2060. The projected number of households in Bonner County is expected to increase at an annual average rate of 1.6% per year to approximately 40,100 in the year 2060. Non-agricultural employment in Bonner County is projected to increase to nearly 44,400 in the year 2060, representing an annual average increase in employment of approximately 2.3% per year.

4.5.3 Rathdrum Prairie Population Forecast

The portion of the Kootenai and Bonner County populations overlying the Rathdrum Prairie Aquifer was estimated using 2000 Census data (see Section 4.3). The projected population of the Bonner County portion of the aquifer study area was assumed to remain at approximately 8% of the county population through 2060. This The Kootenai County population overlying the aquifer was projected to increase slightly from approximately 88% to 90% of the county population due to increased urbanization.

Based on these assumptions, we project that the number of people residing in the aquifer area will likely grow from about 128,500 people in 2010 to between 285,600 and 580,900 people by the year 2060 (Table 8 and Figure 9). The baseline forecast – an increase of approximately 275,000 people over the next 50 years – represents a 214 percent increase over the current population. The projected average annual population increase ranges from approximately 2.1 to 2.6 percent (Table 8). The high forecast represents an average annual population increase of 3 percent; the low forecast represents an average annual population increase of 1.6 percent.

The number of households overlying the Rathdrum Prairie Aquifer is anticipated to increase from approximately 49,400 to between 117,800 to 239,600 (Table 9 and Figure 10). Our base forecast indicates that there will be approximately 166,700 households relying on water from the Rathdrum Prairie Aquifer in the year 2060. The number of residents per household is projected to decrease from approximately 2.6 people per household in 2010 to 2.4 people per household in 2060.

At question is which population growth forecast – low, base, or high – represents the most likely population growth over the next 50 years. The low forecast will be most accurate if population grows at a rate similar to that which occurred in Kootenai County the 1980s. The high forecast will prove to be most accurate if future population growth is at rates at or in excess of the 3% experienced in various Kootenai County cities in the 1970s, 1990s, and between 2000 and 2007 (Table 3). We believe that an average population growth rate of about 2.3%, which is consistent with average long-term historical growth rates, is most likely.

Rathdrum Aquifer Area Population Growth			
	Low Forecast	Base Forecast	High Forecast
2000	99,185	99,185	99,185
2005	114,602	114,602	114,602
2010	127,375	128,544	132,570
2015	137,993	142,881	153,543
2020	149,572	162,127	177,932
2025	162,129	183,164	206,211
2030	175,717	205,523	238,992
2035	190,453	230,615	277,014
2040	206,521	263,259	321,210
2045	223,947	294,299	372,473
2050	242,845	327,752	431,934
2055	263,340	363,616	500,906
2060	285,567	403,391	580,913

Projected/Assumed Annual Population Increase			
	Low Forecast	Base Forecast	High Forecast
2000	0.0%	0.0%	0.0%
2005	3.0%	3.0%	3.0%
2010	2.1%	2.3%	3.0%
2015	1.6%	2.1%	3.0%
2020	1.6%	2.6%	3.0%
2025	1.6%	2.5%	3.0%
2030	1.6%	2.3%	3.0%
2035	1.6%	2.3%	3.0%
2040	1.6%	2.3%	3.0%
2045	1.6%	2.3%	3.0%
2050	1.6%	2.2%	3.0%
2055	1.6%	2.1%	3.0%
2060	1.6%	2.1%	3.0%

Table 8. Rathdrum Prairie population, 2000-2060.

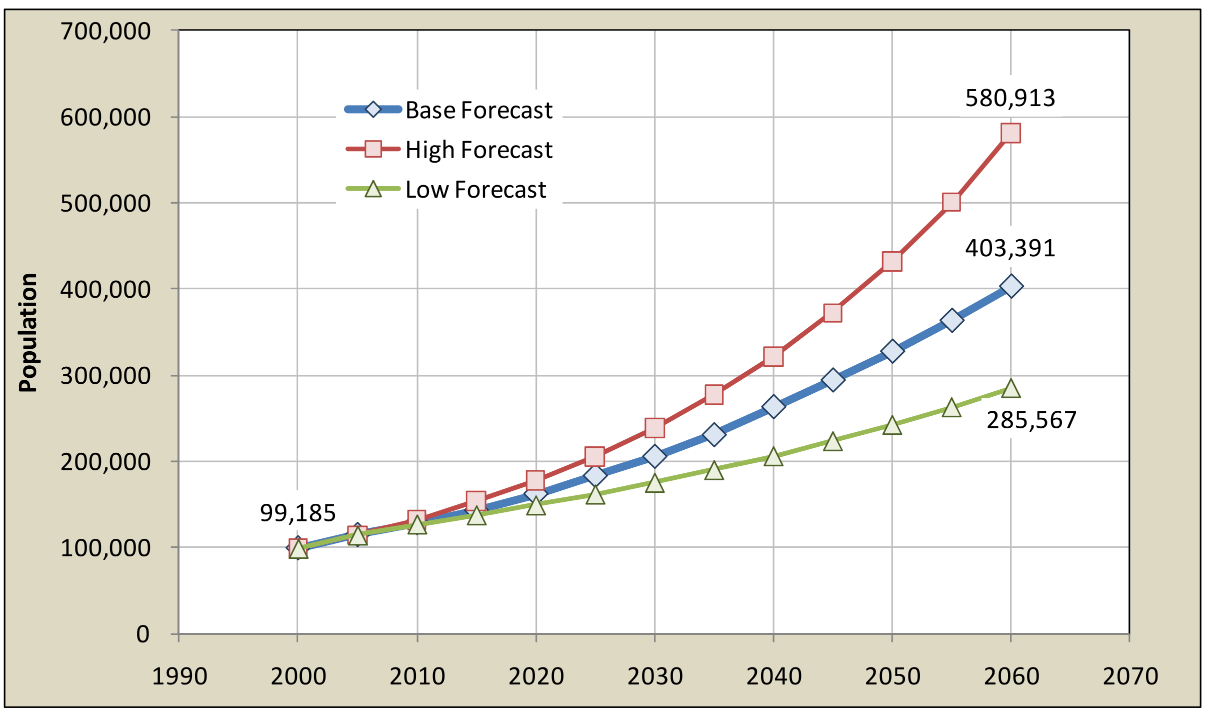

Figure 9. Projected Rathdrum Prairie population (low, base, and high forecasts), 2000-2060.

Projected Number of Households in Rathdrum Aquifer Area				
Year	Low Forecast	Base Forecast	High Forecast	Projected persons per household (base forecast)
2000	37,456	37,415	37,456	2.65
2005	43,614	43,597	43,614	2.63
2010	48,819	49,370	50,810	2.60
2015	53,267	55,265	59,269	2.59
2020	58,151	63,157	69,177	2.57
2025	63,490	71,867	80,753	2.55
2030	69,313	81,225	94,273	2.53
2035	75,679	91,808	110,075	2.51
2040	82,671	105,568	128,581	2.49
2045	90,315	118,885	150,214	2.48
2050	98,673	133,382	175,503	2.46
2055	107,811	149,086	205,070	2.44
2060	117,802	166,644	239,639	2.42

Table 9. Projection of Rathdrum Prairie households, 2000-2060.

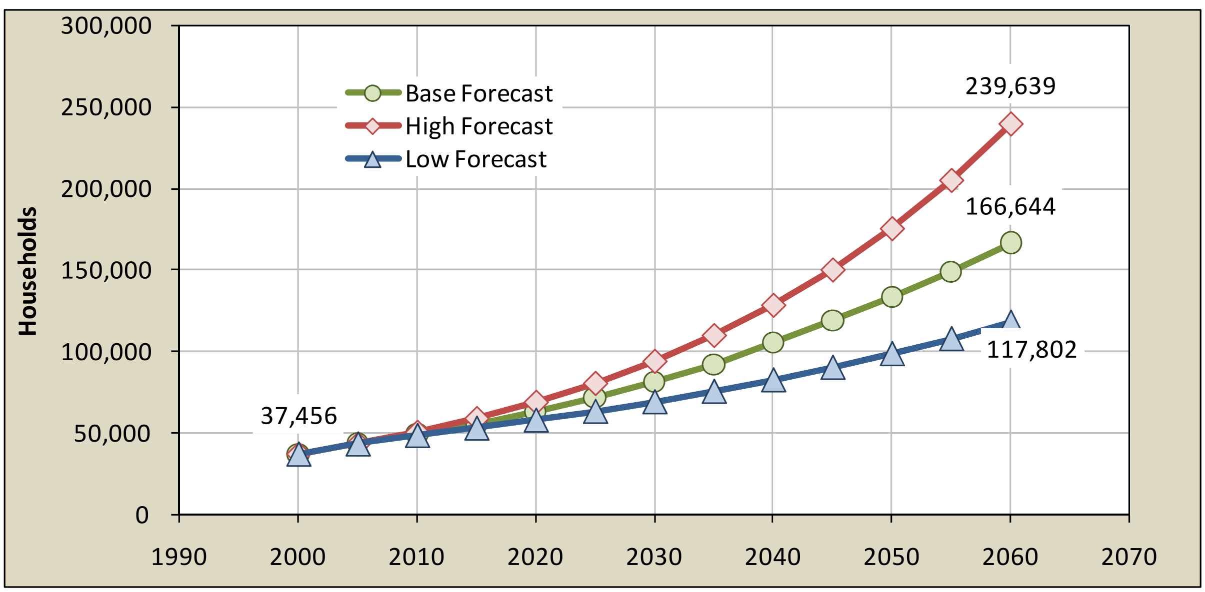

Figure 10. Projected number of Rathdrum Prairie households (low, base, and high forecasts), 2000-2060.

4.5.4 Rathdrum Prairie Employment Forecast

Employment in Kootenai and Bonner counties was projected using the same hybrid approach that was used for forecasting population: employment was projected to the year 2035 using the Idaho Economic Forecasting Model and extrapolated from 2035 to 2060. Rathdrum Prairie employment was estimated as a percentage of the employment in Kootenai and Bonner counties.

The percentage of employment relying on water from the Rathdrum Prairie Aquifer was estimated using ZIP code employment patterns. Based on this method, and the average estimated percentage of the Kootenai County employment overlying the aquifer based on 2000 to 2007 employment data was 92.4% (Table 10). The average estimated percentage of Bonner County employment overlying the aquifer for the same time period was 1.3% (Table 11). It was assumed that these relative percentages of County employment overlying the aquifer would remain the same over the next 50 years.

Kootenai County:	Zip Code	2000	2001	2002	2003	2004	2005	2006	2007
Athol	83801	168	166	193	200	290	302	327	446
Bayview	83803	27	26	27	46	40	37	29	44
Coeur d'Alene	83814	15,981	16,076	15,243	15,653	16,461	17,295	18,335	18,353
Dalton Gardens	83815	5,238	5,641	5,201	5,931	6,453	7,647	8,109	9,148
Hayden	83835	4,298	3,471	3,956	4,158	4,926	5,812	5,564	5,221
Post Falls, Hayden Lake, Hauser, and State Line	83854	6,793	6,405	7,350	7,488	7,663	8,574	9,537	9,612
Rathdrum	83858	1,285	1,484	1,110	1,133	1,363	1,460	1,606	1,887
Spirit Lake	83869	135	151	133	140	183	260	244	311
Sum of employment over the Rathdrum Prairie aquifer		33,909	33,407	33,212	34,748	37,389	41,407	43,782	45,030
Total Kootenai County employment		37,012	36,660	35,917	38,043	40,377	44,391	46,995	47,901
Percentage of employment overlying the aquifer		92%	91%	92%	91%	93%	93%	93%	94%
Average percentage of Kootenai County employment overlying the aquifer, 2000-2007									**92.4%**

Source: U.S. Census Bureau, ZIP Code Business Patterns, www.census.gov/econ/census02/guide.
The place names shows are for reference only. The U.S. Postal Service recognizes multiple names for many zip codes.
The data shown may not precisely correlate with the with the city shown.

Table 10. Percentage of Kootenai County employment overlying the Rathdrum Prairie Aquifer, 2000-2007.

Some of the listed post ZIP codes extend beyond city and aquifer boundaries. It was assumed that all of the employment in ZIP code areas straddling the aquifer boundary occurs over the aquifer area.

Bonner County:	Zip Code	2000	2001	2002	2003	2004	2005	2006	2007
Blanchard	83804	107	115	145	155	141	195	199	107
Careywood (Sandpoint)	83809	4	6	3	6	11	13	12	17
Sum of employment over the Rathdrum Prairie aquifer in Bonner		111	121	148	161	152	208	211	124
Total Bonner County employment		10,425	10,517	10,772	11,501	11,824	12,841	13,421	13,604
Percentage of employment overlying the aquifer		1.1%	1.2%	1.4%	1.4%	1.3%	1.6%	1.6%	0.9%
Average percentage of Bonner County employment overlying the aquifer, 2000-2007									**1.3%**
Source: U.S. Census Bureau, ZIP Code Business Patterns, www.census.gov/econ/census02/guide. The place names shows are for reference only. The U.S. Postal Service recognizes multiple names for many zip codes. The data shown may not precisely correlate with the with the city shown.									

Table 11. Percentage of Bonner County employment overlying the Rathdrum Prairie Aquifer, 2000-2007.

The projected employment overlying the Rathdrum Prairie Aquifer, based on the approach described above, is listed by sector in Table 12 and Figure 11. We project that the non-agricultural employment overlying the aquifer will rise from approximately 53,200 people in 2010 to approximately 183,000 people in the year 2060, although future employment could range from approximately 130,000 (Table 13 and Figure 12) to 197,000 people (Table 14 and Figure 13).

Year	Manufacturing	Mining	Construction	Transporation, Commercial, & Utility	Wholesale & Retail Trade	Financial, Insurance, and Real Estate	Services	Government	Total Non-Agricultural Employment (Base)
1980	2,973	0	778	977	3,982	1,031	2,625	3,961	16,326
1985	3,173	29	1,142	930	4,629	1,394	3,458	4,098	18,853
1990	3,449	158	1,420	1,161	6,374	1,066	5,287	4,981	23,895
1995	4,686	150	2,986	1,192	9,712	1,928	7,703	6,139	34,496
2000	4,939	150	3,104	1,497	11,144	1,746	10,210	8,071	40,862
2005	4,700	159	4,907	1,442	14,879	2,408	11,617	8,301	48,412
2010	4,753	168	4,973	1,411	17,311	3,085	12,544	8,936	53,182
2015	4,753	159	5,318	1,393	19,282	3,075	15,954	9,627	59,560
2020	4,855	168	6,075	1,393	21,953	3,243	20,336	10,505	68,528
2025	4,958	159	6,775	1,402	25,260	3,514	25,447	11,438	78,952
2030	5,004	159	7,915	1,411	29,192	3,813	30,930	12,447	90,871
2035	5,069	150	9,550	1,420	33,704	4,158	37,217	13,624	104,891
2040	5,120	150	11,000	1,566	38,919	4,764	42,006	14,969	118,494
2045	5,170	149	11,629	1,750	44,777	5,505	47,360	16,417	132,757
2050	5,220	149	12,107	1,949	51,277	6,330	53,187	17,947	148,167
2055	5,271	149	12,412	2,162	58,447	7,243	59,494	19,542	164,722
2060	5,323	149	12,580	2,398	66,571	8,280	66,543	21,279	183,123
2010 - 2060 data from "Rathdrum Prairie Employment Scenarios - 2 17 2010.xls".									

Table 12. Base Rathdrum Prairie employment projection, 1980-2060.

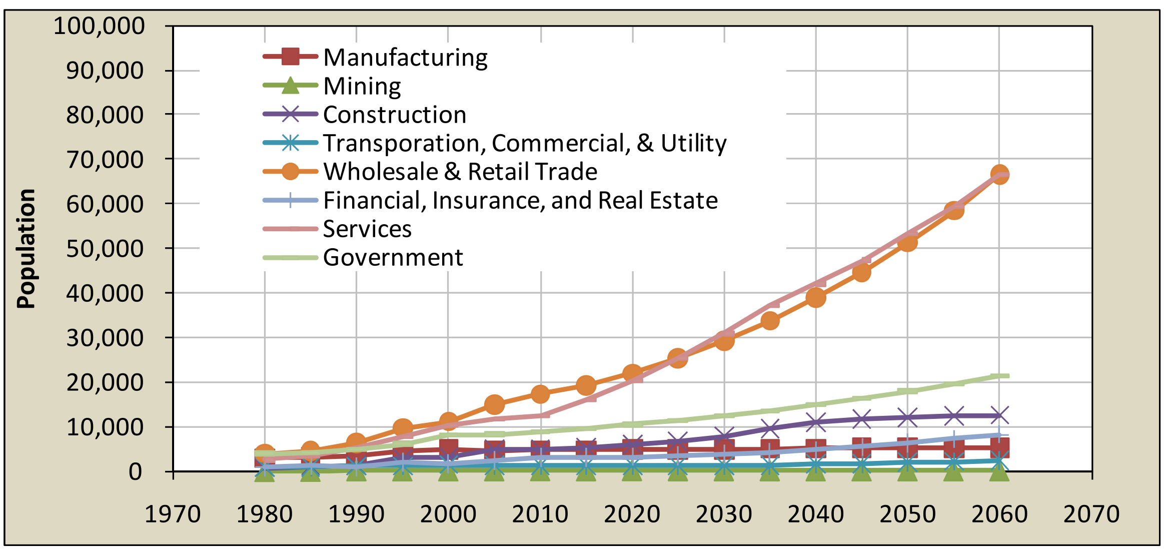

Figure 11. Base Rathdrum Prairie employment projection, 1980-2060.

Year	Manufacturing	Mining	Construction	Transporation, Commercial, & Utility	Wholesale & Retail Trade	Financial, Insurance, and Real Estate	Services	Government	Total Non-Agricultural Employment (Low)
1980	2,973	0	778	977	3,982	1,031	2,625	3,961	16,326
1985	3,173	29	1,142	930	4,629	1,394	3,458	4,098	18,853
1990	3,449	158	1,420	1,161	6,374	1,066	5,287	4,981	23,895
1995	4,686	150	2,986	1,192	9,712	1,928	7,703	6,139	34,496
2000	4,939	150	3,104	1,497	11,144	1,746	10,210	8,071	40,862
2005	4,700	159	4,907	1,442	14,879	2,408	11,617	8,301	48,412
2010	4,710	167	4,928	1,399	17,154	3,057	12,430	8,855	52,698
2015	4,590	153	5,136	1,345	18,622	2,970	15,409	9,298	57,523
2020	4,479	155	5,604	1,285	20,253	2,992	18,762	9,691	63,221
2025	4,388	141	5,997	1,241	22,359	3,110	22,524	10,125	69,884
2030	4,278	136	6,767	1,206	24,959	3,260	26,445	10,642	77,692
2035	4,186	123	7,886	1,173	27,834	3,434	30,736	11,251	86,624
2040	4,016	117	8,630	1,228	30,531	3,738	32,953	11,743	92,956
2045	3,934	114	8,849	1,332	34,073	4,189	36,039	12,492	101,022
2050	3,868	111	8,970	1,444	37,993	4,690	39,408	13,298	109,783
2055	3,818	108	8,989	1,566	42,329	5,246	43,087	14,153	119,296
2060	3,768	106	8,906	1,698	47,126	5,862	47,107	15,063	129,636
2010 - 2060 data from "Rathdrum Prairie Employment Scenarios - 2 17 2010.xls".									

Table 13. Low Rathdrum Prairie employment projection, 1980-2060.

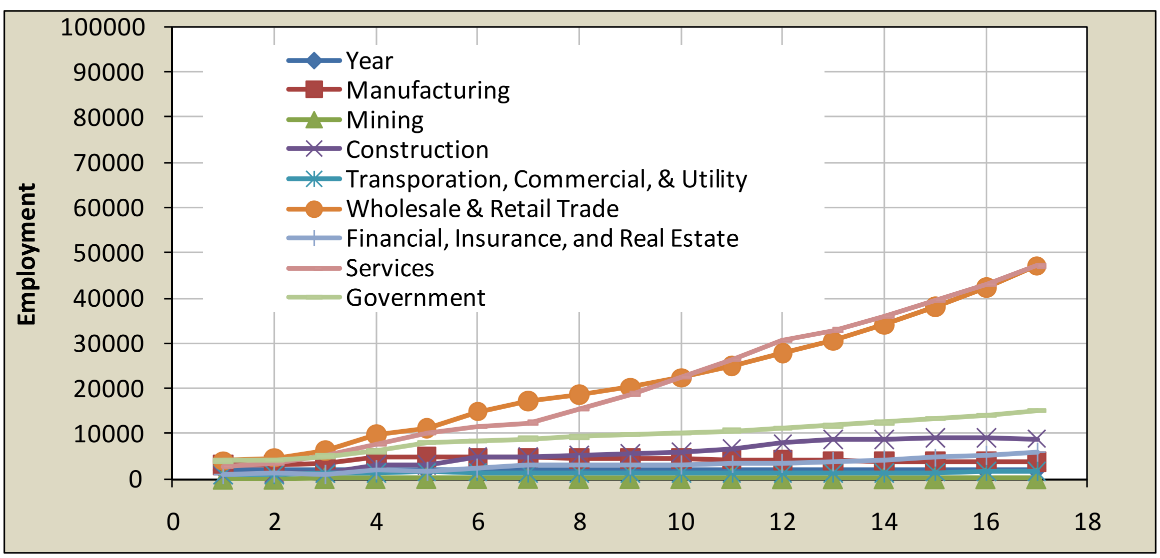

Figure 12. Low Rathdrum Prairie employment projection, 1980-2060.

Year	Manufacturing	Mining	Construction	Transporation, Commercial, & Utility	Wholesale & Retail Trade	Financial, Insurance, and Real Estate	Services	Government	Total Non-Agricultural Employment (High)
1980	2,973	0	778	977	3,982	1,031	2,625	3,961	16,326
1985	3,173	29	1,142	930	4,629	1,394	3,458	4,098	18,853
1990	3,449	158	1,420	1,161	6,374	1,066	5,287	4,981	23,895
1995	4,686	150	2,986	1,192	9,712	1,928	7,703	6,139	34,496
2000	4,939	150	3,104	1,497	11,144	1,746	10,210	8,071	40,862
2005	4,700	159	4,907	1,442	14,879	2,408	11,617	8,301	48,412
2010	4,902	174	5,129	1,456	17,854	3,181	12,937	9,216	54,848
2015	5,107	171	5,715	1,497	20,721	3,304	17,145	10,345	64,005
2020	5,328	185	6,667	1,528	24,093	3,559	22,319	11,529	75,208
2025	5,581	179	7,628	1,578	28,438	3,956	28,648	12,878	88,886
2030	5,819	185	9,204	1,641	33,946	4,433	35,967	14,474	105,669
2035	6,089	180	11,471	1,706	40,485	4,995	44,705	16,365	125,995
2040	6,247	182	13,422	1,911	47,486	5,813	51,253	18,264	144,578
2045	6,543	189	14,718	2,215	56,670	6,968	59,940	20,777	168,021
2050	6,879	197	15,955	2,569	67,576	8,342	70,094	23,652	195,264
2055	7,261	206	17,099	2,979	80,515	9,978	81,958	26,921	226,916
2060	7,665	215	18,116	3,454	95,867	11,924	95,828	30,643	263,711
2010 - 2060 data from "Rathdrum Prairie Employment Scenarios - 2 17 2010.xls".									

Table 14. High Rathdrum Prairie employment projection, 1980-2060.

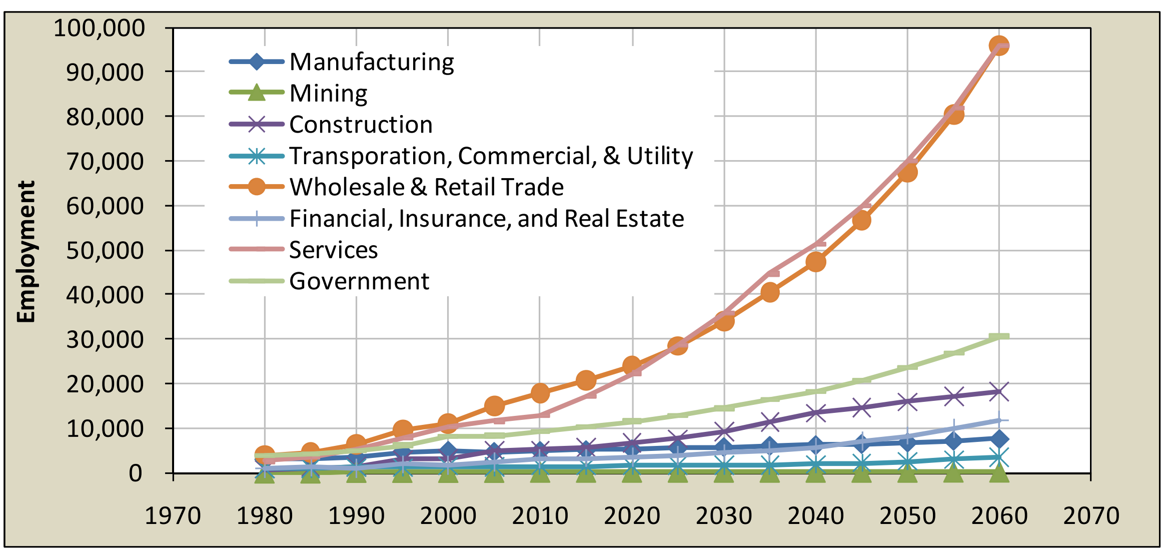

Figure 13. High Rathdrum Prairie employment projection, 1980-2060.

5 ESTIMATE OF CURRENT RATHDRUM PRAIRIE WATER USE

Future water use projections are based, in part, on existing water use rates and patterns. Thus, we estimated existing water use for domestic, commercial, municipal, and industrial (DCMI) purposes as a foundation for projecting future water use.

5.1 Public Water Systems

Public water systems are those water systems that serve potable water to at least 15 service connections or 25 individuals daily at least 60 days out of the year (IDAPA 58.01.08). Public water systems are regulated by the Idaho Department of Environmental Quality (IDEQ). Public water systems include community water systems which supply water for domestic, commercial and industrial uses, irrigation of landscaping and parks, fire protection, and other municipal uses, especially in urban and semi-urban areas. Non-community water systems typically supply water for commercial and industrial facilities, schools, and other facilities located outside of community water system service areas.

Public water systems that pump water from wells located within the Rathdrum Prairie Aquifer Study Area were identified using data available from IDEQ and the U.S. Environmental Protection Agency (EPA) Safe Drinking Water Information System. These sources list 90 community water systems, 4 non-transient, non-community systems, and 23 transient, non-community systems in the Rathdrum Prairie Aquifer study area. A non-transient, non-community water system serves at least 25 of the same people over six months per year. These systems include schools or businesses with more than 25 employees that have their own well. A transient, non-community water system serves at least 25 individuals daily at least 60 days out of the year, but does not serve at least 25 of the same people over six months per year. These systems include camps, churches, rest areas, motels, and commercial systems with fewer than 25 year-round employees.

5.1.1 Community Water Systems

The 90 community water systems overlying the Rathdrum Prairie Aquifer area range in size from a small subdivision serving 25 people, to the City of Coeur d'Alene municipal water system, which serves approximately 46,000 people. Based on data obtained from community water systems and IDEQ, the total population served by community water systems in 2009 was estimated to be approximately 117,400 people, which is approximately 91% of the estimated population within the Rathdrum Prairie Aquifer study area.

Historic water use data were obtained from 20 community water systems (Appendix C) ranging in size from approximately 39 to 46,000 people (based on 17 to 16,267 connections or "hook-ups"). These 20 water systems served a total population of approximately 92,300 people in 2009, or approximately 79% of the population served by community water systems and approximately 72% of the estimated study area population. Data obtained for these water systems were generally production volumes for a certain period of time, and include aggregated domestic, commercial, industrial, and irrigation uses, as well as "unaccounted for"[5] water. Water-use data were provided by water system operators on a monthly basis for periods ranging from one year (2008) to eleven years (1998 to 2008). Estimates of average per-capita water use for these systems ranged from approximately 108 to 419 gallons per day (gpcd). The population-weighted, per-capita, average annual water use for the 92,300 people served by these water systems was 270 gpcd. The average total water use for these 20 systems was approximately 27,900 AFA (AFA) or 9,098 million gallons per year (MGA).

The average winter water use, calculated using November through February data, represents indoor potable (i.e., non-irrigation) water use. Average per-capita winter water use in these 20 community water systems ranged from 56 to 174 gpcd. The population-weighted average winter water use was 121 gpcd.

The community water systems did not provide sufficient data to calculate residential, commercial, industrial, and irrigation use separately. The two largest water systems provided some data on commercial and residential accounts, but the commercial accounts included residential users in multi-family complexes and/or mobile home parks.

Per-capita water use was generally lower for smaller systems than for larger systems; which is probably because smaller systems are less likely to serve commercial or industrial facilities, schools, and parks. In addition, two of the mid-sized public water systems that provided data for this study deliver some water for agricultural irrigation and did not provide enough data to separate agricultural irrigation deliveries from municipal use. Per-capita water use versus community water system size is plotted in Figure 14. The average per-capita water use in community water systems with populations less than 2,500 people was 222 gpcd (based on annual data), and 111 gpcd based on winter use[6]. The average per-capita water use for community water systems with 2,500 to 10,000 people was 297 gpcd (based on annual data), and 130 gpcd based on winter use[7].

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[5] "Unaccounted for" water is the difference between measurements of water diverted from wells and water delivered to customers, based on meter readings. The difference between measured diversion and delivery volumes consist of system leakage, meter or measurement errors, system flushing, fire flows, and other non-metered uses.
[6] This value includes all water uses served by the water purveyor, including water for irrigation, commercial, industrial, and/or institutional uses .
[7] *Ibid*.

Data collected from the 20 community water systems were used to estimate water use for the other 70 community water systems, which range in size from 23 to 7,000 people and serve an estimated population of about 25,100 people. Two methods were used to extrapolate water use to water systems for which data were unavailable. Both methods yielded similar results. The first method used the average per-capita water use for systems with populations less than 2,500 people and the average per-capita water use for systems with 2,500 to 10,000 people to calculate water use. The second method used regressions of water use versus the log of the population served (Figure 14).

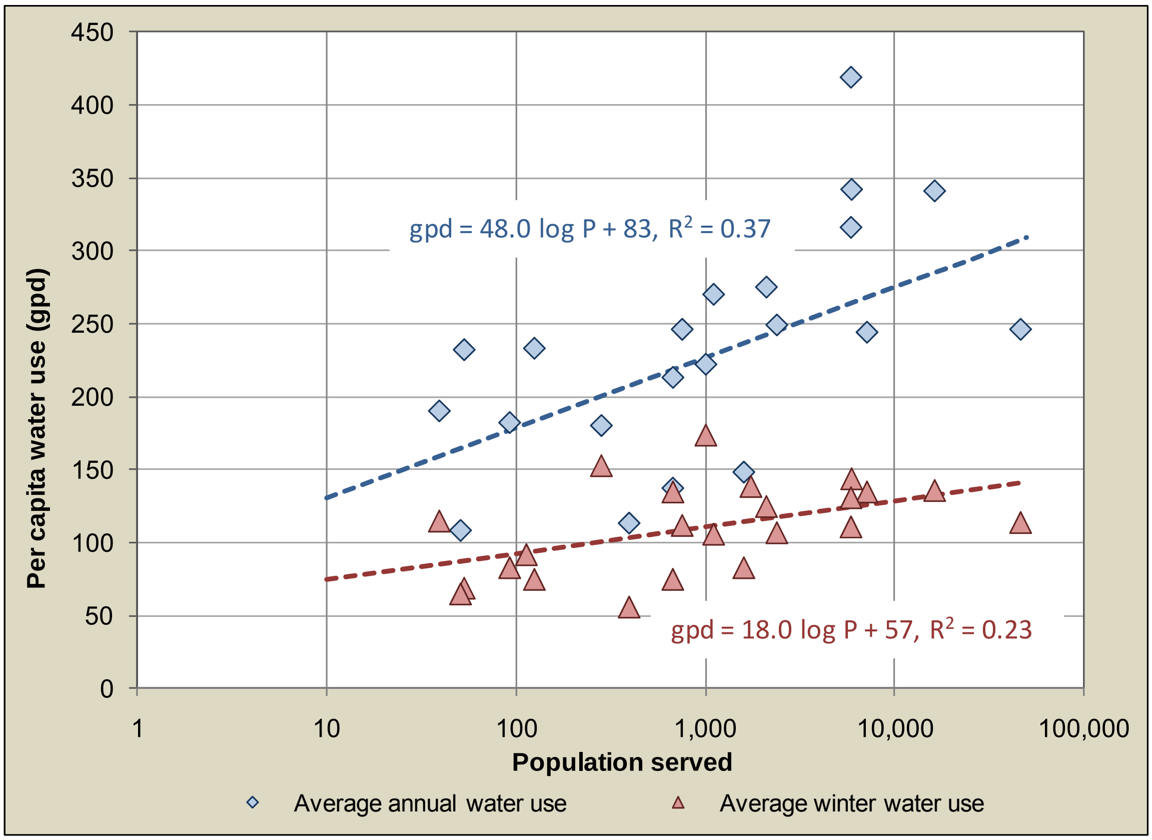

Figure 14. Per-capita water use by community water system size.

The total estimated annual water use estimated for the other 70 community water systems that did not supply data was 2,370 million gallons per year (MGA) using the first method and 2,121 MGA using the second method. This includes estimated irrigation use of 1,250 MGA using the first method and 1,076 MGA using the second method.

In aggregate, the total annual water use for the 90 community water systems located within the study area was estimated to be 34,400 to 35,200 AFA (or 11,220 to 11,470

MGA). This includes estimated irrigation use of 18,700 to 19,300 acre-feet (6,103 to 6,277 MGA). Because these data are derived from well production records, "unaccounted for" water (i.e., system losses, fire flow, system flushing, meter error) is included in these totals. Assuming average unaccounted water of 10 percent, the estimated water delivery to customers in recent years was about 31,000 AFA (10,100 MGA).

5.1.2 Non-Community Water Systems

Water use in non-community water systems was estimated as part of self-supplied commercial and industrial water use (Section 5.3).

5.2 Self-supplied Domestic Use

Self-supplied domestic use includes water use for residences served by individual wells and small residential water systems that serve fewer than 25 individuals (typically less than 10 homes). By Idaho law, domestic use may include irrigation of up to ½ acre of landscaping per residence and total use of up to 13,000 gallons per day[8]. Additional irrigation requires a water right for irrigation use.

In 2009, approximately 117,400 people and 45,150 households within the study area were served by public water systems. An estimated 4,220 households[9] within the study area were served by individual wells or residential water systems that served fewer than 10 homes. The self-supplied water use was estimated assuming an average in-home water use of 190 gpd per household[10] and irrigation of 0.3 acres per household. Irrigation use was estimated using a precipitation deficit of 2.19 feet for irrigated turf grass at the Coeur d'Alene National Weather Service station[11]. The precipitation deficit, equivalent to irrigation demand, is the amount of water needed to meet potential evapotranspiration rates (Allen and Robison, 2007). The precipitation deficit represents consumptive use; additional water will be pumped to deliver the 2.19 feet of water for irrigated turf grass because of inherent inefficiency in any irrigation system.

Based on this approach, self-supplied residential water use in the study area was estimated to be approximately 8,800 AFA (2,866 MGA). This includes including 2,150

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[8] Idaho Code § 42-111(a.).

[9] Based on a 2010 forecast of 49,370 households (Table 9) less the estimated 45,150 households served by public water systems.

[10] This is the same rate that was estimated using community water system data (see Section 5.4.2); it was assumed that per-unit in-home domestic uses are similar regardless of whether the water is provided by an individual wells or a community water system.

[11] Precipitation deficit data obtained from the University of Idaho's ET Idaho program at http://www.kimberly.uidaho.edu/ETIdaho.

acre feet per year (701 MGA) for in-home domestic use and 6,440 acre feet per year (2,165 MGA) for residential irrigation[12].

5.3 Self-supplied Commercial and Industrial Use

Self-supplied commercial and industrial use includes water use in non-community public water systems and other self-supplied commercial, industrial, heating, and cooling systems. Self-supplied commercial and industrial use was estimated from IDWR water right data. Water rights and permits with ground water points of diversion located within the Rathdrum Prairie Aquifer study area were compiled from IDWR graphical information system (GIS) shapefiles. There are a few water users within the study area that divert water from the Spokane River and other surface water bodies; these uses were not included in the following analysis.

Fifty-two commercial and industrial water rights and water right permits were identified as diverting from the Rathdrum Prairie Aquifer (Appendix D). These rights and permits have a cumulative maximum diversion rate of 37.85 cubic feet per second (cfs) and a cumulative maximum annual diversion volume of 6775.19 acre-feet[13] (this includes 9 permits with a cumulative maximum diversion rate of 8.87 cfs). The 52 water rights and permits are owned by 43 different water users.

The largest self-supplied water users (Table 15) identified by water right were the (1) Coeur d'Alene School District, which owns four water rights authorizing the diversion of 4.35 cfs and 2,366 AFA for heating and cooling, and (2) Rathdrum Power, LLC, which owns one water right for diversion of 4.49 cfs and 1,475 AFA for industrial use associated with power plant cooling and operations. Heating and cooling water rights owned by the school district are considered to be non-consumptive. Water use under these water rights is assumed to be mitigated by reinjection of the diverted water into the aquifer at a location near the point of diversion. The power plant water use is assumed to include some consumptive use associated with evaporation during plant processes.

The remaining water rights listed in Table 18 authorize approximately 29 cfs in combined maximum diversion. Based on experience, right holders frequently do not divert the maximum rates or volumes authorized under commercial and industrial water rights. Thus, for the purposes of this study, average annual water use under the remaining water rights listed in Table 18 was assumed to be 70% of the licensed maximum diversion volume. For water rights and permits without a maximum diversion volume, the average annual water use was assumed to be 106 AFA per cfs.

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[12] Some residential irrigation, especially for larger residential parcels (e.g., 5-acre lots), occurs under individual water rights. Estimates of irrigation demand for such parcels is included in Section 5.5.

[13] One acre foot of water is enough water to cover a 1-acre area with 1 foot water. One acre foot contains 43,560 ft³ or 325,850 gallons.

This factor was estimated using 70% of the average ratio of licensed diversion volume to licensed diversion rate for water rights with diversion volumes, excluding Rathdrum Power and Coeur d'Alene School District.

Water Right Owner	Maximum Diversion Rate (cfs)[1]	Maximum Diversion Volume (AFA)[2]	Estimated Average Annual Use (AFA)[3]
Coeur d'Alene School District	4.35	2366.0	1,656
Rathdrum Power	4.49	1475.7	1,033
Chilco Lake Lumber Company	1.35	882.0	617
Silverwood	4.00	>169.5 [1]	458
Hap Taylor & Sons	3.63		385
Idaho Veneer	1.63	493.1	345
Kootenai Medical Center	2.83		300
CPM Development Corp.	2.23	384.8	269
Acme Materials & Construction	2.00	343.7	241
Salvation Army Kroc Center	1.60		170
Other Water Users	9.74	>660.39 [2]	875
Total	37.85	>6,775.19 [3]	6,349

1. Maximum diversion rate includes water rights and permits.
2 Maximum diversion volume from licensed water rights, permits may add additional volume.
3 Average diversion volume estimated at 70% of maximum diversion volume or 106 AFA per cfs for water rights or permits without maximum diversion volumes. Some of this average annual use is non-consumptive (see text).

Table 15. Self-supplied commercial and industrial ground water users.

The estimated average annual use for self-supplied commercial and industrial ground water users is 6,349 AFA or 2,069 MGA. This total includes an estimated 2,126 AFA (693 MGA) used in heating and cooling systems, 1,033 AFA (336 MGA) used at a power plant, 962 AFA (313 MGA) used at lumber mills, and 2,228 AFA (726 MGA) used for other commercial and industrial purposes.

5.4 Water Use Coefficients for Projection of Future DCMI Use

Future domestic, commercial, municipal, and industrial (DCMI) water use was projected using coefficients derived from historical water use patterns. Sections 5.4.1 and 5.4.2 describe the development of these coefficients.

5.4.1 Baseline Commercial and Industrial Water Use Per Employee

Commercial and industrial water use within the study area was projected using 2009 non-agricultural employment (see Section 4.5.4) and estimated per-employee water use. Per-employee water use data for primary employment categories are listed in Table 16. These data are based on (1) water use in the Boise area (Cook et al., 2001)[14], (2) national estimates, and (3) data from the Atlanta, Georgia area. Water use in the construction, transportation, communications, and utilities sectors are similar in all three studies. Water use per employee in the manufacturing, financial, insurance, real estate, and government sectors are higher in the Boise-area study. Per-employee water use in the service sector is lower in the Idaho study. All of these water-use estimates include at least some irrigation.

The 2009 commercial and industrial water use in the Rathdrum Prairie Aquifer area (Table 17) was estimated to be 5,090 acre feet, or 1,660 million gallons (MG). Because this estimate is based on generalized employment categories, water use by the power plant, lumber mills, and hydronic heating and cooling systems (4,120 acre feet or 1,341 MG, Section 5.3) are not included in this total. Of the estimated 5,090 acre feet of commercial and industrial water use in 2009, an estimated 2,230 acre feet was estimated to have been self-supplied (Section 5.3) and the remaining 3,380 acre feet was assumed to have been supplied by community water systems.

5.4.2 Baseline Domestic Water Use Per Household

In-home domestic water use per household was estimated from community water system data by deducting estimated irrigation, commercial, and industrial use as shown in Table 18. Based on this approach, average current in-home domestic water use was estimated to be 186 gpd per household. For comparison, household use was also estimated from one community water system that provided monthly account data for 5,705 residential accounts. The average winter water use for those accounts was 170 gpd per household. Based on available data, the baseline domestic water use per household (not including irrigation) is likely between 170 and 190 gpd per housing unit. A baseline value of 190 gpd per unit was assumed for this study.

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[14] Based on data presented in Cook et al., which was derived from United Water Idaho account data from 1997-1998 and estimated 1998 employment data. United Water Idaho (UWID) serves over 70,000 connections in Boise, Idaho.

Employment Category	Water Use (gpd per employee)			Assumed Value for Projections[4]
	UWID[1]	IWR-MAIN[2]	ARC[3]	
Manufacturing	160	132.5	115	136
Mining	—	—	—	—
Construction	27	20.7	20	23
Transportation, Communications, and Utilities	42	49.3	50	42
Wholesale Trade	70	42.8	50	69
Retail Trade		93.1	90	
Financial, Insurance, and Real Estate	112	70.8	40	74
Services	96	137.5	125	96
Government	150	105.7	125	127

(1) Data presented in Cook et al. (2001), derived from United Water Idaho (UWID) account data.
(2) Data from the Institute for Water Resources - Municipal And Industrial Needs (IWR-MAIN) model, developed by the Corps of Engineers Institute.
(3) Based on data from the Atlanta, Georgia area (Turner, 1997).
(4) Based on lower of (a) average of the value estimated in UWID, IWR-Main, and ARC studies or (b) the UWID value (see text).

Table 16. Estimates of water use per employment sector.

Employment Category	Estimated Employees in Study Area, 2009	Water Use (gpd per employee)[1]	Estimated 2009 Water Use (AF)	Estimated 2009 Water Use (MGA)
Manufacturing	4,823	136	733	239
Mining	0		0	0
Construction	4,946	23	129	42
Transportation, Communications, and Utilities	1,426	42	68	22
Wholesale and Retail Trade	16,988	69	1,313	428
Financial, Insurance, and Real Estate	2,945	74	246	80
Services	12,446	96	1,338	436
Government	8,907	127	1,267	413
Total	52,480		5,094	1,660

(1) Per-employee water use data are an average of those listed in Table 16.

Table 17. Estimated commercial and industrial water use in Rathdrum Prairie study area.

Water Use	Estimated Annual Volume (MGA)	Water Use (gpd per-capita [3])	Water Use (gpd per household [4])
Total [1]	11,219	262	--
Unaccounted [1]	1,122	26	
Irrigation [1]	6,103	142	--
Commercial and Industrial [2]	933	22	--
Domestic	3,061	71	186

[1] Section 5.1.1. Total water use includes water diverted by community water systems for domestic, commercial, industrial, and irrigation uses, and unaccounted for water (i.e. system losses, fire flow, system flushing, meter error).
[2] Section 5.4.1.
[3] Estimated population served by community water systems in 2009 :117,400 persons (Section 5.1.1).
[4] Estimated households served by community water systems was calculated at 2.6 persons per household.

Table 18. Estimated water use per-capita based on community water system data.

5.5 Estimate of Current Agricultural Water Use

Agricultural water use within the study area is supplied by ground water, surface water from lakes, and the Spokane River. This section provides an estimate of current agricultural water use.

Three irrigation districts – East Greenacres Irrigation District, Avondale Irrigation District, and Hayden Lake Irrigation District – have historically provided water for both agricultural irrigation and DCMI uses. Increasing development in the Hayden area has significantly reduced agricultural irrigation in the Avondale and Hayden Lake Irrigation Districts. Agricultural use within the East Greenacres Irrigation District has also been reduced by development but is still substantial.

Because Avondale and Hayden Lake Irrigation Districts provided production data for this study, their water use was tabulated as part of the community water system use (Section 5.1.1). These districts did not provide data quantifying what portion of their deliveries were for agricultural use. The remaining agricultural use in these districts was assumed to be minimal and all water use within these districts was included in the municipal use data in Section 5.1.1.

The East Greenacres Irrigation District did not provide production data for this study. The municipal use for this district was estimated based on population served, as discussed in Section 5.1.1. Agricultural irrigation use was assumed to be included in water use calculated from irrigated crop acreage, as discussed in this section.

The irrigation water demand outside of these districts was assessed by multiplying an estimated aggregate irrigated area by precipitation deficit and assumed irrigation efficiency. The acreage irrigated outside of community public water systems was estimated from water right and permit data and then compared to data obtained from the USDA National Agricultural Statistics Service (USDA-NASS).

Irrigated area values were obtained from water right place-of-use and permit place-of-use shapefiles downloaded from the Idaho Department of Water Resources on-line water rights database[15] on August 10, 2009. Adjudication claim and recommendation records were not used because the adjudication of water rights in this area was in the early stages of claim filing, and these claim records were incomplete. Irrigation water rights and permits owned by community public water systems were eliminated from the data set, because water use associated with these areas is included in the DCMI water use (Section 5.1.1). Water rights and permits for self-supplied irrigation owned by other entities located within public water system service areas (i.e. school districts, churches, etc.) were retained in this data set.

Places of use irrigated by ground water were overlain in GIS to screen irrigation water rights with potential overlapping places of use. Very few overlaps were identified, and these were individually evaluated for overlapping acreage. The reduction to total acreage from apparent overlaps was minimal (19 acres).

This analysis indicates that 271 water rights (established by license, decree, or statutory claim) authorize use of ground water for the irrigation of 25,230 acres outside of community public water systems (Table 19). Of these 271 water rights, 87 rights (32%) authorize the irrigation of 22,145 acres (88% of the total 25,230 acres). In contrast, 142 rights (53%) authorize the irrigation of parcels land 20 acres or less in size, which in aggregate represent 715 acres (3% of the total 25,230 acres).

Fifty water right permits (that have not yet been licensed or decreed) authorize use of ground water for an additional 1,024 acres. Of the 50 permits, 38 (76%) authorize the use of ground water on parcels less than 20 acres in size (for an aggregate 225 acres, or approximately 22% of the aggregate 1,024 acres). In contrast, 12 permits authorize the use of ground water on 798 acres, or 78% of the aggregate 1,024 acres.

In combination, the total Rathdrum Prairie Aquifer area authorized to be irrigated by ground water outside of community public water systems was estimated using water right information to be approximately 26,250 acres[16]. However, data obtained from the USDA National Agricultural Statistics Service (USDA-NASS)[17] indicates that the current irrigated acreage is significantly less. The USDA-NASS Cropland Data Layer

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15 http://www.idwr.idaho.gov/apps/ExtSearch/SearchWRAJ.asp

16 25,230 acres authorized by licenses, decrees, or statutory claims and 1,024 acres authorized by permits.

17 2007 Kootenai County agricultural data, based on census data reported by farmers, can be found at the following website: http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Idaho/index.asp

(2009), which classifies agricultural land use using imagery from the ResourceSat-1 AWiFs sensor at a 56 meter resolution, was clipped to the project study area. The

Irrigation Water Rights				
Irrigation Place of Use Category	License, Decree, or Statutory Claim		Place of Use	
	Number	Percentage of Number	Aggregate Area (acres)	Percentage of Area
< 5 acres	89	33%	203	0.8%
5 to 9.99 acres	30	11%	207	0.8%
10 to 14.99 acres	13	4.8%	140	0.6%
14 to 19.99 acres	10	3.7%	165	0.7%
20 to 99.99 acres	42	15%	2,369	9%
100 to 299.99 acres	58	21%	10,482	42%
300+ acres	29	11%	11,663	46%
Total	271	100%	25,230	100%
Irrigation Permits				
Irrigation Place of Use Category	Permits		Place of Use	
	Number	Percentage of Number	Aggregate Area (acres)	Percentage of Area
< 5 acres	18	36.0%	33	3.2%
5 to 9.99 acres	10	20.0%	68	6.6%
10 to 14.99 acres	7	14.0%	79	7.7%
14 to 19.99 acres	3	6.0%	46	4.5%
20 to 99.99 acres	9	18.0%	498	48.7%
100 to 299.99 acres	3	6.0%	300	29.3%
300+ acres	0	0%	0	0%
Total	50	100%	1,024	100%

Table 19. Summary of irrigation water rights.

cropland data layer indicates that there were approximately 11,440 acres of active agricultural cropland in the study area in 2009 (Figure 15). USDA-NASS Census of Agriculture data, which is reported by farms[18] participating in federal crop insurance or other crop payment programs[19], indicates that Kootenai County had 130,851 acres of farmland, of which 45,579 acres was harvested cropland in 2007, and of which 11,035 acres were irrigated (U.S. Department of Agriculture, 2009, pg. Idaho 254). Assuming that the majority of the irrigated land in Kootenai County is located within the Rathdrum Prairie Aquifer study area, this is generally consistent with data obtained from the USDA-NASS Cropland Data Layer.

The estimate of irrigated area using the USDA-NASS data (11,440 acres) is substantially different from the estimate of irrigated area compiled from water rights data (26,250 acres). Much of this difference likely represents acreage that was once irrigated (and which is represented in dated water right records) but has now been converted to other land uses (i.e. land that has been urbanized or is being used for other non-agricultural purposes). USDA-NASS historic Census of Agriculture data from 1987 to 2007 (Table 20) indicate a 38 percent decrease in irrigated acreage in Kootenai County.

The USDA-NASS data are assumed to represent a better estimate of irrigated agricultural acreage than an estimate based on water right data, because some land for which water rights were originally obtained are no longer irrigated. However, acreage that has been converted to non-agricultural uses may still be irrigated (such as residential areas that are now irrigated through public water systems). Some acreage may still be irrigated on a self-supplied basis for non-crop purposes (e.g., 5-acre residential lots). To account for such non-agricultural irrigation, we have included as irrigated agricultural areas the aggregate acreage of all ground-water irrigation water rights with listed places of use that are less than 20 acres in size. The rationale for this assumption is that these smaller parcels may be irrigated but are not necessarily included in USDA-NASS data. Thus, the estimate of current irrigated agricultural acreage is 11,440 acres (USDA-NASS data), 715 acres (places of use for parcels less than 20 acres authorized by water rights established by license, decree, or statutory claim – see Table 20), and 225 acres (parcels under 20 acres authorized under current permits), for a total of 12,380 acres.

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[18] The census definition of a farm is any place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the census year (US Department of Agriculture, 2009).
[19] Approximately 80% to 85% of Rathdrum-area farmers participate in these federal programs, according to Randy Primmer, Spokane County FSA Executive Director, personal communication, July 9, 2010.

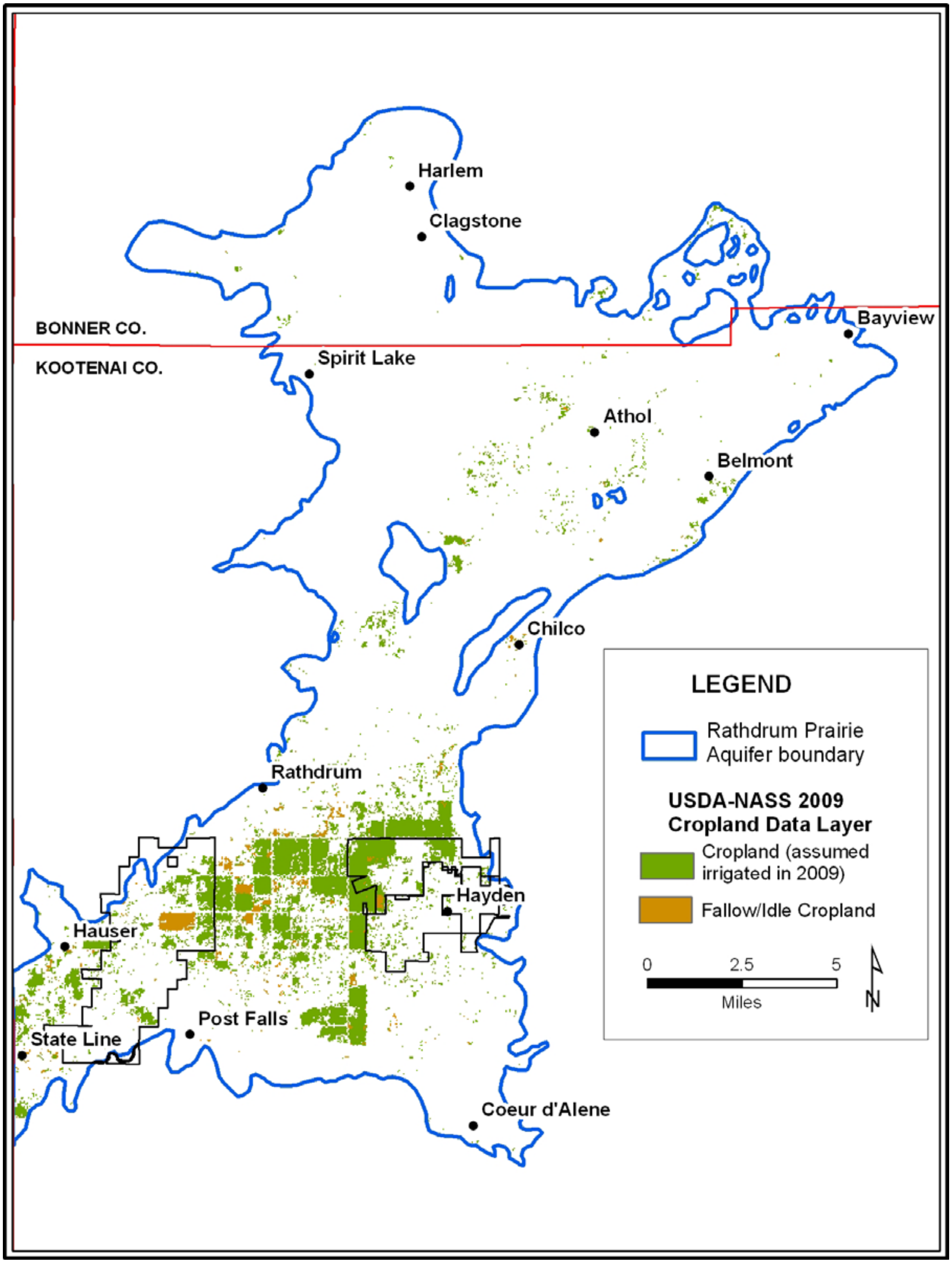

Figure 15. Irrigated agricultural land within the aquifer study area, 2009.

Agricultural per-acre water use was estimated using precipitation deficit data obtained from the University of Idaho's "ET Idaho" website[20]. Estimates of precipitation deficit for this site were based 1963-2007 National Weather Service data (Coeur d'Alene station). A weighted average precipitation deficit was calculated for the 12,380 irrigated acres located in the Rathdrum Prairie Aquifer study area using crop data from the 2007 Census of Agriculture (Table 21). Based on an estimated irrigated acreage of 12,380 acres and an estimated precipitation deficit of 1.51 feet per year, the estimated consumptive use for agricultural irrigation in 2009 was 18,694 acre feet. The estimated ground water diversion for agricultural irrigation, assuming an irrigation efficiency of 70%, was 26,700 acre feet.

Census of Agriculture Year	Irrigated Acres in Kootenai County(1)	Change from 1987
1987	17,895	
1992	18,723	4.6%
1997	15,794	-11.7%
2002	13,280	-25.8%
2007	11,035	-38.3%

(1) Based on USDA-NASS data:
http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_2_County_Level/Idaho/index.asp
http://www.agcensus.usda.gov/Publications/1997/Vol_1_Chapter_2_County_Tables/Idaho/index.asp
http://www.agcensus.usda.gov/Publications/1992/Volume_1_Chapter_2_County_Tables/Idaho/index.asp

Table 20. Change in irrigated acreage in Kootenai County, 1987-2007.

[20] http://www.kimberly.uidaho.edu/ETIdaho/stninfo.php?station=101956

Crop Type	Percentage of Irrigated Acreage in Study Area	Precipitation Deficit (ft)
Hay	41%	2.17
Grass Seed	21%	0.15
Irrigated Pasture	20%	1.74
Wheat	14%	1.27
Oats	4%	1.57
Weighted average	100%	1.51

Table 21. Weighted average precipitation deficit for the Rathdrum Prairie Aquifer study area.

5.6 Current Rathdrum Prairie Water Use Estimates

The preceding sections provide estimates of current water demand and consumptive use in the Rathdrum Prairie Aquifer area. Components of water use include public water system use, self-supplied residential use, self-supplied commercial and industrial use, and agricultural irrigation use. The total estimated ground water diverted in the Rathdrum Prairie Aquifer area for 2009-2010 was approximately 72,150 acre feet (Table 22).

Not all of the water pumped for residential, commercial, industrial, and agricultural purposes is lost from the local hydrologic system. Some of the water used in the 2009-2010 period returned to the aquifer via seepage, or returned to the Spokane River as treated effluent. The amount of actual consumptive use (that which did not return to the aquifer or the Spokane River) was estimated using the following assumptions:

1. Only 5% of self-supplied indoor domestic use is consumptive use; 95% of indoor domestic water use returns to the aquifer via septic seepage.
2. 10% of community water system non-irrigation use is consumptive; 90% of the non-irrigation withdrawals are returned to the aquifer via land application of treated municipal effluent or the discharged to the Spokane River as treated municipal effluent.
3. 40% of the commercial and industrial use is effectively consumed; 60% returns to the aquifer as of land applied municipal effluent or is discharge to the Spokane River as treated municipal effluent.
4. 70% of ground water pumped for irrigation is fully consumed through evapotranspiration.

Based on these assumptions, the Rathdrum Prairie consumptive use was estimated to be approximately 38,400 acre-feet per year in 2009 and 2010. This represents approximately 53% of the total estimated ground water diversions.

Sector	Non-irrigation Use (AFA)	Irrigation Use (AFA)	Total Use (AFA)
Community public water systems	15,700	18,730	34,430
Self-supplied domestic	2,150	6,650	8,800
Self-supplied commercial and industrial	4,220	Assumed negligible	4,220[21]
Agriculture	Assumed negligible	26,700	24,700
Estimated total ground water diversion	22,070	52,080	74,150
Estimated total consumptive use	3,370	36,460	39,830

Table 22. Estimated current average annual water use in Rathdrum Prairie Aquifer study area.

[21] Excludes an estimated 2,130 AF diverted and reinjected for use in heating and cooling systems.

6 WATER SUPPLY CHARACTERISTICS AND ENVIRONMENTAL CONSTRAINTS

6.1 Introduction

This section describes water supply characteristics and potential water supply constraints that may influence future water demand. Section 6.2 provides a brief description of Rathdrum Prairie Aquifer characteristics. Potential water quality and environmental constraints are described in Section 6.3; the potential influence of climate variability on water demand and water supply are addressed in Section 6.4.

6.2 Aquifer Description

The Rathdrum Prairie Aquifer, part of the larger Spokane Valley-Rathdrum Prairie Aquifer, consists of unconsolidated sediments, which are primarily coarse-grained sand, gravel, cobbles, and boulders deposited by repeated immense floods from Glacial Lake Missoula (Kahle and Bartolino, 2007). Discontinuous deposits of fine-grained sand and clay are scattered throughout the Rathdrum Prairie Aquifer, thought to have been deposited in proglacial lakes caused by ice dams downstream of the present-day aquifer area. Depths to water in the aquifer range from approximately 20 to 540 feet (Campbell, 2005).

6.2.1 Recharge

Recharge to the Rathdrum Prairie Aquifer occurs as infiltration from the Spokane River, lakes, precipitation over the aquifer and tributary areas, landscape irrigation, and septic systems (Bartolino, 2007). The aquifer also receives water as underflow from tributary basins and surrounding highlands. The aquifer discharges to the Spokane River (in Washington) and to wells. Substantial underflow occurs from the Rathdrum Prairie Aquifer across the state line into the Washington portion of the Spokane Valley-Rathdrum Prairie Aquifer.

Estimated flows into the entire Spokane Valley-Rathdrum Prairie Aquifer were estimated to be approximately 1,470 cfs under average conditions between 1990 and 2005 (Kahle and Bartolino, 2007). The bulk of these inflows occur as seepage from the Spokane River and Hayden, Pend Oreille, Spirit, Coeur d'Alene, Twin, Newman, Hauser, Fernan, and Liberty Lakes. This recharge rate, if occurring steadily throughout a year, would yield an aggregate annual recharge volume of approximately 1,000,000 acre feet per year.

6.2.2 Hydraulic Characteristics

The Rathdrum Prairie Aquifer is highly transmissive. Kahle and Bartolino (2007) list previously reported estimates of hydraulic conductivity in the Spokane Valley-Rathdrum Prairie Aquifer as ranging from about 1,000 to several tens of thousands feet per day (ft/d). Drost and Seitz (1978) list transmissivity in the Spokane Valley-Rathdrum Prairie Aquifer ranging from about 130,000 to 11,000,000 ft²/day.

Hsieh et al. (2007) summarize hydraulic conductivity values in the following way:

> *"... available data indicate that K_h [hydraulic conductivity] values in the central part of the SVRP [Spokane Valley-Rathdrum Prairie] aquifer range from about 1,000 ft/day to several tens of thousands of feet per day. In … the vicinity of Coeur d'Alene, K_h values appear to be near the low end of the range. Near the aquifer perimeter and inside valleys, K_h values might be a few hundred feet per day or less."*

Calibration of the most recent Spokane Valley-Rathdrum Prairie Aquifer model (Hsieh et al., 2007) resulted in hydraulic conductivity values ranging from approximately 6,000 to 22,000 ft/day in the central portion of the Rathdrum Prairie Aquifer. Calibrated hydraulic conductivity at the margins of the Rathdrum Prairie Aquifer ranged from 5 to 140 ft/day.

The highly transmissive nature of the Rathdrum Prairie Aquifer means that the impact of water use in one portion of the aquifer will rapidly propagate throughout the entire aquifer. In general, increased ground water withdrawals (at least in the amounts projected in this study) from most parts of the Rathdrum Prairie Aquifer will likely not be limited by water availability or hydraulic constraints. However, increases in ground water withdrawals may be constrained along the basin margins by limited aquifer thickness and/or aquifer permeability.

6.3 Water Quality and Environmental Constraints

Future water demand and supply should be considered in the context of potential water-quality or other environmental constraints. These constraints could occur on the supply side (if water quality becomes compromised) or on the discharge side (if communities are unable to treat and discharge effluent).

In general, the current water quality in the Rathdrum Prairie is good. Source water protection plans and activities, including limitations on development densities for subdivisions without centralized community wastewater systems, are currently in place to protect water supplies. Individual subsurface sewage systems are only allowed on parcels of land five acres in size or larger, unless a sewage management plan and agreement are in place. However, future contamination could reduce the amount of water available from the aquifer without extensive treatment.

On the discharge side, potential constraints could arise because of limitations associated with Total Maximum Daily Loads (TMDLs) and the National Pollutant Discharge Elimination System (NPDES) permitting process. In effect, potential discharge constraints could limit the amount of water pumped from the aquifer for non-consumptive purposes. Such discharge constraints could include nutrients (particularly phosphorus) because of their impact on dissolved oxygen in surface water. Sources of phosphorus include wastewater treatment plants and non-point sources such as livestock grazing, cropland/agricultural land uses, septic systems, and residential fertilizer application. A TMDL has been finalized by finalized by WDOE (in approved by EPA) for dissolved oxygen in Lake Spokane, Washington. This TMDL affects discharges to the Spokane River in Idaho. Potential legal challenges have been discussed by the regulated Idaho municipalities[22].

Draft NPDES permits are posted on EPA's website[23]. The NPDES permits are in the process of being finalized and the final numbers may be different from those listed the draft documents. Adoption of the draft permits would result in the lowest phosphorus limits in the country for the Hayden Area Regional Sewer Board (HARSB) and the Post Falls wastewater treatment plants. EPA studies in 2008 also indicated that if all the cities along the Spokane River installed state-of-the-art treatment for phosphorus removal, the river would continue to exceed the dissolved oxygen standard for Lake Spokane. New treatment technologies are being tested in two separate studies at a cost of more than $18 million at the Coeur d'Alene Wastewater Treatment Plant and Spokane's Riverside Park Water Reclamation Facility.

In Idaho, total phosphorus TMDLs were established for Hauser Lake, Hayden Lake, and the Twin Lakes in 2001. The total phosphorous TMDL for the Twin Lakes addresses Fish and Rathdrum Creeks as well. The requirements laid out in the Lake Spokane TMDL described above are greater than the ones laid out in the Upper Spokane River TMDL due to more stringent dissolved oxygen standards in the state of Washington.

Nutrient water-quality standards (which drive TMDLs) are currently in a state of flux in Idaho. Idaho's criterion for nutrients is narrative. The Idaho Department of Environmental Quality (as well as other state agencies around the country) is currently working on a national EPA initiative to develop numeric nutrient criteria.

Current negotiated rulemaking efforts in the State of Idaho for antidegradation and the Wastewater Reclamation and Reuse Rule may have significant impacts on local water supply[24]. The Idaho Department of Environmental Quality (IDEQ) is working to revise Idaho water quality standards (IDAPA 58.01.02) to include an approach for limiting degradation of water quality[25]. IDEQ is also seeking to revise highly-treated wastewater requirements; specifically IDEQ is seeking tape change existing reclaimed

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[22] Paul Klatt, personal communication, June 28, 2010.
[23] See http://yosemite.epa.gov/r10/WATER.NSF/NPDES+Permits/Draft+NP787.
[24] *Ibid*.
[25] See http://www.deq.idaho.gov/rules/water/58_0102_1001_negotiated.cfm (accessed 6/28/2010).

wastewater nomenclature and requirements, adding language to allow for a time extension of reuse permits under certain conditions, and clarifying rule language[26].

6.4 Climate Variability

The prospects for future climate variability and change for the Rathdrum Prairie Aquifer area were evaluated through literature review. The principal work done on this topic has been carried out by the Climate Impacts Group (CIG) at the University of Washington. The most recent CIG study (Climate Impacts Group, 2009) used 20 different climate models to evaluate two greenhouse gas emissions scenarios (the "medium A1B" and "low B1" scenarios). The results of the CIG study are generally presented as averages for the Pacific Northwest region and are stated relative to 1970-1999 averages based on weather observations.

The principal conclusions to be drawn from the CIG study are as follows:

1. Expect changes in temperature and precipitation to accelerate from 20th century trends, though natural variation will somewhat mask these changes.
2. Expect annual average warming of about 3.2°F by 2040 and about 5.3°F by 2080 (some models showed nearly 10 deg F warming by 2080).
3. Expect potential evapotranspiration (PET) to increase up to 6% per C° increase in temperature. The total PET increases for the projected 2040 and 2080 temperature increases are about 12% and 19%, respectively (based on sensitivity analysis using the Hamon equation (Hamon, 1961 - see Appendix F).
4. This translates to an increased irrigation requirement of 12 mm (0.5 inch) in July.
5. The expected change in precipitation is less clear, but expect an overall annual increase of 2.3% by 2040, and of 3.8% by 2080.
6. Expect interior parts of the region (e.g., the Rathdrum Prairie Aquifer area) to become wetter in fall and winter, but drier in spring and summer.
7. The Hamon analysis (see above) does not include effects of changing precipitation. If warming is coupled with irrigation-season drying (as

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[26] See http://www.deq.idaho.gov/rules/waste_water/58_0117_1001_negotiated.cfm (accessed 6/28/2010).

the climate modeling suggests for most of the West), then PET and irrigation requirements (PET minus effect of precipitation) could increase further.

8. Expect runoff to occur earlier, with more winter precipitation falling as rain.
9. Expect heating degree days[27] to decline in the fall, winter and spring, and expect cooling degree days to increase in the summer.
10. Expect extreme temperature and precipitation events to increase in frequency.

These findings are generally consistent with national assessments (e.g., Brown, 1999). More detailed discussion of the assumptions and findings from the CIG study, and presentation of methods for calculating changes in evapotranspiration and heating and cooling degree-days are contained in Appendix F.

Several assumptions were made regarding the future water-demand projections presented in this report:

1. The average precipitation deficit (equivalent to an irrigation demand) could increase between 5% and 20% in the next 5 decades. For the purposes of this analysis, the precipitation deficit was assumed to increase by 10% over the next 50 years as a result of increasing evapotranspiration rates. Our projections (Section 8.6) include a sensitivity analysis based on possible 5% and 20% precipitation deficit increases over the next 50 years.
2. While some increase in average annual precipitation may occur, we assume that this increase will not occur during peak summer irrigation months, but will instead occur during the fall, winter, and or spring. Relatively thin soils will prevent substantial storage of soil moisture from spring into the summer irrigation season. The assumed future precipitation deficit was therefore not reduced to reflect potential precipitation increases.
3. There may be some increase in cooling demand as a result of increased summer temperatures. This would apply primarily to the Rathdrum Power facility. We have insufficient information to evaluate

[27] Heating and cooling degree days are measures of how cold or warm a location is over a period of time relative to a base temperature (usually 65°F). A decrease in heating degree days indicates a general rise in temperature. Similarly, an increase in cooling degree days also indicates a general rise in temperature.

this potential increased need, and therefore have not projected an increase in cooling water demand.

7 ASSESSMENT OF WATER CONSERVATION AND RE-USE POTENTIAL

7.1 Water Conservation

Water conservation measures take many forms, including public education, technical requirements for installation of low-water-use appliances and landscaping, and pricing structures that discourage excessive water use. Present water use rates and factors are not likely representative of future use rates, as federal mandates (low-flow fixtures and appliances) and water-provider costs (prompting leak detection and increased water rates) reduce future per-capita water use. It will take some time for these influences to work their way through existing housing stock, but they will almost certainly be reflected over a 50-year planning horizon.

At least some water conservation will impact future water demands in the Rathdrum Prairie. To evaluate the potential impact of future water conservation, we reviewed existing literature and used professional judgment and experience to develop factors to apply to future water-use rates. In particular, we considered potential conservation impacts associated with residential use, residential irrigation, commercial use, and agricultural irrigation use.

We characterized potential conservation rates – and rates of conservation implementation – at three general conservation levels: no conservation, medium conservation, and aggressive conservation. These conservation levels were applied to the three primary water-demand projection scenarios (based on high population growth, baseline population growth, and low population growth). We did not specify specific conservation measures that would lead to a particular conservation level. Instead, we projected assumed conservation outcomes that could be achieved by a combination of various potential water conservation measures and programs.

7.2 Potential Water Conservation Measures and Programs

Development of a list of potential water conservation measures and programs was completed by evaluating existing measures and programs in the area, reviewing the Idaho Department of Water Resources (IDWR) Draft Water Conservation Measures and Guidelines for Preparing Water Conservation Plans document (IDWR, 2006), and applying experience from developing and evaluating water conservation plans for both municipal and agricultural entities. The following is a list of potential water conservation measures and programs:

1. Water Efficient Fixtures/Appliances and Incentives
    a. Retrofit kits
    b. Indoor retrofitting at water provider facilities
    c. Rebates and incentives -- residential and non-residential
    d. Promotion of new technologies

2. Landscape Efficiency
    a. Promotion of landscape efficiency
    b. Landscape planning and renovation
    c. Selective irrigation sub-metering
    d. Irrigation management
    e. Turf/high water use landscaping buy-back/incentive program
    f. Xeric or drought-tolerant landscaping and demonstration gardens at provider facilities
    g. Certification program/classes for landscape/irrigation professionals
    h. Outdoor water conservation kits
    i. Rain sensor incentive
    j. Evaluation of landscape and irrigation plans for new/re-development
3. Water-Use Audits
    a. Audits of large-volume users
    b. Landscape and irrigation audits
    c. Indoor water audits for residential customers
4. Industrial and Commercial Efficiency
    a. Commercial and industrial water conservation education and support
    b. Low-flow commercial pre-rinse spray washers
5. Education/Information Distribution
    a. Public education
    b. Youth and teacher education
    c. Workshops
    d. Water conservation webpage
    e. Conservation information available for customers
6. Encouraging Water Conservation through Water Rate Structures and Billing
    a. Inverted, tiered water rate schedule
    b. Cost-of-service accounting
    c. User charges
    d. Metered rates
    e. Cost analysis
    f. No promotional rates
    g. Understandable and informational water bill

h. Peer-user information (e.g., average use by neighbors) printed on water bill
i. Water bill inserts

7. Regulations/Ordinances
    a. Water use standards and regulations
    b. Requirements for new developments
8. Other Water Management Activities
    a. Water conservation officer staff position
    b. Customer service
    c. Advisory committee
9. Water Reuse/Recycling
    a. Industrial and commercial applications; large-volume water users
    b. Treatment facility water conservation/efficiency opportunities
10. Universal Metering
    a. Source-water metering
    b. Surface-connection metering
    c. Meter public use water
    d. Fixed-interval meter reading
    e. Meter-extra seat analysis
    f. Test, calibrate, repair, and replace meters
11. Water Accounting and Loss Control
    a. System maintenance, leak detection, and repair program
    b. Analysis of "unaccounted" water
    c. Water system audit
    d. Automated sensors/telemetry
12. Pressure Management
    a. System-wide pressure regulation
    b. Selective use of pressure-reducing valves
13. On-Farm Water Use and Irrigation Districts
    a. On-farm water efficiency improvements
    b. Irrigation district operations (e.g., improved metering, peer water use reporting, etc.).

This list of potential conservation measures may not be appropriate for all water providers in the Rathdrum Prairie Aquifer area, as each of the providers operate under unique conditions. However, this list of water conservation measures and programs can be used as a guide for discussion among the water providers in determining which programs might be most appropriate. Also, the above outline does not represent an exhaustive list of water conservation options available. Additional user measures[28], such as replacing turf with xeric or drought-tolerant landscaping, or running washing machines only with a full load, could offer substantial water savings.

7.3 Potential Water Savings

The following three future water-demand conditions were used to evaluate potential water savings in the Rathdrum Prairie Aquifer area:

1. No conservation – i.e., no measures or programs are implemented throughout the study period. Continued "status quo" water use was assumed.
2. Intermediate conservation – only voluntary water conservation measures and programs are implemented and continuation of current plumbing codes occurs throughout the study period.
3. Aggressive conservation – water conservation programs are implemented with government-mandated measures that require maximum efficiency fixtures, appliances and other water saving behaviors (above and beyond current plumbing codes).

Estimates of potential water conservation in the Rathdrum Prairie Aquifer area were developed for the following general water-use categories:

1. Indoor residential use per household
2. Outdoor residential use per household
3. Commercial use per employee
4. Agricultural use per acre.

These potential water conservation outcomes are described in the following sections. It was assumed that only a minor amount of active water conservation is currently occurring in the Rathdrum Prairie Aquifer area[29]. As such, the baseline water use data calculated for each category reflects usage under this limited water conservation program implementation.

It is important to note that there is a level of uncertainty in the water use estimates and estimates of conservation potential. Estimates of potential savings were made based upon current literature and experience in water conservation planning, and should be considered regional in nature.

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[28] User measures are sometimes referred to as non-structural measures (e.g., using the washing machine only with a full load) as opposed to structural measures (a low water-use washing machine).
[29] Based on general observations, existing water use rates, water district websites.

7.3.1 Indoor Residential use per household

Baseline indoor residential use per household was estimated to be 190 gallons per day per household (Section 5.4.2). This value represents residential in-home use and does not include irrigation use or "unaccounted for" water within purveyor water distribution systems. To determine potential water savings in the indoor residential category, common household fixtures and appliances were evaluated on a water-flow and usage basis for the three different scenarios, as shown in Table 23.

The baseline scenario reflects water use rates for fixtures and appliances in a typical non-conserving home with a manufacture or install date between 1980 and 1995.

The Federal Energy Policy Act (FEPA) of 1992 established national maximum allowable water-flow rates for toilets, urinals, showerheads and faucets. Although there are no current applicable federal water-flow rates for washing machines and dishwashers, these appliances have also recently become more water efficient. The flow rates stated in FEPA are used in the intermediate scenario.

The aggressive scenario uses water-flow rates that are even more efficient than those stated in FEPA and that are currently available on the market. It was assumed that FEPA would remain in effect under the intermediate scenario for the next 50 years, and that even more stringent water efficiency regulations would be adopted with the aggressive scenario in the next 50 years. These different scenarios could be implemented through rebate and incentive programs, retrofit kits, and promotion of new technologies listed in Section 7.2.

Estimated annual implementation/replacement rates were applied to each scenario (Table 24) to calculate potential savings at 10-year intervals from 2010 to 2060 (Table 25). From 2010 to 2020, only one-third of the applicable implementation/ replacement rate was applied to reflect lower availability of more efficient fixtures and technology (e.g., those considered for the aggressive conservation level). Beyond 2020, the implementation/ replacement rate was applied consistently on an annual basis. Overall, washing machines and dishwashers have lower implementation rates because there are no current federal codes applicable to them and there is a wide variety of these appliances available (in terms of water use rates).

Level of Conservation →	Baseline		Intermediate		Aggressive	
Component	**Flow rate**	**Water use (gpd/unit)**	**Flow rate**	**Water use (gpd/unit)**	**Flow rate**	**Water use (gpd/unit)**
Toilets	4.00 gpf[1]	47.3	1.60 gpf[1]	18.9	1.28 gpf[2]	15.1
Showerheads	3.25 gpm[1]	26.6	2.50 gpm[1]	20.9	2.00 gpm[3]	16.4
Faucets	2.88 gpm[1]	35.7	2.00 gpm[1]	31.9	1.50 gpm[1]	18.8
Washing Machines	51 gpl[1]	43.7	27 gpl[1]	23.1	23 gpl[4]	19.3
Dishwashers	12 gpl[1]	2.7	7.0 gpl[1]	1.6	4.5 gpl[1]	1
Baths	N/A	3.3	N/A	3.3	N/A	3.3
Leaks	N/A	26.3	N/A	9.3	N/A	3.3
Other Domestic	N/A	4.4	N/A	4.4	N/A	4.4
Total (Daily Average)		**190**		**113**		**82**

gpf = gallons per flush
gpm = gallons per minute
gpl = gallons per load

References:

[1] Vickers (2001).

[2] EPA WaterSense tank-type high efficiency toilet specification (January 24, 2007).

[3] New specifications for EPA WaterSense labeled showerheads (available beginning early 2010).

[4] Horizontal axis/front loading residential washing machine (http://www.allianceforwaterefficiency.org)

Assumptions:

1. Data corresponding to the number of toilet flushes/person/day, minutes/person/day, faucet use, etc. used in calculating water use (gpd/household) are based on Vickers, 2001.
2. The number of baths, showers, and other domestic uses remain the same for each scenario.
3. Leaks will always be present in the indoor sector, although technology will allow for this number to decrease with each scenario (except for Baseline scenario).

Table 23. Potential per-unit residential domestic (indoor) water conservation.

For the baseline scenario, no conservation programs were assumed over the next 50 years, although in reality there will still be some natural retrofit occurring as fixtures and appliances reach the end of their service life and are replaced. These new appliances and fixtures that replace older, less water-efficient ones were assumed to align with the water-flow rates in the intermediate scenario because those reflect current plumbing codes and are items readily available on the market. For example, in 50 years under the baseline scenario, 60% of washing machines will still use 51 gallons per load (gpl), but the remaining 40% will use 27 gpl.

Level of Conservation →	Baseline		Intermediate		Aggressive	
Component	Annual Conversion Rate	Total Number Converted by 2060	Annual Conversion Rate	Total Number Converted by 2060	Annual Conversion Rate	Total Number Converted by 2060
Toilets	0.5%	25%	1.8%	90%	1.9%	95%
Showerheads	0.5%	25%	1.8%	90%	1.9%	95%
Faucets	0.5%	25%	1.8%	90%	1.9%	95%
Washing Machines	0.8%	40%	1.0%	50%	1.5%	75%
Dishwashers	0.8%	40%	1.0%	50%	1.5%	75%
Baths	N/A		N/A		N/A	
Leaks	N/A		N/A		N/A	
Other Domestic	N/A		N/A		N/A	

Note: From 2010 – 2020, 1/3 of the replacement/implementation rates were applied
-Baths and other domestic uses will remain the same for each scenario
-Leaks will always be present in the indoor sector, although technology will allow for this number to decrease with each scenario (except for Baseline scenario)

Table 24. Potential replacement/implementation rates for domestic (indoor) water conservation measures.

Applying the replacement/implementation rates to each of the conservation levels provide a use per household rate (presented in the form of average daily demand per-unit – see Table 25). In this analysis, water savings are applied to existing customers and new development in the same manner, and it was assumed that water use behaviors (non-structural water use) remain the same as present day. Also included in Table 25 are the percentage reductions in water use as compared to the current baseline level of 190 gpd/household (82 gallons per-capita per day). These values range from 1% in the baseline scenario by 2020 to over 50% savings in the aggressive scenario by 2060. The potential savings are significant because the current baseline level represents a fairly high indoor residential water usage amount.

Level of Conservation →	Baseline		Intermediate		Aggressive	
Year	Average Daily Demand (gpd/unit)	% reduction from 2010 baseline	Average Daily Demand (gpd/unit)	% reduction from 2010 baseline	Average Daily Demand (gpd/unit)	% reduction from 2010 baseline
2010	190	0%	190	0%	190	0%
2015	189	1%	187	2%	185	3%
2020	187	1%	184	3%	180	5%
2025	181	5%	175	8%	166	13%
2030	174	9%	165	13%	151	21%
2035	170	11%	159	17%	141	26%
2040	165	13%	153	20%	131	31%
2045	161	15%	147	23%	121	37%
2050	157	17%	141	26%	111	42%
2055	153	20%	135	30%	101	47%
2060	149	22%	128	33%	91	52%

These average reductions in residential water demand over the next 50 years are based on the per-unit potential savings listed in Table 23 and the potential replacement/implementation rates listed in Table 24.

Table 25. Potential average reduction in residential domestic (indoor) water use.

7.3.2 Outdoor Residential Conservation

Water systems with a service population of 750 people or less were analyzed to evaluate existing water outdoor use in the study area. The larger water providers were excluded from this evaluation because many of them have commercial, industrial, and institutional irrigation components included in their total irrigation water use. Baseline outdoor residential use per household was estimated to be 224 gpd/household, or approximately 54% of total annual household usage.

Over the next 50 years, reduction in residential outdoor usage across the Rathdrum Prairie could be achieved through installation of xeriscape (native plants, grasses, mulches, etc.) as a replacement of typical turf grass. Water-use reductions also could be achieved with improved irrigation efficiency measures such as proper soil amendment practices, better irrigation management, implementing water budgets, and using current irrigation technology. Various programs described in Section 7.2 above under the landscape efficiency category could assist water providers in implementing these outdoor water use changes.

Table 26 provides the annual replacement/implementation rates for xeriscape landscaping and improved irrigation efficiency. It was assumed that the baseline water-use conservation level would remain consistent over the next 50 years with no changes in existing application rates.

Potential annual reduction in outdoor residential water use						
Method	Level of Conservation					
	None		Intermediate		Aggressive	
Xeriscape Landscaping	0%/yr		0.1%/yr to 4.9% total in 2060		0.4%/yr to 18% total in 2060	
Improved Irrigation Efficiency	0%/yr		0.1%/yr to 4.9% total in 2060		0.4%/yr to 18% total in 2060	
Total Outdoor Water Use Reduction	0%/yr		0.20%/yr to 9.5% total in 2060		0.80%/yr to 33.0% total in 2060	
Year	**Annual Reduction in Demand (%)**	**Reduction from 2010 baseline (%)**	**Annual Reduction in Demand (%)**	**Reduction from 2010 baseline (%)**	**Annual Reduction in Demand (%)**	**Reduction from 2010 baseline (%)**
2010	0%	0%	0.2%	0%	0.8%	0%
2015	0%	0%	0.2%	1.0%	0.8%	3.9%
2020	0%	0%	0.2%	2.0%	0.8%	7.7%
2025	0%	0%	0.2%	3.0%	0.8%	11.4%
2030	0%	0%	0.2%	3.9%	0.8%	14.8%
2035	0%	0%	0.2%	4.9%	0.8%	18.2%
2040	0%	0%	0.2%	5.8%	0.8%	21.4%
2045	0%	0%	0.2%	6.8%	0.8%	24.5%
2050	0%	0%	0.2%	7.7%	0.8%	27.5%
2055	0%	0%	0.2%	8.6%	0.8%	30.3%
2060	0%	0%	0.2%	9.5%	0.8%	33.1%

Table 26. Potential reduction in outdoor residential water use.

It was assumed that under the intermediate scenario (which includes only voluntary water conservation measures); the average xeriscape will use approximately 5% less water annually (per actual irrigated acre) at the end of the 50 year timeframe. It was further assumed that improving landscape irrigation efficiency across the study area will provide an additional 5% water savings.

The aggressive scenario provides higher water savings rates compared to the intermediate scenario reflecting an assumption that households would be required to convert a certain amount of outdoor area to xeriscape landscape and install more efficient irrigation systems. These two programs were estimated to each provide approximately 18% annual water savings at the end of the 50 year timeframe.

Table 26 provides an estimate of the water savings that could be achieved in the outdoor residential sector during the 50-year study timeframe. Ranges of potential water savings in the outdoor residential sector via implementation of xeriscape landscaping and improved irrigation efficiency vary from 0% under the baseline (no conservation) scenario to approximately 33% by 2060 under the aggressive conservation scenario.

7.3.3 Commercial and Industrial Conservation

It was assumed that fairly similar levels of efficiency exist in the commercial sector and residential sectors. However, the reduction factors described above were only applied to the potential residential indoor and outdoor water savings. Potential reductions in commercial and industrial facilities are likely less than in a typical residential home. For instance, the frequency of showerhead, faucet, washing machine and dishwasher use is smaller, and less water is used for toilet flushing due to the increased prevalence of more water-efficient urinals available for use by males in commercial settings. Additionally, it is likely the commercial sector is more water efficient compared to the residential sector in terms of its outdoor usage (due to more technologically advanced irrigation systems, professional landscape care, etc.).

Potential reductions in commercial water use per employee were assumed to be 0% for the "no conservation" level, 20% by 2060 for the "moderate conservation" scenario, and 40% by 2060 for the "aggressive conservation" scenario.

7.3.4 Potential Agricultural Water-Use Reduction

In the Rathdrum Prairie Aquifer area, forage crops are often irrigated using ground water delivered via pressurized lines. It was assumed that the irrigation efficiency of existing Rathdrum Prairie sprinkler-irrigation systems is approximately 70%. However, it was also assumed that irrigation deliveries could be made more efficient with more efficient sprinkler heads, irrigation timing, etc. Thus, it was assumed that the irrigation efficiency in the moderate conservation scenario would be 75% by the year 2060, and 80% by the year 2060 in the aggressive conservation scenario. These values are consistent with a range of sprinkler irrigation efficiency values (Table 27) developed by the Idaho Irrigation Water Conservation Task Force (1994) and accepted by the Idaho Department of Water Resources (1999).

Sprinkler System	Application Efficiency
Stationary letter (wheel or hand move)	60 to 75%
Solid set lateral	60 to 85%
Traveling big gun	55 to 67%
Stationary big gun	50 to 60%
Center pivot lateral	75 to 85%
Moving lateral (linear)	80 to 87%
Source: Idaho Department of Water Resources, 1999 (pg. 38)	

Table 27. Sprinkler system efficiency.

7.4 Water Reuse

In general, water reuse is a potential method to increase water supplies, and does not bear directly on future water demands. Indirect reuse, wherein treated wastewater is stored in the environment (e.g., in aquifers, ponds, reservoirs, or river flows) before it is re-diverted, is widely practiced in many areas of the United States. Highly developed reuse systems using ground water recharge have operated for decades in Texas and Southern California. Water reuse in the Rathdrum Prairie mainly takes the form of irrigation associated with land-application programs. Direct potable reuse remains rare and will likely not become a substantial source of potable water in the Rathdrum Prairie over the next 50 years.

However, changing discharge and reuse regulations (see Section 6.3) could have an indirect effect on water demand. Increasing water reuse as a result of stringent discharge regulations could lead to (1) more retained agricultural irrigation, (2) pressure to use municipal water "to extinction" (i.e., reduce discharge), and (3) increased urban density (because otherwise buildable ground is protected for the application of treated wastewater). Some of these indirect changes could lead to higher consumptive-use rates.

The standards for water reuse in the Rathdrum Prairie are governed by the Idaho Administrative Procedures Act (IDAPA) Part 58, Title 01, Chapter 17, “Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater.” According to these rules, reuse water falls under one of five classes, A through E. Class A requires the most stringent treatment and reliability standards, and Class E has the least stringent treatment standards with the most restrictive buffer zones and access requirements. If the reuse water is intended for ground water recharge, additional provisions apply. In particular, one provision within IDAPA 58.01.17 states:

“Ground water recharge site locations shall be a minimum of one thousand (1000) feet from any down gradient drinking water extraction well and shall also provide for a minimum of six (6) months time of travel in the aquifer prior to withdrawal.” (IDAPA 58.01.17, Section 608[d]).

This provision renders ground water recharge not practical in most cases because the Rathdrum Prairie Aquifer area contains a large number of drinking water wells, and the subsurface hydraulic conductivity is high (Kahle and Bartolino, 2007). There is a low likelihood of finding a suitable location for a facility where the recharge water time of travel in the aquifer is at least six months. Another obstacle to ground water recharge is that all recharge activities must comply with IDAPA 58.01.11, the “Ground Water Quality Rule.” The Rathdrum Prairie Aquifer is classified as a “Sensitive Resource Aquifer,” and as such will be held to a higher water quality standard under the Ground Water Quality Rule than a “General Resource Aquifer.”

Irrigation and other reuse activities that are not classified as recharge under the Ground Water Quality Rule are still feasible. Such uses include irrigation of farmland, orchards, vineyards, golf courses, cemeteries, parks, playgrounds, and schoolyards (IDEQ, 2007). The quality of the effluent will affect what it can be used for and the degree of access restrictions required. To assist with the design of reuse programs, the IDEQ published a document titled “Idaho Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater” (IDEQ, 2009)[30]. This document is available from the IDEQ website and describes the permitting process and other considerations for a reclamation and reuse system.

[30] Accessed January 14, 2010. <http://www.deq.state.id.us/water/permits_forms/permitting/wlap.cfm>

8 WATER DEMAND PROJECTIONS

8.1 Introduction

The primary task of this study was to project Rathdrum Prairie water demand for the next 50 years. This was done in the form of scenarios characterizing various levels of future water demand. This section provides a discussion of scenario development and presents water demand projections for each scenario.

8.2 Factors Influencing Future Water Demand

There are two general categories of factors that will shape future water demand: (1) exogenous factors over which local policies have limited influence and (2) local factors over which public policy and private incentive can have substantial influence. Exogenous factors include the strength of the national or global economy and national demographic trends that strongly influence regional population and job growth. Although local governmental policy can influence local economic growth to some degree, the local economy is largely influenced by national or global factors. One needs to look only at economic trends in the last several years to see that some of these factors are difficult to predict. In contrast, regional land-use policies, building codes, governmental policies, water delivery pricing, and other more local measures can be influenced locally and can have a substantial impact on future water demand.

8.3 Scenario Descriptions

Future water demand projections were made based on three general scenarios of future water demand. The three water demand scenarios were defined by three different population growth scenarios: low population growth, medium-level ("baseline") population growth, and high population growth.

Because population growth is largely influenced by national and global economic and demographic trends, there is likely little that can be done by water managers to influence the level of population growth in the Rathdrum Prairie Aquifer area over the next 50 years. However, local policies could have a substantial influence on the amount of water use within these population-growth scenarios. Thus, we also projected future water demand for three different conservation levels within each of the primary water-demand scenarios.

The three primary scenarios, each with three sub-scenarios, result in nine different projections of potential future water demand (Table 28). These scenarios are categorized by "external realm" (population and economic growth) and "policy realm" (housing density, conservation level, and implementation rate).

8.4 Primary Scenario Assumptions

The following subsections describe primary assumptions that were used in the water demand projections.

8.4.1 External Realm

The "external realm" scenarios are based on projected employment and numbers of households, which correspond closely with population projections. The population and employment growth rates are presented in Section 4.5.3 and 4.5.4, respectively. The "baseline forecast" probably represents the most likely population- and employment-growth outcomes. However, the annual percentage population growth represented by the "low forecast" (based on an annual growth rate of about 1.6% per year) has occurred in the past and regional growth could conceivably occur for extended periods at this rate in the future. Similarly, the annual percentage growth represented by the "high forecast" (3% population growth per year) has also occurred in the past and could conceivably occur for extended periods of time in the future.

Scenario Summary				
Scenario Matrix		External Realm (Population growth, economic growth)		
		Low growth	Baseline growth	High growth
Policy Realm (Conservation level)	No conservation	Scenario 1a	Scenario 2a	Scenario 3a
	Intermediate conservation	Scenario 1b	Scenario 2b	Scenario 3b
	Aggressive conservation	Scenario 1c	Scenario 2c	Scenario 3c

Table 28. Water-demand scenario matrix.

8.4.2 Policy Realm

It was assumed that some of the water conservation measures described in Section 7.1 could be implemented and would result in water demand reductions. Three general conservation levels were embodied in these scenarios: no conservation, an intermediate conservation level, and an aggressive conservation level. These conservation levels were not based on specific conservation measures but rather on an assumed outcome (see Section 7.3). Various conservation strategies could yield the water conservation outcomes assumed in these scenarios.

8.4.3 Other Assumptions

A number of other assumptions were made in the development of these scenarios. These assumptions are listed below:

1. Precipitation deficit will increase by about 10% over the next 50 years. This value reflects the uncertainty inherent in climate models that suggest that evapotranspiration could range from approximately 5% to 20% over the next 50 years (see Section 6.4). Despite this general assumption, the effect of a 5% and a 20% increase in irrigation demand was evaluated for one scenario (Scenario 2b).
2. The current aggregate irrigation efficiency for agricultural irrigation is approximately 70%. It was assumed that moderate conservation efforts could lead to an irrigation efficiency of 75% by the year 2060; aggressive conservation efforts could lead to an irrigation efficiency of 80% a year 2060. Again, it was assumed that these increases would occur evenly throughout the next 50 years.
3. It was assumed that approximately 70% of the existing housing stock could be described as "high-density" (four units per acre or more); 10% of the existing housing stock could be described as "medium density" housing (approximately 2 units per acre); and 20% of the existing housing stock could be described as "low density" (less than 1 unit per acre). The density percentages for new housing were assumed to be 85%, 5%, and 10%, respectively. These percentages do not describe land use; they pertain solely to the density of current and future housing units. Also, these are project densities; overall density accounting for common spaces, neighborhood access roads, arterials and transportation corridors, etc. would be less.
4. It was assumed that the irrigated area of high-density housing, medium-density housing, and low-density housing would be 0.08, 0.2, and 0.3 acres per housing unit. The first value is based on the assumption that 60% of high-density residential areas are impervious. Irrigated-area assumptions for medium-density and low-density housing were based on the assumption that not all pervious area is irrigated.
5. It was assumed that there would be no changes in the amount of irrigated area per household over the next 50 years. However, some assumed conservation outcomes (i.e. hardscaping or xeriscaping) could lead to reduced irrigated acreage.
6. It was assumed that 6,400 acres of currently irrigated agricultural ground will be retained for potential land application of municipal wastewater.
7. The percentage reduction in commercial, industrial, and institutional water use over the next 50 years would be about 20% with moderate

conservation and 40% with aggressive conservation. These values are based on personal experience and professional judgment.

8. Institutional irrigation (irrigation for public parks, schools, etc.) is not fully described in the water use per governmental employee data listed in Section 4.5.4. Estimates of "institutionally-irrigated" area (0.07 acres per resident) were made based on the Post Falls municipal water-use data.
9. Irrigation demand for residential, commercial, and institutional areas were based on the precipitation deficit for irrigated turf lawns. The irrigation demand for agricultural areas was based on a weighted precipitation deficit for grains, alfalfa, grass seed, and pasture.
10. It was assumed that 10% of withdrawals in community water systems is "unaccounted" water -- water that is pumped but lost through pipe leakage, used for system flushing, or used for fire protection.

Future consumptive use was estimated in the following way:

1. Only 5% of self-supplied indoor domestic use was considered to be consumptive use; 95% of future indoor domestic water use returns to the aquifer via septic seepage, aquifer infiltration resulting from the land application of treated municipal effluent[31], and discharge of treated municipal effluent to the Spokane River.
2. 10% of community water system non-irrigation use is consumptive; 90% of the non-irrigation withdrawals are returned to the aquifer via land application of treated municipal effluent or the discharged to the Spokane River as treated municipal effluent.
3. 40% of the commercial and industrial use is effectively consumed; 60% returns to the aquifer as of land applied municipal effluent or is discharge to the Spokane River as treated municipal effluent.
4. 70% of ground water pumped for irrigation is fully consumed through evapotranspiration.
5. All "unaccounted for" water was assumed to return to the aquifer (i.e. it is non-consumptive).

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[31] Some land-applied municipal effluent used for irrigation is lost to evapotranspiration. However, the use of treated municipal effluent of averts the need for ground water diversions. Thus, in effect, we considered the municipal domestic use to be non-consumptive even if it is land applied.

8.5 Future Water Demand

By the year 2060, water demand (assuming a general 10% evapotranspiration increase over the next 50 years – see Section 6.4) in the Rathdrum Prairie could range from approximately 77,600 acre-feet to 223,000 acre-feet (Figure 16 and Table 28), depending on the level of population and employment growth and on the level of water conservation. An annual use of 77,600 acre-feet would represent an approximate 5% increase from the projected 2010 water demand, and would result from slow population growth (approximately 1.6% per year) and aggressive water conservation (Scenario 1c). In contrast, higher population growth (3% per year) and minimal water conservation would result in an annual demand of approximately 223,000 acre-feet by the year 2060 (Scenario 3a), which would represent an increase of 195% over the estimated 2010 demand.

If history is a guide, the population and employment growth will likely fall between the 1.6% and 3.0% annual growth rates used in Scenarios 1 and 3. The projected future water demand for the baseline (i.e., medium) population and employment forecast (based on average annual population increase of approximately 2.3%) ranges from approximately 101,000 acre-feet (Scenario 2c) to 163,000 acre-feet (Scenario 2a). This range in future water demand reflects differences in potential conservation levels and conservation implementation rates.

These projected future water demands represent aggregate ground water withdrawals from the Rathdrum Prairie Aquifer. However, a substantial portion of the withdrawals return to the aquifer as seepage from system leakage, septic effluent, land-applied municipal wastewater, and excess irrigation applications. Similarly, some treated municipal effluent is discharged to the Spokane River. In general, most of the *consumptive use* – that portion of the water lost from the local hydrologic system – consists of water lost to evapotranspiration as a result of irrigation.

The estimated consumptive use in the year 2010 is approximately 53%[32] of the total water demand (Figure 17 and Table 30). The projected Rathdrum Prairie consumptive use in the year 2060 ranges from approximately 46,000 to 102,000 acre-feet (Figure 17 and Table 30). For baseline population growth projections (Scenario 2), the 2060 consumptive use could range from approximately 59,000 to 76,000 acre-feet, depending on the level of conservation. The 2060 baseline consumptive use projections represent a 49% and 92% increase over 2010 levels, respectively (Table 30).

Water demand for individual sectors is shown by scenario in Figure 18 through Figure 20. In 2010, residential, agricultural, and institutional irrigation represents approximately 68% of the total water demand; 14% of the water is used for residential

[32] 39,700 acre-feet divided by 74,400 acre-feet.

domestic purposes, 13% is used for commercial and industrial purposes, and approximately 5% of the water is "unaccounted for" water. These percentages will vary in the future depending on the level of water conservation.

Irrigation consumptive use is approximately 89% of the aggregate estimated 2010 consumptive water use. The consumptive use for Scenario 2b is shown in Figure 21.

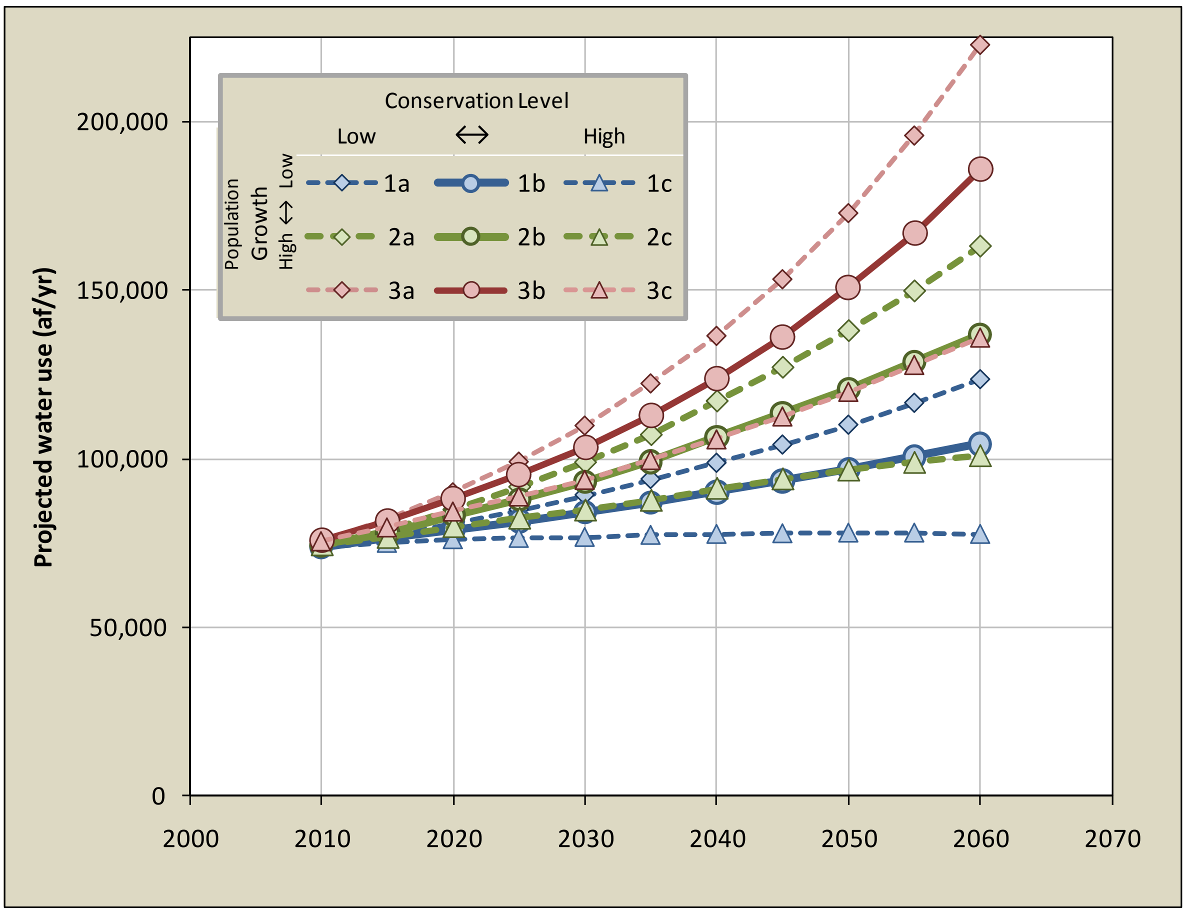

Figure 16. Water demand projections.

Scenario Summary (Water Demand)									
Population and employment growth →	Scenario 1			Scenario 2			Scenario 3		
	Low			Baseline			High		
Conservation Level →	None	Medium	Aggressive	None	Medium	Aggressive	None	Medium	Aggressive
Year	1a	1b	1c	2a	2b	2c	3a	3b	3c
2010	73,900	73,900	73,900	74,400	74,400	74,400	75,600	75,600	75,600
2015	77,200	76,400	74,900	78,900	78,100	76,600	82,300	81,300	79,700
2020	80,800	79,100	76,000	84,900	83,100	79,800	90,100	88,000	84,400
2025	84,800	81,500	76,400	91,600	88,000	82,300	99,200	95,100	88,900
2030	89,100	84,100	76,700	98,900	93,000	84,700	109,900	103,200	93,800
2035	93,800	87,100	77,300	107,100	99,100	87,600	122,400	112,900	99,700
2040	98,600	90,100	77,600	117,100	106,500	91,200	136,500	123,700	105,800
2045	104,000	93,400	77,800	127,100	113,400	94,000	153,300	136,300	112,600
2050	109,900	96,900	78,000	138,000	120,800	96,600	172,900	150,700	119,900
2055	116,400	100,500	78,000	149,800	128,600	98,900	195,900	167,100	127,900
2060	123,400	104,300	77,600	163,100	136,800	100,900	222,800	185,800	136,000
Percent increase over 2010 levels	67%	41%	5%	119%	84%	36%	195%	146%	80%

Table 29. Water demand projections.

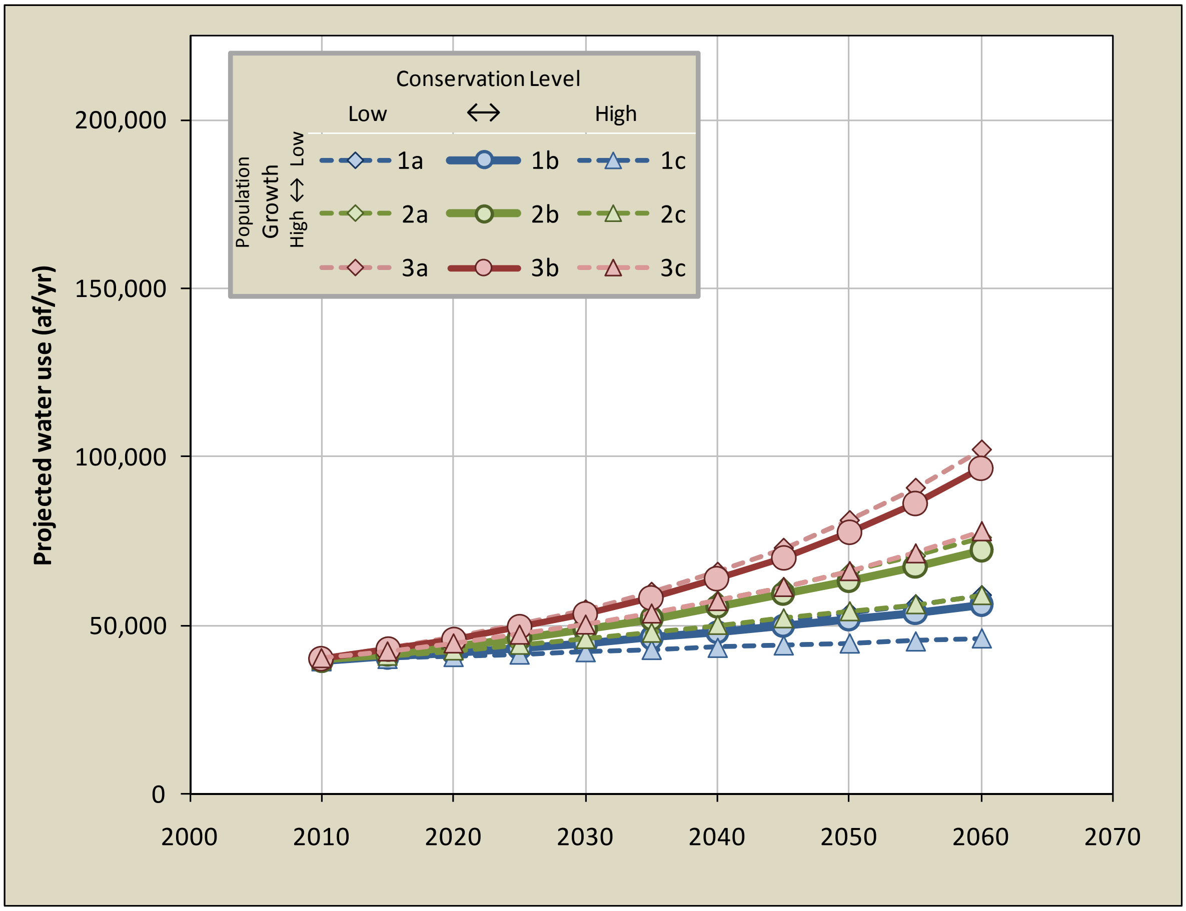

Figure 17. Consumptive use projections.

Scenario Summary (Consumptive Use)									
Population and employment growth →	Scenario 1			Scenario 2			Scenario 3		
	Low			Baseline			High		
Conservation Level →	None	Medium	Aggressive	None	Medium	Aggressive	None	Medium	Aggressive
	1a	1b	1c	2a	2b	2c	3a	3b	3c
2010	39,500	39,500	39,500	39,700	39,700	39,700	40,300	40,300	40,300
2015	40,800	40,700	40,200	41,600	41,500	40,900	43,100	42,900	42,300
2020	42,300	42,000	40,800	44,100	43,800	42,500	46,400	46,000	44,700
2025	43,900	43,400	41,500	46,800	46,300	44,200	50,200	49,500	47,300
2030	45,600	44,800	42,200	49,800	48,900	45,900	54,700	53,600	50,300
2035	47,400	46,400	42,900	53,200	52,000	47,800	59,900	58,400	53,600
2040	49,300	48,100	43,500	57,300	55,700	50,100	65,800	63,900	57,300
2045	51,500	49,800	44,200	61,400	59,300	52,100	72,900	70,200	61,500
2050	53,800	51,800	44,800	65,900	63,200	54,200	81,100	77,700	66,200
2055	56,300	53,800	45,400	70,700	67,400	56,300	90,700	86,300	71,500
2060	59,000	56,300	46,300	76,200	72,400	59,000	102,000	96,700	78,100
Percent increase over 2010 levels	49%	43%	17%	92%	82%	49%	153%	140%	94%

Table 30. Consumptive use projections.

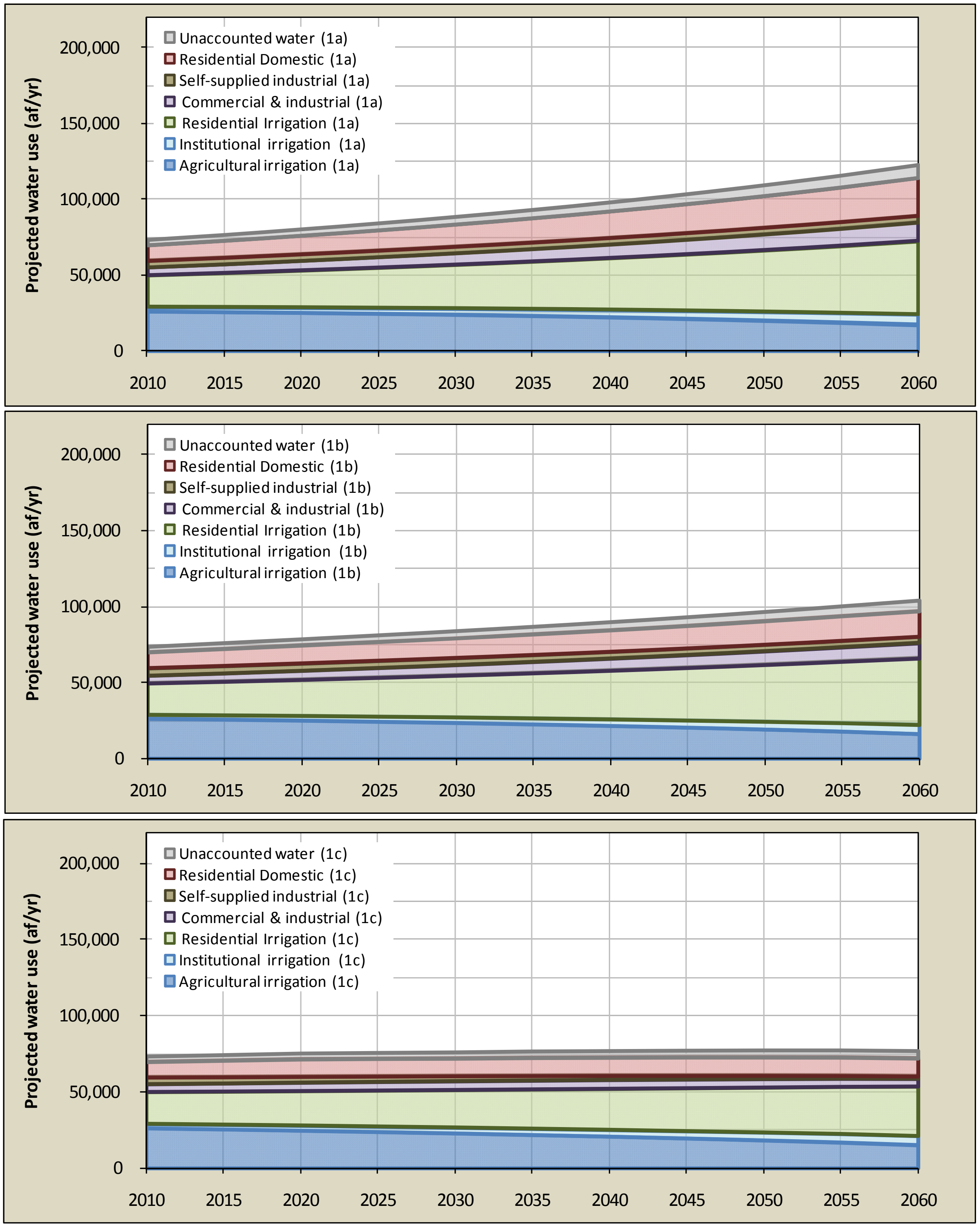

Figure 18. Future water demand, Scenario 1.

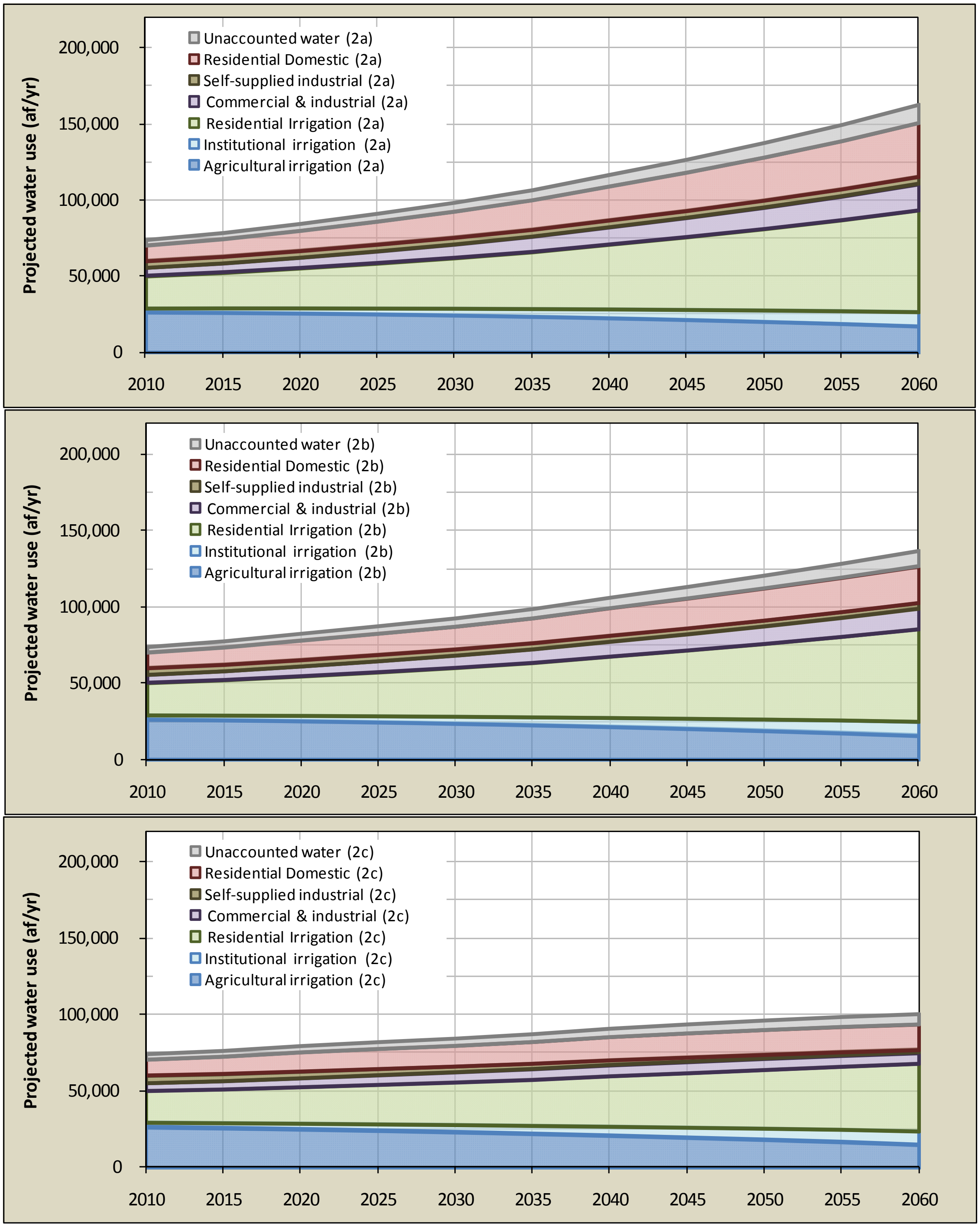

Figure 19. Future water demand, Scenario 2.

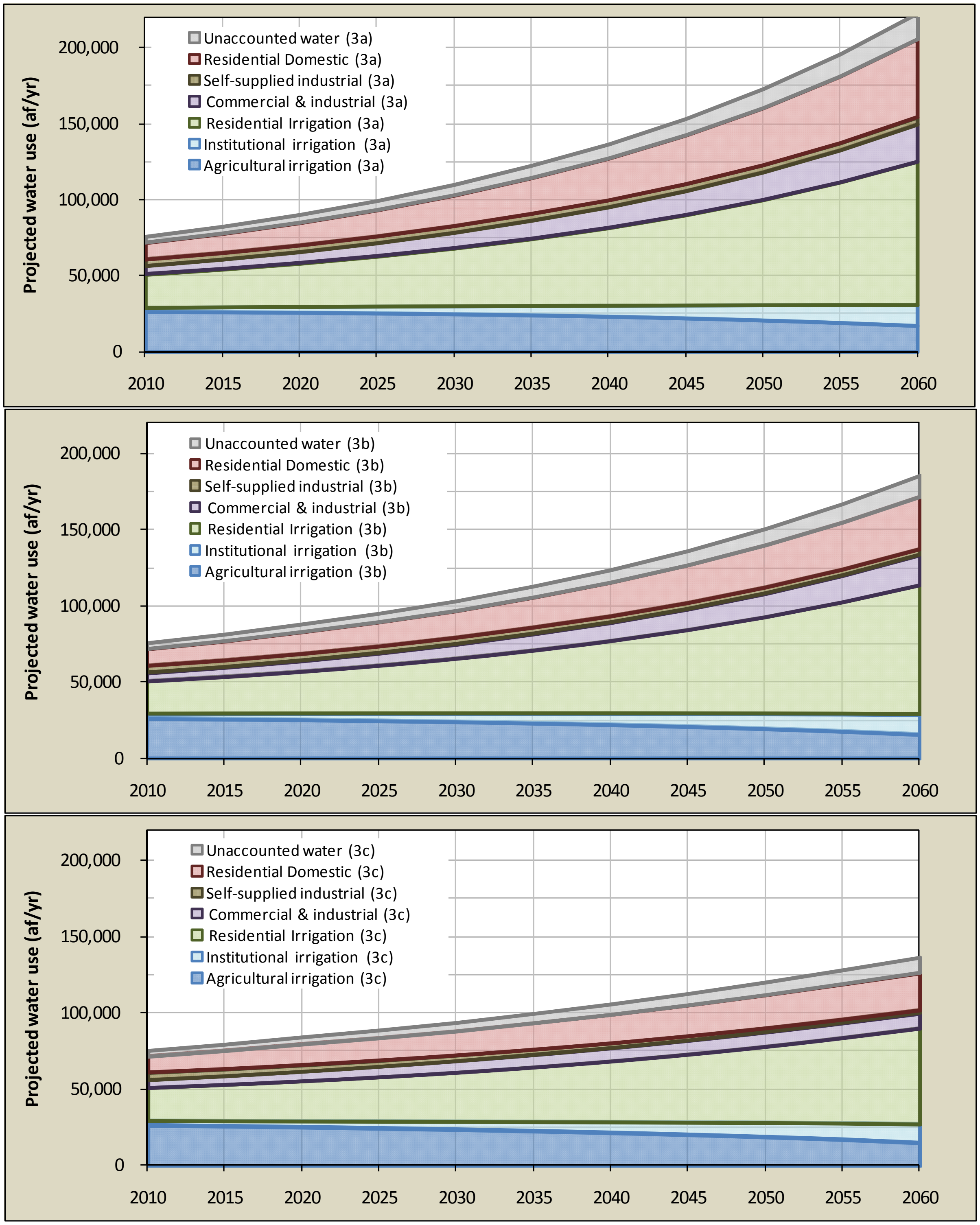

Figure 20. Future water demand, Scenario 3.

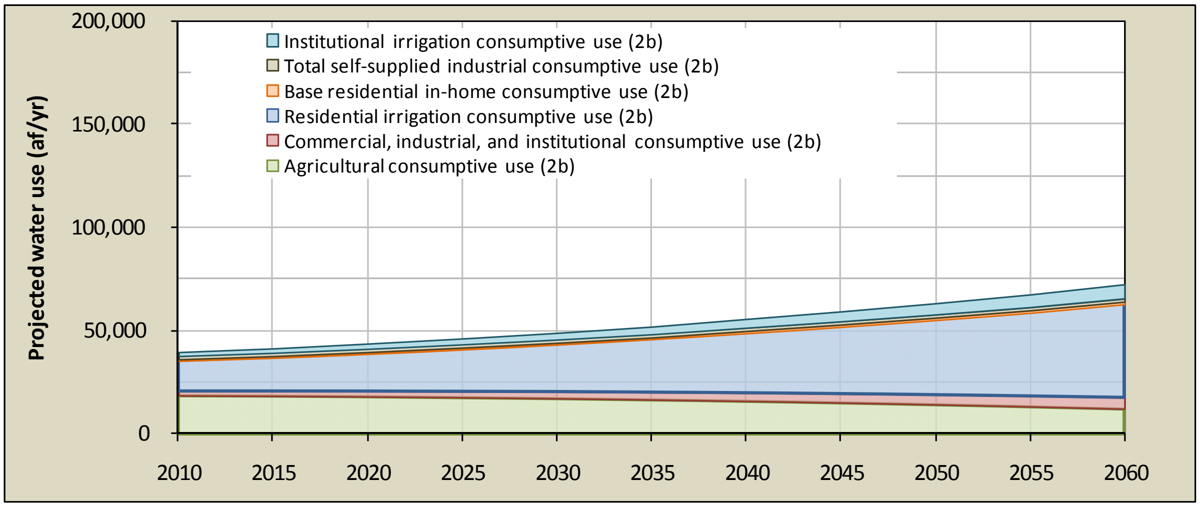

Figure 21. Future consumptive use, Scenario 2b.

8.6 Sensitivity to Increase in Precipitation Deficit

There is uncertainty in the magnitude of the projected increase in precipitation deficit resulting from climate change over the next 50 years. The preceding scenarios were run under the assumption that precipitation deficit could increase by approximately 10% by the year 2060. Two sensitivity runs were conducted to illustrate the projected water demand in Scenario 2b if precipitation deficit increases by (1) 5% over the next 50 years or (2) 20% over the next 50 years.

Results for these two sensitivity runs are presented in Figure 22 and Table 31 through Table 34. Future water demand under moderate population growth and water conservation levels (Scenario 2b) could range from approximately 133,000 acre-feet with a 5% increase in evapotranspiration to 145,000 acre-feet with a 20% increase in evapotranspiration. Similarly, the consumptive use for the same scenario (Scenario 2b) could range from approximately 70,000 acre-feet to 78,000 acre-feet, depending on the level of increase in potential evapotranspiration.

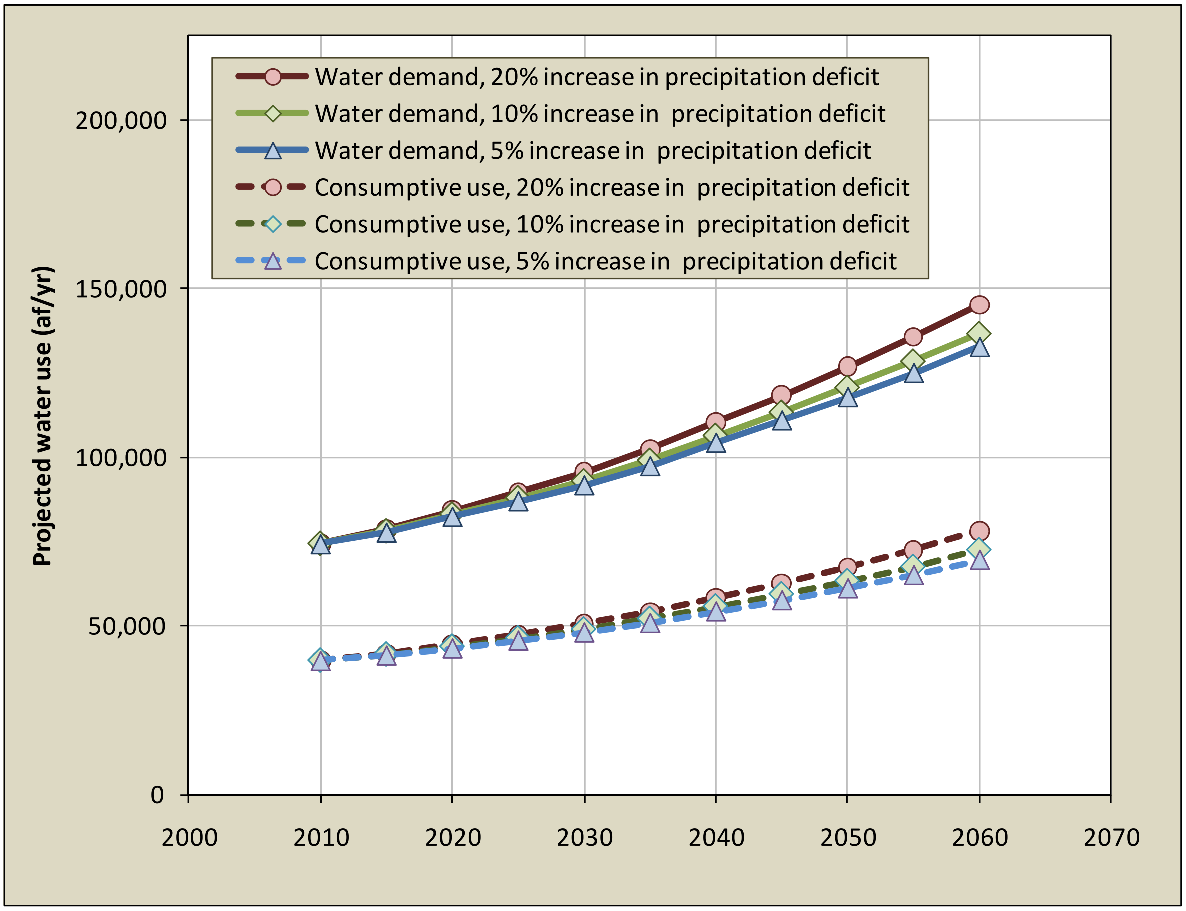

Figure 22. Comparison of water demand and consumptive use for Scenario 2b with a 5%, 10%, and 20% increase in irrigation demand by 50 years.

Water Demand with 5% Increase in Precipitation Deficit									
Population and employment growth →	Scenario 1			Scenario 2			Scenario 3		
	Low			Baseline			High		
Conservation Level →	None	Medium	Aggressive	None	Medium	Aggressive	None	Medium	Aggressive
Year	1a	1b	1c	2a	2b	2c	3a	3b	3c
2010	73,900	73,900	73,900	74,400	74,400	74,400	75,600	75,600	75,600
2015	76,900	76,100	74,600	78,700	77,800	76,300	82,000	81,000	79,400
2020	80,300	78,500	75,400	84,400	82,500	79,200	89,500	87,400	83,900
2025	83,900	80,700	75,600	90,700	87,100	81,500	98,200	94,100	88,000
2030	87,900	83,000	75,600	97,600	91,800	83,600	108,500	101,800	92,500
2035	92,400	85,700	76,000	105,400	97,500	86,200	120,500	111,200	98,000
2040	96,800	88,300	76,000	115,000	104,400	89,400	134,100	121,400	103,700
2045	101,800	91,300	76,000	124,500	111,000	91,900	150,100	133,300	110,000
2050	107,300	94,400	75,900	134,800	117,900	94,100	168,900	147,000	116,900
2055	113,300	97,700	75,700	146,000	125,000	96,000	190,900	162,600	124,200
2060	119,900	101,000	75,000	158,500	132,700	97,600	216,600	180,200	131,600
Increase over 2010 levels	62%	37%	1%	113%	78%	31%	187%	138%	74%

Table 31. Future water demand, 5% assumed increase in precipitation deficit over the next 50 years.

Water Demand with 20% Increase in Precipitation Deficit									
Population and employment growth →	Scenario 1			Scenario 2			Scenario 3		
	Low			Baseline			High		
Conservation Level →	None	Medium	Aggressive	None	Medium	Aggressive	None	Medium	Aggressive
Year	1a	1b	1c	2a	2b	2c	3a	3b	3c
2010	73,900	73,900	73,900	74,400	74,400	74,400	75,600	75,600	75,600
2015	77,700	76,900	75,400	79,500	78,600	77,100	82,800	81,900	80,300
2020	81,900	80,200	77,000	86,100	84,200	80,800	91,300	89,100	85,600
2025	86,500	83,200	77,900	93,400	89,700	84,000	101,100	96,900	90,700
2030	91,400	86,300	78,700	101,400	95,500	87,000	112,600	105,900	96,300
2035	96,800	90,000	79,900	110,400	102,300	90,500	126,200	116,500	102,900
2040	102,300	93,600	80,700	121,400	110,500	94,800	141,400	128,400	109,900
2045	108,500	97,600	81,500	132,400	118,400	98,300	159,600	142,200	117,600
2050	115,200	101,800	82,200	144,400	126,800	101,700	180,800	158,100	126,100
2055	122,500	106,200	82,700	157,500	135,700	104,800	205,700	176,200	135,300
2060	130,500	110,700	82,700	172,200	145,200	107,500	235,000	196,900	144,800
Increase over 2010 levels	77%	50%	12%	131%	95%	44%	211%	160%	92%

Table 32. Future water demand, 20% assumed increase in precipitation deficit over the next 50 years.

Consumptive Use with 5% Increase in Precipitation Deficit									
Population and employment growth →	Scenario 1			Scenario 2			Scenario 3		
	Low			Baseline			High		
Conservation Level →	None	Medium	Aggressive	None	Medium	Aggressive	None	Medium	Aggressive
	1a	1b	1c	2a	2b	2c	3a	3b	3c
2010	39,500	39,500	39,500	39,700	39,700	39,700	40,300	40,300	40,300
2015	40,700	40,500	40,000	41,400	41,300	40,700	42,900	42,700	42,100
2020	41,900	41,600	40,500	43,700	43,400	42,200	46,000	45,600	44,300
2025	43,300	42,800	41,000	46,200	45,700	43,700	49,600	48,900	46,700
2030	44,800	44,100	41,500	49,000	48,100	45,100	53,800	52,700	49,400
2035	46,400	45,500	42,000	52,100	50,900	46,800	58,700	57,200	52,500
2040	48,100	46,900	42,400	55,900	54,300	48,800	64,200	62,300	55,800
2045	50,000	48,400	42,800	59,600	57,600	50,600	70,800	68,200	59,700
2050	52,000	50,100	43,300	63,700	61,100	52,400	78,500	75,100	64,000
2055	54,300	51,900	43,700	68,200	65,000	54,200	87,500	83,100	68,800
2060	56,700	54,000	44,400	73,200	69,500	56,500	98,000	92,800	74,800
Increase over 2010 levels	44%	37%	12%	84%	75%	42%	143%	130%	86%

Table 33. Future consumptive use, 5% assumed increase in precipitation deficit over the next 50 years.

Consumptive Use with 20% Increase in Precipitation Deficit									
Population and employment growth →	Scenario 1			Scenario 2			Scenario 3		
	Low			Baseline			High		
Conservation Level →	None	Medium	Aggressive	None	Medium	Aggressive	None	Medium	Aggressive
	1a	1b	1c	2a	2b	2c	3a	3b	3c
2010	39,500	39,500	39,500	39,700	39,700	39,700	40,300	40,300	40,300
2015	41,200	41,100	40,500	42,000	41,800	41,300	43,500	43,300	42,700
2020	43,000	42,700	41,600	44,900	44,500	43,300	47,200	46,800	45,400
2025	45,000	44,500	42,600	48,000	47,500	45,400	51,500	50,800	48,500
2030	47,100	46,400	43,600	51,500	50,600	47,500	56,500	55,500	52,000
2035	49,400	48,400	44,700	55,400	54,100	49,900	62,400	60,900	55,900
2040	51,800	50,500	45,700	60,100	58,400	52,700	69,100	67,100	60,200
2045	54,400	52,700	46,800	64,900	62,700	55,200	77,000	74,300	65,100
2050	57,200	55,200	47,800	70,100	67,400	57,900	86,300	82,700	70,700
2055	60,300	57,800	48,900	75,800	72,400	60,600	97,200	92,600	76,900
2060	63,600	60,800	50,200	82,100	78,200	63,900	110,000	104,500	84,600
Increase over 2010 levels	61%	54%	27%	107%	97%	61%	173%	159%	110%

Table 34. Future consumptive use, 20% assumed increase in precipitation deficit over the next 50 years.

9 CONCLUSIONS AND RECOMMENDATIONS

Primary conclusions from this analysis include the following:

1. Water demand by the year 2060 is projected to rise from estimated current withdrawals of 74,000 acre-feet to between 101,000 and 163,000 acre-feet, depending on the level of water conservation. This is based on a moderate level of population growth (approximately 2.3% per year) over the next 50 years.
2. Population growth rates and conservation levels will strongly influence future water demand. The water demand in 2060 could be as low as about 78,000 acre-feet with a lower average population growth rate (e.g., 1.6% per year) and aggressive water conservation, or as high as 223,000 acre-feet with a higher population growth rate (e.g., 3% per year) and no water conservation. The Rathdrum Prairie Aquifer area has experienced both of these growth levels over multi-year periods in past decades.
3. A substantial portion of existing and future ground water withdrawals will return to either the aquifer or the Spokane River. The consumptive use is water lost from the local hydrologic system (i.e., aquifer and Spokane River), mostly through evapotranspiration. The consumptive use is projected to increase from approximately 40,000 acre-feet in 2010 to between 59,000 and 76,000 acre-feet in the year 2060 under moderate population- and employment-growth rates.
4. The water use for agricultural irrigation will likely decrease in time as irrigated agricultural land is replaced by more urban and suburban land uses. However, development of new residential and municipal irrigation on land that is currently non-irrigated will likely lead to an overall increase in total irrigation demand.

Population and Employment Projections

5. The Kootenai County population grew from approximately 22,300 people in 1940 to 134,400 people in 2007. Bonner County grew from 15,700 people in 1940 to approximately 41,000 people in 2007.
6. Annual population growth rates in Kootenai County (most of which overlies the Rathdrum Prairie Aquifer) have ranged from 1.6% (between 1980 and 1990) to 5.4% (between 1970 and 1980). The average annual growth rate between 1970 and 2007 was 3.7%.
7. The Rathdrum Prairie Aquifer area population growth is projected to grow from approximately 128,000 people to approximately 400,000 people by the year 2060, reflecting an average growth rate of approximately 2.3% per year. If population growth for the next 50 years is at the same 1.6% annual rate

experienced between 1980 and 1990, the 2060 population overlying the aquifer will be approximately 286,000 people. If the population grows at a rate of 3% per year (which is less than the 3.7% annual growth between 1970 and 2007), the 2060 population overlying the Rathdrum Prairie Aquifer will be approximately 581,000 people.

8. Employment over the aquifer area is projected to increase from approximately 53,000 employees in the year 2010 to 183,000 employees in the year 2060. The largest employment sector will likely continue to be wholesale and retail trade.

Existing Water Use

9. Existing water use was estimated with data from 20 community water systems ranging in size from approximately 39 to 46,000 people; these 20 community water systems serve approximately 72% of the total Rathdrum Prairie population. Data from the 20 community water systems were used to extrapolate water use to 70 additional community water systems that serve approximately 19% of the study area population. Estimates of self-supplied domestic water use for the remaining 9% of the population were made based on household domestic use rates estimated from community water system data. Self-supplied industrial water use estimates were based on IDWR water right information. Agricultural water use rates were estimated based on irrigated acreage, USDA crop information, and precipitation-deficit data

10. Approximately 72,000 acre feet of water were withdrawn annually from the Rathdrum Prairie Aquifer in recent years. Of this, an estimated 34,400 acre-feet were withdrawn by community water systems, 8,800 acre-feet were withdrawn by individual domestic wells, 4,200 acre-feet were withdrawn for self-supplied commercial and industrial uses, and 24,700 acre-feet were used for agricultural irrigation. The estimated aggregate consumptive use (water that is lost from the local hydrologic system) was approximately 38,400 AFA.

11. Approximately 67% of the projected 2010 ground water withdrawals are used for the irrigation of residential, commercial, institutional, and agricultural lands. Other residential uses (14%), commercial, industrial, and institutional uses (14%), and unaccounted water (5%) constitute the balance.

Water Supply Characteristics

12. The Rathdrum Prairie Aquifer, part of the larger Spokane Valley-Rathdrum Prairie Aquifer, consists of unconsolidated sediments that are primarily course-grained sand, gravel, cobbles, and boulders deposited by immense floods.

13. The highly transmissive nature of the Rathdrum Prairie Aquifer means that the impact of water use in one portion of the aquifer will rapidly propagate throughout the entire aquifer.

14. Recharge to the entire Spokane Valley-Rathdrum Prairie Aquifer is approximately 1,000,000 acre feet per year.

15. The existing Rathdrum Prairie Aquifer consumptive water use (consumptive use is a measure of aquifer impact) is approximately 38,000 AFA, or approximately 3.8% of the 1,000,000 acre feet of aggregate Spokane Valley-Rathdrum Prairie Aquifer recharge.

16. In general, increased ground water withdrawals of the amounts projected in this study will likely not be limited by aquifer hydraulic properties, especially in central portions of the aquifer. However, pumping rates may be constrained along the aquifer margins.

17. It is unlikely that ground water availability in most portions of the Rathdrum Prairie Aquifer will limit future water demand over the next 50 years. A projected consumptive use of approximately 71,000 AFA in the year 2060 (based on medium population and employment growth and medium levels of water conservation) represents only about 7% of the Spokane Valley-Rathdrum Prairie Aquifer recharge (although, recharge rates are not equivalent to water available for use). Given the transmissive nature of the Rathdrum Prairie Aquifer sediments, it is likely that this amount of water could be withdrawn from the aquifer (except for, perhaps, along the basin margins where the aquifer is less thick than in central portions of the Rathdrum Prairie).

Potential Environmental Constraints

18. Aquifer water quality is good in most areas and does not presently pose a constraint on future ground water demand.

19. Future water demand may, however, be limited by the ability to discharge treated municipal effluent.

20. A portion of the Rathdrum Prairie agricultural land will almost certainly be maintained for the land application of treated municipal effluent. Residential or municipal irrigation, to the extent that it occurs on currently non-irrigated land, will contribute to a likely increase in overall irrigation demand.

Climate Variability

21. Annual average temperatures are projected to increase by approximately 3.2°F by 2040 and about 5.3°F by 2080.

22. Evapotranspiration may increase by approximately 6% per degree centigrade over 2010 values. This could lead to potential evapotranspiration increases of between 12% and 19% by the years 2040 and 2080, respectively. Another study suggests possible potential evapotranspiration increases of 5% to 9% by the year's 2040 and 2080, respectively. Based on these predictions, irrigation demand could increase by 5% to 20% in the next 50 years.

23. Annual precipitation may increase by approximately 2.3% by the year 2040, and by approximately 3.8% by the year 2080. The Rathdrum Prairie Aquifer area is expected to become wetter in the fall and winter and dryer in the spring and summer.
24. Extreme temperature and precipitation events will likely increase in frequency. Extreme and/or extended drought periods will increase irrigation demands.
25. For most of the projections in this study, we assumed a 10% increase in future precipitation deficit (irrigation water requirement) as a result of increased evapotranspiration. However, the effects of a 5% increase and a 20% increase in future precipitation deficit were also evaluated for a moderate population-growth and conservation-level scenario. A 5% increase in precipitation deficit would result in an overall water demand that is approximately 3% less than the demand projected based on a 10% increase in precipitation deficit. A 20% increase in future precipitation deficit would result in an overall aquifer demand that is approximately 6% greater than the demand projected based on a 10% increase in precipitation deficit.

Water Conservation Potential

26. Aggressive water conservation can help mitigate some of the projected future water use. Aggressive conservation can result in aggregate water demand that is approximately 60% of the non-conservation demand for a given population growth outcome in 2060.
27. Aggressive water conservation could lead to a 52% reduction in per-household domestic water demand by the year 2060 (from 2010 levels).
28. Per-household outdoor residential irrigation use could be reduced by up to approximately 33% from 2010 levels.
29. Commercial and industrial use could likely be reduced by approximately 40% over the next 50 years compared to 2010 per-employee use rates.
30. Specific water conservation measures are outlined in the report.
31. Water reuse is a potential method to increase water supply, but does not bear directly on future Rathdrum Prairie water demands.

Recommendations

1. Develop a comprehensive, consistent system to report, collect, and compile water-use data. Use these data to monitor and report future pumping and consumptive water use.
2. Use spatial data to better define and quantify irrigated areas.

3. Compare future population and employment growth with the population and employment projections made in this study. Modify future water demand projections based on actual population and employment growth numbers.

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Appendix A:

The Idaho Economic Forecasting Model

The Idaho Economic Forecasting Model uses forecasts of national inputs and demands for particular sectors of the Idaho economy having a national or international exposure to project employment, population, and households. The model has four primary components: (1) national economic inputs, (2) Idaho basic and secondary industry equations, (3) Idaho personal income equations, and (4) Idaho population equations (Figure 1).

Model equations are highly dependent on one another. For example, the personal income equations are dependent upon the population, secondary industry, and basic industry equations. Similarly, the secondary industry equations are dependent upon personal income and population. The model solves these equations using simultaneous-equation methods.

Primary model segments are described with greater detail in the following sections.

Basic and Secondary Industries

The Idaho economic model industry equations relate national demand (an index of industry output) to local activity of the basic industries. The secondary industries are a function of local product and service demand and are modeled as a function of Idaho disposable income per capita, Idaho population, and wage rates.

Demand for products and services from Idaho's basic industries are a function of national industry demand (Figure 2). In addition, Idaho wage rates by industry also are treated as a function of national wages in each industry. In turn, Idaho basic industry employment is a function of local output and wage rates. The agriculture and mining sectors of Idaho's economy could not be successfully modeled as a function of national activity measures. Although econometric methods were used for these sectors of the economy, judgment is applied to the resulting forecasts.

The agricultural industry forecast assumes that Idaho will maintain its historical share of national agricultural output. Implicit in that assumption is an outlook of future agricultural industry productivity gains and slow or no growth in Idaho agricultural cropland.

Idaho secondary industry employment a function of local economic activity as measured by Idaho real per capita disposable income and industry specific real wages. As in the basic industry equations, average wage and salary rates by industry are a function of U.S. industry wage trends and employment by industry is a function of local economic activity and wage rates.

The transition to the personal income sector of the model occurs through the concept of wage bills, the money paid in wages and salaries in each industry sector. Total wages and salaries are the sum of basic and secondary industry employment multiplied by each specific industry's wage rate.

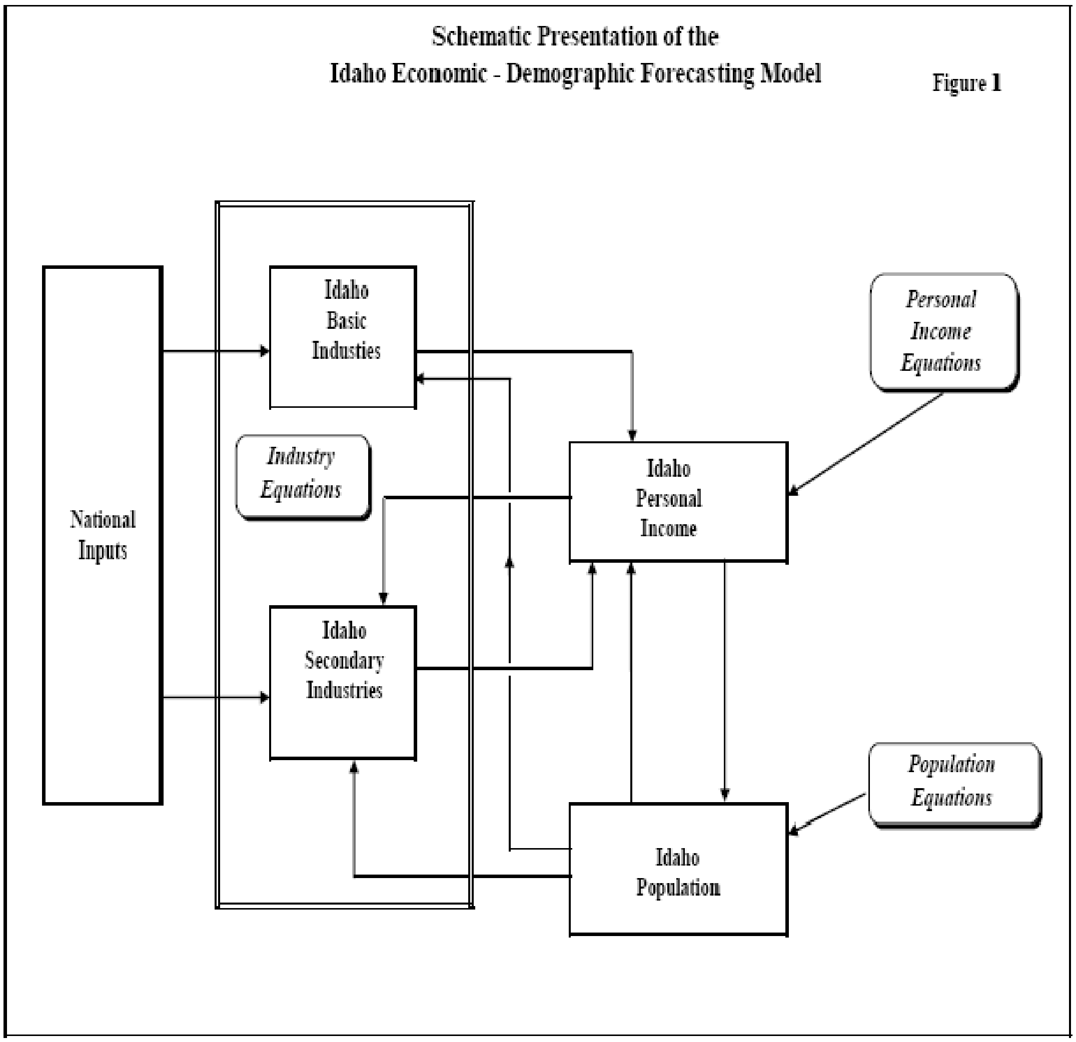


Figure 1. Schematic presentation of the Idaho Economic – Demographic Forecasting Model.

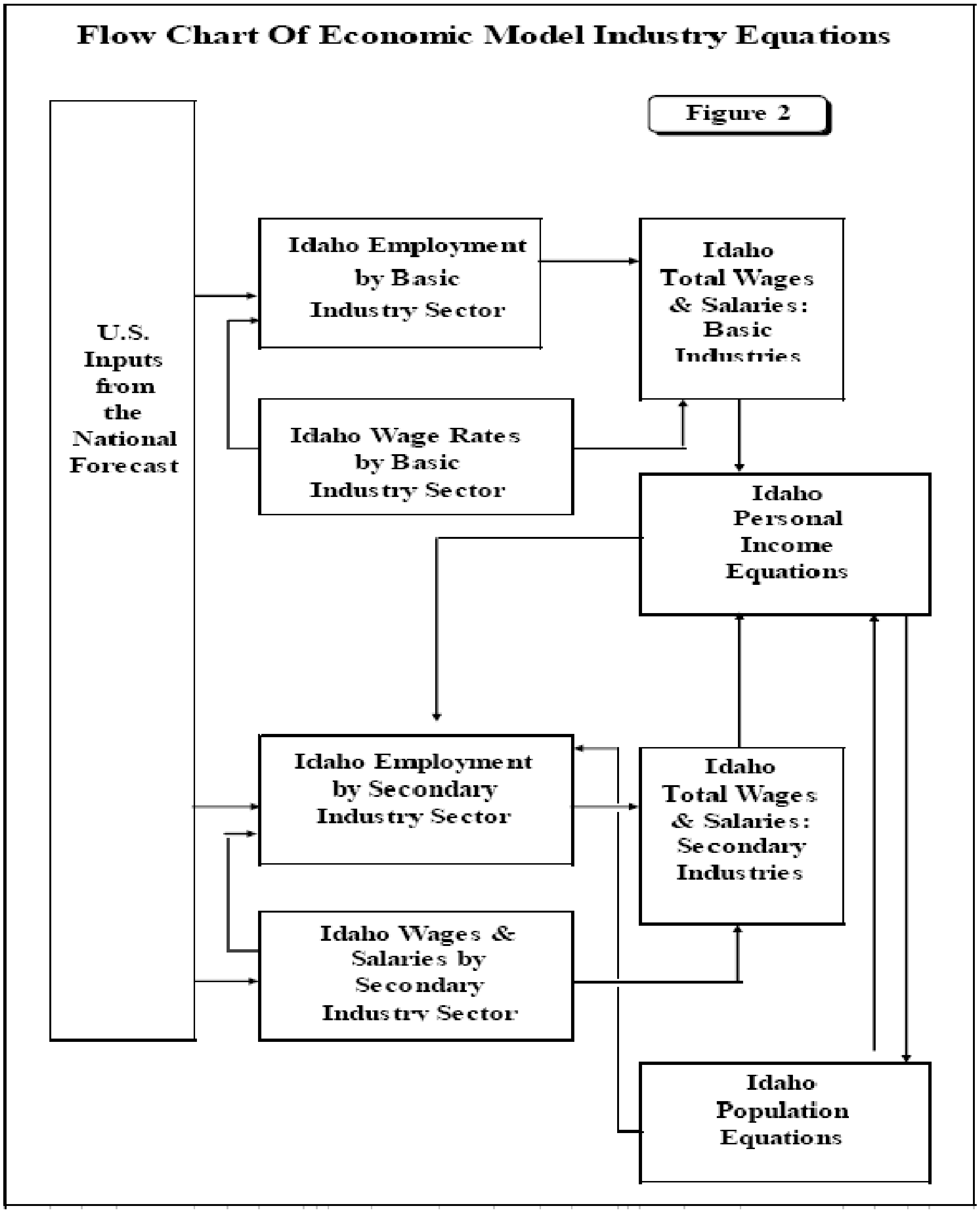


Figure 2. Flow chart of industry equations.

Per Capita Personal Income

Per capita personal income is the ratio of total personal income, from all sources and before income taxes, to total resident population. It is one indicator of the economic well-being of a state and plays an important role in any modeling effort of regional economic activity.

National per capita personal income has been consistently higher than that in the state of Idaho. Stronger economic conditions in the state have helped close the gap in the 1960 to 1980 period and during the most recent expansion, 1987 through 1995. However, despite faster growth, Idaho's per capita income has consistently been below the national average in absolute terms throughout this period.

Differences between state and national per capita income stem from several sources: industry mix, sources of unearned income, labor force participation rates, fertility rates, and the age distribution of the population. Per capita income in Idaho averages several hundred dollars below the national average. Part of this difference is due to Idaho's relatively large proportion of non-working age population, the result of Idaho's higher birth rates. This relationship reduces total earnings relative to "older" populations of the same number. Idaho's industry mix also contributes to the differences in per capita personal income. The predominance of relatively lower-paying basic industry jobs in Idaho are also a cause of the state's lower per capita income when compared to other regions having a higher proportion of higher-wage rate basic industry jobs.

Idaho total personal income is projected within the economic model by major income component, as depicted in Figure 3. The forecast of total wage and salary income is the sum of the products of employment by industry times average annual wage and salary earnings by industry. Projections of non-farm proprietors' income, farm proprietors' income, and other labor income are added to the total wage and salary income to obtain a projection of total labor and proprietors' income. In the next step, total personal income is obtained by adding property income (dividends, interest, and rent) and transfer payments to the labor and proprietors' income, and subtracting contributions to social security, and making a "residence adjustment". This adjustment estimates the net difference of income inflows and outflows resulting from commuting employees, absentee landlords and proprietors.

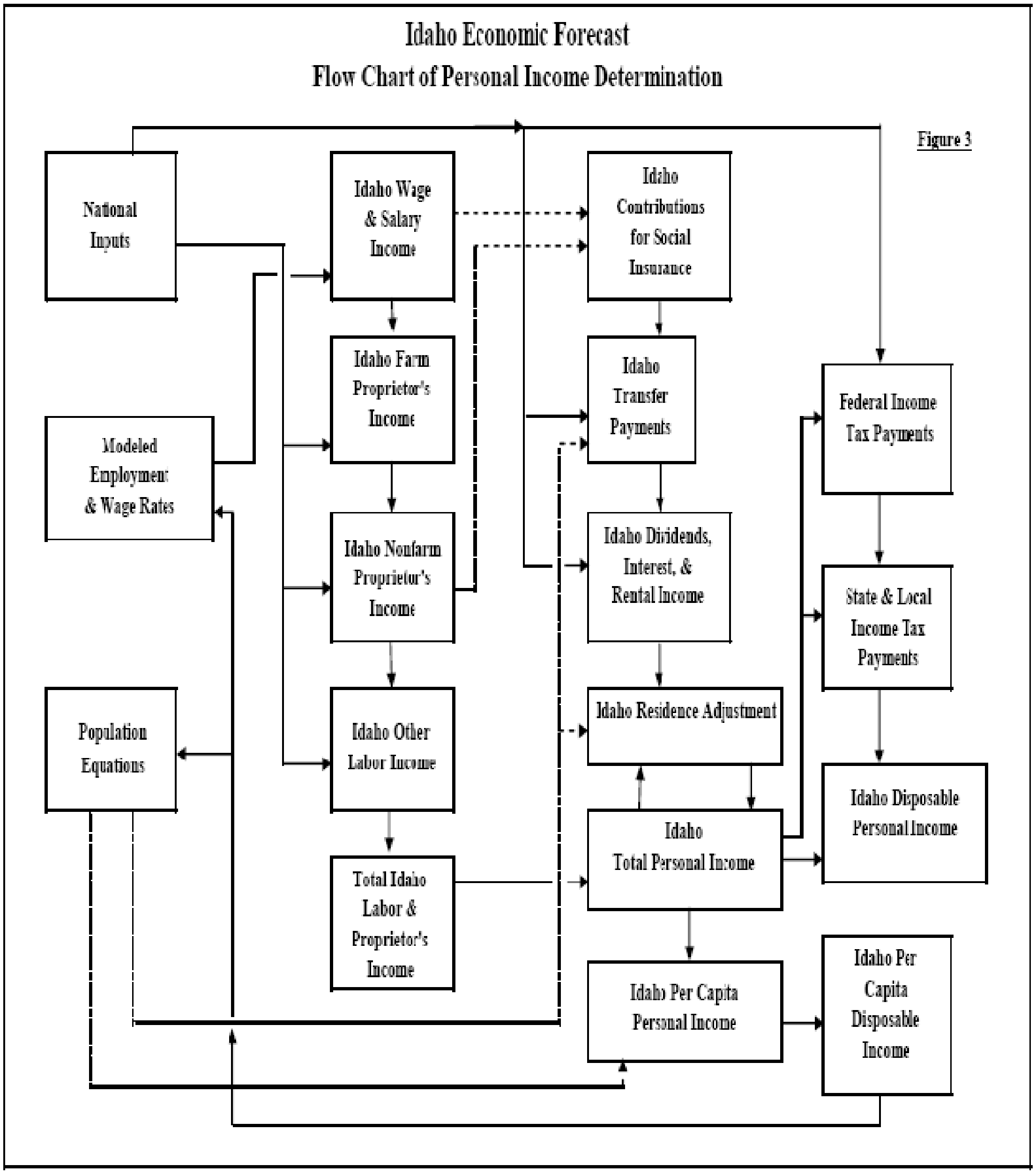


Figure 3. Flow chart of personal income determination.

Property income and transfer payments are modeled as a function of projected regional population and national property income and transfer payments per capita. Projected contributions to social security are expressed as a function of projected regional employment and national contributions per employee. Finally, per capita personal income is derived by dividing total personal income by the projected population.

The model further determines disposable personal income (personal income less personal income taxes), using an effective tax rate equation for federal and state taxes. Per capita disposable personal income is derived by dividing the total disposable personal income by the projected population.

Finally, projected disposable personal income per capita is one of the determinants of employment in the secondary industry sectors, therefore causing the system of equations (employment, personal income, and population) to be simultaneous in their solution.

Population

The population forecast utilizes a cohort-component method, which forecasts components of population change for each cohort a five-year age grouping; i.e., ages 0 to 4, 5 to 9, etc). The components of change in population are births, deaths, and migration. Births and deaths are projected by applying age and sex-specific fertility rates and death rates to the base-year population, which is carried forward into the next year.

The migration component of population change is projected by incorporating a total employment and labor force forecast. Labor force participation rates are applied to the existing working-age population, resulting in a locally supplied labor force. The net migration of workers makes up the difference between the labor force supplied by the existing population and the labor force produced by total employment and an "unemployment adjustment." The migrating workers are converted by an appropriate factor to a migrating population. This is then distributed by age in accordance with historical patterns. The migrating population is added to the "survived" base-year population and carried forward to the next year.

The population model projects net migration from the difference between the labor force supplied by the existing population and the required labor force projected by the employment forecast and the unemployment adjustment. In actuality, some portion of the population migrates out of the region (gross out-migration) and others migrate in (gross in-migration). Net migration is dependent on the level of employment and the size of the labor force supplied by the existing population.

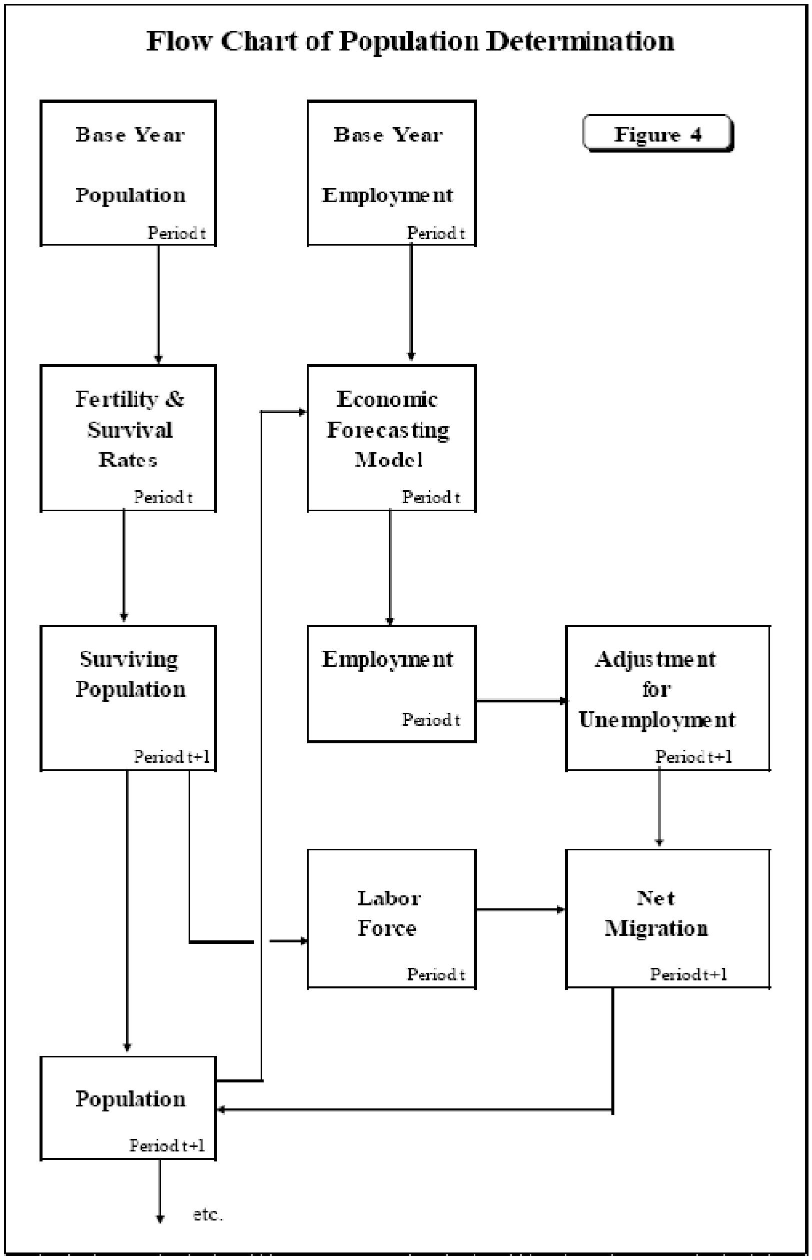


Figure 4. Flow chart of population determination.

Net migration is a critical component in the growth or decline of regional or local area population. The contribution of natural population increases, while important, is less subject to wide fluctuations because it is largely dependent on a gradually changing age structure. Even in a 20-year population forecast, the change in population, and the age structure resulting from natural increases alone is fairly certain because most of the population is already born and mortality rates behave predictably.

Appendix B:

Population Growth Interviewees

The following individuals were contacted by Bob Taunton as part of this project regarding future population growth and spatial distribution perspectives:

1. Collin Coles, Senior Planner, City of Post Falls
2. Lisa Key, Community Development Director, City of Hayden
3. Dave Yadon, Planning Director, Coeur d'Alene
4. Sean Holm, Planner, Coeur d'Alene
5. Chris Riffe, City Planner, City of Rathdrum
6. Scott Clark, Planning Director, Kootenai County
7. Bonnie Gow, Transportation Planner, KMPO
8. Anna Regaza-Bourassa, Transportation Planner, SRTC
9. Paul Klatt, Senior Project Manager, J-U-B Engineers
10. Steve Griffits, President, Jobs Plus
11. Terry Harris, Executive Director, Kootenai Environmental Alliance
12. Rand Wichman, Powderhorn Ranch Project Manager

APPENDIX C

Community Water Systems

Community water systems serving 15 or more connections or 25 or more persons are regulated by the Idaho Department of Environmental Quality (IDEQ). IDEQ records and information provided by community water systems were used to determine the population within the Ratdrum Prairie Aquifer study area served by community water systems. A list of community water systems and the estimated population served is provided in Table C-1. Community water systems that provided population and water use data for this study are highlighted. Several of the community water systems are operated by the North Kootenai Water and Sewer District (NKSWD)

Public Water System Name	Estimated Population	% of Estimated Population Served by Community Public Water Systems
COEUR D ALENE CITY OF	46,000	39.2%
POST FALLS CITY OF	16,170	13.8%
RATHDRUM CITY OF	7,100	6.0%
EAST GREENACRES WATER DIST	7,000	6.0%
AVONDALE IRRIGATION DIST	5,890	5.0%
HAYDEN LAKE IRRIGATION DIST	5,844	5.0%
ROSS POINT WATER DIST	2,750	2.3%
DALTON WATER ASSN INC	2,500	2.1%
RIMROCK SERVICE AREA, NKWSD	2,371	2.0%
HILLSIDE SERVICE AREA, NKWSD	2,088	1.8%
SPIRIT LAKE CITY OF	1,730	1.5%
TWIN LAKES SERVICE AREA	1,587	1.4%
HAUSER LAKE WATER ASSN INC	1,200	1.0%
HAYDEN PINES GROUSE MEADOWS, NKWSD	1,099	0.9%
BAYVIEW WATER AND SEWER DIST	1,000	0.9%
GREEN FERRY WATER & SEWER DISTRICT	750	0.6%
ATHOL CITY OF	670	0.6%
HONEYSUCKLE HILLS, NKWSD	669	0.6%
SPIRIT LAKE EAST WATER COMPANY	655	0.6%
REMINGTON REC WATER DIST	625	0.5%

Public Water System Name	Estimated Population	% of Estimated Population Served by Community Public Water Systems
PINEVILLA PARK AND WATER ASSN	500	0.4%
EMERALD ESTATES WATER ASSN INC	485	0.4%
LEISURE PARK	469	0.4%
PINEVIEW ESTATES WATER DIST	450	0.4%
HOLIDAY ACRES WATER ASSN	418	0.4%
MOUNTAIN VIEW TERRACE, NKWSD	393	0.3%
BAR CIRCLE S RANCH	345	0.3%
HOFFMAN TROY WATER CORP	336	0.3%
ALPINE MEADOWS WATER AND SEWER DIST	300	0.3%
CHILCO SERVICE AREA, NKWSD	281	0.2%
CHATEAUX WATER ASSN INC	275	0.2%
ROYAL HIGHLAND WATER SYSTEM	275	0.2%
OHIO MATCH ROAD WATER DIST	225	0.2%
GARWOOD WATER COOP	220	0.2%
MAJESTIC VIEW SERVICE AREA	212	0.2%
UPPER TWIN LAKES WATER COMPANY INC	200	0.2%
POST FALLS SOUTH PARK	200	0.2%
PANHANDLE VILLAGE WATER SYSTEM	160	0.1%
SOUTHVIEW TERRACE INC	160	0.1%
MCGUIRE ESTATES WATER	150	0.1%
PANHANDLE MOBILE ESTATES	150	0.1%
SOUTH RIVER WATER ASSN	150	0.1%
BITTERROOT WATER COMPANY	150	0.1%
HOYT BLUFF WATER ASSOCIATION	143	0.1%
FARRAGUT VILLAGE PROPERTY ASSN INC	133	0.1%
VALLEY GREEN, NKWSD	124	0.1%
PRAIRIE SCHOONER ESTATES	115	0.1%
HAUSER LAKE HOA	115	0.1%
HAYDEN ORCHARDS WATER SYSTEM, NKWSD	113	0.1%
SPIRIT BEND WATER ASSN	105	0.1%
DIAMOND BAR ESTATES	103	0.1%
ROCKY BEACH WATER DIST	100	0.1%
SAVORY MOBILE HOME PARK/NORTHWEST MANAGEMENT PROPERTIES	100	0.1%
OHIO MATCH ESTATES, NKWSD	92	0.1%
HUETTER CITY OF	90	0.1%
PARKVIEW WATER ASSN	90	0.1%

Public Water System Name	Estimated Population	% of Estimated Population Served by Community Public Water Systems
STEPPING STONES ESTATES	85	0.1%
HIGHWAY 54 WATER DIST	84	0.1%
HACKNEY WATER AND SEWER DIST	83	0.1%
RAMSEY ESTATES HOA	80	0.1%
DRY ACRES WATER AND SEWER DIST	75	0.1%
MOUNTAIN VIEW PARK	75	0.1%
SCENIC MOBILE ESTATES	70	0.1%
MORRISON ESTATES HOMEOWNER WATER ASSN	70	0.1%
SUN AIRE ESTATES	70	0.1%
PINE HAVEN MOBILE PARK	66	0.1%
HARDING ACRES TRACTS WATER ASSN INC	64	0.1%
MALABAR MOBILE HOME PARK	60	0.1%
PRAIRIE WATER ASSN	55	0.0%
EIGHT MILE PRAIRIE	55	0.0%
MEADOWLAND ACRES, NKWSD	53	0.0%
EAST SEASON ACRES, NKWSD	51	0.0%
HACIENDA HILLS WATER COMPANY	50	0.0%
PANHANDLE MOBILE HOME PARK	50	0.0%
HAPPY VALLEY WATER DISTRICT	50	0.0%
BERRY PATCH WATER ACRES ASSN	45	0.0%
ARUNDEL BY THE RIVER A MOBILE HOME COMM	45	0.0%
SINGER RANCH WATER SYSTEM	44	0.0%
LYNNWOOD ESTATES	43	0.0%
PINE HAVEN WATER ASSN	40	0.0%
HIDDEN HILL MOBILE HOME PARK	40	0.0%
RANCH VALLEY WATER ASSN, NKWSD	39	0.0%
ASHLEY ESTATES WATER ASSOCIATION	38	0.0%
ATLAS ACRES, NKWSD	35	0.0%
ELKHORN RANCH HOA	30	0.0%
WESTVIEW SUBD	30	0.0%
WILD MEADOWS I SUBD	27	0.0%
WATERFORD ESTATES	26	0.0%
SEASONS ROAD WATER ASSN	25	0.0%
SCHAEFFER ADDITION WATER USERS ASSN	23	0.0%
PINEGROVE DUPLEXES	0	Closed

Public Water System Name	Estimated Population	% of Estimated Population Served by Community Public Water Systems
ROCK SPRINGS WATER ASSN	0	Closed
UNITS WATER ASSN INC	0	Closed
TOTAL ESTIMATED POPULATION	117,401	100%

Table C-1. Community water systems located within study area.

APPENDIX D

Commercial and Industrial Water Rights

Self-supplied commercial and industrial water rights were obtained from IDWR water right and permit shapefiles downloaded on August 10, 2009. Ground water rights for commercial, industrial, and heating and cooling use within the Rathdrum Prairie Aquifer study area are listed in Table D-1. Ground water permits are listed in Table D-2.

Basin	Sequence	Water Use	Maximum Diversion Rate (cfs)	Maximum Diversion Volume (AFA)	Owner
95	8924	INDUSTRIAL	4.49	1475.70	RATHDRUM POWER LLC
95	7033	INDUSTRIAL	1.21	878.30	CHILCO LAKE LUMBER COMPANY LLC
95	9229	HEATING & COOLING	1.50	816.00	COEUR D ALENE SCHOOL DISTRICT #271
95	8964	HEATING & COOLING	1.00	544.00	COEUR D ALENE SCHOOL DISTRICT #271
95	9028	HEATING & COOLING	1.00	544.00	COEUR D ALENE SCHOOL DISTRICT #271
95	8794	HEATING & COOLING	0.85	462.00	COEUR D ALENE SCHOOL DISTRICT #271
95	9042	COMMERCIAL	2.23	384.80	CPM DEVELOPMENT CORP.
95	8821	COMMERCIAL	2.00	343.70	ACME MATERIALS & CONSTRUCTION CO
95	7141	COMMERCIAL	0.69	294.00	IDAHO VENEER CO
95	8880	COMMERCIAL	0.94	199.10	IDAHO VENEER CO
95	9940	COMMERCIAL	0.80	169.50	SILVERWOOD INC
95	8232	COMMERCIAL	0.53	106.20	LARRY W GILMAN
95	8860	COMMERCIAL	0.84	93.40	POE ASPHALT PAVING INC
95	7697	COMMERCIAL	0.36	75.30	D A DAUGHARTY
95	8801	INDUSTRIAL	0.79	61.50	CENTRAL PREMIX CONCRETE CO
95	8049	COMMERCIAL	0.27	55.90	G DON MURRELL
95	9260	COMMERCIAL	0.20	43.80	MILESTONE INVESTMENTS LLC
95	8805	INDUSTRIAL	0.11	31.40	INTERSTATE CONCRETE & ASPHALT CO
95	8921	COMMERCIAL	0.12	27.30	COEUR D ALENE PAVING INC
95	7201	COMMERCIAL	0.16	26.40	EL ARR INVESTMENTS

Basin	Sequence	Water Use	Maximum Diversion Rate (cfs)	Maximum Diversion Volume (AFA)	Owner
95	7983	COMMERCIAL	0.51	26.30	US DEPT OF AGRICULTURE
95	7187	INDUSTRIAL	0.09	19.00	INTERSTATE PLASTIC INC
95	8463	COMMERCIAL	0.15	18.10	RAY GRANNIS
95	8246	INDUSTRIAL	0.20	13.20	IDAHO ASPHALT SUPPLY INC
95	8510	INDUSTRIAL	0.50	13.19	CURTIS CONSTRUCTION CO
95	8234	INDUSTRIAL	0.11	10.60	MURPHY BROTHERS INC
95	7899	COMMERCIAL	0.04	8.30	D A DAUGHARTY
95	8181	COMMERCIAL	0.06	5.40	C NORMAN SHOCKLEY
95	9935	COMMERCIAL	0.06	5.40	SPIRIT VALLEY INDUSTRIAL PARK
95	7560	INDUSTRIAL	0.06	4.20	ROBERT YANDT JR
95	8480	COOLING	0.04	4.20	JANET BERNHART
95	8183	COMMERCIAL	0.16	3.80	HUETTER SPEEDWAY
95	8354	INDUSTRIAL	0.14	3.70	CHILCO LAKE LUMBER COMPANY LLC
95	8151	INDUSTRIAL	0.14	3.60	MESENBRINK LUMBER LLC
95	7145	COMMERCIAL	0.02	2.40	JAMES W HUNT
95	7023	INDUSTRIAL	0.25	0.80	WESTERN FARMERS ASSN
95	8030	COMMERCIAL	0.04	0.50	DON L HORNE
95	8022	COMMERCIAL	0.04	0.20	CAROL JONES
95	2188	INDUSTRIAL	1.00	0.00	DIAMOND NATIONAL CORP
95	4492	COMMERCIAL	0.18	0.00	CITY OF HUETTER
95	4520	COMMERCIAL	0.22	0.00	W-I FOREST PRODUCTS INC
95	9089	COMMERCIAL	3.63	0.00	HAP TAYLOR & SONS
95	9091	INDUSTRIAL	1.25	0.00	SPOKANE ROCK PRODUCTS INC/EUCON CORP
		Total	28.98	6775.19	

Table D-1. Ground water rights for commercial, industrial, heating, and cooling use.

Basin	Sequence	WaterUse	Maximum Diversion Rate (cfs)	Owner
95	9365	HEATING & COOLING	0.78	RIVER HOUSE DEVELOPMENT INC
95	9395	COMMERCIAL	0.83	KOOTENAI MEDICAL CENTER
95	9447	COMMERCIAL	0.11	CAROL A TOBIN
95	9468	HEATING & COOLING	1.60	SALVATION ARMY KROC CENTER
95	9474	COMMERCIAL	1.70	SILVERWOOD INC
95	9484	HEATING & COOLING	2.00	KOOTENAI MEDICAL CENTER
95	9530	COMMERCIAL	0.20	FRED GRUBB
95	9996	COMMERCIAL	1.50	SILVERWOOD INC
95	10411	COMMERCIAL	0.15	STATELINE STADIUM SPEEDWAY
		Total	8.87	

Table D-2. Ground water permits for commercial, industrial, heating, and cooling use.

APPENDIX E

Irrigation Water Rights

Self-supplied irrigation water rights were obtained from IDWR water right and permit shapefiles downloaded on August 10, 2009. Ground water rights for irrigation use within the Rathdrum Prairie Aquifer study area and outside of irrigation districts or community water systems are listed in Table E-1. Ground water permits are listed in Table E-2.

Basin	Sequence No.	Place of Use (acres)	Acre Limit
95	7045	803	
95	7049	751	
95	7093	602	
95	2124	480	
95	2127	480	
95	2131	473	
95	2163	472	
95	7263	470	
95	2165	465	
95	7094	465	
95	7104	400	
95	9579	396	
95	7009	371	
95	2160	345	
95	2110	320	
95	2130	320	
95	7043	320	
95	7113	318	
95	2147	316	
95	2164	316	
95	7133	316	
95	2141	314	
95	2178	312	
95	2151	310	
95	7571	310	
95	2176	306	
95	7124	306	
95	9549	304	
95	2185	302	
95	9537	296	

Basin	Sequence No.	Place of Use (acres)	Acre Limit
95	2177	295	
95	7041	290	
95	2137	280	
95	7032	278	
95	9185	273	
95	2099	270	
95	2167	266	
95	2126	262	
95	7804	256	
95	9570	256	
95	7776	252	
95	2168	233	
95	7409	215	
95	2093	210	
95	9542	210	
95	7063	208	
95	2170	204	
95	2134	198	
95	2142	198	
95	2169	198	
95	7504	197	
95	9951	196	
95	9574	190	
95	7128	169	
95	2112	160	
95	2114	160	
95	2153	160	
95	7096	160	
95	7801	160	
95	9534	160	
95	9535	160	
95	2168	158	
95	8279	158	
95	2156	157	
95	2200	157	
95	7082	157	
95	2162	156	
95	7584	156	
95	9545	156	
95	9524	153	
95	7129	152	
95	7949	150	

Basin	Sequence No.	Place of Use (acres)	Acre Limit
95	9498	150	
95	2171	149	
95	9309	148	
95	4172	130	
95	9002	130	
95	9903	120	
95	8273	107	
95	9242	106	
95	2101	105	
95	8855	104	
95	9536	102	
95	7107	101	
95	8574	100	
95	2094	100	
95	7230	100	
95	7698	99	
95	9541	99	
95	9564	90	
95	7044	80	
95	7164	80	
95	7525	80	
95	9550	80	
95	7133	79	
95	2183	78	
95	8269	78	
95	2152	77	
95	9308	75	
95	8896	75	
95	9539	75	
95	2166	71	
95	8546	70	
95	7779	69	
95	9881	68	
95	9932	60	
95	8700	59	
95	9705	57	
95	2107	52	
95	9829	51	
95	7148	50	
95	8636	50	
95	7130	49	

Basin	Sequence No.	Place of Use (acres)	Acre Limit
95	9500	49	
95	7227	41	
95	7680	40	
96	9091	40	
95	9186	39	
95	7135	38	
95	7738	38	
95	8680	33	
95	8274	30	
95	9575	30	
95	9696	30	
95	9172	28	
95	8130	21	
95	9609	21	
95	4669	20	
95	7551	20	
95	7825	19	
95	8743	18	
95	7845	18	
95	8663	18	
95	8031	16	
95	8804	16	
95	2118	15	
95	2122	15	
95	9066	15	
95	9523	15	
95	7466	14	
95	9190	14	
95	8646	12	
95	8842	10	
95	2174	10	
95	8007	10	
95	8278	10	
95	8508	10	
95	8617	10	
95	8674	10	
95	8779	10	
95	9243	10	
95	9091	10	
95	9128	10	
95	8807	9	

Basin	Sequence No.	Place of Use (acres)	Acre Limit
95	8212	9	
95	8723	9	
95	9947	9	
95	8644	9	
95	8597	8	
95	4674	8	
95	7434	8	
95	7464	8	
95	7529	8	
95	7813	8	
96	8855	8	
95	8772	8	
95	8830	8	
95	7692	7	
95	9622	7	
95	4372	6	
95	8516	6	
95	8689	6	
95	8765	5	
95	4410	5	
95	7989	5	
95	8001	5	
95	8091	5	
95	8238	5	
95	8824	5	
95	9623	5	
95	9813	5	
95	9816	5	
95	9150	5	
95	8240	5	
95	8357	5	
95	8358	5	
95	8749	5	
96	8907	5	
95	9436	5	
95	9957	5	
95	9892	4	
95	8750	4	
95	2152	4	
95	4408	4	
95	8620	4	

Basin	Sequence No.	Place of Use (acres)	Acre Limit
95	9339	4	
95	9476	4	
95	9423	4	
95	9841	4	
95	9133	4	
95	9439	4	
95	8534	3	
95	9121	3	
95	8852	3	
95	8775	3	
95	7766	3	
95	8069	3	
95	8182	3	
95	8379	3	
95	8442	3	
95	8601	3	
95	9571	3	
95	9976	3	
95	9369	3	
95	9122	3	2.5
95	9927	2	
95	8864	2	
95	8934	2	
95	4258	2	
95	4373	2	
95	4607	2	
95	4624	2	
95	7191	2	
95	7612	2	
95	7745	2	
95	7778	2	
95	7781	2	
95	8027	2	
95	8177	2	
95	8295	2	
95	8437	2	
95	8498	2	
95	8643	2	
95	8741	2	
95	8805	2	
95	8921	2	

Basin	Sequence No.	Place of Use (acres)	Acre Limit
95	9030	2	
95	9577	2	
95	9698	2	
95	9884	2	
95	9889	2	
95	9916	2	
95	9966	2	
95	9981	2	
95	8704	2	
95	8757	1	
95	8342	1	
95	4170	1	
95	4314	1	
95	4630	1	
95	7354	1	
95	7423	1	
95	7576	1	
95	7602	1	
95	7634	1	
95	7895	1	
95	7908	1	
95	8253	1	
95	8305	1	
95	8309	1	
95	8469	1	
95	9112	1	
95	9834	1	
95	9911	1	
95	9923	1	
95	9930	1	
95	10002	1	
95	2136	0	
95	2153	0	
95	7015	0	
95	9435	0	
	Total Acres	25230	

Table E-1. Ground water rights for irrigation use outside of irrigation districts and community water systems.

Basin	Sequence No.	Place of Use (acres)	Acre Limit
95	9149	100	
95	9215	100	
95	9255	100	
96	8597	87	
95	9179	84	
95	9371	83	
95	9193	70	
95	9220	51	
95	10211	45	
95	9499	30	
95	10023	28	
95	10030	20	
95	8681	16	
95	9560	15	
95	10411	15	
95	9412	14	
95	9263	13	
96	9000	12	
95	9276	10	
95	9332	10	
95	9562	10	
95	10207	10	
95	10022	9	
95	10203	9	
95	9388	8	
95	10020	8	
95	9424	7	
95	9392	6	
95	10021	6	
95	9325	5	
95	9415	5	
95	10028	5	
95	9526	5	
95	10001	5	
95	10059	4	
95	10171	3	
95	10232	3	
95	9387	2	
95	9432	2	
95	10029	2	
96	9022	2	
96	9306	2	

Basin	Sequence No.	Place of Use (acres)	Acre Limit
95	9496	1	
95	10027	1	
95	10270	1	
95	10535	1	
95	9447	1	
95	9305	0	
95	9395	0	
95	9533	0	
	Total Acres	1024	

Table E-1. Ground water permits for irrigation use outside of irrigation districts and community water systems.

APPENDIX F

Climate Variability and Change

Literature Review - Climate Change in the Pacific Northwest

Climate and ecology in the Pacific Northwest (PNW)[1] are largely influenced by the interactions between seasonally varying atmospheric circulation patterns, or weather, and the mountainous terrain within the region. Large-scale atmospheric circulation occurring over the Pacific Ocean, including the Gulf of Alaska, is the driving influence of seasonal variations in precipitation and weather. Approximately two-thirds of the Pacific Northwest precipitation occurs during half of the year (October-March) from the Pacific storm track, and much of this precipitation is captured in the region's mountains. Precipitation declines from late spring to early fall with high pressure systems to the west, generally keeping the northwest fairly dry. Important fluctuations in regional climate are related to the El Niño/Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) phenomena. In their warm phases, ENSO, El Nino and PDO increase the odds for a warmer-than-average Pacific Northwest winter and spring and decrease the odds for a wetter-than-average winter. The opposite tendencies are true for cool phase ENSO (La Niña) and PDO.

A recent study by the Climate Impact Group (2009) at the University of Washington used 20 different climate models to explore the consequences of two different greenhouse gas emissions scenarios (Medium A1B and Low B1), which resulted in a wide range of possible future climates for the Pacific Northwest. All of the models indicate that this future climate will be warmer than the past and together, they suggest that Pacific Northwest warming rates will be greater in the 21st century than those observed in the 20th century. All changes below are relative to the period between 1970 and 1999 unless otherwise noted, and all are regionally-averaged changes that apply to the Pacific Northwest.

Climate models project increases in the annual average temperature of 2.0°F (range of projections from all models: +1.1°F to +3.3°F) by the 2020s; 3.2°F (range: +1.5°F to +5.2°F) by the 2040s; and 5.3°F (range: +2.8°F to +9.7°F) by the 2080s (Table 1).

[1] Source, http://www.fws.gov/Pacific/Climatechange/changepnw.html.

Period	Temperature Change (F°)	Precipitation Change (%)
2020s	+2.0 (+1.1 to +3.3)	+1.3 (-9 to +12)
2040s	+3.2 (+1.5 to +5.2)	+2.3 (-11 to +12)
2080s	+5.3 (+2.8 to +9.7)	+3.8 (-10 to +20)
Source: (Climate Impacts Group, 2009). Reported averages are changes relative to 1970-1999, for both medium (A1B) and low (B1) scenarios and all models (39 combinations averaged for each cell in the table). The ranges for the lowest to highest projected change are in parentheses.		

Table 1: Average and range of projected changes in temperature and precipitation for the Pacific Northwest.

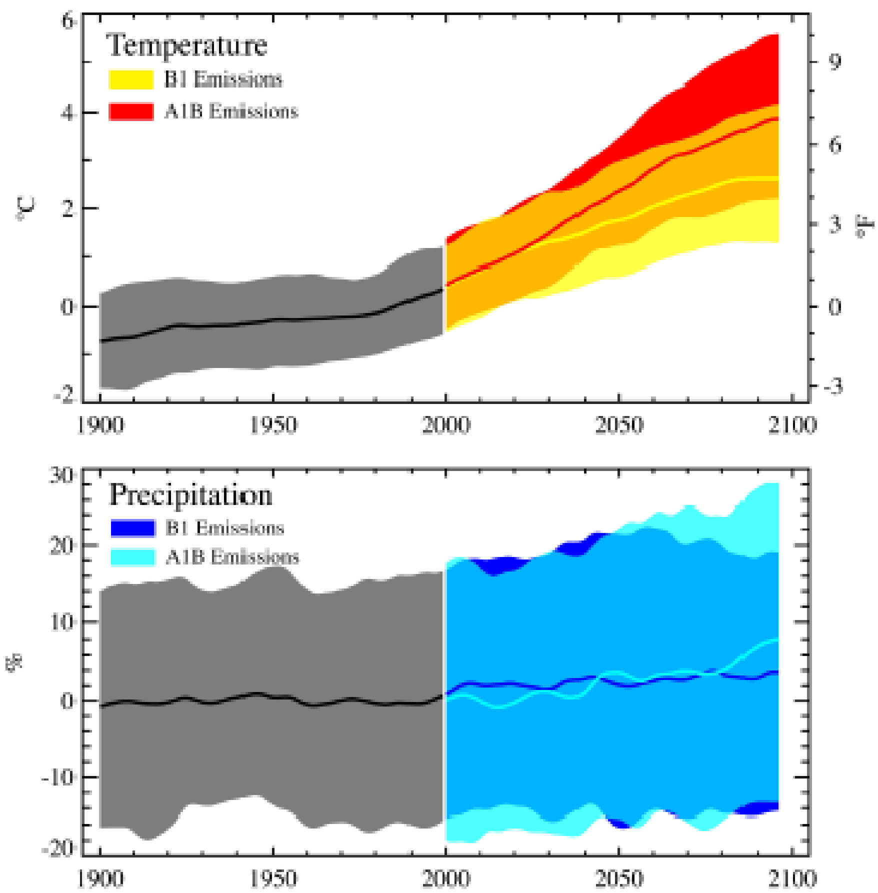
Climate models are able to match the observed 20th century warming (+1.5°F since 1920, or +0.2°F per decade for 1920 to 2000) in the Northwest, and foresee a warming rate of roughly +0.5°F per decade of warming in the 21st century (Figure 2).

Projected changes in annual precipitation vary considerably between models, but averaged changes in annual precipitation over all models are small (+1 to +2%). Changes early in the 21st century may not be noticeable given the large natural variations between wetter and drier years. Some models show large seasonal changes, tending toward wetter autumns and winters and drier summers.

Regional modeling suggests that some areas within the region and some seasons will become drier even as the region as a whole becomes wetter. Warming is expected to occur during all seasons with most models projecting the largest temperature increases in summer. The models with the most warming also produce the most summer drying.

Regional climate models project some changes that are similar across global models, namely increases in extreme high precipitation in western Washington and reductions in Cascade snowpack. Regional climate models project a larger increase in extreme daily heat and precipitation events in some locations than the global climate models suggest.

Regional climate models suggest that some local changes in temperature and precipitation may be quite different than average regional changes projected by the global models. For example, the two global models examined suggest winter precipitation will increase in many parts of the Pacific Northwest, but potentially decrease in the Cascades. Future research is required to understand if this is a trend consistent across many global models.



Source: (Climate Impacts Group, 2009). The black curve for each panel is the weighted average[9] of all models during the 20th century. The colored curves are the weighted average of all models in that emissions scenario ("low" or B1, and "medium" or A1B) for the 21st century. The colored areas indicate the range (5th to 95th percentile) for each year in the 21st century. All changes are relative to 1970-1999 averages.

Figure 1. Simulated temperature change (top panel) and percent precipitation change (bottom panel) for the 20th and 21st century global climate model simulations.

Climate Variability and Potential Impacts on Water Demand

Nationally, water withdrawals increased faster than population growth for most of this century and reached 341 billion gallons per day in 1995 (Brown, 1999).

However, since 1975 water use has been decreasing on a per capita basis, and total withdrawals have declined 9% since their peak in 1980. Per capita consumptive use is expected to continue to decline in some areas, due primarily to reductions in irrigated acreage, improvements in water use efficiency, recycling and reuse, and use of new technologies. Brown (1999) developed water use forecasts to the year 2040 under several scenarios. Total withdrawals would increase only 7% by 2040 with a 41% increase in population under changes in average temperature, precipitation, and soil moisture caused by climate changes. Increased temperatures and decreased soil moisture are very likely to increase irrigation water needs for some crops. Under drought conditions, competition for water between the agricultural and urban users is likely to intensify. Hydropower and navigation are not consumptive uses, but they are affected by both the volume and the timing of streamflows. Spring runoff peaks are expected to occur earlier and demand for electricity is very likely to increase with higher temperatures due to corresponding demands for summer air conditioning, but the water available for hydropower and cooling at electric generating plants may decrease because of increased pressure to divert more water for other uses.

Heating Degree Days

A data analysis was conducted to evaluate the variation of heating degree days (HDD) with mean monthly temperature (*T*). Mean monthly temperature and corresponding HDD for Idaho Climate Division 1 for the period 1895-2008 was obtained from the NCDC (National Climate Data Center)[2] archive. Monthly variation of temperature and HDD are shown in Figure 1.

Figure 1 shows that that the variation of HDD with temperature is primarily linear for all months except for July. Thus monthly HDD variation (*HDD*) can be modeled using a linear relationship of the form:

$$HDD = a * T + b \qquad (1)$$

Where, a and b are the constant coefficients (slope and intercept respectively) of the linear model (Eq. 1). The constants of the linear model and the degree of fit (measured by the coefficient of determination R^2) are given in Table 1.

[2] NCDC URL, http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp, accessed 11/23/09.

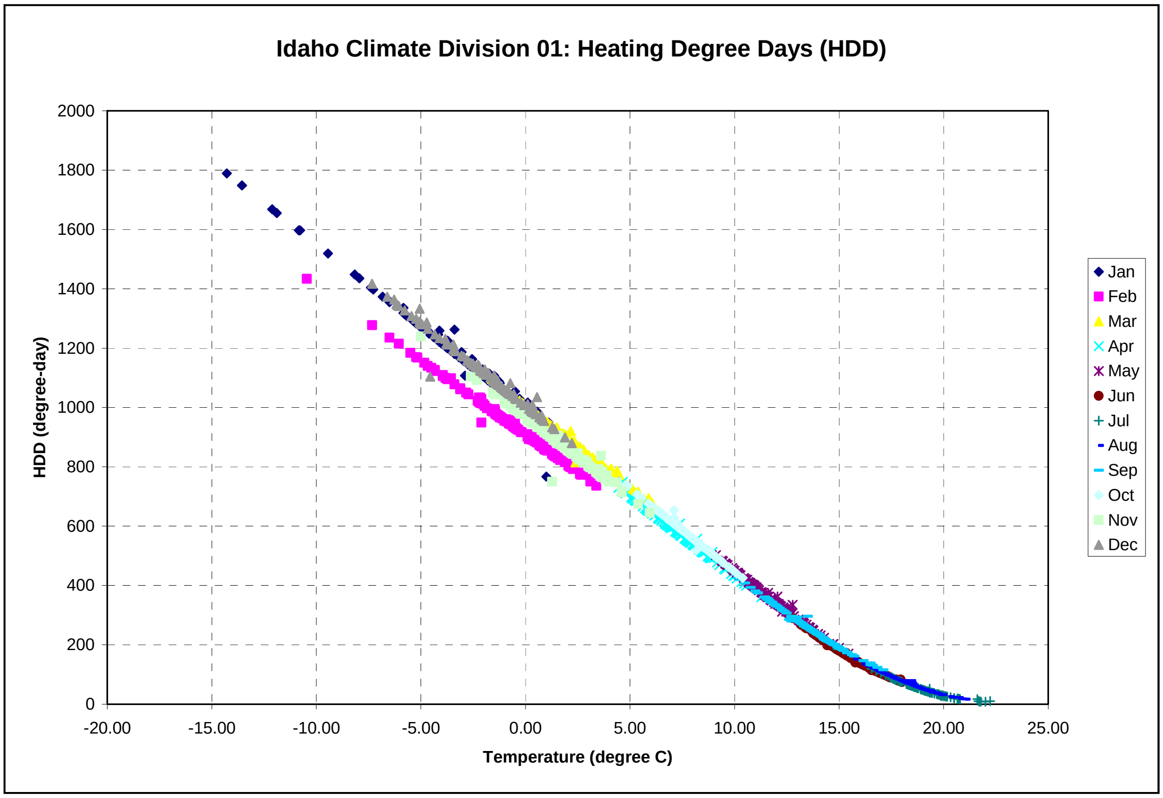


Figure 2. Monthly variation of heating degree days (HDD) with mean monthly temperature for Idaho Climate Division 1.

Now, taking the first derivative of Equation (1) with respect to temperature we get the following difference equation:

$$\Delta HDD = a * \Delta T \qquad (2)$$

Where, ΔHDD is the change in value of monthly heating degree days corresponding to change in mean monthly temperature ΔT. Then for 1°C change in mean monthly temperature, i.e., if ΔT =1°C, $\Delta HDD = a$.

For example, the January HDD (HDD_{Jan}) is modeled using the equation (refer to Table 1):

$$HDD_{Jan} = -55.88 * T_{Jan} + 995.01 \qquad (3)$$

Where, T_{Jan} is the mean monthly temperature for January. Each data point in Figure 1 for January (Jan) corresponds to a year from the period 1895-2008 (114 years). If we assume that if the mean January temperature increases by 1°C then from Equation (3), we see that HDD_{Jan} will decrease by nearly 56 degree days. This is logical because with an increase in temperature we should expect a decline in the energy need to heat, and hence a decrease in the degree-days. Also, from the NCDC archive we estimated that the average degree-days (average over all Januarys for the period 1895-2008) is 1177. With +1°C change in mean monthly January temperature we have estimated a decrease in HDD of nearly 56, so the average HDD for January with +1°C change is 1122 (rounded to nearest integer). Then the percentage change in HDD for January is calculated to be -4.75. Similar calculations were carried out for all months and the results are given in Table 2.

Month	***a***	***b***	**R^2**
Jan	-55.88	995.01	0.9855
Feb	-49.83	909.84	0.9936
Mar	-55.25	1007.60	0.9930
Apr	-54.12	972.74	0.9921
May	-52.71	975.12	0.9949
Jun	-40.72	794.45	0.9879
Jul	-22.36	477.90	0.9252
Aug	-27.05	566.93	0.9776
Sep	-46.10	883.63	0.9915
Oct	-56.27	1008.70	0.9921
Nov	-53.69	967.29	0.9711
Dec	-54.90	1008.30	0.9767

Table 2. Coefficients of the linear model fitted to monthly HDD and mean monthly temperatures, and corresponding coefficient of determination.

Month	Average HDD	∆HDD	Average HDD With +1 °C	%HDD Change
Jan	1177	-56	1122	-4.75
Feb	955	-50	905	-5.22
Mar	854	-55	798	-6.47
Apr	573	-54	518	-9.45
May	351	-53	298	-15.03
Jun	165	-41	125	-24.64
Jul	54	-22	31	-41.73
Aug	75	-27	48	-36.07
Sep	261	-46	215	-17.67
Oct	583	-56	527	-9.65
Nov	882	-54	829	-6.08
Dec	1115	-55	1060	-4.93

HDD values are rounded to nearest integer.

Table 3. Average HDD by month, average HDD with 1°C mean monthly temperature increase and percentage change in HDD for each month.

Furthermore, changes in HDD by season and annually were also estimated and are given in Table 3.

Season	Average HDD	Average HDD With +1 °C	%HDD Change
DJF	3247	3087	-4.95
MAM	1777	1615	-9.12
JJA	294	204	-30.67
SON	1726	1570	-9.04
Annual	7044	6476	-8.08

Table 4. Seasonal change in HDD.

To analyze the impacts of climate variability on HDD, the sensitivity results from Table 2 – percentage change in HDD to +1°C can be utilized. For the winter season (Dec-Jan-Feb, DJF) HDD decline by nearly 5%. For spring (Mar-Apr-May, MAM) and fall (Sep-Oct-Nov, SON), HHD decline by nearly 9% (Table 3). For the summer months the variable of interest is cooling degree days (CDD), and the HDD results are of little value for the Jun-Jul-Aug (JJA) season. The average annual decline in HDD for the study region is also estimated to be about 8%. Despite decreasing heating degree days with projected warming, annual heating energy demand is expected to increase due to population growth.

Cooling Degree Days

To study the variation of cooling degree days (CDD) with mean monthly temperature (*T*) we undertook a data analysis similar to the HDD analysis. Mean monthly temperature and corresponding CDD for Idaho climate division 1 for the period 1895-2008 was obtained from the NCDC (National Climate Data Center)[3] archive. This analysis was restricted to the summer season, June-July-August (JJA). Unlike the HDD, the relationship between mean monthly temperature and CDD for the summer months was found to be largely non-linear. To simplify, we assumed a linear approximation to the CDD versus monthly temperature relationship, and found an increase of nearly 35% in the CDD value over the historical 1895-2008 period for the JJA season for +1°C temperature change.

Evapotranspiration

Monthly potential evapotranspiration (PET) for Idaho Climate Division 1 was estimated from mean monthly temperature for this climate division using the Hamon equation (Hamon, 1961). Monthly Hamon PET (PET_{Hamon}) was estimated using the equation (McCabe and Wolock, 2002):

$$PET_{Hamon} = 0.1651 dLW_t \quad (1)$$

Where PET_{Hamon} is the PET in millimeters (mm) per month; d is the number of days in a month, L is the mean monthly hours of daylight in multiples of 12 hours, and W_t is the saturated water vapor density (g/m^3) calculated by:

$$W_t = 4.95 \exp(0.062T) \quad (2)$$

Where T is the monthly mean temperature in degrees Celsius.

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[3] NCDC URL, http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp, accessed 11/23/09.

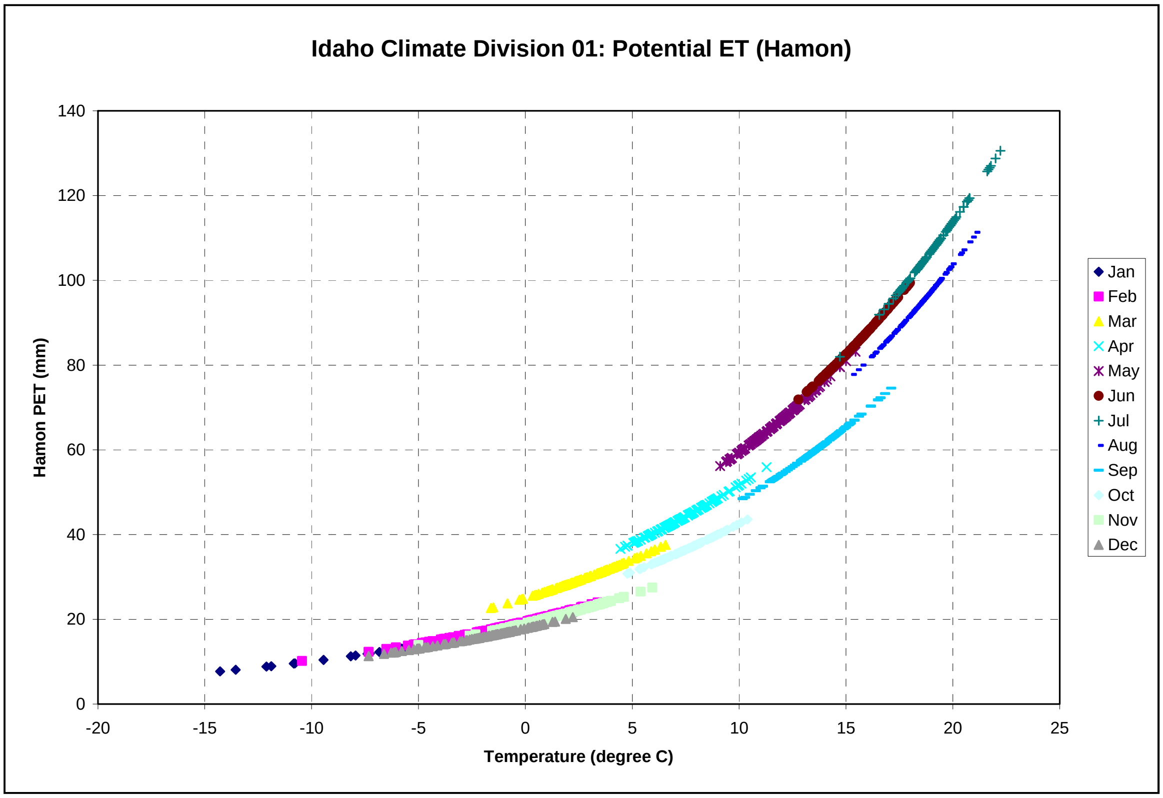

Figure 3. Monthly variation of potential evapotranspiration (Hamon, 1961) with mean monthly temperature.

The monthly variation of PET (Hamon, 1961) is given in Figure 1. Mean monthly temperatures were then increased by 1°C and the Hamon PET was recalculated. The results from this analysis are summarized in Table 1.

Month	Hammon PET (mm)	
	Historical	*With +1 degree C*
Jan	15.57	16.56
Feb	18.58	19.77
Mar	29.93	31.85
Apr	44.14	46.96
May	66.76	71.03
Jun	85.10	90.55
Jul	107.09	113.94
Aug	93.47	99.45
Sep	59.88	63.71
Oct	36.67	39.02
Nov	21.08	22.43
Dec	16.00	17.02

Table 5. Monthly PET (Hamon) – historical and with 1°C increase in temperature.

Based on this analysis, the percentage PET change was estimated to be 6.4% for every 1°C increase in mean temperature.

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