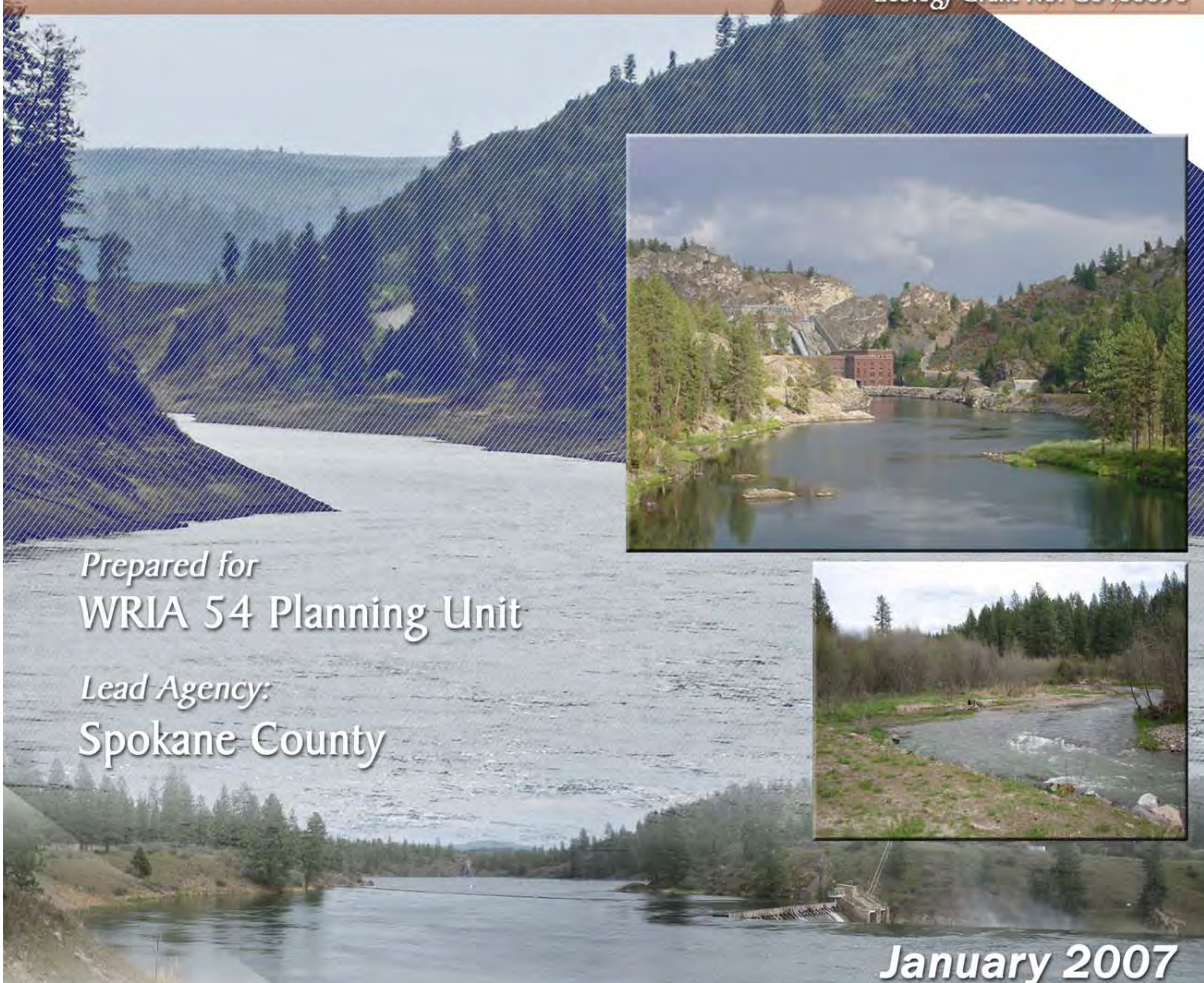
Water Resource Inventory Area 54 (Lower Spokane) Watershed Plan

Phase 2, Level 1 Data Compilation and Technical Assessment

Ecology Grant No. G0400096



Prepared for

WRIA 54 Planning Unit

Lead Agency:

Spokane County

January 2007

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Triangle

GEOENGINEERS

WRIA 54 Planning Unit

WATER RESOURCE INVENTORY AREA 54 (LOWER SPOKANE) WATERSHED PLAN PHASE 2, LEVEL 1 DATA COMPILATION AND TECHNICAL ASSESSMENT

JANUARY 2007

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WRIA 54 Planning Unit

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EXECUTIVE SUMMARY

The Level 1 Data Compilation and Technical Assessment is the first comprehensive compilation and synthesis of water-resource data for Water Resource Inventory Area (WRIA) 54, which is the watershed of the Lower Spokane River. WRIA 54 is one of 62 major watersheds in Washington State delineated for planning purposes under the state's Water Resources Management Program.

The Level 1 assessment was prepared under Phase 2 of the WRIA 54 watershed planning effort, which is being led by Spokane County in cooperation with other private and government agencies and groups that make up the WRIA 54 Planning Unit. The Planning Unit will use the data assembled for the technical assessment to make recommendations for water quantity, in-stream flow, and water quality issues. These recommendations will be outlined in a watershed management plan for WRIA 54, to be completed by 2008.

WATERSHED CHARACTERISTICS

WRIA 54, an 885-square-mile watershed in eastern Washington, encompasses portions of the Cities of Spokane and Medical Lake, Spokane, Stevens and Lincoln Counties, and Fairchild Air Force Base; most of the Spokane Indian Reservation; and the City of Airway Heights (see Figure 1-1). The dry but temperate climate of the area has interacted with local geology to create soils, aquifers, and water bodies that interact in complex ways. The watershed consists of 13 subbasins:

- Airway (81 square miles)
- Camas Valley (90 square miles)
- Coulee Creek (54 square miles)
- Deep Creek, North-South (80 square miles)
- Ford (100 square miles)
- Harker Canyon (60 square miles)
- Little Chamokane (71 square miles)
- Long Lake, North (48 square miles)
- Long Lake, South (66 square miles)
- Orazada (29 square miles)
- Pitney (46 square miles)
- Sand Blue (95 square miles)
- Spring Creek (63 square miles)

Surface Water

The Spokane River enters WRIA 54 at its confluence with Latah (Hangman) Creek and exits WRIA 54 at its confluence with the Columbia River. WRIA 54 includes 75.6 percent of the river's length. Much water-resource information exists for the main stem Spokane River throughout WRIA 54, but very little exists for most of the tributaries, such as Deep and Coulee Creeks, Spring Creek, and Mill Creek. While the main stem Spokane River is by far the largest surface water body in the WRIA and therefore may warrant a primary focus, it will be impossible to comprehensively manage the watershed without better data for the tributary subbasins. This need is particularly acute in the Deep Creek, Coulee Creek, Airway and Long Lake North subbasins, which are experiencing rapid change resulting from development.

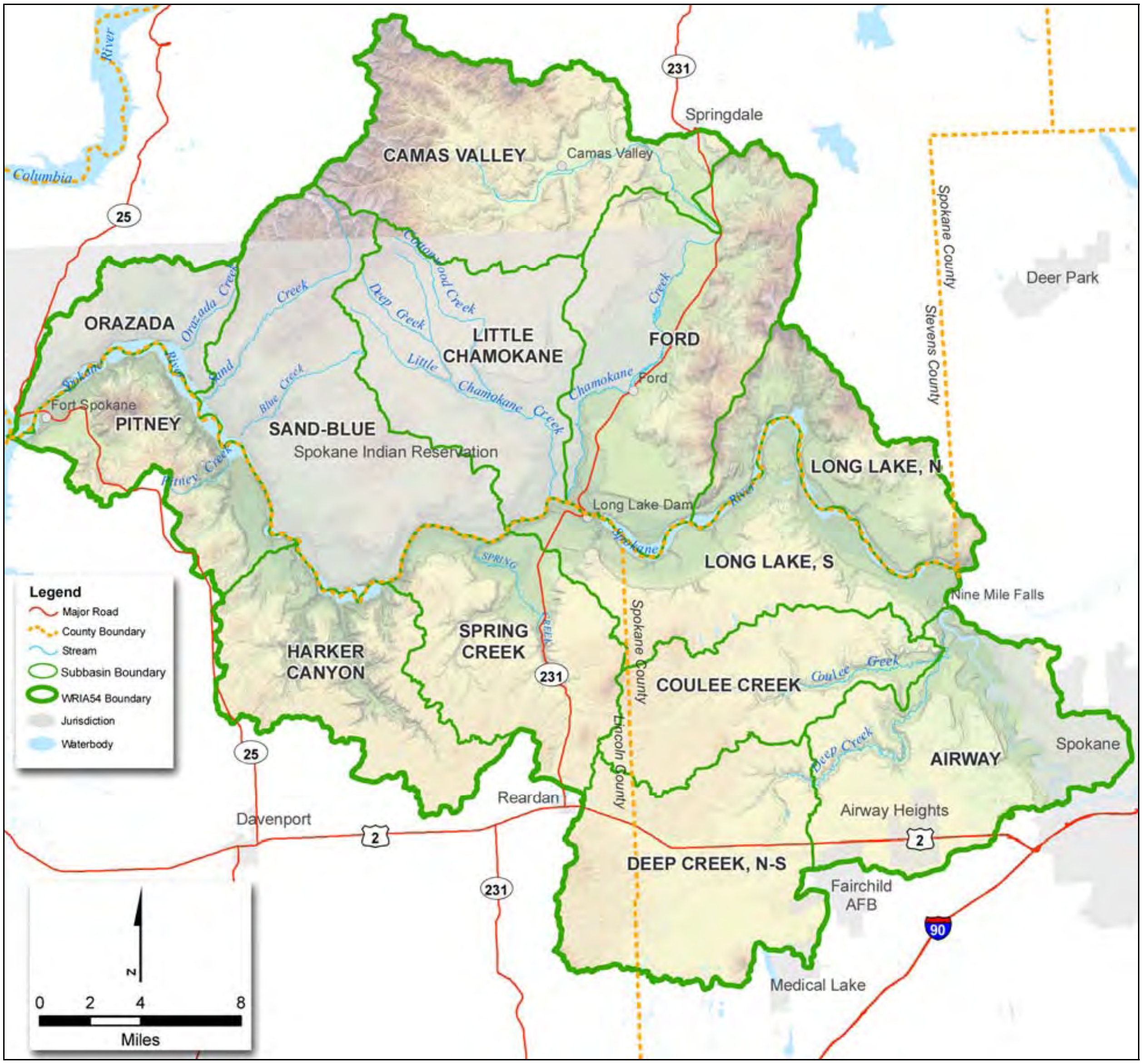

Figure ES-1. WRIA 54 Boundaries and Key Features

Groundwater

The Spokane Valley-Rathdrum Prairie (SVRP) Aquifer discharges water to the Spokane River between Latah (Hangman) Creek and Nine Mile Falls Dam. During low-flow periods, this discharge is a significant component of flow for the Spokane River in WRIA 54, and the WRIA 54 Planning Unit will have a keen interest in the quality and quantity of SVRP water that contributes flow to the Spokane River. Significant groundwater interaction with the Spokane River below Nine Mile Falls Dam has not yet been adequately studied, and warrants further investigation.

A number of other groundwater aquifers whose characteristics are not currently well-known warrant further study as well, as they hold promise for water supply purposes or appear to be already over-utilized in some areas. These include the following:

- The Chamokane Valley Aquifers—These aquifers lie in unconsolidated sand and gravel in the drainage basin of Chamokane Creek (in the Ford subbasin and possibly the Camas Valley subbasin). An upper aquifer lies in sands and gravels 20 to 100 feet thick. A lower aquifer is below the upper aquifer, separated by a layer of silt and clay; little information about the lower aquifer is currently available.

- Columbia River Basalt Group (CRBG) aquifers that are present in most of the southern portion of the WRIA (south of the Spokane River):
  - Grande Ronde Formation Aquifers—The Grande Ronde Basalt Formation is the most voluminous of the CRBG formations, making up 85 to 88 percent of the total volume of the CRBG. The Grande Ronde has been observed to be up to 514 feet thick in the West Plains area.
  - Wanapum Basalt Formation Aquifers—The Wanapum Basalt Formation is the second-most voluminous of the CRBG formations, making up about 6 percent of the total volume. It overlies the Grande Ronde Basalt and is present throughout much of the study area south of the Spokane River. The Wanapum Basalt has been observed to be up to 292 feet thick in wells in the West Plains area.
  - Paleochannel Aquifers—Some locations in the Wanapum basalt feature "paleochannels," which are channels carved into the basalt by ancient rivers that later filled with glacial sands and gravels. Sediment accumulations in these channels are over 200 feet thick in spots and provide large quantities of usable groundwater.

Groundwater/surface water interaction is a dynamic component of the intra-basin water balance throughout WRIA 54. This exchange of water is not well understood below Lake Spokane (Long Lake) on the Spokane River, and even less well documented in tributary subbasins. Hydraulic continuity between the Upper Chamokane Valley Aquifer and Chamokane Creek is believed to be significant, based on historical observations of water levels, stream flow and water well pumping.

Population and Land Use

The 2000 population of WRIA 54 is estimated to be slightly over 89,000, and the population is projected to grow to slightly over 122,000 by 2025, a 37-percent increase.

Currently, 49 percent of the area of WRIA 54 is forested, 25 percent is used for agriculture, and 18 percent is open land. The remaining 8 percent is a mix of residential, commercial and industrial development, open water, wetlands and barren land. At buildout (full development allowed by current zoning), the area of the watershed could be 47 percent agricultural, 33 percent low-intensity residential and 11 percent forest, with all other uses making up the remaining 9 percent of the area. These percentages indicate allowed development under current zoning, not actual growth projections.

WATER RIGHTS

Water right claims, which are assertions of vested water rights established through beneficial use that began prior to state regulation of water rights, dominate the recorded water documents in WRIA 54. More than 1,700 claims are included in state records, with a total estimated claim to almost 38,000 acre-feet of water annually, based on standard quantity assumptions recommended by the Department of Ecology (Ecology). This annual volume is about evenly divided between surface water claims and groundwater claims. Water rights authorized by state-approved certificates or temporarily authorized by state-approved permits amount to a total annual allocation of 78,500 acre-feet of water—about 80 percent from groundwater sources and 20 percent from surface water sources. The Spokane Tribe holds quantified irrigation rights to Chamokane Creek totaling more than 25,000 acre-feet; these rights were affirmed in a 1979 federal court order. It is estimated that permit-exempt rights, which require no permit based on their size or intended use, account for an additional allocation of about 5,800 acre-feet per year. Figure ES-2 summarizes available records on claims, permits and certificates, and permit-exempt rights.

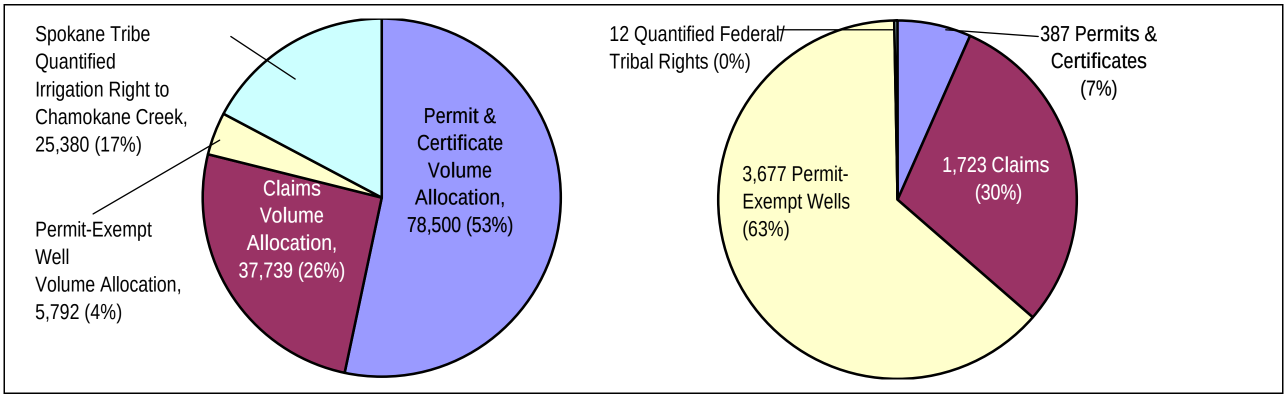

Figure ES-2. Summary of Water Rights by Allocated Annual Volume in Acre-Feet (left) and Number of Rights (right)

Uncertainty about the true quantity of water appropriated through claims restricts the ability to effectively manage water resources in WRIA 54. The understanding of the probable appropriation could be refined through additional targeted studies, but only an adjudication can actually validate these potential appropriations. The first targeted studies we recommend are the following:

- Investigate the largest claims to evaluate the likelihood that they are actively being used, and if so, the nature of the use.
- Further investigate potential duplicate claims to establish greater confidence that they can be removed from water-rights calculations.
- Because so many of the claims are to groundwater for small quantities, it is likely that many of these serve single domestic needs. The estimates for permit-exempt wells in this document may overlap significantly with this category of claims. A study to evaluate the magnitude of this overlap would help refine the understanding of this potential appropriation.

Significant tribal reserved water rights exist in WRIA 54, owned by the Spokane Tribe. These rights pre-date Washington State's water code, and are partially quantified for the Tribe's use of Chamokane Creek. Other tribal and federal reserved water rights in WRIA 54 are not quantified; rather, they are described qualitatively as water needed to serve the purposes of the reservation or other land holding. For instance, if an Indian reservation is set aside in a treaty for "farming and fishing purposes," the measure of the water rights reserved is not a specific amount of water appropriated at some historical time, but the amount of water that is necessary now or in the future for the reservation's use in farming and fishing. Federal and Indian reserved water rights are not subject to state law provisions requiring continuous beneficial use of water to retain a water right. (Pharris et al, 2002) .

The estimates for permit-exempt wells were developed using standard methodologies. However, because there is almost no information to verify the location and use of these wells, it is impossible to accurately evaluate the impacts of permit-exempt wells. For exempt wells that are simply providing water to one home, the individual impact is not likely to be significant. Significant impacts may be occurring where exempt wells provide significant water for agricultural or industrial purposes, for multiple homes, or where there is a high density of permit-exempt wells.

WATER USE

Actual current water use in WRIA 54 was estimated for several types of uses as follows:

- Irrigation—27,223 acre-feet per year
- Large public water systems (Group A systems)—22,404 acre-feet per year
- Permit-exempt wells—5,792 acre-feet per year
- Small public water systems (Group B systems)—39 acre-feet per year
- Stock watering—259 acre-feet per year
- Other uses—524 acre-feet per year

Although the total estimated current use in WRIA 54 (56,639 acre-feet per year) is well below the amount allocated by potential water rights (147,411 acre-feet per year), the estimated actual use exceeds potential water right appropriations in three subbasins: Harker Canyon, Little Chamokane, and Pitney. This may be the result of transfer of water between subbasins (a water right in one subbasin with actual use in a different subbasin). In some heavily populated subbasins, actual current water use that exceeds current allocated withdrawals may not be identified in this analysis if the estimates of allocated withdrawal include inchoate water rights (currently unused portions of water rights) held by municipal water purveyors in those subbasins. Illegal water use—not covered by a water right permit, certificate, claim, or permit-exempt well—is not addressed in this assessment.

WATER BALANCE

A water balance provides an understanding of the magnitude of each component of water entering and leaving the watershed (precipitation, surface water inflow, consumptive use, etc.) and identifies where surpluses and deficits exist, both spatially throughout the watershed, and seasonally throughout the year. A water balance over such a large planning area as WRIA 54 has limited direct connection to water-resource allocation management, but it does provide useful information for general planning, education, and targeting further detailed work efforts. Table ES-1 summarizes the estimated annual water volumes for the water balance components evaluated for this technical assessment.

The Spokane River accounts for 4,845,000 acre-feet of the total annual inflow to WRIA 54 and 5,278,000 acre-feet of the annual outflow from the watershed. Although the river dominates the water balance to such a large extent that other components of the water balance appear insignificant, the other water balance components are significant with respect to water resource management. For example, water balance components such as groundwater flow and net demand could be critical factors in water resource management at the basin and particularly subbasin level. These components are among the least understood at this time.

FUTURE WATER NEEDS

Future water needs, which are anticipated to be primarily for municipal and domestic supply (this includes associated commercial/industrial uses), are expected to increase by approximately 57 percent by 2025, based on WRIA 54 growth projections. This increase will likely be focused in two areas—the West Plains region of Spokane County and near the Spokane River downstream from the City of Spokane—and the increase may exceed 57 percent in those areas. Some of the new demand will be within established water service areas, but existing purveyors’ systems may not be fully built at this point. Other growth areas will be outside of established water service areas.

TABLE ES-1.
WRIA 54 WATER BALANCE SUMMARY

Component	Average Annual Volume (acre-feet)	% of Total
Inflows		
Surface Water Inflow	5,502,871	91.6%
Groundwater Inflow	130,340	2.2%
Precipitation	333,972	5.5%
Imported Water[a]	40,825	0.7%
Total Inflow	**6,008,006**	**100%**
Outflows		
Surface Water Outflow	5,280,479	84.5%
Groundwater Outflow	15,922	0.3%
Evapotranspiration[b]	923,212	14.8%
Exported Water	267	0.0%
Net Demand[c]	25,970	0.4%
Total Outflow	**6,245,849**	**100%**
Difference Between Outflow and Inflow	237,843	
% Difference Between Outflow and Inflow	4.0%	

a. Discharge of treated wastewater effluent from sources outside the watershed
b. Loss of water through evaporation to the atmosphere and uptake by plants
c. Municipal, domestic, commercial, industrial and agricultural water consumption

Municipal purveyors' inchoate water rights will help meet this future demand. The magnitude of inchoate rights differs among purveyors, however, and may not be matched to where actual growth in water demand will occur. This should be approached as a regional issue through a coordinated planning effort.

Water conservation can be an important component in meeting current and future water supply needs. All municipal purveyors currently have conservation programs described in their water system plans; implementation of these programs, as well as additional conservation activities, will produce significant water savings. Because outdoor water use (residential, commercial, and agricultural irrigation) is such a large component of water use in WRIA 54, conservation efforts targeted to reducing outdoor water use will be most fruitful. For example, outdoor water use accounts for approximately three-quarters of the water consumed by the Group A and Group B systems alone in WRIA 54. One exception to this is on the Spokane Indian Reservation where few homes maintain lawns.

Water needs for in-stream flow are being evaluated through the WRIA 54/57 Instream Flow Study currently being conducted. Results of the instream flow study will help quantify stream flow requirements for fish in the free-flowing portion of the main stem Spokane River, Deep Creek, Coulee Creek, Little Chamokane Creek, and Lower Spring Creek. These results will be integrated with other instream flow needs and Level 1 Assessment results by the Planning Unit as the WRIA 54 Watershed Plan is developed.

POTENTIAL FUTURE WATER SOURCES

One of the primary goals of watershed planning is to estimate the amount of water available for future allocation in the watershed. In WRIA 54, gaps in the existing data set limit the understanding of watershed hydrology and make a comprehensive determination of water availability difficult. Water availability considerations for WRIA 54 include the following:

- Surface water could be available for future allocation from the Lower Spokane River. This determination will depend upon, among other factors, the in-stream flow analysis currently being performed for the WRIA 54 Planning Unit on the free-flowing reach of the Lower Spokane River.
- Surface water could be available for future allocation from tributaries of the Lower Spokane River if further investigation shows it could be done with acceptable impacts. Stream flow data are currently not available for most of the tributaries and would be necessary before allocations are feasible. Though a number of these tributaries are intermittent (do not flow continuously throughout the year), continuous supply could be achieved by implementing water storage projects. This determination also will depend upon, among other factors, the in-stream flow analysis currently being performed for the WRIA 54 Planning Unit.
- The paleochannel aquifers appear to be a relatively promising source for additional groundwater allocation. Given the relatively low number of wells currently pumping from paleochannel aquifers, well interference issues likely would be less extensive than in CRBG aquifers. Aquifer recharge and recovery may be a component of development of the paleochannel aquifers as water supply sources.
- The CRBG aquifers in the West Plains area appear to have significant existing groundwater mining and well interference issues, suggesting that these aquifers could be over-allocated in the West Plains area. Additional allocation of this resource should be limited until the impact of future allocation is evaluated by groundwater flow modeling. Aquifer recharge and recovery projects may be viable in these aquifers, but this concept has yet to be evaluated.
- Groundwater elevation data associated with CRBG aquifers in the southwest portion of WRIA 54 are limited. However, based on the current distribution of wells in the basin and aquifer hydraulic characteristics, there could be opportunity for significant additional withdrawal in this area.
- The SVRP Aquifer is an important source of water throughout the region. Further use of this resource in WRIA 54 will depend on the results of an ongoing U.S. Geological Survey investigation, possible water right adjudication efforts, and in-stream flow analysis for the free-flowing reach of the Lower Spokane River.

WATER QUALITY

The water quality information provided with this Level 1 Assessment is limited to a brief summary of water quality information related to total maximum daily loads (TMDLs) developed for the Spokane River and Lake Spokane (Long Lake). The TMDLs are associated with the following water quality parameters:

- Dissolved oxygen—Dissolved oxygen levels in the Spokane River and Lake Spokane (Long Lake) have been among the most significant water quality issues in WRIA 54, and the Washington Department of Ecology is preparing TMDL limits for nutrients entering the Spokane River system to help ensure that the river meets state water quality standards.

- Dissolved metals—Upstream mining areas in Idaho are the primary source of metal contamination in the Spokane River. The TMDL implementation plan calls for continued cleanup of these mining areas as well as of beaches along the Spokane River where contaminated sediments have accumulated.
- Polychlorinated biphenyls (PCBs)— Spokane River and Lake Spokane (Long Lake) violate the water quality standards for PCBs in several locations. The TMDL process for the Spokane River is just beginning, with a problem assessment study to examine the levels of PCBs in the Spokane River and to determine possible sources.
- Total phosphorus—The 1992 Lake Spokane (Long Lake) Total Phosphorus TMDL, which placed initial controls on phosphorus loading to the Spokane River system, will be superseded by the TMDL for dissolved oxygen.

The planning unit intends to undertake additional water quality assessment work under a separate project, funded through a supplemental grant from the Department of Ecology.

CHAPTER 1.
INTRODUCTION

Spokane River

Water Resource Inventory Area (WRIA) 54 in eastern Washington encompasses portions of the City of Spokane, Spokane County, Stevens County, Lincoln County, and the Spokane Indian Reservation (see Figure 1-1). The 885-square-mile watershed has been subdivided into 13 subbasins. The subbasins in the western portion of WRIA 54 drain predominantly rural and agricultural land; the eastern subbasins drain more urban areas. The tributaries in all the subbasins discharge into (or flow toward) the Spokane River, which flows east to west through the middle of WRIA 54.

Spokane County (County) is leading a watershed planning effort for WRIA 54 and in 2003 submitted an application for funding to organize the planning effort (Phase 1 funding). The County also received $200,000 in Phase 2 funding to develop a technical assessment. This technical assessment report is being developed as a component of a watershed management plan to identify the characteristics of the watershed, including geology, climate, hydrology, hydrogeology, land use, and certain water quantity data. These data will be used during the watershed planning process to make recommendations for water quantity, in-stream flow, and water quality issues. It is expected that the watershed management plan will be completed by 2008.

The only previously prepared watershed plan in WRIA 54 is the *Chamokane Creek Watershed Management Plan,* published by the Stevens County Conservation District in 2000. This document provides a detailed look at water quality issues within the Chamokane Creek Watershed.

WASHINGTON STATE WATERSHED PLANNING

The Washington Water Resources Act of 1971 (Revised Code of Washington (RCW) 90.54) was developed with the following purpose (Washington State Legislature, 2006):

> *…to set forth fundamentals of water resource policy for the state to insure that waters of the state are protected and fully utilized for the greatest benefit to the people of the State of Washington and, in relation thereto, to provide direction to the Department of Ecology, other state agencies and officials, and local government in carrying out water and related resources programs. It is the intent of the Legislature to work closely with the executive branch, Indian tribes, local government, and interested parties to ensure that water resources of the state are wisely managed.*

The Washington Department of Ecology was directed to develop and implement a comprehensive state water program for making future decisions related to water resource allocation and use. The outcome was the Water Resources Management Program (Washington Administrative Code (WAC) 173-500), which divided the state into 62 areas known as WRIAs, representing the state's major watershed boundaries (Ecology, 2006a; Washington State Legislature, 2006). These boundaries were developed jointly by the Washington Departments of Ecology, Natural Resources, and Fish and Wildlife (Ecology, 2006b).

To address the water resource issues in each WRIA with the greatest input on local needs, the state enacted the Watershed Management Act in 1998 (RCW 90.82), which includes the following statement (Washington State Legislature, 2006):

> *The legislature finds that the local development of watershed plans for managing water resources and for protecting existing water rights is vital to both state and local interests. The local development of these plans serves vital local interests by placing it in the hands of people: Who have the greatest knowledge of both the resources and the aspirations of those who live and work in the watershed; and who have the greatest stake in the proper, long-term management of the resources. The development of such plans serves the state's vital interests by ensuring that the state's water resources are used wisely, by protecting existing water rights, by protecting in-stream flows for fish, and by providing for the economic well-being of the state's citizenry and communities. Therefore, the legislature believes it necessary for units of local government throughout the state to engage in the orderly development of these watershed plans.*

RCW 90.82 provides a process for citizens and local government entities to come together and assess the water resources in their WRIA and determine an agreeable method to address the issues. It also brought 12 state agencies together to sign a Memorandum of Understanding outlining the roles and responsibilities of each agency in the watershed planning process, so that the agencies work together and speak as one during the local watershed planning process (Ecology, 2006c).

Memorandum of Understanding Agencies

- Department of Agriculture
- Conservation Commission
- Department of Community, Trade, and Economic Development
- Department of Ecology
- Department of Fish and Wildlife
- Department of Health
- Department of Natural Resources
- Department of Transportation
- Interagency committee for Outdoor Recreation
- Puget Sound Water Quality Action Team
- Salmon Recovery Office, within the Governor's Office
- State Parks and Recreation Commission

RCW 90.82 also outlines state funding in the form of grants for each watershed planning phase (Ecology, 2006c). The phases and funding options are as follows (Spokane County, 2003):

- **Phase 1, Organizational Phase**—$50,000 per WRIA or $75,000 for multi-WRIA planning units.
- **Phase 2, Assessment Phase**—Up to $200,000 per WRIA
  - Level 1 Assessment—A compilation and review of existing data relevant to defined objectives. If a planning unit decides that the existing data are sufficient to support the management requirement of all or some of the issues, the planning unit may choose to skip Level 2 and move on to Level 3 for these issues.
  - Level 2 Assessment—New data collection or additional analysis of existing data within the time frame of the planning process to fill data gaps and support decision needs.
  - Level 3 Assessment—Long-term monitoring of selected parameters following completion of the initial watershed plan to improve management strategies.

Supplemental assessments may be conducted in the following focused areas:

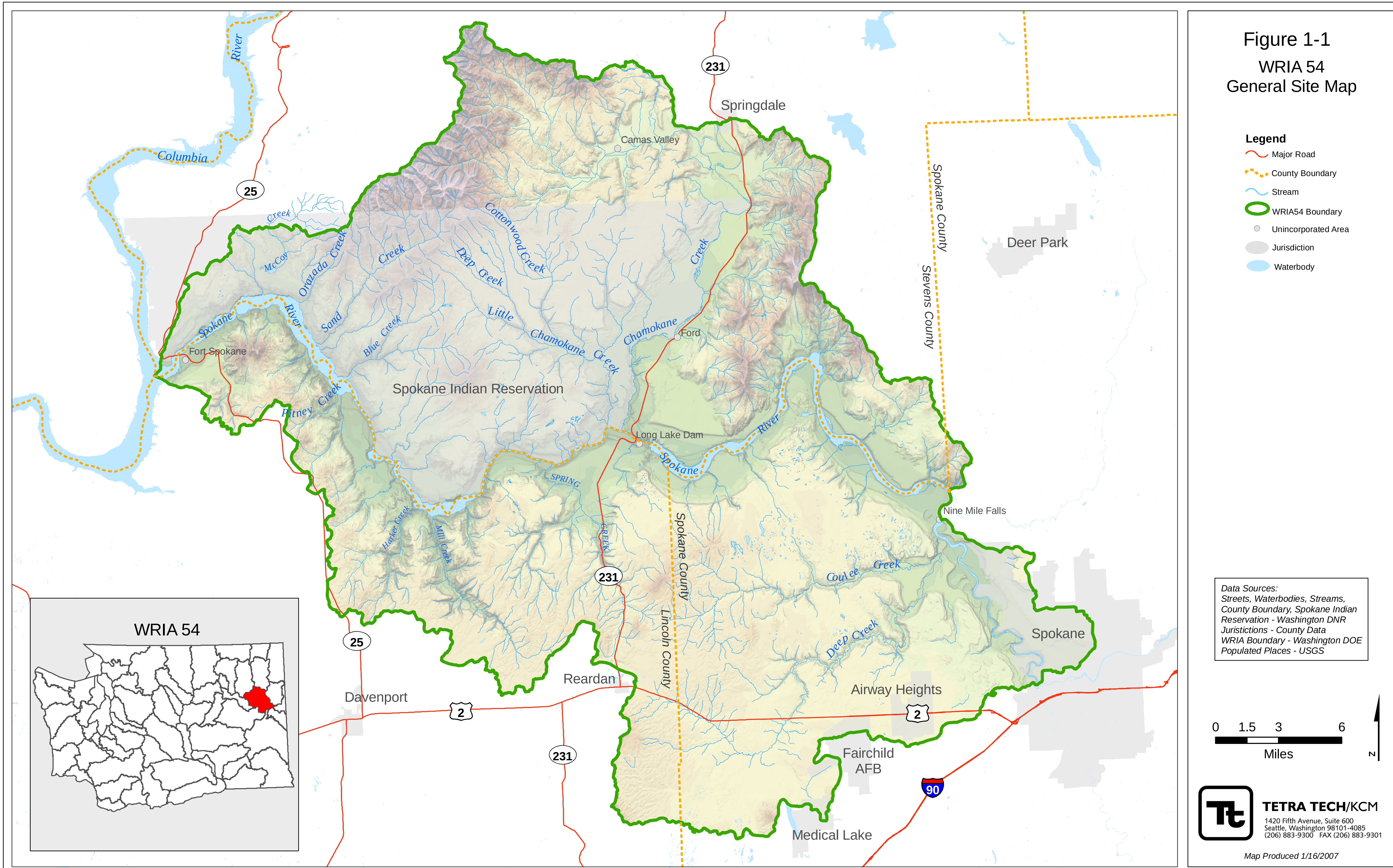
Figure 1-1
WRIA 54
General Site Map
Legend
Major Road
County Boundary
Stream
WRIA54 Boundary
Unincorporated Area
Jurisdiction
Waterbody
Data Sources:
Streets, Waterbodies, Streams,
County Boundary, Spokane Indian
Reservation - Washington DNR
Juristictions - County Data
WRIA Boundary - Washington DOE
Populated Places - USGS
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Miles
N
TETRA TECH/KCM
1420 Fifth Avenue, Suite 600
Seattle, Washington 98101-4085
(206) 883-9300 FAX (206) 883-9301
Map Produced 1/16/2007
WRIA 54
Springdale
Camas Valley
Deer Park
Spokane Indian Reservation
Fort Spokane
Ford
Long Lake Dam
Nine Mile Falls
Spokane
Airway Heights
Fairchild AFB
Medical Lake
Reardan
Davenport
Spokane County
Stevens County
Lincoln County
Columbia River
Spokane River
Chamokane Creek
Little Chamokane Creek
Cottonwood Creek
Deep Creek
Sand Creek
Blue Creek
Orazada Creek
McCoy Creek
Pitney Creek
Harker Creek
Mill Creek
Coulee Creek
Spring Creek
231
25
2
90

  - Multipurpose Storage; up to $100,000 per WRIA—Conduct a detailed assessment of multipurpose water storage opportunities or studies of specific multipurpose storage projects that are consistent with and support the other elements of the planning unit's watershed plan.
  - In-stream Flows; up to $100,000—Establish new minimum in-stream flow regulations or amend existing regulations.
  - Water Quality; up to $100,000—Conduct a water quality assessment in fulfillment of RCW 90.82.090 to support development of the watershed plan.
- **Phase 3, Planning Phase**—Up to $250,000 per WRIA for watershed plan development. The watershed management plan requires a consensus by all members of the planning unit, or at least an initiating government consensus and a majority vote by the planning unit. After approval from the planning unit and adoption by local governing authorities with territory in WRIA 54, the plan must be implemented by the local and state agencies. This phase of work must be completed within four years of initiating Phase 2 work.
- **Phase 4, Implementation**—Up to $400,000. A detailed implementation plan is required. Funds are distributed over five years and require 10-percent matching funds.

WRIA 54 PLAN INITIATION

Spokane County's grant agreement for Phase 1 of the WRIA 54 watershed management plan became effective October 10, 2003, establishing the needed structure, processes and scope of work to ensure that this watershed planning effort results in all parties acting in unison to manage the water and fishery resources of WRIA 54 (Ecology, 2006a). The initiating governments of this project include the City of Spokane, Lincoln County, Spokane County, Stevens County, Stevens PUD #1, and the Spokane Tribe. Spokane County was identified as the lead agency for the planning process. The key task of Phase 1 was the formation of a planning unit to oversee the watershed planning process for WRIA 54.

Phase 2 of the WRIA 54 watershed planning effort began in the fall of 2005, when the planning unit embarked on an in-stream flow study and development of its Level 1 data compilation and technical assessment, which would compile available water resources data and present the data and conclusions for use by the planning unit in developing the WRIA 54 watershed plan. A consultant team, led by Tetra Tech, Inc., partnering with GeoEngineers and Triangle Associates, was retained to prepare the Level 1 assessment.

CONTENTS OF THIS TECHNICAL ASSESSMENT

The Phase 2 Level 1 data compilation and technical assessment identifies existing information about the WRIA and additional information that needs to be collected in the Level 2 assessment. The Level 1 assessment focuses on the characteristics of the watershed, including physical attributes, land use, and the rights and uses of resources. The purpose of identifying these characteristics is to evaluate the nature and sustainability of the water resources in order to develop a plan for managing them. This Level 1 assessment for WRIA 54 describes the following:

- **Watershed Characteristics**—The watershed characteristics of WRIA 54 are diverse and distinctive. Geologically, the watershed has experienced volcanic activity, metamorphism, sedimentation, and glaciations. These geologic activities have led to the vast hydrogeologic resources in the eastern portion of the watershed and complex interaction of surface waters with groundwater systems. The geologic characteristics, combined with the moderate climate, have also led to most of the watershed being used for private agricultural purposes. Only the easternmost portions of the watershed have significant urban areas.

- **Water Rights and Water Use**—The users of water resources in WRIA 54 include municipal, industrial, commercial, agricultural, and residential users. The Level 1 assessment looks at the water rights of each type of user and estimates the actual amount of water being used. The water use estimates provide valuable information for preparing a water balance and making decisions to ensure the sustainable use of water resources.
- **Water Balance**—The water balance is an accounting of all the water entering the watershed, used in the watershed, and leaving the watershed. Understanding what happens to all of the water in the watershed is a major step in identifying how the water must be managed to provide for all uses while maintaining appropriate stream flow for in-stream uses.
- **Future Water Demand**—Expansion of urban areas is a common trend in many of the watersheds in Washington. The Growth Management Act encourages urban densities within a designated "urban growth area." WRIA 54 appears to be experiencing such growth pressures, specifically outside the Spokane urbanized area. The Level 1 assessment reviews the potential growth within the watershed and identifies approximate levels of water demand in the future. These increased levels will influence the amount of water allocated to each use.
- **Water Availability**—Water availability is a crucial outcome from the Level 1 assessment. Estimates of how much water is available will guide the development of recommended in-stream flow rates and suggest how water resources can best be managed to meet water needs, including in-stream flows, residential, commercial, and industrial growth in WRIA 54.

CHAPTER 2.
WATERSHED CHARACTERISTICS

WRIA 54, an 885-square-mile watershed in eastern Washington, encompasses portions of the Cities of Spokane and Medical Lake, Spokane, Stevens and Lincoln Counties, and Fairchild Air Force Base; most of the Spokane Indian Reservation; and the City of Airway Heights (see Figure 1-1). A complex sequence of events over geologic time has created a unique geology in the watershed. The dry but temperate climate has interacted with local geology to create soils, aquifers, and water bodies that interact in complex ways.

WRIA 54 covers multiple counties, cities and towns and a tribal reservation. The land is used in a variety of ways, primarily for agriculture, but also including urban centers concentrated in the eastern portion of the watershed. Future changes in land use and population will change the way resources are used and ultimately may change some of the characteristics of the watershed.

GEOLOGIC SETTING

Geologic History

The oldest rocks in WRIA 54 are from the Precambrian period, more than 544 million years ago. Precambrian sediments originally were deposited in a shallow, north-south trending sea (Kahle et al., 2005). Igneous rock then intruded into the sediments and metamorphosed. Over the next 200 million years, sediments including carbonates, quartz sands, and silts were deposited on the exposed Precambrian metamorphic rocks. These later sediments then underwent low grade metamorphism. Volcanic activity 34 to 55 million years ago resulted in discontinuous, intermediate to silica-rich lava flows and volcanic deposits.

A major shift in geologic activity began about 10 to 20 million years ago with the onset of basalt flows of the Columbia River Basalt Group (CRBG). The lava flowed from fissures as much as 90 miles long that were located primarily in northeast Oregon and southeast Washington (Taubeneck, 1970; Griggs, 1976). The resulting basalt deposits are hundreds to thousands of feet thick and extend throughout the Columbia Plateau. The CRBG has been subdivided into five formations that include, from oldest to youngest, the Imnaha Basalt, Picture Gorge Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. Two of these formations, the Grande Ronde and Wanapum, have been mapped within WRIA 54 (Drost and Whiteman, 1986).

As the basalt flowed into this area, it filled preexisting depressions, lapping onto elevated areas of older, uplifted metamorphic and igneous rocks. Steptoes (vertical formations rising above the surrounding surface) were formed where knobs of the underlying “basement” rock were completely encircled by the Columbia River Basalt flows.

The Grande Ronde Basalt is the most voluminous of the CRBG formations, making up 85 to 88 percent of the total volume of the CRBG (Whiteman et. al, 1994). The Grande Ronde has been observed to be up to 514 feet thick in the West Plains area. In places, the Grande Ronde Basalt flows blocked existing rivers. Lakes formed behind these basalt dams, resulting in the deposit of sediments known as the Latah Formation (Robinson, 1991). Latah Formation sediments occur discontinuously throughout WRIA 54, usually interbedded with or overlying the Grande Ronde Basalt.

Following the placement of the Grand Ronde Basalt, an extended hiatus in volcanic activity allowed deposition of sediments on the flows and the formation of a weathered surface. The top of the Grande Ronde Basalt is often marked by a weathered zone (described in water well reports as a water-bearing, fractured or vesicular zone with minor clay) or a sedimentary interbed (Latah Formation) that separates it from the overlying Wanapum Basalt Formation (Deobald and Buchanan, 1995).

The Wanapum Basalt is the second-most voluminous of the CRBG formations, making up about 6 percent of the total volume (Whiteman et. al 1994). It overlies the Grande Ronde Basalt and is present throughout much of the study area south of the Spokane River except where it pinches out at steptoes or has been removed by erosion. Surface exposures are abundant (Stoffel et. al, 1991). The Wanapum Basalt has been observed to be up to 292 feet thick in wells within the West Plains.

Beginning about 1.8 million years ago, a period of repeated expansion and recession of glaciers and ice sheets known as the Pleistocene Epoch took place, during which the Cordilleran ice sheet expanded across what is now Canada and the northern United States. The expanding glaciers and ice sheets carried sediments, which they deposited at their edges. In WRIA 54, this resulted in thick layers of poorly sorted glacial sediments. Winds whipped up the finer glacial silts and clays. The resulting dust combined with volcanic ash from the newly-forming Cascade Range to form thick, wind-blown, fine-grained deposits called loess that settled on the Columbia River Basalt and the uplifted metamorphic rocks (Donaldson and Giese, 1968). The loess deposits are known as the Palouse Formation.

As the ice sheets advanced south, thick lobes of ice at the end of the sheets would dam rivers, creating large glacial lakes. The Okanagan lobe of the Cordilleran ice sheet blocked the Columbia River, creating Glacial Lake Columbia (Wait and Thorson, 1983). Glacial Lake Spokane was dammed by the Columbia lobe of the Cordilleran ice sheet. The glacial lakes deposited layers of clay and silt that have been recorded in deep boreholes in WRIA 54.

The largest of the glacial lakes was formed when the Purcell Trench lobe of the ice sheet blocked the ancestral Clark Fork River, creating Glacial Lake Missoula. Glacial Lake Missoula became deep enough that it would periodically float its ice dam, causing catastrophic failure of the dam and releasing a massive flood of up to 500 cubic miles of water (Bretz, 1930). The processes of damming the Clark Fork River, filling Glacial Lake Missoula, and releasing the lake’s waters in a massive flood recurred up to 100 times (Atwater, 1986) until the end of the Pleistocene, approximately 11,000 years ago. The Missoula Floods scoured sediments in WRIA 54 down to bedrock, eroded portions of the Columbia River Basalts, and left deposits that consist predominantly of reworked glacial gravels (Deobald and Buchanan, 1995). These deposits are frequently interbedded with sediments (typically clay, silt, or silty fine sand) that were deposited in a low-energy depositional environment.

Recent alluvial deposits typically are associated with existing drainages and consist of complex sequences of gravel, sand, silt, and clay.

Geologic Units and Cross Sections

The complex geological history of WRIA 54 has resulted in diverse “geologic units.” Figure 2-1 shows the distribution of these units throughout the watershed. Table 2-1 gives a brief description of each unit.

Geologic cross sections show subsurface relationships among geologic features. Figures 2-2 and 2-3 show typical cross-sections of geological conditions within WRIA 54; the locations of the cross-sections are indicated on Figure 2-1.

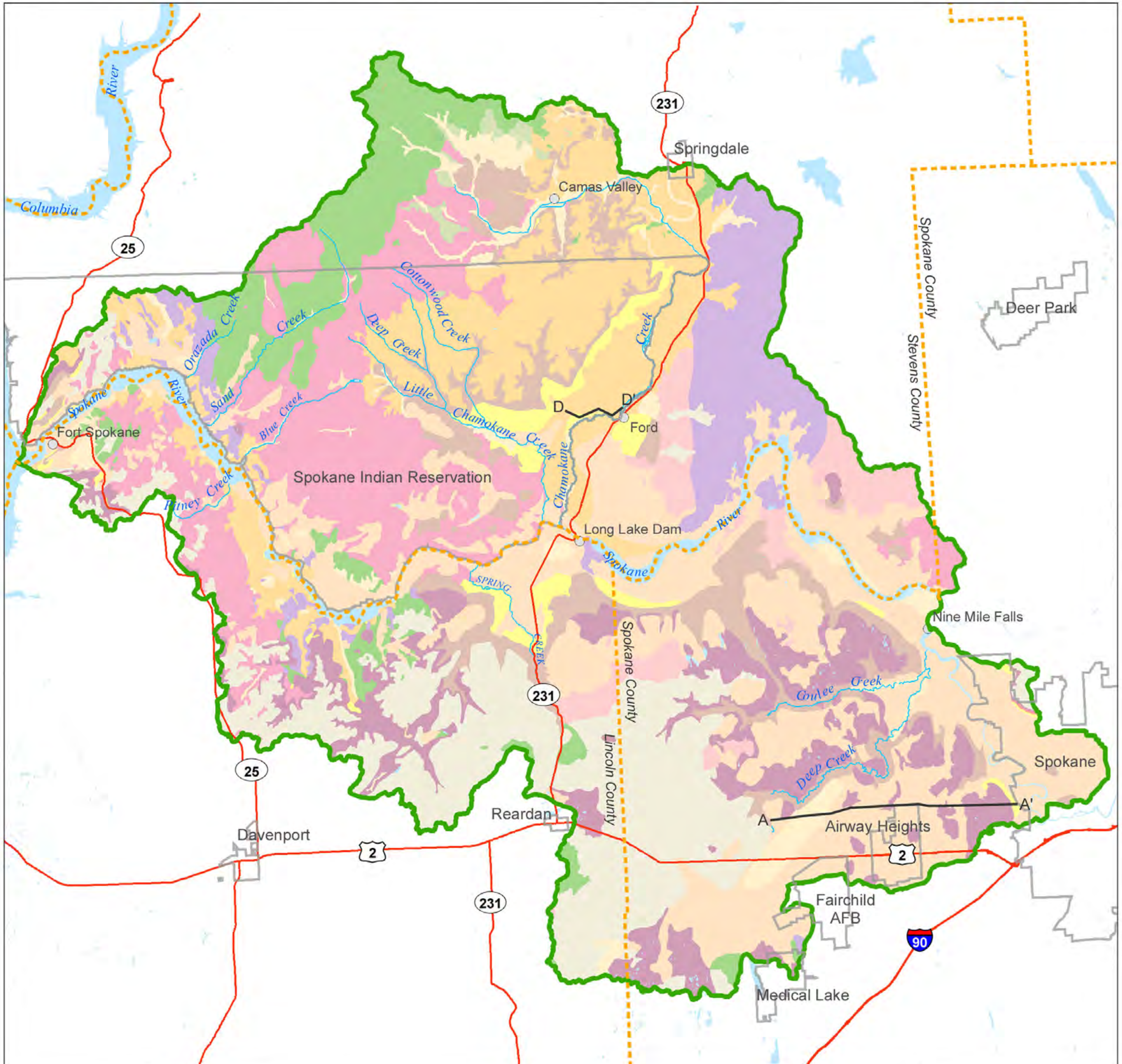

Figure 2-1

WRIA 54 Geology

Legend

- Major Road
- Cross Section*
- County Boundary
- Stream
- WRIA54 Boundary
- Jurisdiction
- Waterbody

Geologic Unit Grouping

- Cretaceous intrusive basement
- Eocene igneous rocks
- Middle Proterozoic through Carboniferous metasediment basement
- Pleistocene glacial outburst flood deposits
- Pleistocene glacial sediments
- Pliocene-Miocene continental sedimentary deposits and rocks
- Quaternary loess
- Quaternary mass wasting
- Quaternary peat deposits
- Quaternary sedimentary deposits and rocks
- Tertiary Latah Formation
- Tertiary Grande Ronde Basalt and intercalated sediments
- Tertiary Wanapum Basalt and intercalated sediments
- Tertiary-Cretaceous intrusive rocks
- Upper Proterozoic intrusive, metasedimentary and metavolcanic basement

**Cross Section A-A' (see Figure 2-2) - (Deobald and Buchanan 1995)*
Cross Section D-D' (see Figure 2-3) - (Buchanan and others 1988)

Data Sources:
Streets, Waterbodies, Streams, County Boundary - Washington DNR
Geology - 100K Washington DNR
WRIA Boundary - Washington DOE

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Map Produced 01/16/2007

TABLE 2-1.
DESCRIPTION OF GEOLOGIC UNITS IN WRIA 54

Geologic Unit	Description
Formed 2,500 to 544 Million Years Ago	
Upper Proterozoic intrusive, metasedimentary, and metavolcanic rocks	Magnesium- and iron-rich intrusive rock and metamorphosed sediments and volcanic rock. Occurrence at the surface and in the subsurface is similar to that of the Middle Proterozoic through Carboniferous metasedimentary rocks.
Formed 2,500 to 286 Million Years Ago	
Middle Proterozoic through Carboniferous metasedimentary rocks	Marine metamorphosed sedimentary rocks. These rocks occur as basement and outcrop in higher elevations to the northwest and in steptoes scattered throughout WRIA 54. The rocks are generally of low permeability, though the weathered surfaces can contain significant quantities of groundwater.
Formed 145 to 65 Million Years Ago	
Cretaceous intrusive rocks	Silica-rich intrusive igneous rocks occurring as basement rocks and outcrop in higher elevations in the northwestern portion of WRIA 54, in scattered steptoes, and in the eastern portion of WRIA 54.
Formed 65 to 1.8 Million Years Ago	
Eocene igneous rocks	Silica-rich to intermediate intrusive and extrusive rocks occurring as basement in a north-south trending band on the northeastern side of WRIA 54.
Pliocene-Miocene continental sedimentary deposits and rocks	Conglomerates mantling the Cretaceous intrusive igneous rocks in the northwestern part of WRIA 54 near Chamokane Creek.
Tertiary basalt flows and interbedded sediments	Grande Ronde and Wanapum members of the Columbia River Basalt Group. Fractured and weathered basalt zones contain aquifers. Discontinuous sediments are found interbedded with the basalts throughout WRIA 54.
Tertiary Latah Formation	Poorly lithified gravels, sands, silts, and clays interbedded with the Grand Ronde Basalt. Outcrops are limited to a small band in the southeastern portion of WRIA 54 along Deep Creek canyon. The Latah formation occurs over and within basement in many locations in the subsurface.
Tertiary-Cretaceous intrusive rocks	Silica-rich intrusive rocks crop out in the middle and eastern portions of WRIA 54 and form the basement in the subsurface.
Pleistocene glacial sediments	Glacial till, drift, outwash, and glaciolacustrine silt and clay deposits mantle Columbia River Basalt and metamorphic basement rocks in the north-central and western parts of WRIA 54.
Pleistocene glacial outburst flood deposits	Unconsolidated boulders, cobbles, gravels, and sands associated with the Missoula Floods are distributed discontinuously throughout WRIA 54. The flood deposits are often interbedded with silts and clays of glacial lakes Columbia and Spokane.
Formed 1.8 Million Years Ago to Present	
Quaternary loess	Loess deposits consist of windblown silts, clays, sand, and volcanic ash. The loess deposits mantle areas of higher elevation that were not affected by the Missoula Floods.
Quaternary mass wasting	Mass wasting deposits occur along the bases of basalt cliffs where weak sediment layers in the basalt have caused the cliffs to collapse.
Quaternary peat deposits	Peat (partially decomposed plant material) deposits occur primarily along rivers and lakes.
Quaternary sedimentary deposits and rocks	Assorted alluvial sediments, dune sands, and sedimentary rocks.

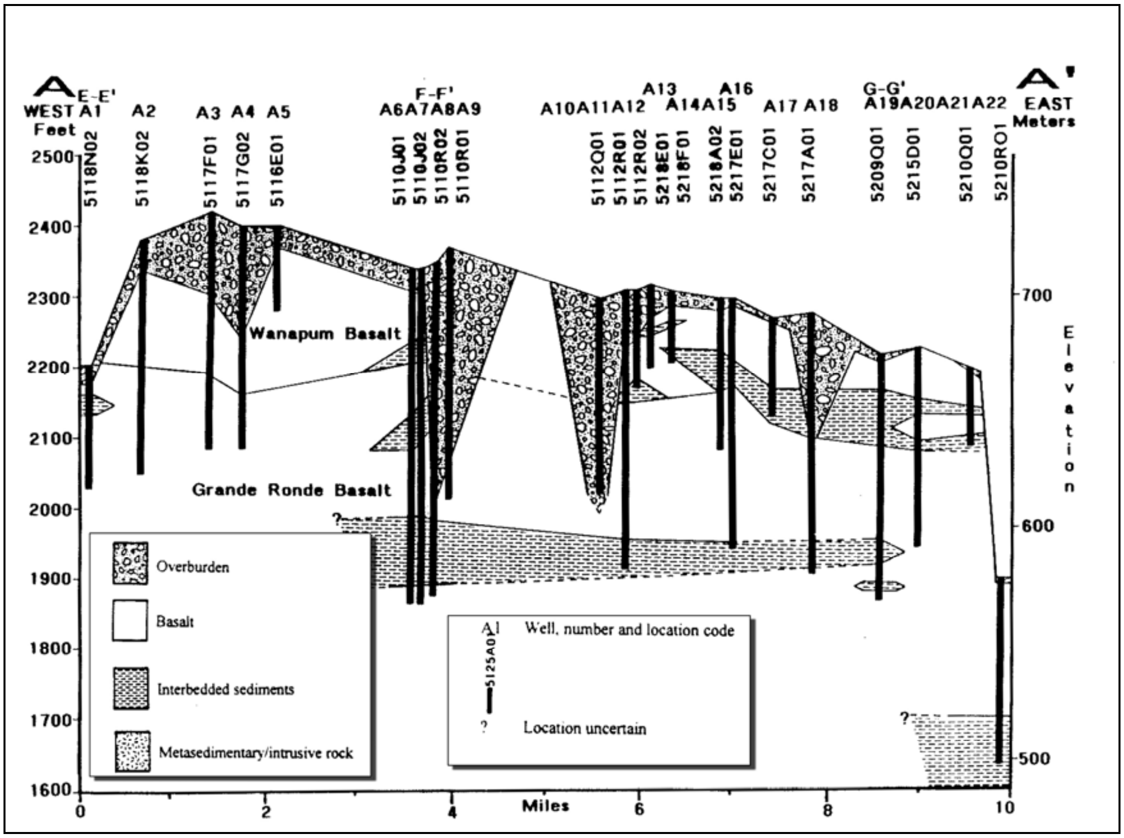

Figure 2-2. Typical WRIA 54 Geological Cross Section, Airway Heights Area

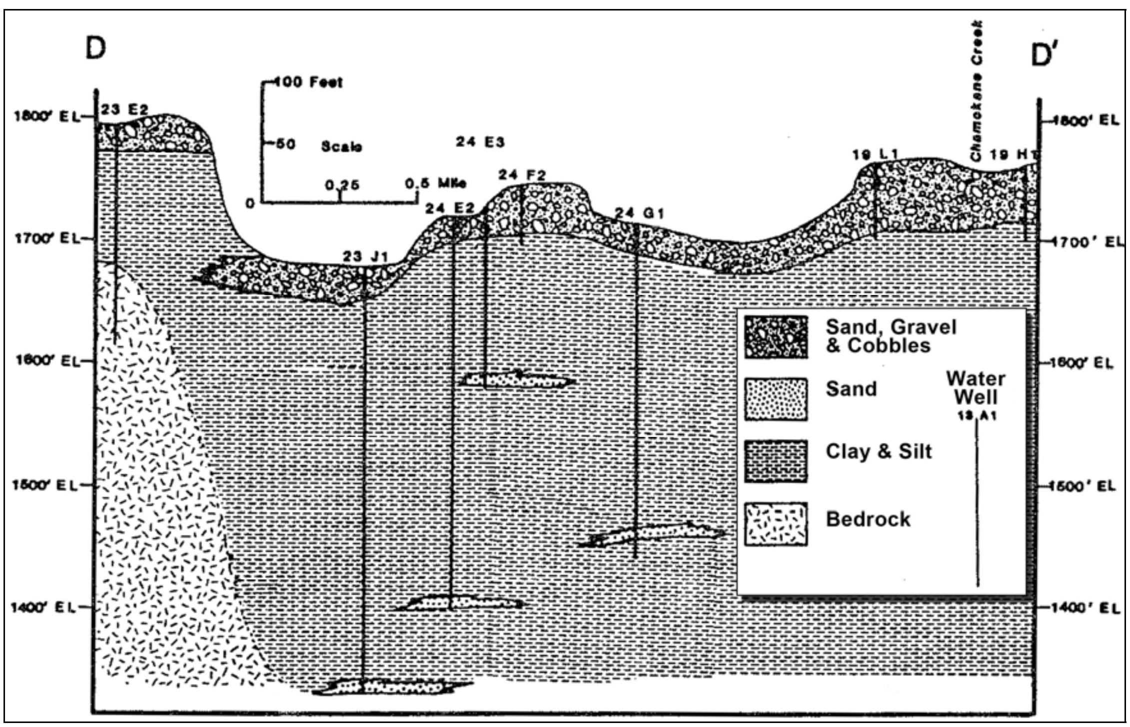

Figure 2-3. Typical WRIA 54 Geological Cross Section, Chamokane Valley

Soil Groups

Soils generally are grouped based on their hydrologic characteristics. The characteristics used are runoff potential, infiltration rate, soil depth and drainage, texture, and water transmission rate. Runoff potential is a measure of how likely it is that water falling on the surface of the soil will fail to be absorbed, remain on the surface, and move into surface water bodies such as rivers and lakes. Infiltration rate is the rate at which water falling on the surface of the soil penetrates the soil surface. Soil depth and drainage indicate the thickness of the soil and how well water absorbed by the soil can drain out of it. The water transmission rate measures the ease with which water flows through the soil. The Natural Resource Conservation Service (1996) has defined four basic soil hydrologic groups:

- **Group A** soils are deep, well drained to excessively drained sands and gravels. Infiltration rates are high as are water transmission rates. The runoff potential is low.
- **Group B** soils are moderately deep, moderately well drained to well drained, and consist of moderately fine to moderately coarse material such as silts, fine to coarse sands, and fine gravels. Group B soils have moderate infiltration and water transmission rates and corresponding moderate runoff potential.
- **Group C** soils are somewhat poorly drained, moderately fine to fine material, with slow infiltration and water transmission rates. Since Group C soils impede downward movement of water, their runoff potential is higher than Group B soils.
- **Group D** soils are shallow soils containing a clay pan or clay layer near the surface and have a permanent high water table. Infiltration and water transmission rates are very low for Group D soils and the corresponding runoff potential is very high.

Figure 2-4 maps the locations of the different hydrologic soil groups in WRIA 54. Group A soils make up 15 percent of the area of WRIA 54 (85,100 acres) and are found predominantly along the Spokane River, Deep Creek, and Chamokane Creek. Group B soils make up the majority of WRIA 54, covering nearly 65 percent of the surface area (367,100 acres). Group C soils make up 11 percent of the watershed (62,100 acres). Group D soils make up the smallest percentage of the watershed, covering approximately 7 percent of the land surface (36,600 acres). Another 2.6 percent of the area of WRIA 54 (14,900 acres) is open water.

Soils also are classified based on characteristics such as texture, thickness, and arrangement of layers. Together, the characteristics of a soil form the soil profile, and soils with similar profiles are placed in groups called series. Certain series of soils tend to occur together, forming a soil association. Maps of soil associations provide a large-scale picture of the different types of soils over an area. Table 2-2 describes the soil associations in WRIA 54 and identifies the soil hydrologic group of each.

CLIMATE

WRIA 54 is in the portion of the Columbia River Basin where the general slope of the basin begins to rise to meet the Rocky Mountains and form a plateau. This area transitions from the desert-like areas of the Columbia Basin to the forested mountains of North Idaho (NOAA, 2006). There are seven National Ocean and Atmospheric Association (NOAA) climate-recording stations in and around WRIA 54.

To acquire a higher degree of climate data and have it spatially represented across WRIA 54 for the technical assessment, data were gathered from the *Parameter-elevation Regressions on Independent Slopes Model* (PRISM). PRISM is a model that uses point data for area climate stations, a digital elevation model, and other spatial data sets to generate climate estimates (SCAS, 2006).

TABLE 2-2.
DESCRIPTION OF MAJOR SOIL ASSOCIATIONS IN WRIA 54

Soil Associations[a]	Description[a]	Hydrologic Groups[b]
Aits-Newbell-Donovan	Very deep, well drained, nearly level to very steep soils formed in mixed glacial till, with a mantle or admixture of volcanic ash and loess; on foothills	B
Athena-Reardan	Medium-textured and moderately fine textured soils formed chiefly in loess	B, C
Badge-Bakeoven-Rock outcrop	Steep, very deep and very shallow, well drained soils on canyon slopes and plateaus, and Rock outcrop	B, D
Bernhill	Deep, well drained and moderately well drained soils that formed chiefly in glacial lake sediments and glacial till on uplands	B, C
Bernhill-Green Bluff-Drearyton	Very deep, well drained and moderately well drained, nearly level to very steep soils formed in mixed glacial till, with a mantle or admixture of loess and volcanic ash; on basalt plateaus and foothills	B, C
Bonner-Elioka-Scrabblers	Very deep, well drained, nearly level to very steep soils formed in glacial outwash; on terraces and terrace escarpments	B
Broadax-Hanning	Nearly level to steep, very deep soils in 15- to 18-inch precipitation zone	C
Clayton-Cedonia-Martella	Very deep, well drained and moderately well drained, nearly level to very steep soils formed in lake sediment and glaciofluvial material; on terraces and terrace escarpments	B
Clayton-Laketon	Very deep, medium-textured and moderately coarse textured soils on terraces.	B
Colville-Peone-Narcisse	Very deep, moderately well drained and poorly drained, nearly levels soils; on bottom lands, flood plains, alluvial fans, perimeters of lakes and in depressional areas	C, D
Ewall-Springdale	Nearly level to steep, very deep, excessively drained and somewhat excessively drained soils on river terraces	A, B
Garrison-Marble-Springdale	Somewhat excessively drained and excessively drained sandy and gravelly soils formed in glacial outwash	A, B
Hesseltine-Cheney-Uhlig	Dominantly moderately deep to shallow, gravelly or rocky soils of the channeled scablands	B
Huckleberry-Raisio-Hartill	Moderately deep, well drained, nearly level to very steep soils formed in material weathered from shale rock; on mountains	B
Spokane-Dragoon	Shallow to deep, medium-textured soils that formed in material weathered from silica-rich igneous rock on mountain foot slopes	B, C, D
Spokane-Moscow-Rock outcrop	Moderately deep, well drained, nearly level to very steep soils formed in material weathered from granite, with an admixture of loess and volcanic ash, and rock outcrop; on mountains	B
Springdale-Spens-Bisbee	Very deep, somewhat excessively drained, nearly level to very steep soils formed in glacial outwash; on terraces and terrace escarpments	A, B
Stevens-Rock outcrop-Dragoon	Moderately deep and very deep, well drained, nearly level to very steep soils formed in residuum from granite and glacial till and Rock outcrop; on foothills	B
Tucannon-Rock outcrop	Nearly level to strongly sloping, moderately deep soils in 15- to 18-inch precipitation zone, and Rock outcrop	C

a. From Donaldson and DeFrancesco (1982), Donaldson and Giese (1968) and Stockman (1981).
b. From Natural Resource Conservation Service (2006).

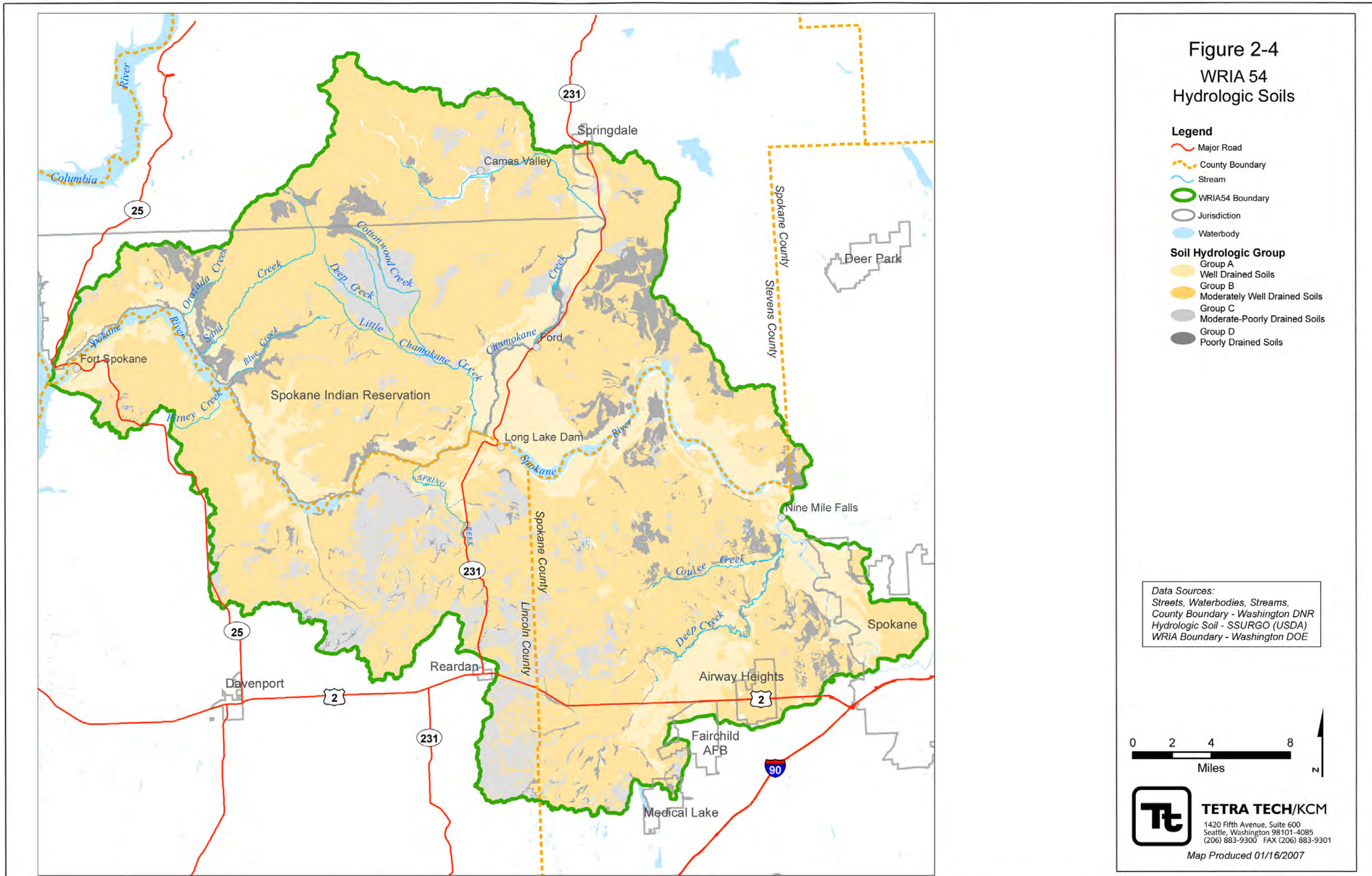

Figure 2-4
WRIA 54
Hydrologic Soils

Table 2-3 shows average precipitation in the watershed. The average annual precipitation is 15.8 inches; approximately half of that amount falls as snow (NOAA, 2006). Most of this precipitation falls between October and the end of March. November is the wettest month in the watershed, with average precipitation of 2.13 inches. July is the driest month in the watershed, averaging 0.57 inches of precipitation.

TABLE 2-3.
AVERAGE MONTHLY AND ANNUAL RAINFALL IN WRIA 54

Month	Average Precipitation (inches)	Month	Average Precipitation (inches)
January	1.89	July	0.57
February	1.52	August	0.59
March	1.39	September	0.82
April	1.08	October	1.15
May	1.40	November	2.13
June	1.20	December	2.08
		Annual Total	**15.82**

Temperatures in the watershed are characterized by cold winters and warm summers. The warmest month on average is July, while the coldest month, on average, is January. Figure 2-5 shows average temperatures over the course of the year.

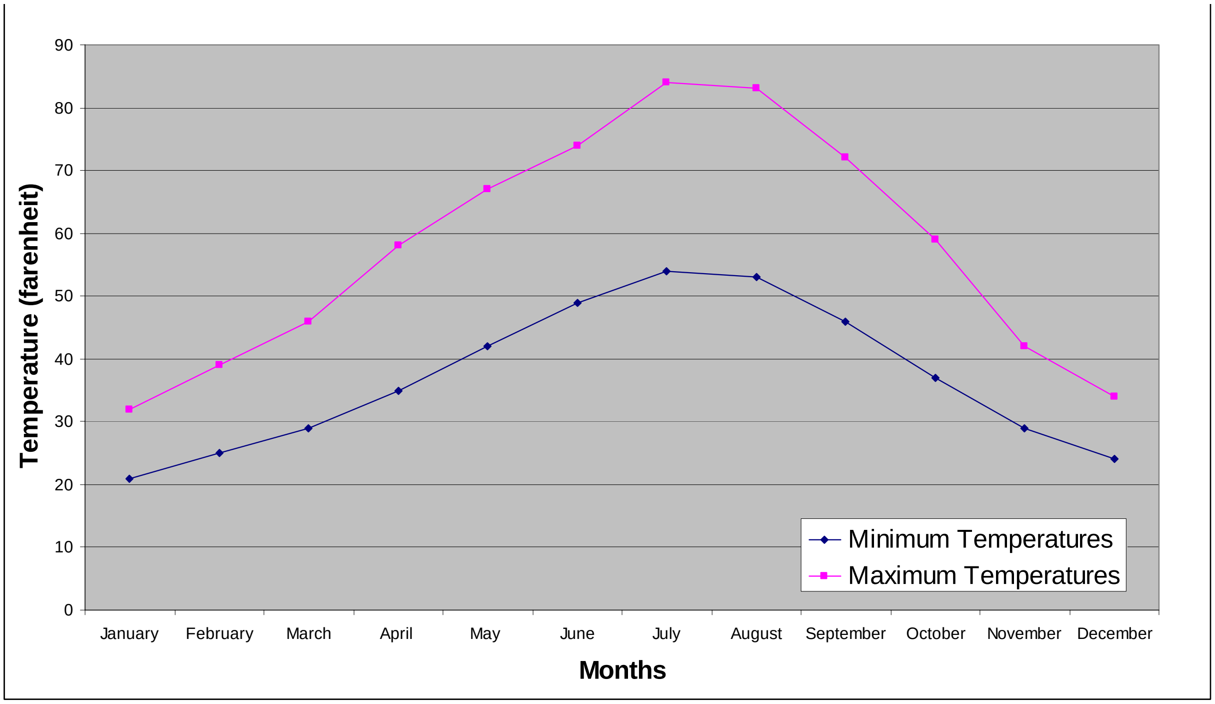

Figure 2-5. Average Temperature Ranges in WRIA 54

GROUNDWATER

Groundwater is an important resource. In addition to supplying water for human needs such as drinking, crop irrigation and industrial use, groundwater plays a critical role in the environment. Water that moves from the subsurface into streams maintains a base level of flow in the streams during the summer when there is relatively little contribution from precipitation and snow melt. Therefore, increased use of groundwater in WRIA 54 could impact surface water resources. Management of the watershed's water resources requires a thorough understanding of the watershed's hydrogeology.

Local and regional studies of hydrogeology in portions of WRIA 54 that were reviewed for this technical assessment include the following:

- A regional study of the hydrogeology and geochemistry of the Columbia Plateau (Whiteman et al., 1994)
- A study of the West Plains area of Spokane County (Deobald and Buchanan, 1995).
- A study of the Chamokane Valley aquifer system (Buchanan et al., 1988).
- A hydrogeologic evaluation of the city of Airway Heights to identify potential nitrate sources (GeoEngineers, 2003).
- An evaluation of the boundaries of the West Plains high risk drainage area (GeoEngineers, 2004a).
- A study of the Spokane Valley-Rathdrum Prairie aquifer in Idaho and Washington (Kahle et al., 2005).
- A hydrogeologic and geotechnical study of the area for the expansion of the Graham Road Recycling and Disposal Facility (CH2M-Hill, 1998).
- An evaluation of a municipal water supply well for the city of Airway Heights (GeoEngineers, 2004b).
- A study of the aquifer systems on the Spokane Indian Reservation (Matt and Buchanan, 1993).

In WRIA 54, principal aquifers generally lie within unconsolidated sands and gravels, basalt, and basement rocks. The unconsolidated and basalt aquifers are the most suitable for extracting groundwater of sufficient quantity for municipal distribution systems. The basalt aquifers occur within the Wanapum and Grande Ronde members of the CRBG. Figure 2-6 shows the primary aquifers in WRIA 54.

Unconsolidated Sand and Gravel Aquifers

In WRIA 54, unconsolidated sand and gravel deposits consist primarily of relatively clean, highly permeable sand and gravel deposited by glacial processes. Aquifers in these soils are located principally in valley bottoms; the sands and gravels thin and become discontinuous at higher elevations where basalts and crystalline basement rocks are closer to the surface. The saturated thickness of these aquifers varies from less than 10 feet in higher elevation areas to more than 780 feet in Spokane Valley (Kahle et al., 2005). In the higher elevation areas underlain by basalt, locally-thick accumulations of sediment occur within "paleochannels," as discussed below. Unconfined aquifers are relatively susceptible to contamination from point and non-point pollutant sources due to the lack of an overlying confining unit and the generally shallow depth to the groundwater table. Recharge to the unconfined aquifers is primarily from precipitation, applied irrigation and septic systems, and, potentially, from leakage from underlying basalt aquifers.

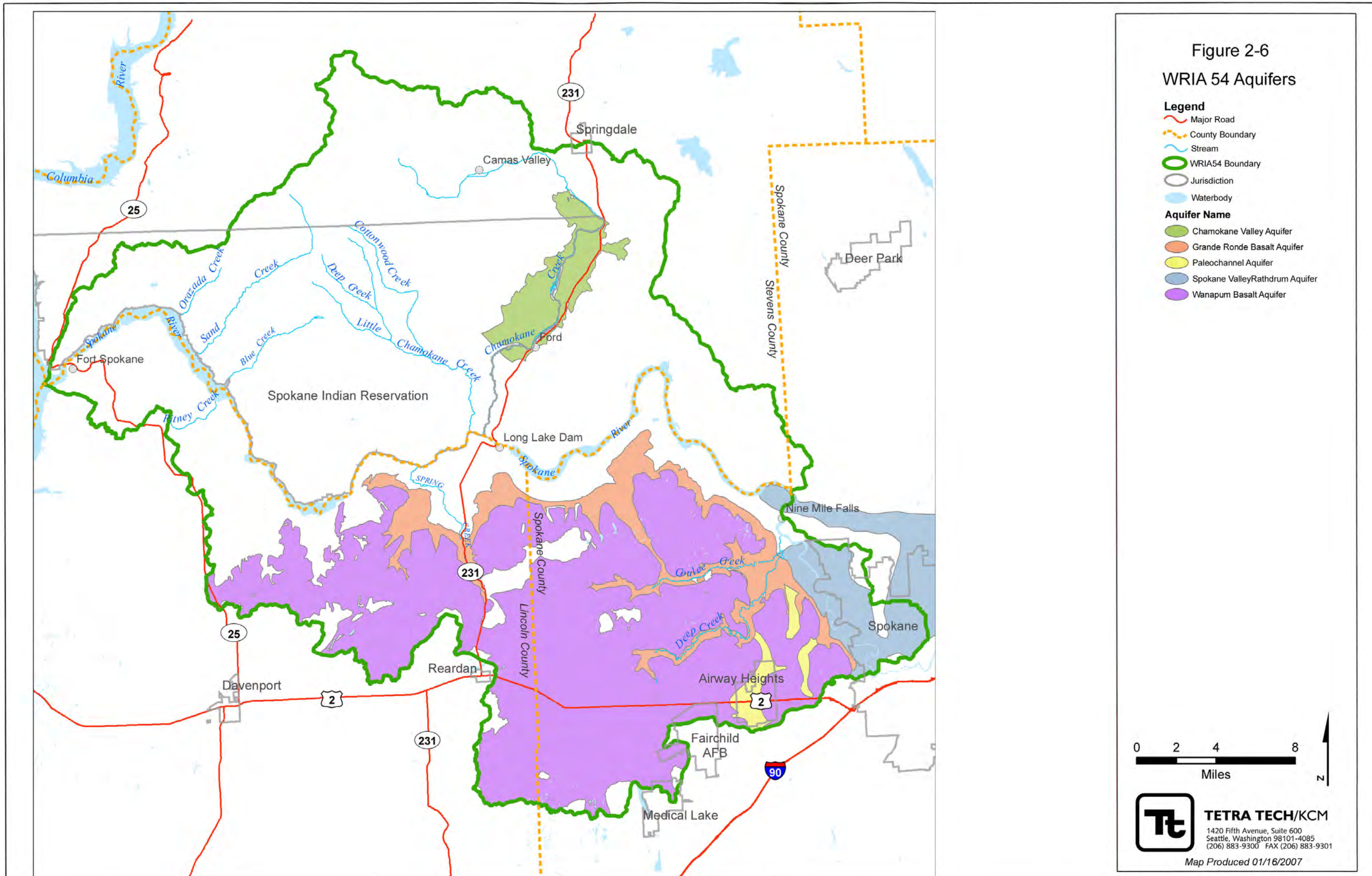

Figure 2-6
WRIA 54 Aquifers

Spokane Valley-Rathdrum Prairie Aquifer

The most important of the unconsolidated aquifers in the region is the Spokane Valley-Rathdrum Prairie (SVRP) Aquifer, a small part of which extends into the southeast corner of WRIA 54. This major aquifer is a major water supply source. A November 2005 report by the U.S. Geological Survey (USGS) compiled previous research about the aquifer. The discussion below is taken from that study (Kahle et al., 2005), which the USGS prepared jointly with the Idaho Department of Water Resources and the Washington Department of Ecology.

Hydrogeologic Terms

Aquifer—A water saturated rock or soil unit that transmits water and can provide economically useful quantities of water.

Aquitard-—A water or rock unit that transmits water poorly and acts as a barrier to water movement.

Confined Aquifer-—An aquifer bound on top and bottom by an aquitard.

Unconfined Aquifer-—An aquifer that sits on top of an aquitard, but is open to water infiltration from the surface.

Water Table-—The water surface in an unconfined aquifer.

Hydraulic Head-—The elevation of the water surface inside a well.

Hydraulic Head Gradient-—Difference in the hydraulic head over a distance, causing water to flow.

Hydraulic Conductivity-—The ease with which a given hydraulic head gradient creates a given flow.

Transmissivity-—The rate at which water flows through a unit width of an aquifer.

Storativity-—The volume of water that will be released from an aquifer per unit of surface area for a given change in hydraulic head.

Characteristics of the Aquifer

The SVRP Aquifer is located in Bonner and Kootenai Counties in western Idaho and Spokane County in eastern Washington. The aquifer is the sole source of water for more than 400,000 people for residential, commercial, industrial and agricultural uses. It also is critical in supplying flow to the Spokane and Little Spokane Rivers. The 370-square-mile aquifer is located in the valley east of the Columbia Plateau between the Bitterroot and Selkirk mountain ranges. The valley is composed predominantly of deep glacial-flow deposits and is bounded by igneous and metamorphic basement rocks. The aquifer consists primarily of thick layers of coarse-grained sediments including gravels, cobbles, and boulders.

The SVRP Aquifer is estimated to contain 10 trillion gallons of water, with 250 to 650 million gallons flowing through the aquifer daily near the Washington-Idaho border (Kahle et al., 2005). The hydraulic conductivity, a measure of the rate of groundwater flow through an aquifer, is over 1,000 feet per day for most of the aquifer; it can be as high as 6,000 feet per day. As a result, the potential water yield from the aquifer with little drawdown of the water table is relatively high. Wells near Spokane yield up to nearly 5,000 gallons per minute.

Recharge

Kahle et al. (2005) concluded that the SVRP Aquifer is recharged primarily through the valley floor that overlies it, tributary basins, adjacent uplands, and the Spokane River. Previous water balance analyses indicated that Lake Pend Oreille and Coeur d'Alene Lake also are primary sources of recharge to the aquifer. The primary source of recharge from the valley floor is infiltration of precipitation, irrigation water, canal losses, stormwater, and septic-tank effluent (Kahle et al., 2005). Of these, precipitation is the largest source of water infiltrating into the valley floor.

The largest sources of recharge to the aquifer are the water bodies in tributary basins and upland areas. Coeur d'Alene Lake and Lake Pend Oreille in Idaho are among the largest sources of recharge. Combined recharge from smaller subbasins is also considered to be substantial. The Spokane River is both a source of recharge to the aquifer and a discharge point for it.

Discharge

Net groundwater discharge to rivers and streams is indicated by an increase in flow in the river or stream over a given distance. The principal discharge points for the SVRP Aquifer are the Spokane and Little Spokane Rivers. Kahle et al. (2005) found the following discharge rates from the SVRP Aquifer, averaged over the course of a year:

- Spokane River:
  - One of the more significant points of groundwater discharge from the SVRP Aquifer to the Spokane River appears to be between Latah (Hangman) Creek and the Nine Mile Falls Dam. Stream flow data collected in the 1950s showed a groundwater contribution to this portion of the river of nearly 400 cubic feet per second (cfs).
  - A later study demonstrated that the Spokane River was gaining approximately 780 cfs from groundwater discharge between the Barker Road Bridge and the confluence with the Little Spokane River.
  - The total discharge from the aquifer to the river system, reported from several studies outlined in the 2005 USGS report, is approximately 1,000 cfs.
- The Little Spokane has been identified as gaining 310 cfs from the aquifer.

Chamokane Valley Aquifer System

The Chamokane Valley Aquifer System (CVA) is located in the Camas Valley and Ford subbasins, through which Chamokane Creek flows. There is a distinct basalt pinch point and significant fall in elevation between these two subbasins, and the Camas Valley subbasin is generally referred to as the "upper basin" of the Chamokane system. The most detailed study of the CVA was completed by Buchanan et al. (1988). The following summary is derived from that report and from a report by Matt and Buchanan (1993).

Characteristics of the Aquifer

The sediments in the Chamokane Valley are predominantly glacial in origin. During the Pleistocene Epoch, the Colville lobe of the Cordilleran Ice Sheet advanced and retreated across the valley. Older episodes of Colville Lobe advance probably scoured the valley down to bedrock and are largely responsible for the shape of the bedrock surface. During the most recent glaciation, the furthest advance of the Colville lobe reached what is now Springdale, Washington. Glacial outwash from the end of the ice sheet deposited coarse sands and gravels in the Chamokane Valley.

During the same period, periodic advances of the Okanogan Lobe of the Cordilleran Ice Sheet blocked the Columbia River, creating glacial Lake Columbia. Glacial Lake Columbia partially filled the Chamokane Valley, depositing a thick layer of silts and clays. The other major depositional events in the Chamokane Valley were the periodic Lake Missoula outburst floods which washed over the valley, depositing coarse sands and gravels.

The CVA consists of two principal aquifers. The upper aquifer consists of surficial sands and gravels deposited by the outwash from the Colville lobe of the Cordilleran Ice Sheet and the Missoula Floods. This layer varies in thickness throughout the valley, ranging from 20 to 100 feet thick (see Figure 2-3). Yields from shallow wells drilled in the upper aquifer are very good. The following characteristics have been calculated for the upper aquifer (see definitions on page 2-9 for "transmissivity," "conductivity" and "storativity"):

- Hydraulic conductivity has been estimated to be 2,500 to 3,500 feet per day.

- Transmissivity has been estimated to be 95,000 to 134,000 square feet per day.
- Storativity has been estimated to be around 0.3, based on sediment sample grain size distributions, although sediment characteristics and the presence of clays and silts probably reduce the storativity to around 0.2.

The upper aquifer is perched on a thick silt and clay layer deposited by glacial Lake Columbia (see Figure 2-3). The thickness of the silt and clay layer ranges from 150 to more than 300 feet. Within the silt and clay layer, isolated lenses of sand and gravel produce enough water for domestic well use. Beneath the silt and clay layer lies a layer of glacial outwash sand and gravel that produces large quantities of water. Because relatively few wells penetrate this deep, the lower aquifer is poorly characterized.

Recharge and Discharge

Flow in the CVA moves from the northern portion of the valley to the southern portion. In the northern portion of the basin at Walkers Prairie, Chamokane Creek sits on the sands and gravels of the upper aquifer. Recharge of the upper aquifer comes from infiltration from Chamokane Creek and its tributaries and from precipitation. Many tributaries to Chamokane Creek infiltrate completely into the valley floor sands and gravels, never reaching Chamokane Creek as surface flow. Further south, in the Ford area, Chamokane Creek's bed comes to rest on the silt and clay layer. From this point south, the upper aquifer discharges into Chamokane Creek through seeps and springs. The upper aquifer is largely drained in the southern portion of the valley. Wells in the southern portion of the valley are drilled to greater depths (>100 feet) to reach the lower aquifer beneath the silt and clay layer.

Columbia River Basalt Group Aquifers

Wanapum Basalt Formation Aquifers

The Wanapum Basalt Formation consists of a series of individual basalt flows. Figure 2-7 shows the typical structure of these flows. Groundwater is most readily transmitted through the broken "vesicular" interflow zones that characterize the top of each flow. The interflow zones are separated by the less porous and less transmissive "entablature" and "colonnade," which make up 90 to 95 percent of the total flow volume (Whiteman et al., 1994). The flows are locally interlayered with sedimentary deposits, resulting in multiple, stacked aquifers that are confined to semi-confined, which can yield significant volumes of groundwater to wells (Buchanan, 1992).

Characteristics of the Aquifer

The Wanapum Basalt is separated from the underlying Grande Ronde Basalt by the Wanapum-Grande Ronde Interbed. This unit generally consists of clay with variable sand and gravel content. Interbed thickness has been documented as great as 120 feet in the West Plains area, suggesting it might function as a confining unit separating the two basalt aquifers in some locations.

Estimates of aquifer characteristics for the Wanapum Basalt in WRIA 54 are not widely available. Previous studies have provided the following estimates:

- Pump tests performed on wells in the vicinity of the Graham Road Recycling and Disposal Facility near Medical Lake yielded transmissivities of 0.02 to 1,100 square feet per day and corresponding hydraulic conductivities of 0.002 to 75 feet per day. Storativity ranged from 0.9×10^{-5} to 6×10^{-5} (CH2M-Hill, 1998).

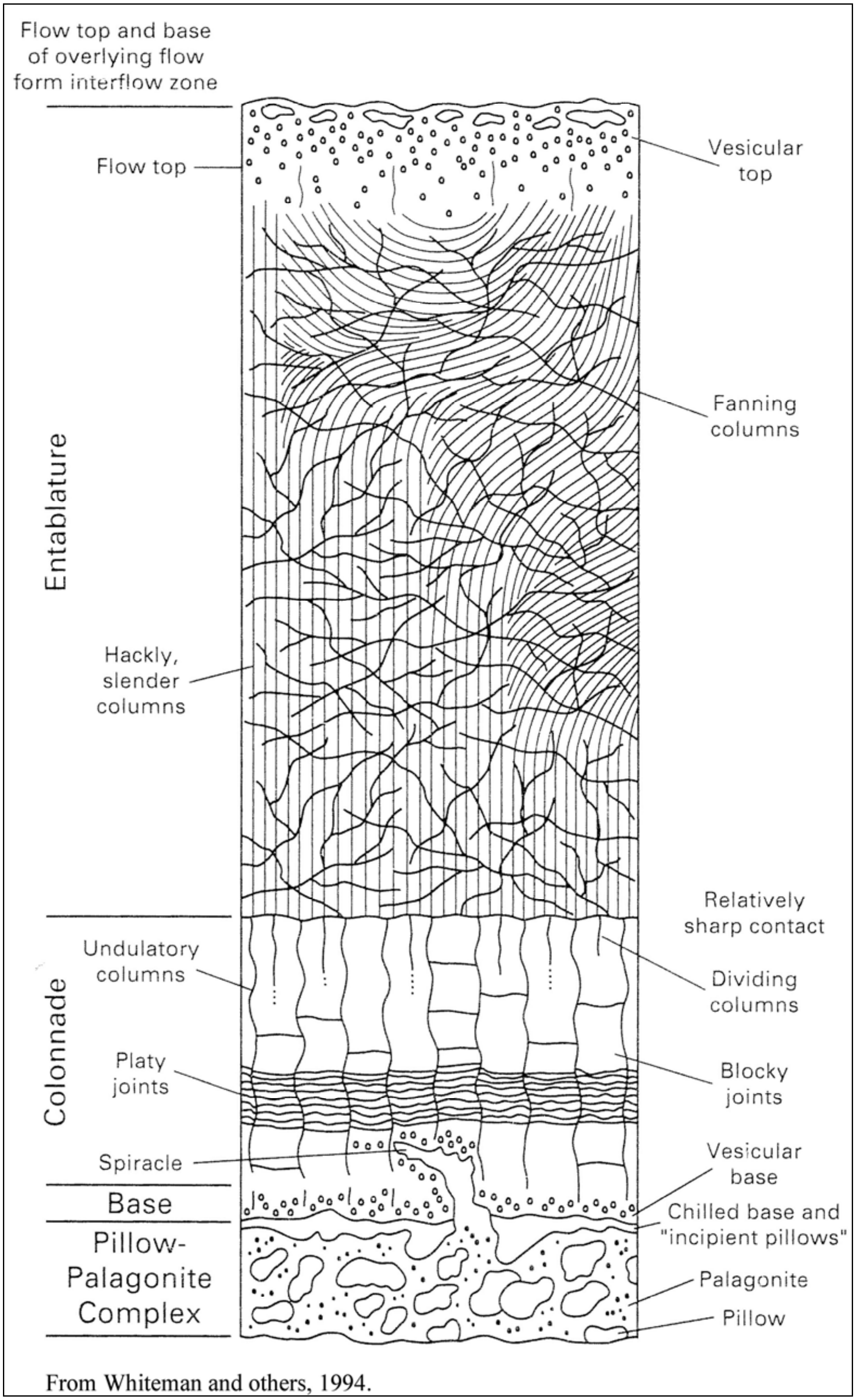

Figure 2-7. Typical Structure of Basalt Flow

- Whiteman et al. (1994) performed a review of hydraulic conductivity data for the Columbia River Basalt Group in locations throughout the Columbia Plateau. Hydraulic conductivity values ranged from 0.007 to 5,244 feet per day. The median value in the Wanapum Basalt Formation was 5.2 feet per day. The Columbia River Basalt Group aquifers are heterogeneous; wells with large horizontal hydraulic conductivity values are often close to wells with low horizontal hydraulic conductivity values.
- Whiteman et al. (1994) calculated the storativity of Columbia River Basalt Group aquifers to be from 1.8×10^{-6} to 9.9×10^{-5} with a median value of 3.2×10^{-5}.

Recharge

The Wanapum Basalt Formation is overlain by relatively coarse deposits in some places, but it crops out on the surface in others. Recharge to the Wanapum Basalt occurs through direct precipitation, vertical infiltration from the overlying unconfined aquifer, and lateral recharge from upgradient areas. A minor component of recharge could be upward leakage from underlying layers.

Declining Groundwater Levels in West Plains Wells

The Washington Department of Ecology has documented groundwater levels in wells drilled into the basalt aquifers of the West Plains area. Appendix A provides plots of the groundwater level data provided by Ecology. In all but one of the wells, groundwater levels declined between 1955 and 2005. The declines ranged from about 15 feet in the Medical Lake well between 2001 and 2003 to about 120 feet in the Four Lakes well between 1997 and 2005. The data suggest well interference among the Shrum, Pearce/Martino, Parkwest, Four Lakes, and Medical Lake wells.

Paleochannel Aquifers

Generally, sediment aquifers on top of the Wanapum basalt are thin and do not produce large quantities of water. Some locations, however, feature “paleochannels,” which are channels carved into the basalt by ancient rivers that later filled with glacial sands and gravels. Sediment accumulations in these channels are over 200 feet thick in spots and provide large quantities of usable groundwater. Deobald and Buchanan (1995) identified three paleochannels in the West Plains area that follow north-south, sinuous courses (shown as dark bands on Figure 2-8). The westernmost and central paleochannels are thought to discharge to Deep Creek while the easternmost channel discharges to the Spokane River. Recharge to the paleochannels comes from infiltration of precipitation and discharge from the Wanapum and Grande Ronde basalt aquifer (SAIC, 1992).

Westernmost Paleochannel Aquifer

The westernmost of the identified paleochannels is east of Fairchild Air Force Base and generally trends north through the City of Airway Heights. Outside the boundaries of this paleochannel, depth to the unconfined water table, where present, is generally less than about 20 feet, and aquifer thickness is generally less than about 10 feet. Groundwater in these areas migrates vertically into the Wanapum Basalt Formation or follows the top of the basalt topography before discharging to the paleochannel. Unconfined aquifer thickness is at least 89 feet within the paleochannel, though this has not been well-defined throughout much of the paleochannel. Contemporary water level data for the paleochannel are not available; however, SAIC (1992) measured groundwater levels from elevation 2,245 feet to elevation 2,256 feet in several paleochannel wells in September 1991. Groundwater flow direction was to the northwest, under a hydraulic gradient of about 0.004 feet per foot. Recent aquifer testing data performed by GeoEngineers, Inc. (unpublished) suggest that the paleochannel aquifer is very transmissive.

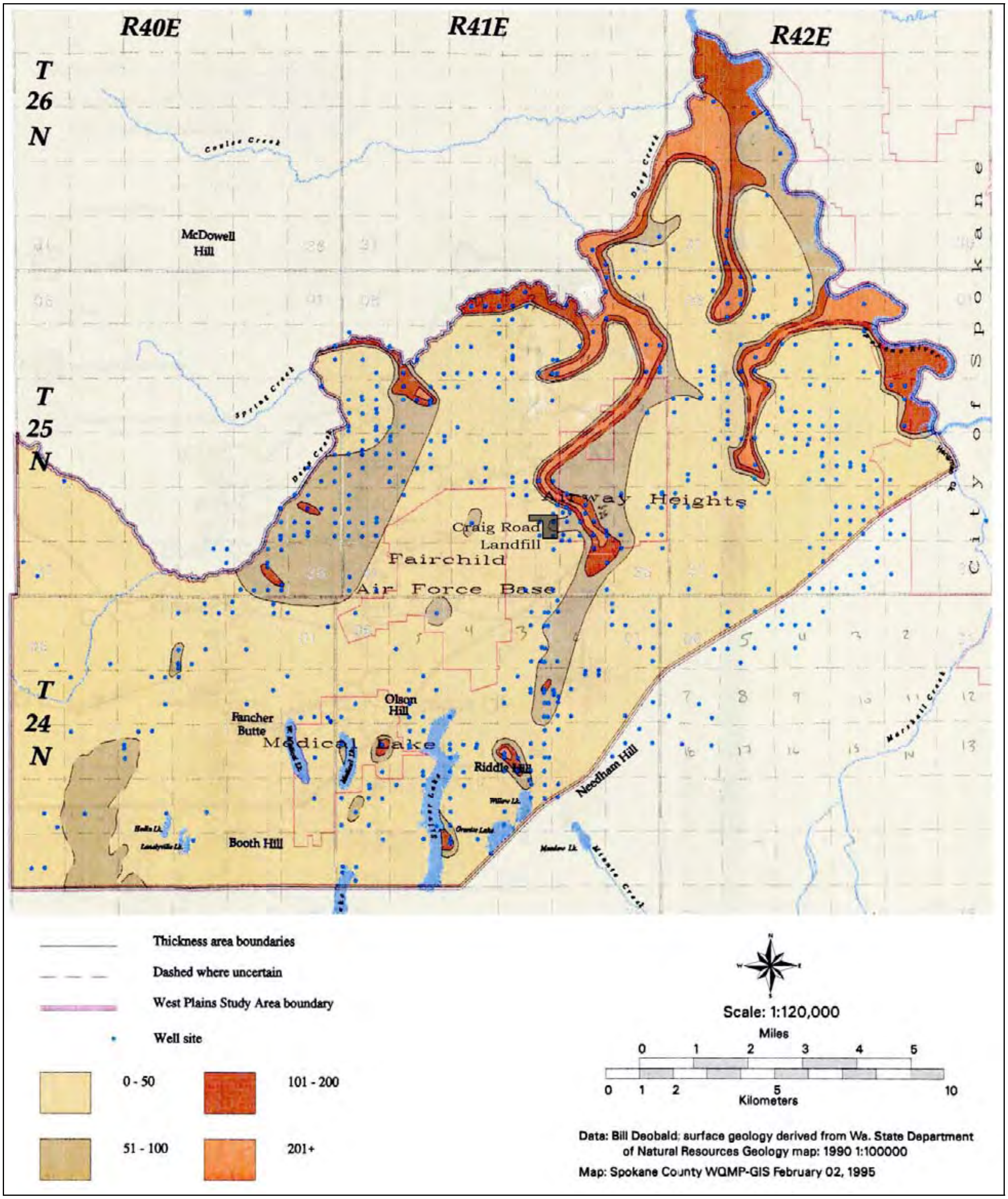

Figure 2-8. Thickness of the Overburden Layer

The following aquifer parameter estimates were derived:

- Transmissivity—18,000 square feet per day
- Hydraulic conductivity—1,200 feet per day
- Storativity—0.02

For comparison, GeoEngineers (2002) estimated a permeability value of about 5,700 feet per day for paleochannel sediments located about three miles northeast of the site.

Near the paleochannel, SAIC (1992) identified three hydrostratigraphic units within the Wanapum Basalt: an upper basalt aquifer (Basalt Flow A); a sedimentary interbed (Interbed A); and a lower basalt aquifer (Basalt Flow B). Outside the paleochannel, the uppermost confined aquifer occurs within Basalt Flow A, which was found by SAIC to be about 90 to 141 feet thick. Mapping performed by SAIC indicates that groundwater flows from Basalt Flow A into the paleochannel along each side of the paleochannel perimeter. Elevations ranged from 2,380 feet at the west end of Craig Road Landfill to 2,270 feet at the margins of the paleochannel. SAIC interpreted that the sedimentary interbed under Basalt Flow A is relatively impermeable and continuous and that the paleochannel truncates Basalt Flow A. This suggests that the paleochannel captures water from the entire thickness of Basalt Flow A.

The unconfined aquifer within the paleochannel, because of its relatively high permeability and low head, acts as a drain, resulting in leakage from Basalt Flow A into the paleochannel. Interbed A is underlain by a lower basalt aquifer, designated by SAIC as Basalt Flow B. Though water-level data for Basalt Flow B are sparse, SAIC (1992) determined that the flow direction within Basalt Flow B in the vicinity of Craig Road Landfill is to the northeast. The paleochannel intersects the top portion of Basalt Flow B, and head conditions reported in SAIC (1992) suggest that some groundwater discharges from Basalt Flow B into the paleochannel.

Easternmost Paleochannel Aquifer

The easternmost of the identified paleochannels is north of Spokane International Airport and west of Spotted Road near Airway Heights. Geophysical work and area water well reports suggest that this depression is a minimum of about 1,000 feet wide, extends to a maximum depth of at least 250 feet below ground surface, and trends to the north-northeast where it merges with the Spokane River valley. Depth-to-basalt data from area water well reports, the site location, and the approximate outline of the paleochannel were defined by Budinger & Associates (2001).

Previous studies by GeoEngineers (2002) indicate that hydraulic conductivity of the easternmost paleochannel aquifer is about 0.2 centimeters per second; hydraulic gradient is about 0.012 feet per foot ;and groundwater velocity is about 26 feet per day.

Grande Ronde Formation Aquifers

Like the Wanapum Basalt, the Grande Ronde Basalt consists of a series of basalt flows, with groundwater most readily transmitted through the interflow zones at the top of each. This series of basalt flows, interbedded with coarse sedimentary deposits, create multiple, stacked, confined aquifers and relatively high well yields.

Characteristics of the Aquifer

Estimates of aquifer characteristics for the Grande Ronde Basalt in WRIA 54 are not widely available. Whiteman et al. (1994) presented the following estimates:

- Median hydraulic conductivity of 4.9 feet per day.
- Storativity ranging from 6.0×10^{-6} to 1.1×10^{-3} with a median value of 1.8×10^{-4}. Storativity estimates for the Grande Ronde Basalt are generally higher than the Wanapum Basalt because of its larger aquifer thickness.

Recharge and Discharge

Recharge to the Grande Ronde Formation occurs primarily through outcrops along the margins of the Columbia Plateau, flowing laterally to discharge areas within the plateau interior. Recharge could also occur through leakage from the overlying Wanapum Basalt or underlying basement rocks, depending on hydraulic head conditions.

Regionally, groundwater flow direction parallels the southwest dip slope of the Grande Ronde Basalt, discharging to major surface water features such as the Spokane, Columbia, and Snake Rivers. Due to the Grande Ronde's depth and the presence of overlying units, flow in the Grande Ronde Basalt is relatively unaffected by small surface water bodies and paleochannels (Lane and Whiteman, 1989; Deobald and Buchanan, 1995).

Basement Rock Aquifers

Groundwater occurs in the fractured or weathered zones of basement rocks underlying the CRBG, where present, and surface sediments. Basement rock aquifers are the primary source of groundwater in significant portions of the watershed, primarily north of the Spokane River, where unconsolidated and CRBG aquifers are not available. The permeability, transmissivity, and storage properties of the basement rock aquifers generally are low. Water wells penetrating into basement rock aquifers generally have low yields, frequently on the order of several gallons per minute or less.

Recharge to basement rock aquifers occurs primarily from infiltration of precipitation and from upgradient areas to the north and east of the Columbia Plateau flowing laterally to discharge areas within the plateau interior. Recharge could also occur through leakage from the overlying CRBG aquifers and sediments.

HYDROLOGY AND RIVER SYSTEMS

Hydrology is the study of the complex interactions of precipitation, land use and geology on the movement of water through a watershed. As precipitation falls on the landscape, the geology, soils, and land use determine whether the water will infiltrate into the ground, recharging the underlying aquifer, or remain on the surface. Water that does not infiltrate into the groundwater system or evaporate generally becomes runoff, which drains via sheet flow and channelized flow to water bodies throughout the watershed. Water that infiltrates into the aquifer may reappear later in rivers, streams and lakes as base flow.

In WRIA 54 there are approximately 3,000 miles of rivers and streams draining the landscape, many of which are intermittent, that is, not having continuous year-round flow. Perennial water bodies such as the Spokane and Little Spokane Rivers gain flow from groundwater along certain reaches, providing a continuous base flow. The major water bodies in WRIA 54 are shown on Figure 2-9, and include:

- Spokane River
- Chamokane Creek
- Little Chamokane Creek
- Orazada Creek
- Sand Creek
- Coulee Creek
- McCoy Creek
- Pitney Creek
- Blue Creek
- Cottonwood Creek
- Deep Creek
- Spring Creek
- Mill Creek

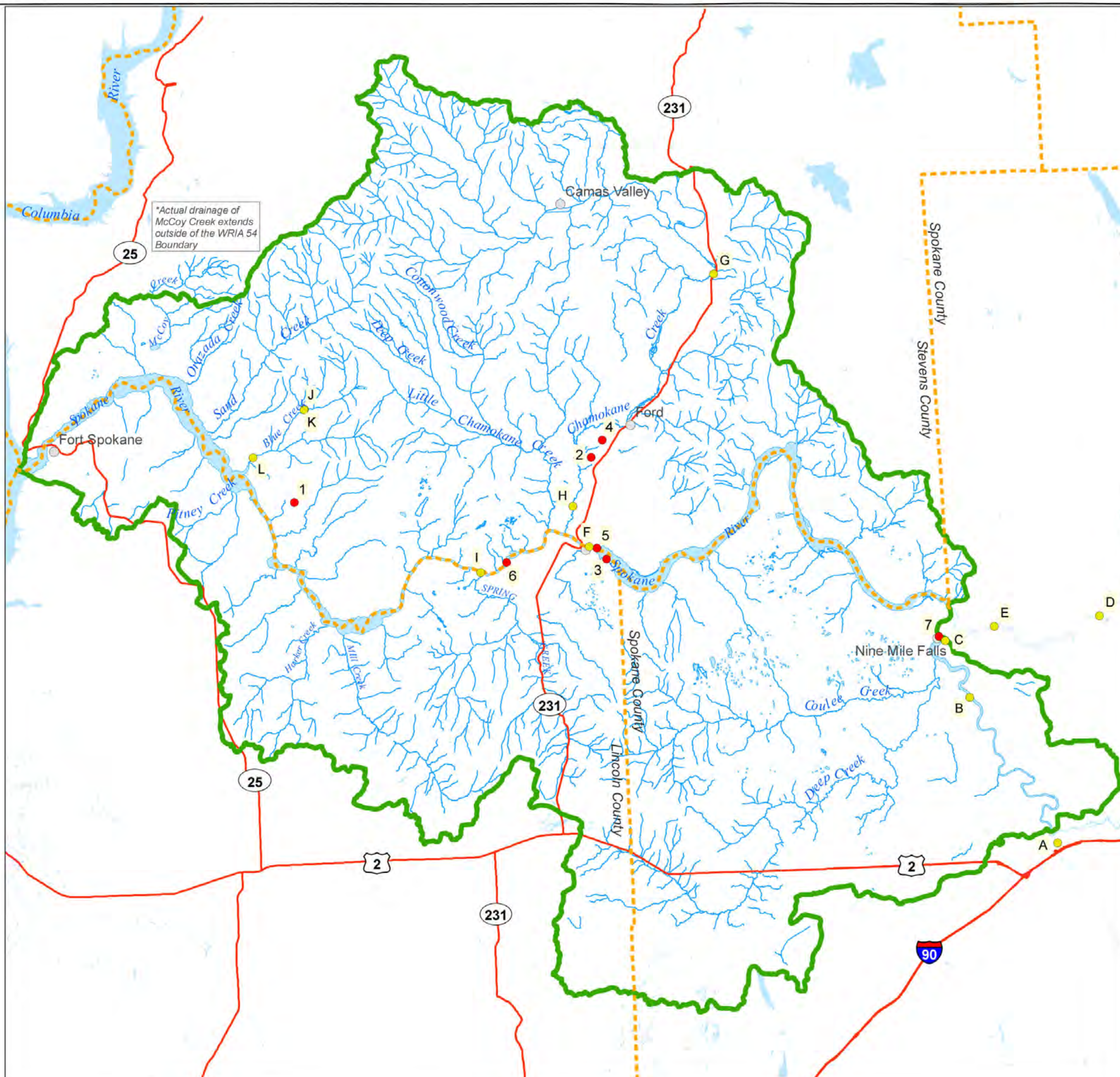

Figure 2-9
WRIA 54 Predominate River Systems

Legend

- Dam
- Stream Gauge
- Major Road
- Stream
- County Boundary
- Waterbody
- WRIA54 Boundary
- Unincorporated Area

Map ID	Gauge ID	Map ID	Gauge ID
*A	12424000	G	12433100
B	12424500	*H	12433200
C	12426000	I	12433500
*D	12431000	*J	12433542
E	12431500	*K	12433556
F	12433000	L	12433561

*Active USGS Stream Gauge

Map ID	Dam Name or Containment Structure
1	Western Nuclear Pond
2	Dawn Mines Pond 4
3	Long Lake Crescent
4	Dawn Mines Evap. Ponds
5	Long Lake Dam
6	Little Falls Dam
7	Nine Mile Dam

Data Sources:
Streets, Waterbodies, Streams, County Boundary - Washington DNR
Stream Gauges - USGS
Dams- Stream Net
WRIA Boundary - Washington DOE

0 2 4 8
Miles
N

TETRA TECH/KCM
1420 Fifth Avenue, Suite 600
Seattle, Washington 98101-4085
(206) 883-9300 FAX (206) 883-9301

Map Produced 01/16/2007

The stream flow data discussed below come predominantly from USGS gauging stations and was downloaded from the USGS National Water Information System website (2006). Figure 2-9 shows the location of the 12 gauging stations that have recorded stream flow data in WRIA 54. Of these gauges, the following are currently collecting data:

- Latah (Hangman) Creek (12424000)
- Little Spokane River (12431000)
- Spokane River (12433000)
- Blue Creek (12433542)
- Chamokane Creek (1243320)
- Midnite Mine Drainage (1243310).

Stream flow data for selected streams within the boundaries of the Spokane Tribe Reservation were collected periodically from 1993 through 2006 by the Department of Natural Resources of the Spokane Tribe (personal communication, Crossley, 2006). Due to the relatively low number of data points and gaps in the data collection, no data analysis or graphing were performed on these data. However, the data were incorporated into the water balance (see Chapter 4) and can be found in Appendix B.

Spokane River

The Spokane River is about 100 miles long, beginning in northwestern Idaho at Coeur d'Alene Lake and flowing west through the City of Spokane and eventually to the Columbia River through the Spokane Arm of Lake Roosevelt. The Spokane River enters WRIA 54 at the confluence with Latah (Hangman) Creek and exits WRIA 54 at the river’s mouth. WRIA 54 includes 75.6 percent of the river’s length.

Figure 2-10 shows minimum, maximum, and average daily flows in the Spokane River at Lake Spokane (Long Lake) for the period of record. Data from the Lake Spokane (Long Lake) gauging station were chosen because that station has the longest period of record of the stations on the Spokane River in WRIA 54. While this gauging station is located below the Lake Spokane (Long Lake) Dam, that dam is operated as a “run-of-the-river dam” meaning incoming flows are passed through. The highest flows at Lake Spokane (Long Lake) occur in late April through May, when flows range from 5,000 cfs to 47,000 cfs; over the period of record, the average April-May flow ranges from 15,000 to 20,000 cfs. The lowest flow values are in September, when flows range from 100 cfs to 3,100 cfs, with an average of about 1,800 cfs. Table 2-4 summarizes average monthly flows at Lake Spokane (Long Lake).

Historical discharge data are available for three other gauges on the Spokane River within WRIA 54. These gauges have shorter periods of record than the Lake Spokane (Long Lake) gauge and are not currently operating:

- The gauge at Seven Mile Bridge operated from November 1948 through September 1952. Average, maximum, and minimum daily flow hydrographs are included in Appendix B. The highest flows occur in late April through May, when flows range from 20,000 cfs to 34,000 cfs, with an average of about 27,000 cfs. The lowest flow values are in early September, when flows range from 1,100 cfs to 1,600 cfs, with an average of about 1,300 cfs.
- The gauge at Nine Mile Falls Dam operated from March 1948 through September 1950. Average, maximum, and minimum daily flow hydrographs are included in Appendix B. The highest flows occur in late May, when flows range from 31,000 cfs to 44,000 cfs, with an average of about 34,000 cfs. The lowest flow values are in mid to late September, when flows range from 340 cfs to 1,200 cfs, with an average of about 850 cfs. This gauge should not be confused with the currently operating gauge at Nine Mile Falls Dam maintained by Avista.

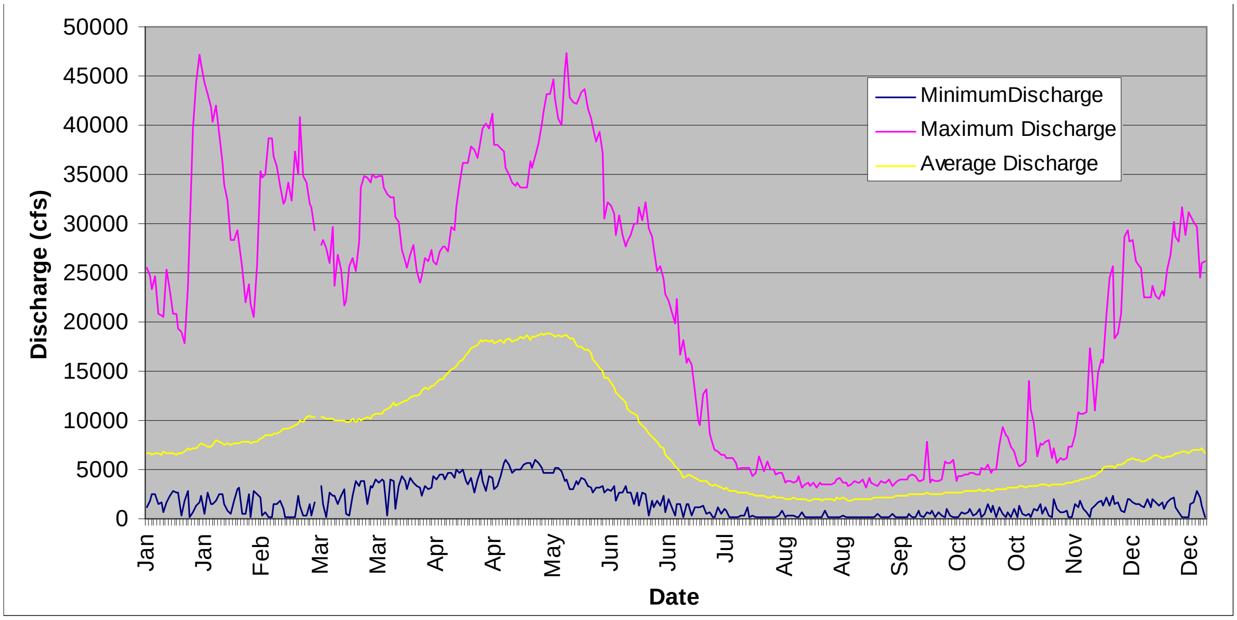

Figure 2-10. Spokane River Flow (Discharge) Measured at Lake Spokane (Long Lake)

**TABLE 2-4.
MONTHLY AVERAGE SPOKANE RIVER FLOW AT LAKE SPOKANE (LONG LAKE)**

Month	Average Flow (cfs)
January	7,112
February	8,860
March	10,589
April	15,350
May	18,308
June	11,302
July	3,454
August	2,019
September	2,276
October	2,909
November	4,033
December	6,334

- The gauge below Little Falls operated from October 1913 through September 1940. Average, maximum, and minimum daily flow hydrographs are included in Appendix B. The highest flows occur in late April through late May, when flows range from 11,000 cfs to 41,000 cfs, with an average of about 21,000 cfs. The lowest flow values are in early September, ranging from 500 cfs to about 2,200 cfs, with an average of about 1,300 cfs. Flows as low as 500 cfs occur from early August through late December.

Spokane River Flow Trends

A USGS report (Hortness and Covert, 2005) identified statistically significant trends in flow data from the Spokane River gauging station at Spokane, just upstream of the WRIA 54 boundary. The trends, based on discharge data collected between 1968 and 2002, identified a decrease in monthly mean stream flows for the month of September. A similar trend for monthly mean flows was identified for the gauging station on the Spokane River near Post Falls, Idaho and for the Little Spokane River at Dartford gauge (period of record: 1930-32, 1947-2002). No similar trend is apparent from the Latah (Hangman) Creek at Spokane gauge (period of record: 1949-2002).

An analysis of discharge data for 1891 through 2002 also showed a distinct decreasing trend in low-flow characteristics for both gauges on the Spokane River. At the Spokane River at Spokane gauge, until the 1930s, annual seven-day low stream flows exceeded 1,500 cfs. After 1985, seven-day low flows rarely exceeded 1,000 cfs (Hortness and Covert, 2005). A slight downward trend is also visible for Little Spokane River low flow data, although this trend is not statistically significant. No similar trend is apparent for Latah (Hangman) Creek.

Four historical events likely have affected flows in the Spokane River (Hortness and Covert, 2005):

- Completion and start of Post Falls Dam operation in 1906
- Diversion of water into the Spokane Valley Farms Canal above the Post Falls gauging station, beginning in 1924
- Change in operating practices at Post Falls Dam in 1941 to raise summer lake levels in Coeur d’Alene Lake
- Discontinuation of diversion of Spokane Valley Farms Canal water in 1967.

Most of the trend analysis conclusions reported in Hortness and Covert (2005) focus on the period 1968 to present, following cessation of the Spokane Valley Farms Canal irrigation diversion.

Dams

Flow on the Spokane River is regulated by a series of dams (see Figure 2-9). There are four hydroelectric projects upstream of WRIA 54, comprising six dams: Post Falls (three dams), which maintains the summer lake level in Coeur d’Alene Lake; Upriver Dam; Upper Falls Dam; and Monroe Street Dam. Within WRIA 54 there are three dams on the Spokane River: Nine Mile Falls Dam; Lake Spokane (Long Lake) Dam; and Little Falls Dam. These dams were constructed in 1908, 1914, and 1910, respectively, and regularly store near their maximum capacity. Three smaller dams, associated with mining activity, are located in tributary drainages: two in the Chamokane Creek drainage (associated with Dawn Mines); and one in an unnamed drainage within the Spokane Indian Reservation, associated with the Sherwood Mine.

Although not located in WRIA 54, Grand Coulee Dam has a significant effect on the watershed, with backwater from Lake Roosevelt impacting the lower 30 miles of the Spokane River. Water levels throughout this lower reach fluctuate throughout the year, with levels reaching a low point in September/October before refilling to a maximum level, usually in June.

Tributaries

Tributaries to the Spokane River vary considerably in length and discharge. Table 2-5 and Figure 2-11 show average monthly flows for tributaries for which sufficient USGS flow data exist.

TABLE 2-5.
MONTHLY AVERAGE FLOW OF MAJOR WRIA 54 SPOKANE RIVER TRIBUTARIES

Month	Average Flow (cfs)			
	Blue Creek	Little Spokane River	Latah (Hangman) Creek	Chamokane Creek
January	2.8	287.9	463.3	60.2
February	5.2	410.4	730.1	78.8
March	13.0	584.7	732.3	172.9
April	7.1	626.5	343.3	158.3
May	2.7	416.1	193.6	66.1
June	1.6	260.8	75.4	39.2
July	0.7	165.2	22.7	29.5
August	0.4	132.5	13.4	27.0
September	0.4	137.3	13.5	27.1
October	0.6	155.6	18.0	28.6
November	0.6	189.9	44.7	30.2
December	0.8	238.5	196.6	44.6

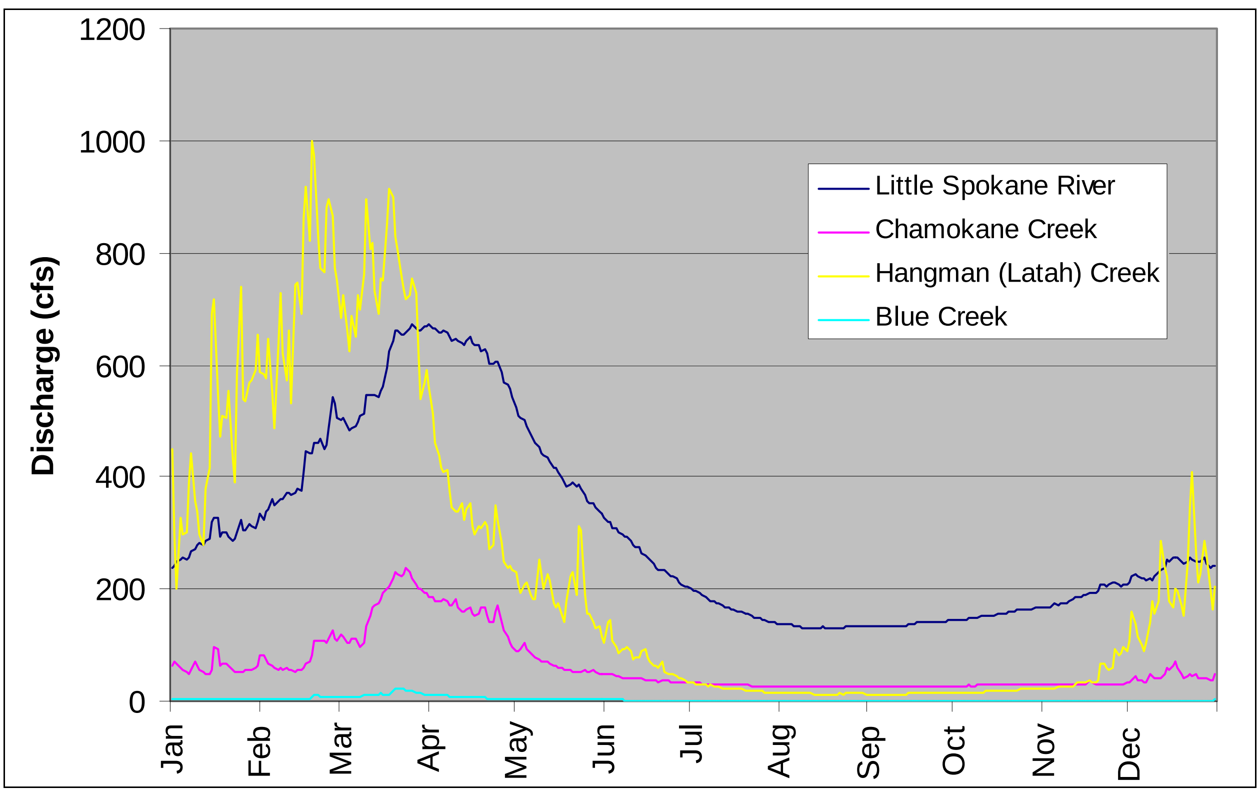

Figure 2-11. Tributary Average Flows

Many smaller tributaries in WRIA 54 run dry or nearly dry from July through October. The Little Spokane River, Latah (Hangman) Creek, Chamokane Creek, and Little Chamokane Creek maintain flow year-round along their length, while Blue Creek and Spring Creek retain flow year-round except near their confluence with the Spokane River.

Of the tributaries within the watershed, only Chamokane and Blue Creeks are gauged. The Little Spokane River and Latah (Hangman) Creek are not in WRIA 54 but provide some of the highest tributary discharges to this section of the Spokane River. Figure 2-9 shows major tributaries in WRIA 54. Figure 2-12 shows perennial and intermittent sections of streams within the Spokane Tribe Reservation, based on data collected during fish stock studies during 1999 through 2003 and during flow and water quality monitoring activities during 1999 through 2006.

Tributary data developed by the Spokane Tribe are given in Appendix B: Table 1 of the appendix lists instantaneous flows; Table 2 presents measurement location information; and Table 3 gives monthly average flows calculated from the instantaneous flow data.

Chamokane Creek

Chamokane Creek joins the Spokane River just west of the intersection of Route 231 in the middle of WRIA 54. Chamokane Creek exhibits the smallest difference between maximum and minimum average daily flows for the major Spokane River tributaries. Discharge data in Figure 2-11 are from the gauge near Lake Spokane (Long Lake). The period of record for this gauge is from February 1971 to the present. Maximum average daily flows peak at approximately 240 cfs around the end of March. Minimum average daily flows are approximately 27 cfs, occurring at the beginning of September. Peak instantaneous flows can be much higher, with flows up to 1,750 cfs measured at this gauging station. A gauge on Chamokane Creek near Springdale was active from May 1973 to October 1978. Appendix B shows daily flows averaged over the periods of record for the Chamokane Creek gauges near Lake Spokane (Long Lake) and Springdale.

Blue Creek

Blue Creek is in the western half of WRIA 54. The active gauge on Blue Creek is located upstream of Midnite Mine near Wellpinit. In Figure 2-11, monthly average flows in Blue Creek for most of the year are below 3 cfs. Peak flows occur in mid to late March, with maximum daily average flows of about 22 cfs. The maximum and minimum flow curves peak from mid-March to late April at about 15 cfs and 0.4 cfs, respectively. The minimum of the average maximum daily flow curve, about 0.17 cfs, occurs during mid-October. The minimum of the average minimum daily flow curve is 0.09 cfs in mid-September.

A gauge further downstream near the mouth of Blue Creek has a period of record from June 1984 to November 1998. Drainage from the Midnite Mine eventually reaches Blue Creek, and a gauge on the Midnite Mine drainage has been active since June 1984. Appendix B contains daily flows averaged over the periods of record for the active Blue Creek gauge, the gauge near the mouth of Blue Creek, and the gauge on the Midnite Mine drainage

Little Spokane River

The Little Spokane River joins the Spokane River approximately two miles downstream of the Nine Mile Falls Dam. Although not in the WRIA, the Little Spokane River is a significant tributary. Its average flows peak at approximately 670 cfs around the end of March or beginning of April. Minimum average flows are approximately 130 cfs and occur around the middle of August. Appendix B contains daily flows averaged over the period of record for the gauge on the Little Spokane River.

Latah (Hangman) Creek

The confluence of Latah (Hangman) Creek and the Spokane River is in the southeast corner of WRIA 54. Latah (Hangman) Creek shows the greatest range of discharges throughout the year of the tributaries for which data were available. The peak average flow occurs earlier than for the Little Spokane River or Chamokane Creek, around the middle to end of February, with a value of approximately 1,000 cfs. Summer flows are low, with minimum average flows around 12 cfs in the middle of August. Appendix B contains daily flows averaged over the period of record for the gauge on Latah (Hangman) Creek.

Subbasins

Washington State's Watershed Administrative Units, established under Washington Administrative Code (WAC) 222-22-020, were chosen to represent the subbasins in WRIA 54. These units divide Washington State into 825 drainage subbasins (USGS, 2006). Table 2-6 lists the subbasins in WRIA 54 and their size. Figure 2-13 shows the subbasin boundaries.

TABLE 2-6.
WRIA 54 SUBBASINS

Subbasin Name	Area (square miles)	Subbasin Name	Area (square miles)
Airway	81	Long Lake, North	48
Camas Valley	90	Long Lake, South	66
Coulee Creek	54	Orazada	29
Deep Creek, North-South	80	Pitney	46
Ford	100	Sand Blue	95
Harker Canyon	60	Spring Creek	63
Little Chamokane	71		

GROUNDWATER/SURFACE WATER INTERACTION

When surface water elevation in a stream exceeds groundwater elevation in an adjacent aquifer, the stream tends to recharge, or lose water to, the aquifer. Under this scenario, the stream is called a "losing stream." If groundwater elevation exceeds surface water elevation, the aquifer tends to discharge water to the stream, and the stream is called a "gaining stream." In general, the rate and volume of water that is exchanged between groundwater and surface water increases with increasing soil permeability, hydraulic gradient, and streambed area. Groundwater/surface water interaction in some streams varies over space and time. Spatially-varying streams are gaining in some reaches and losing in other reaches. Temporally varying streams are gaining during some portions of the year and losing during others.

The Spokane River is the only surface outflow from Coeur d'Alene Lake. Flow in the Spokane River is initially regulated by dams in Post Falls, Idaho, which generally retain water in Coeur d'Alene Lake during the summer. The Coeur d'Alene Lake level is gradually lowered during the fall to provide storage capacity for winter and spring runoff. The Spokane River flows westward through the Cities of Spokane Valley and Spokane, where the river is in hydraulic connection with the SVRP Aquifer. In downtown Spokane, the Spokane River flows through a short reach surrounded by shallow basalt. The Spokane River receives a significant amount of discharge from the SVRP Aquifer's western terminus and possibly from the northern terminus of the Latah Creek alluvial aquifer. Once past the confluence with the Little Spokane River, the Spokane River flows primarily through areas of shallow basalt and basement rock.

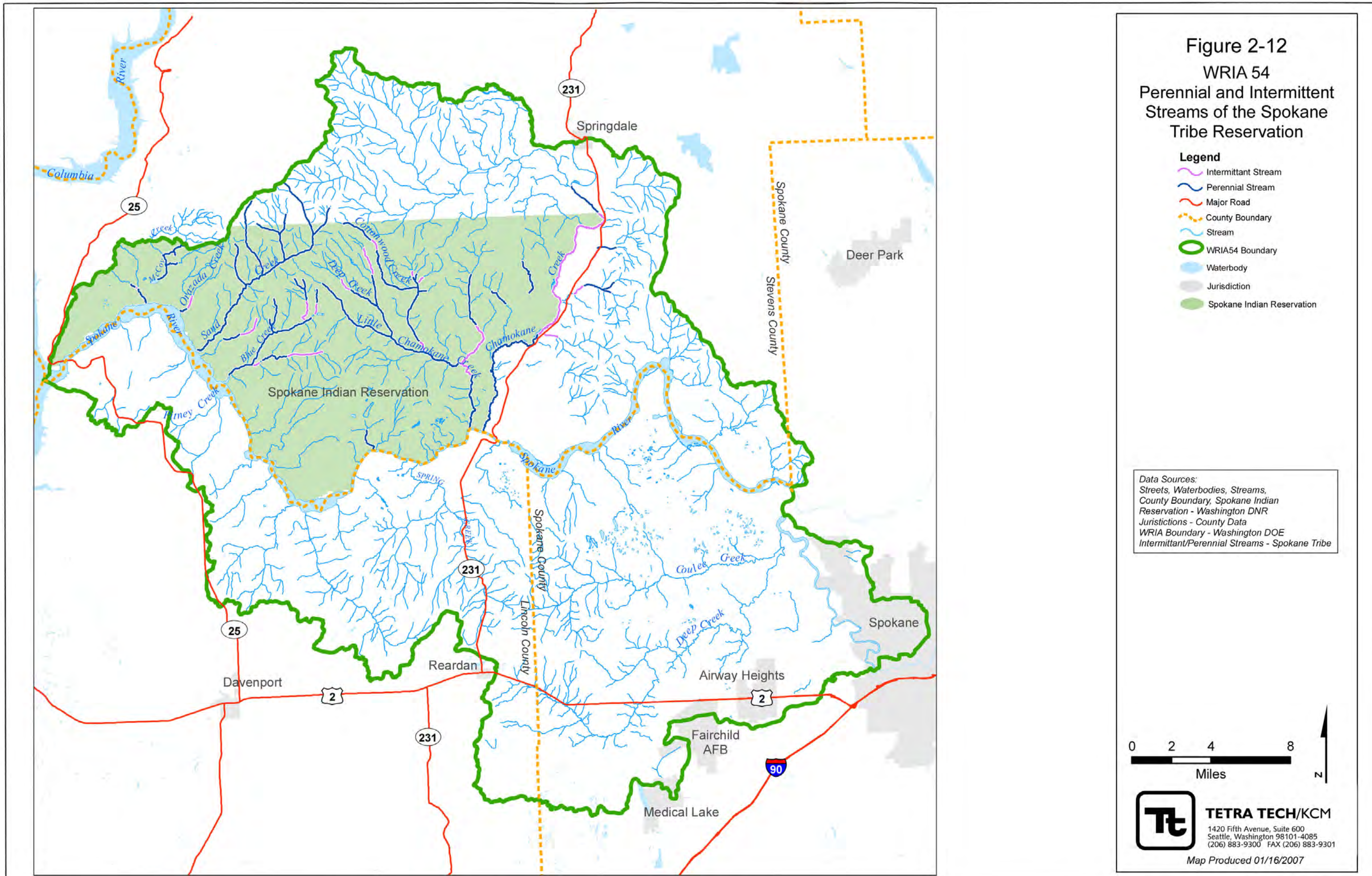

Figure 2-12
WRIA 54
Perennial and Intermittent Streams of the Spokane Tribe Reservation

Figure 2-13

WRIA 54 Subbasins

Legend

- Major Road
- County Boundary
- Stream
- Subbasin Boundary
- WRIA54 Boundary
- Jurisdiction
- Waterbody

Data Sources:
Streets, Waterbodies, Streams, County Boundary, Spokane Indian Reservation - Washington DNR
Juristictions - County Data
WRIA Boundary - Washington DOE
Watersheds - Washington DOE (WAUs)

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TETRA TECH/KCM
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Map Produced 01/16/2007

Previous Studies

Kahle et al. (2005) compiled the results of previous analyses to evaluate groundwater/surface water interaction along the main stem Spokane River to Lake Spokane (Long Lake). A number of the previous investigations evaluated gaining and losing conditions along the Spokane River within the boundaries of WRIA 54; key analyses performed include the following:

- Stream flow data from Spokane River gauging stations were used to estimate gains and losses between gauges (Broom, 1951).
- Stream flow data from Spokane River gauging stations were used to estimate gains and losses between gauges. The net annual gain of the Spokane and Little Spokane Rivers from the SVRP Aquifer was estimated (Drost and Seitz, 1978).
- A numerical flow model was used to identify gaining and losing reaches along the Spokane River (Bolke and Vaccaro, 1981).
- A groundwater flow model was developed as a component of City of Spokane wellhead protection planning for the SVRP Aquifer downgradient of the Idaho-Washington state line (CH2M Hill, 1998).
- Groundwater flow models were developed for the Little Spokane and Middle Spokane Watersheds (WRIAs 55 and 57), which included the computation of average annual gains and losses along 13 Spokane River reaches (Golder Associates, 2004).

The results of the review are presented in Appendix C. Data are presented as a function of river reach. These previous estimates are contradictory in places, but the bulk of data suggest that the Lower Spokane River primarily gains water as it traverses WRIA 54 to Lake Spokane (Long Lake).

Exchange Rates on the Spokane River

The most recent, and arguably most comprehensive, study was performed by Golder and Associates (2004), which estimated the following exchanges along the Lower Spokane River:

- Spokane River at Cochran Street to T.J. Meenach Bridge: Mean gain of 30.4 cfs.
- T.J. Meenach Bridge to Bowl and Pitcher Bridge: Mean gain of 52.1 cfs.
- Bowl and Pitcher Bridge to Seven Mile: Mean gain of 94.8 cfs.
- Seven Mile to Nine Mile Falls: Mean loss of 9.6 to 71 cfs.
- Nine Mile Falls to Little Spokane River Confluence: Mean gain of 63.9 cfs.

This analysis yields a total gain of 250.8 cfs to 312.2 cfs. These model estimates are based on hydrologic data from 1994 to 1999, which are described in the following section.

Groundwater/surface water interaction data downstream of Lake Spokane (Long Lake) generally are not available, primarily because of a lack of hydrologic modeling and stream flow data for this section of the river. Existing data regarding groundwater/surface water interaction along tributaries in WRIA 54 boundaries are also not available.

EXISTING GROUNDWATER AND SURFACE WATER MODELING

One approach to understanding and managing water resources is to develop computer models that describe and simulate water flow. These numerical models use input data such as precipitation, flow data, aquifer properties, and groundwater elevations to simulate and predict the way water flows through a region, including flow rates. Numerical models containing a portion of WRIA 54 within their model grids that have previously been developed include the following:

- Bolke and Vaccaro (1981)—A two-dimensional, finite element, groundwater flow model was developed for the SVRP Aquifer that extended from near the Washington-Idaho border on the east to about Nine Mile Falls on the west. This model was used to identify gaining and losing reaches along the Spokane River.
- CH2M Hill (1998)—A three-dimensional, finite element, groundwater flow model (MicroFEM) was developed for the SVRP Aquifer that extended from the Washington-Idaho border on the east to the Nine Mile Falls Reservoir on the west. The groundwater flow model was used to define wellhead protection areas for existing and planned wells for the City of Spokane.
- Buchanan (2000)—A two-dimensional, finite difference groundwater flow model (MODFLOW) was constructed to encompass the entire SVRP Aquifer.
- U.S. Geological Survey (Ongoing)—As a component of a joint (bi-state) study with the Washington State Department of Ecology and the Idaho Department of Water Resources, the USGS is developing a three-dimensional, finite-difference hydrologic model of the SVRP Aquifer and associated surface water bodies. Results of this ongoing study could contribute to the understanding of the water balance in WRIA 54, including groundwater/surface water interaction, surface and groundwater inflow and outflow, imported water volume, and net demand.
- Golder Associates (2004)—A numerical model was developed for the Little Spokane and Middle Spokane Watersheds (WRIAs 55 and 57). This model is of interest to the WRIA 54 Planning Unit because it was constructed as a component of the technical assessment for two adjacent WRIA basins. Characteristics of the model include the following:
  - The model was constructed as a coupled groundwater and surface water model that simulates hydrologic conditions observed from 1994 to 1999. Steady-state and transient-state simulations were performed. Surface water flow was simulated with the one-dimensional MIKE 11 HD model. Groundwater flow was simulated with the three-dimensional MIKE SHE model.
  - The model grid extends from near the Washington-Idaho border on the east to about Lake Spokane (Long Lake) on the west. Within WRIA 54, Lake Spokane (Long Lake) was simulated using a constant head boundary. Internal surface water boundary conditions were used to simulate surface water flows from Latah (Hangman) Creek and the City of Spokane Wastewater Treatment Plant.
  - The SVRP Aquifer was divided into two layers. Layer 1 consists of relatively high-permeability, glaciofluvial sand and gravel deposits. Layer 2 consists of relatively low-permeability CRBG and Latah Formation material. A relatively low-permeability lens of glaciofluvial material was simulated in the Hillyard Trough portion of the SVRP Aquifer. The model base was simulated as an impermeable boundary. Prior to calibration, initial hydraulic conductivity and anisotropy ratios were estimated based on previous investigations.
  - Prior to calibration, initial estimates for the exchange of groundwater and surface water were derived from previous investigations.
  - Groundwater withdrawals associated with 191 water supply, industrial, commercial, irrigation, and residential wells were modeled.
  - Precipitation and temperature distribution were estimated using PRISM.

  - Model calibration was based on groundwater elevation data for Spokane Valley and stream flow data from four locations along the Spokane River.
  - Model results included the computation of average annual gains and losses along 13 Spokane River reaches.
- The Washington Department of Ecology has calibrated and used a water quality model, CEQUAL-W2 on Lake Spokane (Long Lake). This model is currently being calibrated for use in analyzing all of Lake Roosevelt, including the Spokane Arm.

JURISDICTIONS AND LAND OWNERSHIP

WRIA 54 includes several jurisdictional areas of varying levels of government. These include Spokane County, Lincoln County and Stevens County; the Cities of Spokane, Airway Heights, Springdale, and Medical Lake; Fairchild Air Force Base; and the Spokane Indian Reservation. Of these jurisdictions, only Airway Heights is completely within WRIA 54. Table 2-7 lists the jurisdictions and their area within WRIA 54. The majority of the watershed consists of rural unincorporated lands, and the land is predominantly privately owned. The Spokane Indian Reservation accounts for approximately 25 percent of the watershed; and publicly owned municipal, county, state, and federal land account for around 4 percent (see Figure 2-14).

TABLE 2-7.
WRIA 54 JURISDICTIONAL AREAS

Jurisdiction	Jurisdictional Area (square miles)	Percent of Jurisdiction in WRIA 54	Percent of Area of WRIA 54
City of Airway Heights	5.0	100	0.6
City of Medical Lake	4.3	22.3	0.1
City of Spokane	59.1	28.6	1.9
Fairchild Air Force Base	6.6	35.0	0.3
City of Springdale	1.1	39.5	0.1
Lincoln County	2,339.2	8.7	23.1
Spokane County	1,783.4	12.7	25.6
Stevens County	2,537.7	17	48.7
Spokane Indian Reservation	215.3	90	24.3

POPULATION

The population in the WRIA was estimated from 2000 census block information. The population of all US Census tracks whose center is inside the WRIA boundary was included in the estimate. Population data for 1910 and 2025 were obtained from the Washington Office of Financial Management and adjusted to account for the percent of historical and future population within the watershed.

Approximately 19 percent of Spokane County’s population falls within WRIA 54, accounting for about 90 percent of the total WRIA population, and most of that is in the urban area around the City of Spokane. An estimated 21 percent of Stevens County’s population falls within the WRIA, which accounts for about 8 percent of the WRIA population. Lincoln County has approximately 9 percent of its population within the WRIA, making up the remaining 2 percent of the of the WRIA population. Historically, these percentages have remained approximately the same. The population trends of the three counties from 1910 to 2000 are as follows (OFM, 2006a):

- Lincoln County's population decreased by 45 percent from 1910 to 2000. The greatest decrease—22 percent—occurred between 1920 and 1930. This trend of population loss or no change continued at varying rates until 1990. In 2000 the county recorded a 15 percent increase in population.
- Stevens County's population grew 58 percent between 1910 and 2000. The county's greatest growth occurred between 1970 and 1980, at approximately 66 percent growth. Its largest decrease occurred between 1910 and 1920, at 15 percent; this population decline continued at a rate of 14 percent between 1920 and 1930.
- Spokane County experienced a 200-percent increase in population from 1910 to 2000. The largest population growth occurred between 1940 and 1950, with a 35-percent increase. Spokane County has never decreased in population; its smallest growth period was between 1910 and 1920, at a 1-percent growth rate.

Population projections show all three counties growing over the next 20 years. Table 2-8 outlines the historical and future population growth.

TABLE 2-8.
POPULATION TRENDS

	Estimated WRIA Population			Percent Change	
	1910	2000	2025	1910-2000	2000-2025
Lincoln County	1,572	913	1,148	-41.9%[a]	25.7%
Spokane County	26,658	79,922	107,399	199.8%[b]	34.4%
Stevens County	5,424	8,591	13,735	58.4%[c]	59.9%
Total	**33,654**	**89,426**	**122,282**	**165.7%**	**36.7%**

a. Max. population gain for one census period was 15%; max population loss for one census period was -22%.
b. Max population gain for one census period was 35%.
c. Max population gain for one census period was 66%; max population loss for one census period was -15%.

LAND USE

Current Land Uses

Land use data for WRIA 54 were acquired from the USGS and were developed based on aerial photos taken in 1992. This represents the most current land use data available for the WRIA. Figure 2-15 shows current land uses in WRIA 54. The categories used for this discussion are based on divisions provided by the USGS, which are grouped to simplify the analysis.

WRIA 54 consists mainly of forest and agricultural land. In Stevens County and the Spokane Indian Reservation, the land is almost all forested, with small, scattered, low-intensity residential areas. Much of the existing development is in the Long Lake North subbasin. South of the Spokane River in Spokane and Lincoln Counties, the land use is mostly agricultural, with intermittent forests and open land.

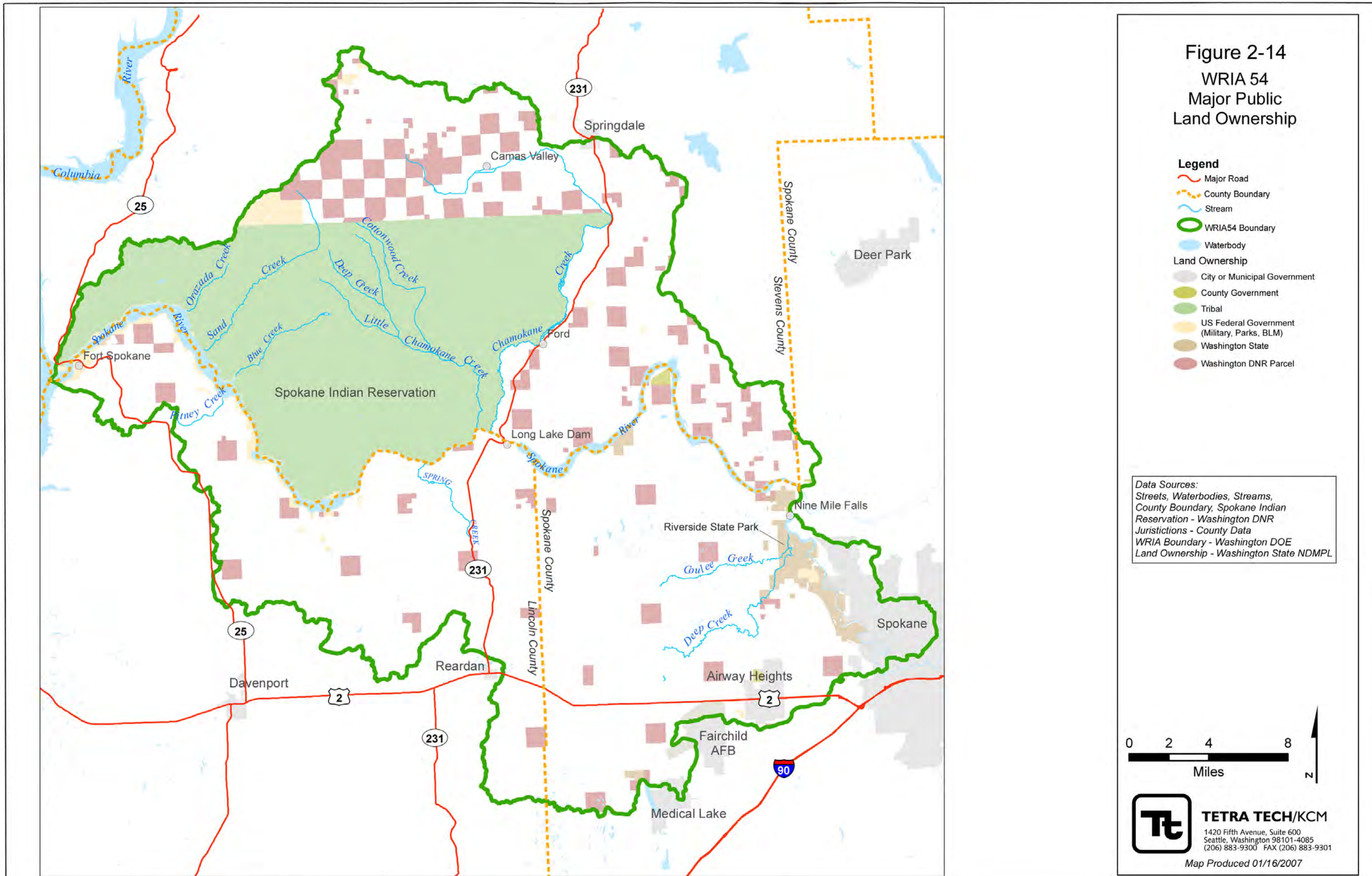


Figure 2-14
WRIA 54
Major Public
Land Ownership
Legend
Major Road
County Boundary
Stream
WRIA54 Boundary
Waterbody
Land Ownership
City or Municipal Government
County Government
Tribal
US Federal Government (Military, Parks, BLM)
Washington State
Washington DNR Parcel
Data Sources:
Streets, Waterbodies, Streams, County Boundary, Spokane Indian Reservation - Washington DNR
Juristictions - County Data
WRIA Boundary - Washington DOE
Land Ownership - Washington State NDMPL
0 2 4 8
Miles
N
TETRA TECH/KCM
1420 Fifth Avenue, Suite 600
Seattle, Washington 98101-4085
(206) 883-9300 FAX (206) 883-9301
Map Produced 01/16/2007
Springdale
Camas Valley
Deer Park
Spokane County
Stevens County
Lincoln County
Spokane Indian Reservation
Fort Spokane
Ford
Long Lake Dam
Nine Mile Falls
Riverside State Park
Spokane
Airway Heights
Fairchild AFB
Medical Lake
Reardan
Davenport
Columbia River
Spokane River
Orazada Creek
Sand Creek
Cottonwood Creek
Deep Creek
Little Chamokane Creek
Chamokane Creek
Blue Creek
Pitney Creek
Spring Creek
Coulee Creek
25
231
2
90

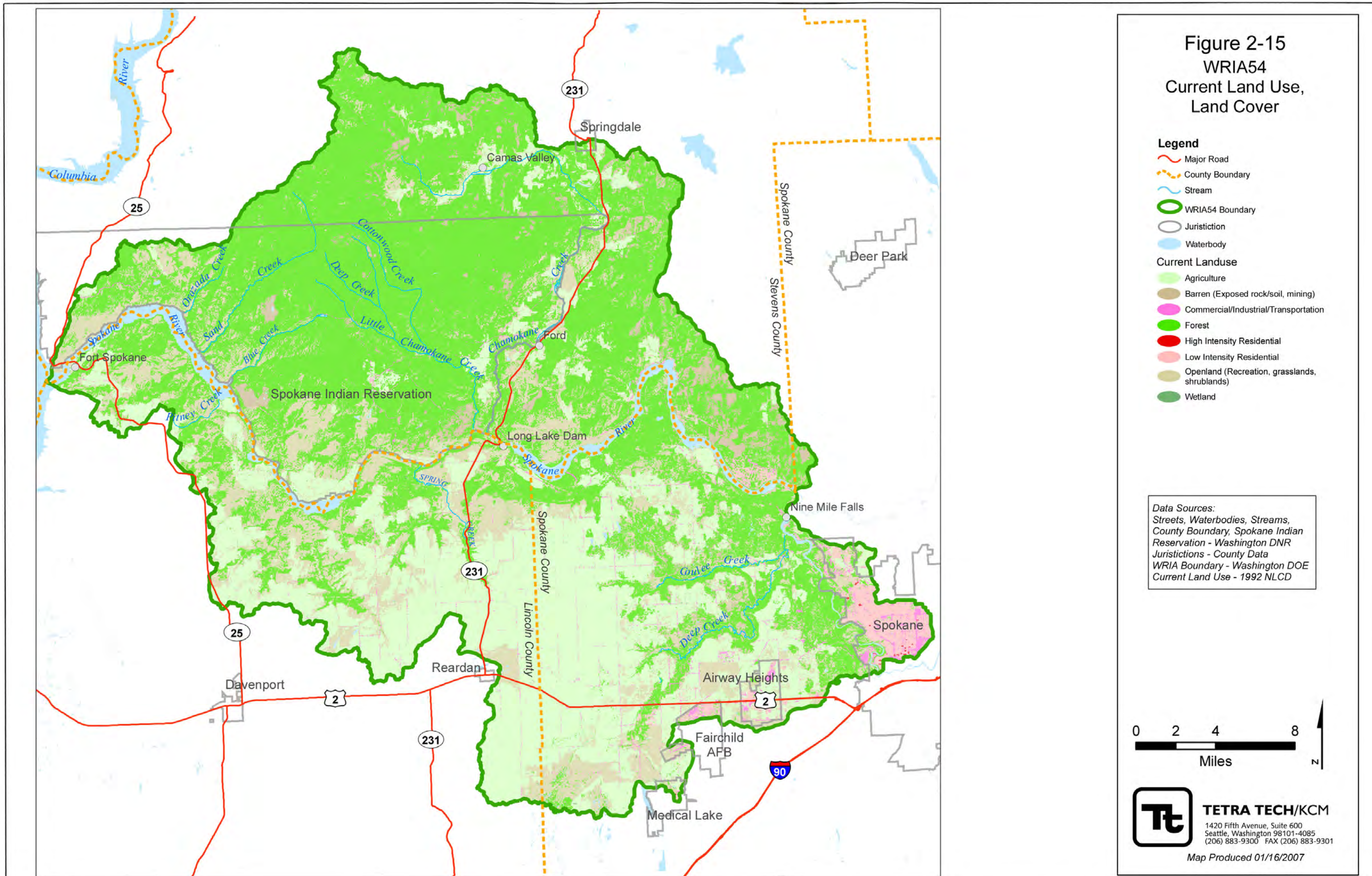


Figure 2-15
WRIA54
Current Land Use,
Land Cover

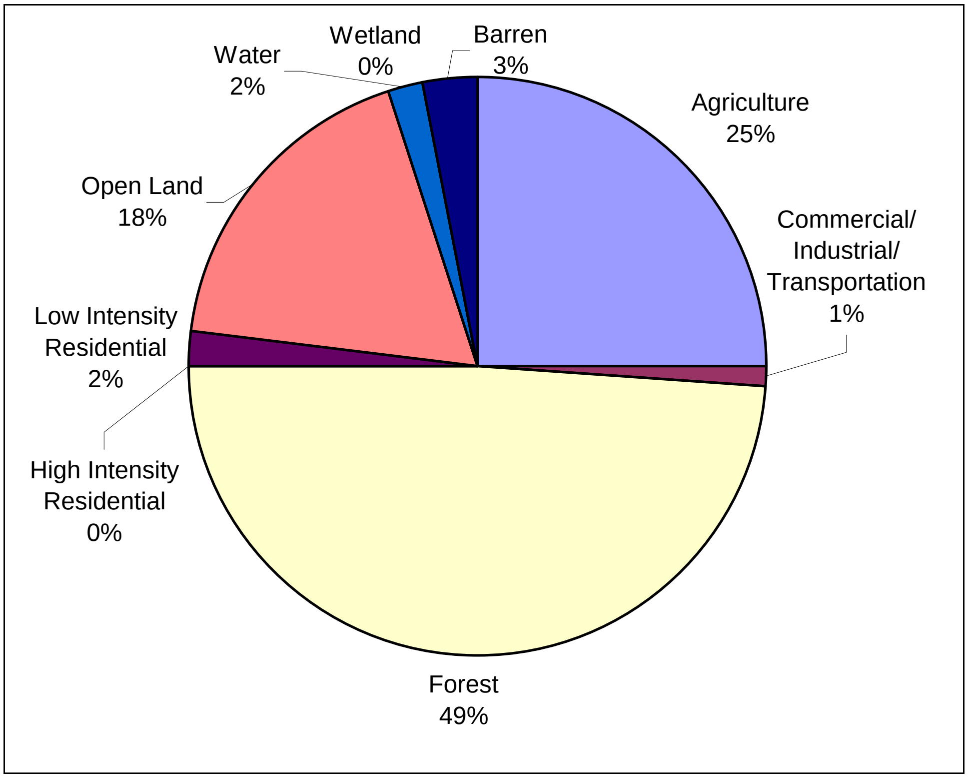


Figure 2-16 Current Land Use

Most of the urban development is in the Airway subbasin in the southeast portion of the WRIA, where approximately 15 percent of the land is composed of low-intensity residential development. This reflects the Spokane urban area and the City of Airway Heights, the two largest developments in the watershed. Figure 2-16 shows the distribution of current land uses in WRIA 54.

Future Land Uses

Future land uses were determined based on zoning designations for Spokane, Lincoln and Stevens Counties and the Spokane Tribe's Integrated Resource Management Plan. The zoning data present a conceptual idea of buildout conditions, rather than projections of growth that is actually expected to occur. To compare future land use against existing land uses, the zoning classes were grouped into the land use classifications. Zoning data from Stevens County as of April 2006 are in draft format and have not been finalized.

Figures 2-17 and 2-18 present the possible future land use for WRIA 54 as allowed by current zoning. The zoning would allow low-intensity residential land uses to grow by approximately 2,000 percent, primarily in the southeastern portion of the watershed around the City of Spokane and Airway Heights and to continue along the Spokane River, Lake Spokane (Long Lake), Coulee Creek, and Deep Creek.

Stevens County zoning allows for additional low-density residential growth near Springdale in the northern portion of the watershed. Land zoned for agriculture would accommodate an estimated 90 percent increase, predominantly in the Camas Valley, Ford, and Long Lake North subbasins. If these area were developed to the full extent that the zoning allows, it would result in a nearly 80 percent decline in forested and open land areas. These possible future scenarios are based entirely on the land use zoning, which indicates allowed uses, not necessarily changes that are likely or expected.

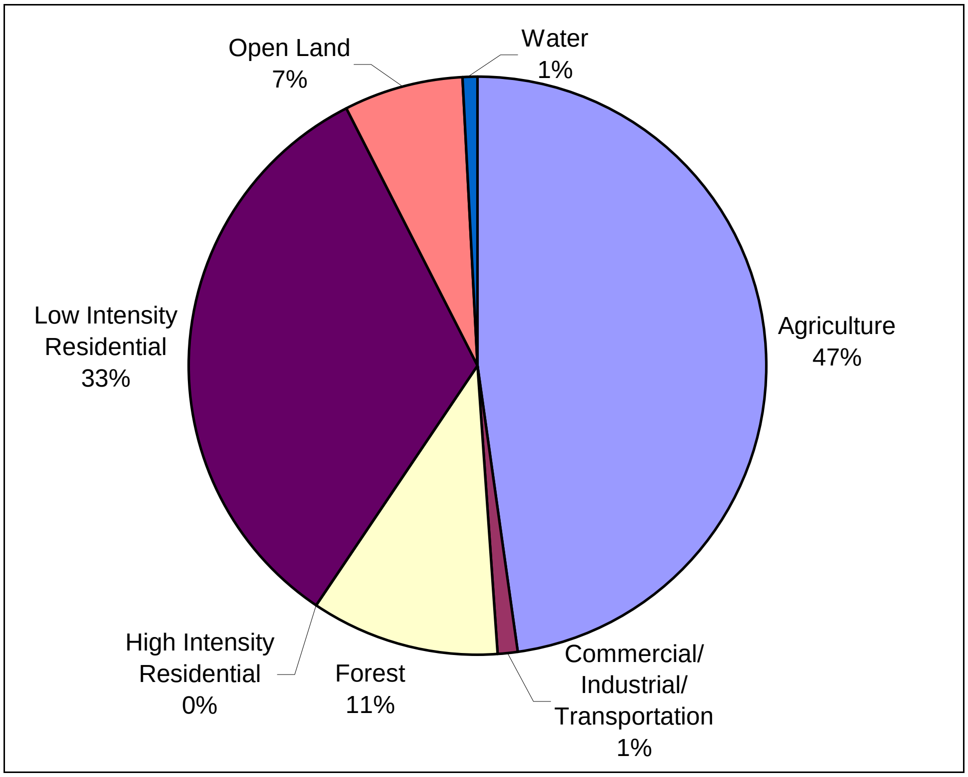


Figure 2-17 Future Land Uses

AQUATIC LIFE IN WRIA 54

Table 2-9 summarizes information regarding fisheries use of stream segments in WRIA 54, provided by the Washington Department of Fish and Wildlife.

TABLE 2-9.
AQUATIC LIFE IN WRIA 54

Reach	Critical Species	Life Stages and Timing	Comments
Latah (Hangman) Creek to mouth of Deep Creek	Rainbow trout (redband)	• Spawning/incubation - April-June • Adult rearing – year-round • Juvenile rearing – year-round	Pure redband rainbow trout strain over entire reach. Supports all life stages of rainbow trout and mountain whitefish along entire reach.
	Mountain whitefish	• Spawning/incubation – November-April • Adult rearing – year-round • Juvenile rearing – year-round	

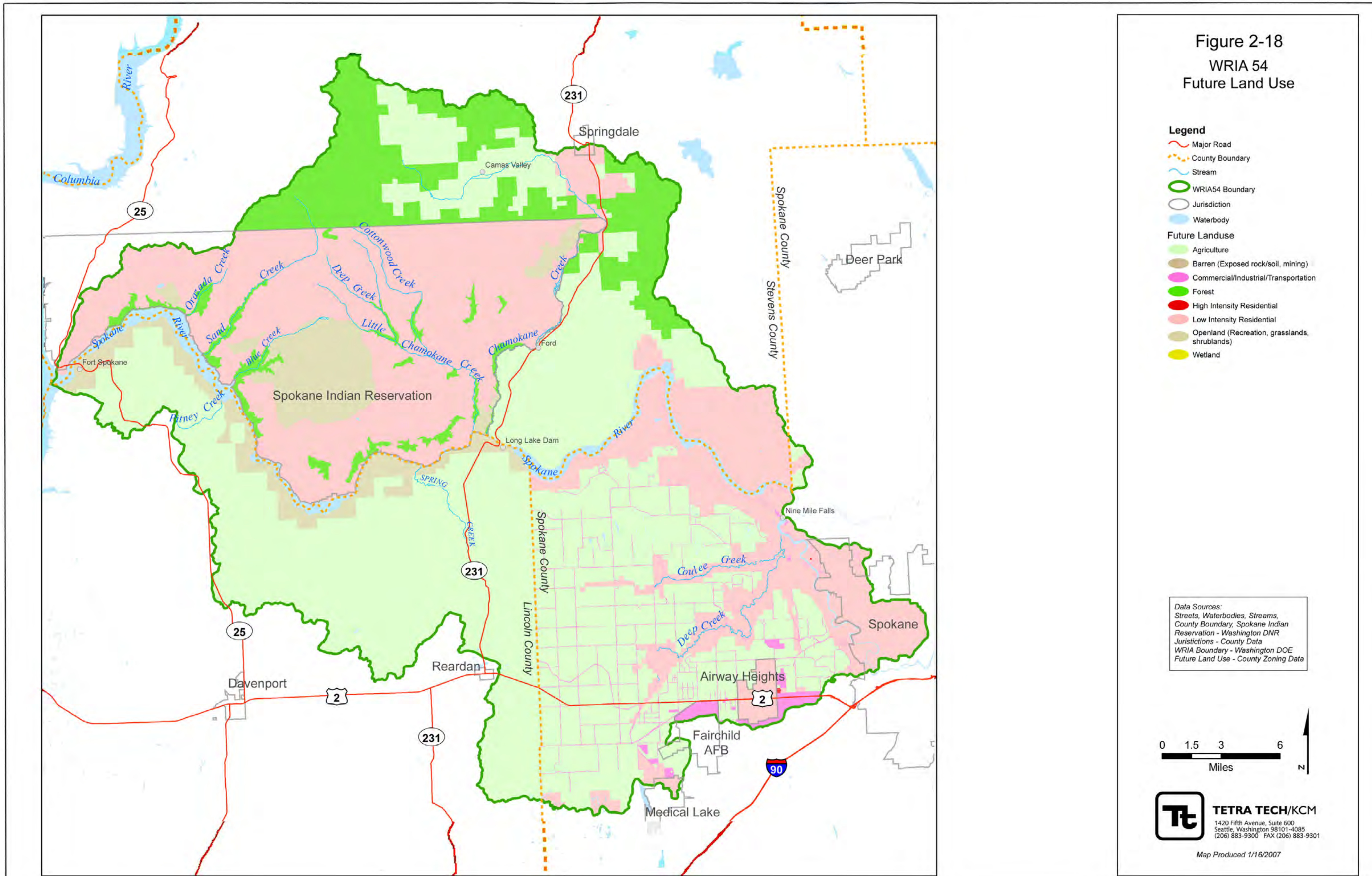


Figure 2-18
WRIA 54
Future Land Use

TABLE 2-9 (continued).
AQUATIC LIFE IN WRIA 54

Reach	Critical Species	Life Stages and Timing	Comments
Below Nine Mile Falls	Rainbow trout	• Adult rearing – year-round (assumed; data lacking)	It is possible that this reach could produce and support a substantial number of salmonids, but very little information exists on this stretch of river.
	Mountain whitefish	• Adult rearing - year-round (assumed; data lacking)	
Below Lake Spokane (Long Lake)	Rainbow trout	• Adult rearing - year-round	Very short reach
	Brown trout	• Adult rearing - year-round	
	Mountain whitefish	• Adult rearing - year-round	
Below Little Falls	Rainbow trout	• Adult rearing - year-round	Total Dissolved Gas problems
	Brown trout	• Adult rearing - year-round	
	Mountain whitefish	• Adult rearing - year-round	
Deep Creek	Rainbow trout	• Spawning/incubation - April-June • Adult rearing – year-round • Juvenile rearing – year-round	Redbands present but hybridized with coastal rainbows, majority of native genetic material is present. Year around flow to Gordon Road. Seasonal flow from that point to about 2 miles below. Dry below that, rarely watered up.
	Eastern brook trout	• Spawning/incubation - October-April • Adult rearing – year-round • Juvenile rearing – year-round	

TABLE 2-9 (continued).
AQUATIC LIFE IN WRIA 54

Reach	Critical Species	Life Stages and Timing	Comments
Coulee Creek	Rainbow trout	• Spawning/incubation - April-June • Adult rearing – year-round • Juvenile rearing – year-round	Coulee Creek has a pure strain of redband rainbow trout. This plus the support of all life stages makes it a high priority. Year around flow on upper portion only. Seasonal flow from that point to approx. 2 miles downstream. From that point to mouth is dry, rarely watered up
	Eastern brook trout	• Spawning/incubation - October-April • Adult rearing – year-round • Juvenile rearing – year-round	
Spring Creek	Rainbow trout	• Spawning/incubation - April-June • Adult rearing – year-round • Juvenile rearing – year-round	Supports all life stages of rainbow trout. Genetic status is unknown.

CHAPTER 3.
WATER RIGHTS AND USE

As urbanization occurs in WRIA 54, especially in the eastern portion, water needs will increase. Groundwater and surface water resources support this primarily agricultural, but urbanizing watershed. These water resources belong to the public and are managed by the State of Washington. Claims, certificates, or permits give users the right to use these water resources for a particular beneficial use, such as municipal water supply, agricultural irrigation, stock watering, and domestic use. In WRIA 54, only municipalities, larger commercial and industrial users, and adjudicated water rights holders in the Chamokane Creek drainage (Camas and Ford subbasins) meter their water consumption. The amount of water use for the remainder of the users can only be quantified by an analysis of water rights and water use practices. This chapter reviews existing documented water rights and presents estimates for maximum annual allocations of water under known water rights as well as current annual use. The estimates in many cases rely on generic assumptions for assessing water rights and water use.

WATER RIGHTS

History of State Laws Relating to Water Rights

Delivery of Pipe for the Early City of Spokane Water System

Original (surface) water rights in the State of Washington were based on the riparian doctrine and the prior appropriation doctrine. The riparian doctrine allowed landowners adjacent to water bodies to use the water. Prior appropriation provided landowners without adjacent water to use remote waters, based on a priority system ("first in time, first in right"). Prior to 1917, the state did not have an official permitting system or specific controls on water rights, but in 1917 the state Water Code was established. The Water Code established three main principles:

- All waters within the state belong to the public.
- Prior appropriation became the official water right method.
- The administration and establishment of new water rights would be handled by the state.

A proposed water right must meet four primary requirements in order for Ecology to issue a water right permit:

- The water will be put to beneficial use.
- There will be no impairment to existing rights.
- Water is available.
- The water use will be in the public interest.

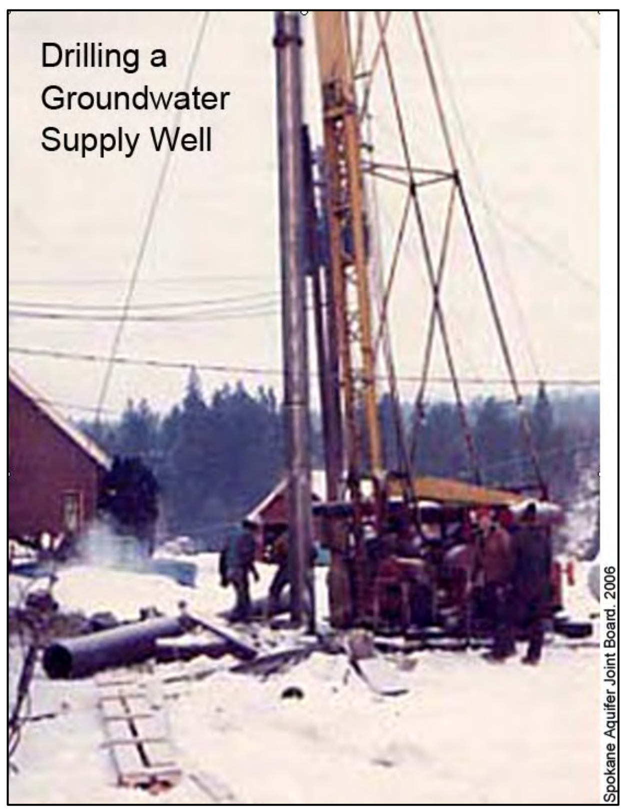
The Water Code of 1917 did not affect existing rights and is still in use today (Ecology, 2006).

The Groundwater Code of 1945 addressed the widespread use of groundwater for water needs. The groundwater code was developed to use the same permitting process and four-part test as the surface water code and to be managed by the state. The Groundwater Code provided an exemption to the permitting process—any well used for domestic or industrial purposes (5,000 gallon per day limit), or for stock watering and irrigation of up to half an acre of non-commercial lawn or garden, is not required to go through the permitting process.

The Surface Water Code of 1917 and Groundwater Code of 1945 set forth the basis for state-administered water rights, but these state laws exist within a larger federal context. The federal context brings into play two other types of water rights: Federal and Tribal reserved water rights. Federal and Tribal reserved water rights are grounded in the principles upheld in the federal court case Winters v. United States (207 U.S. 564, 28S. Ct. 207, 52 L. Ed. 340 (1908)) that when the United States acquires or sets aside land through reservation for some specific federal purpose, including an Indian reservation, the federal government also reserves sufficient water to meet the purpose of the reservation.

Federal reserved water rights are typically unquantified, and are reserved to meet the purposes associated with lands held by the federal government, including national parks and military installations. While not bound by state law, federal reserved water rights are frequently addressed and resolved in state court general adjudications.

Tribal reserved water rights, like federal rights, pre-date Washington State's water code, and have seldom been quantified, but rather are described by their use in providing water to serve the purposes of the reservation. Neither federal nor Indian reserved water rights are subject to state law provisions requiring continuous beneficial use of water to retain a water right. For instance, if an Indian reservation is set aside in a treaty for "farming and fishing purposes," the reserved water right is not the actual amount of water appropriated at some historical time, but the amount of water that is necessary, now or in the future, to meet the purposes of the reservation. (Pharris et al, 2002) .



Two acts passed in 1967 affected water rights in Washington. The Minimum Water Flows and Levels Act of 1967 allowed the Department of Ecology to protect fish, wildlife, water quality, and other in-stream values by establishing a minimum flow requirement for a water body. The Water Right Claims Registration Act of 1967 was created to address the lack of documentation about water rights, specifically those pre-dating the Water Code and the Groundwater Code. As a result of this act, the state opened three periods for filing water right claims, establishing a process that users were required to complete in order to claim a water right established prior to the state water codes. Users were not automatically guaranteed the claim. The Water Rights and Claims Act also defined that water under a water right had to be used or the right could be revoked by the state.

The Water Resource Act of 1971 requires data collection on stream flow and subsequent development and management of comprehensive basin plans. Currently, this act is the governing law protecting in-stream flow.

The 1971 Water Well Construction Act regulates well drillers, requiring operator licensing and notification to the Department of Ecology prior to digging a new well.

The Growth Management Acts of 1990 and 1991 address water rights by establishing a requirement that applicants for building permits provide evidence of adequate water supply prior to construction.

Finally, the Watershed Management Act of 1998 established a framework, based on Water Resource Inventory Areas (WRIA), "to develop a more thorough and cooperative method of determining what the current water resource situation is in each water resource inventory area of the state and to provide local citizens with the maximum possible input concerning their goals and objectives for water resource management and development"(RCW 90.82.005). The outcome is the development and implementation of a watershed management plan that will guide decisions on development and water use. Through this process, Watershed Planning Units are also able make recommendations regarding in-stream flow requirements, water quality and habitat.

Water Rights Data for WRIA 54

As a result of the Water Right Claims Registration Act of 1967, the State of Washington maintains a database of all water rights in the state. The Water Right Application Tracking System (WRATS) provides summary information on each right, including a file number, the name of the user, the status of the right, the priority data, purpose, location, and withdrawal data. Complete copies of water right documents are available from the Department of Ecology; these were not consulted for the analysis below. The summary data in the WRATS database are often incomplete, and duplications and errors are common. The water rights information presented below was screened for duplicate records and obvious anomalies. The following sections summarize data available from the WRATS database for WRIA 54.

Claims

Claims represent an assertion of vested water rights established through beneficial use that began prior to 1917 for surface water and prior to 1945 for groundwater. Claims are potential rights to water that remain in effect until they can be verified by an adjudication. The adjudication process requires that it be proven that the claim has been in continuous beneficial use since before 1917 for surface water and before 1945 for groundwater. If a claim has not been used for more than five consecutive years, it may become invalidated. Typically, adjudications do not occur unless there are proven problems with water quantity in the area (Ecology, 2006).

The WRATS database lists more than 1,700 claims within WRIA 54. Approximately 73 percent are claims for groundwater sources and 27 percent are for surface waters (see Figure 3-1). Even though there are fewer rights for surface water than for groundwater, the estimated volume of maximum annual withdrawal (Qa) is greater for surface water claims (see Figure 3-1), at about 20,322 acre-feet, or 6.6 billion gallons per year. This accounts for approximately 54 percent of the total potential water right for all claims. Groundwater claim withdrawal rights represent approximately 17,417 acre-feet, or 5.6 billion gallons, of water annually (46 percent).

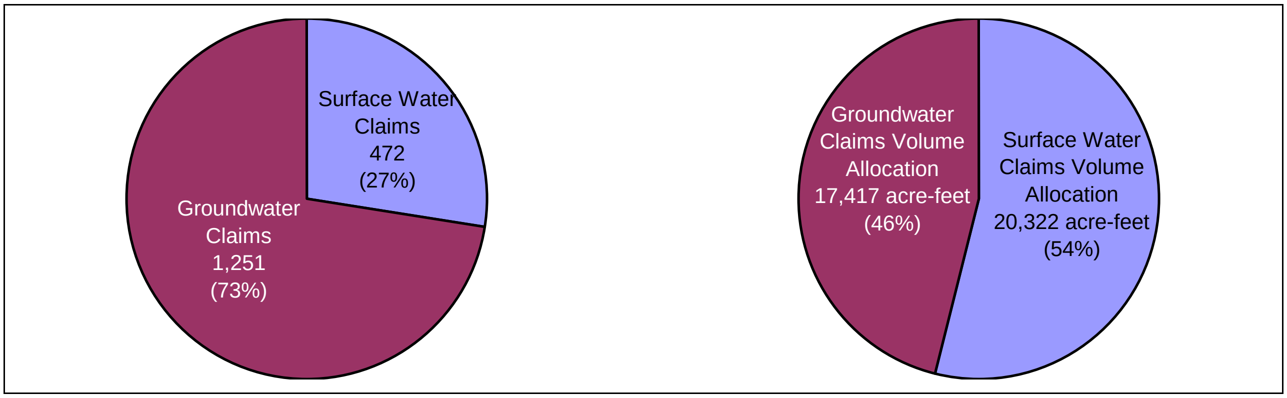


Figure 3-1. Distribution of WRIA 54 Water Claims by Water Source; Number of Claims (left) and Maximum Annual Volume Allocation (right)

Review of records in the WRATS database identified 154 potential duplicates—38 percent of which were for surface water claims, with a total allocation of 340 million gallons per year and 62 percent of which were for groundwater claims, with a total potential allocation of 258 million gallons per year. These records are not confirmed as duplicates, but if all of them are, in fact, duplicates, then the correct total number of claims in WRIA 54 could be 9 percent lower and the total annual maximum water withdrawal would be 5 percent lower, reducing the total potentially allocated water right by 1,838 acre-feet per year. Table 3-1 summarizes the effects these potential duplicate records could cause on the existing claims in the database.

TABLE 3-1.
TOTAL WRIA 54 CLAIMS IN WRATS DATABASE AND POTENTIAL DUPLICATE CLAIMS

	Surface Water Claims		Groundwater Claims		Total Claims	
	Number of Claims	Total Maximum Annual Withdrawal (acre-feet)	Number of Claims	Total Maximum Annual Withdrawal (acre-feet)	Number of Claims	Total Maximum Annual Withdrawal (acre-feet)
WRATS Total	472	20,322	1,251	17,417	1,723	37,739
Potential Duplicates	59	1,045	95	793	154	1,838
Corrected Total[a]	413	19,277	1,156	16,624	1,569	35,901
Percent Change[b]	13	5	8	5	9	5

a. Total if all potential duplicates are in fact duplicate claims
b. Percent reduction in WRATS total if all potential duplicates are in fact duplicate claims

Most claims are for one or more of the following uses: domestic, stock watering, and irrigation. Thirty-four of the claims have no identified purpose; 10 of them belong to Washington Water Power (now known as Avista) and are probably related to power production. Most claims records in the WRATS database do not include the maximum annual withdrawal, so estimates were made based on the following assumptions:

- For claims with a domestic use – 2 acre feet per year.
- For claims with a stock watering use – 1 acre foot per year.

- For claims with an irrigation use that identify the number of irrigated acres, it was assumed that 4 acre-feet per year would be used to irrigate each acre.
- For claims with an irrigation use without acreage identified, the withdrawal right was given a value based on the defined use of the claim - 16 acre-feet per year for irrigation.

These assumptions were based on previously developed regional data. A Qa of 2 acre-feet per year is the maximum quantity assigned to private domestic use certificates in the Deadman Creek subbasin of WRIA 55 (Little Spokane) surface water rights adjudication in 1985 (Case No. 246952). This is equivalent to 1,786 gallons per day. A Qa of 1 acre-foot per year was assigned to the stock watering purpose in the same Deadman Creek subbasin adjudication. An irrigation duty of 4 acre-feet per year to irrigate each acre was used because of the low precipitation in the watershed. Claims with irrigation as a purpose but without acreage identified were assigned a duty of 4 acre feet for 4 acres, which is close to the median area listed in claims with identified irrigated acres.

After maximum annual withdrawal had been estimated for each claim in the watershed, the claims with the largest allowed annual withdrawals were identified. The 10 largest claims have a total maximum annual withdrawal of almost 17,000 acre-feet, about 45 percent of the total for all 1,723 claims in the watershed. Table 3-2 lists these largest claims.

TABLE 3-2.
LARGEST WRIA 54 CLAIMS IN WRATS DATABASE, BY MAXIMUM ANNUAL WITHDRAWAL

Name Listed on Claim	Purpose[a]	Maximum Annual Withdrawal (acre-feet)	Subbasin
Trans-West Co	IR	2,560	Camas Valley
Trans-West Co	IR	2,560	Camas Valley
Rinker, James C.	No ID	1,282	Spring Creek
FAC No. 10020/GKAW	IR, DG	1,242	Airway
FAC No. 11070/GKAW	IR, DG	1,242	Airway
FAC No. 10030/GKAW	IR, DG	1,242	Airway
Peterson, Ethel M.	ST, IR	1,201	Coulee Creek
Trans-West Co	IR	1,000	Camas Valley
Lyka Corporation	IR, DG	802	Spring Creek
Peterson, Ethel M.	ST, IR	641	Coulee Creek
Total		**13,772**	

a. IR=irrigation; DG=Domestic General; ST=Stock Watering; No ID=No Purpose Listed

Table 3-3 and Figures 3-2 and 3-3 summarize the estimated annual allocation of claim rights in WRIA 54 based on these assumptions. The data are presented to show the distribution by water source and water use. Instantaneous withdrawal/diversion rates are not listed for water right claims, and no estimates were developed as part of this water rights analysis.

TABLE 3-3.
DISTRIBUTION OF WRATS WATER CLAIM ALLOCATION BY SOURCE AND REPORTED TYPE OF USE

	Irrigation	Stock Watering	Domestic Use	Irrigation/ Domestic	Stock Watering/ Domestic	Stock Watering/ Irrigation	Unknown/ Stock Watering	No ID	**Total**
All Sources									
Qa (acre-feet)	11,600	239	1,164	9,304	1,137	12,765	2	1,528	**37,739**
% of Total Qa	31	1	3	25	3	34	0	4	**100**
Surface Water									
Qa (acre-feet)	10,684	190	186	454	222	7,198	2	1,386	**20,322**
% of Total Surface Water Qa	53	1	1	2	1	35	0	7	**100**
% of Total Qa for Specified Use	92	79	16	5	20	56	100	91	—
Groundwater									
Qa (acre-feet)	916	49	978	8,850	915	5,567	—	142	**17,417**
% of Total Groundwater Qa	5	0	6	51	5	32	—	1	**100**
% of Total Qa for Specified Use	8	21	84	95	80	44	—	9	

Permits and Certificates

All new water rights after 1917 for surface water and after 1945 for groundwater require an application to be submitted to the Department of Ecology. The Department of Ecology reviews the applications and conducts an investigation to confirm that the right would meet the following requirements:

- The water will be put to beneficial use.
- There will be no impairment of existing rights.
- Water is available for the right.
- The water use will be in the public interest.

If the request is approved, the applicant receives a Permit to Appropriate Public Waters of the State of Washington. A permit allows the holder to begin construction of water withdrawal facilities and to use the water as specified in the permit. The permit allows the holder to use the water, but the permit is not a permanent water right. Once the Department of Ecology confirms that the holder has met all requirements of the permit, a Certificate of Water Right will be issued. The certificate is a legal right to the water as specified by the certificate and is considered attached to the land (Ecology 2006). The certificate specifies the authorized uses, location for use and water source, and usually an instantaneous and annual maximum water quantity. Thirty-one certificates and permits in WRIA 54 do not specify authorized annual water quantity; these include several rights for single domestic supply, fire suppression, power, and irrigation.

Any proposed change in an existing claim or certificate also requires an application to Ecology or the local Water Conservancy Board, and these applications are included in the WRATS database. Table 3-4 summarizes the information on permits and certificates in WRIA 54 from the WRATS database. Figure 3-4 shows the distribution of certificates and permits for various intended uses.

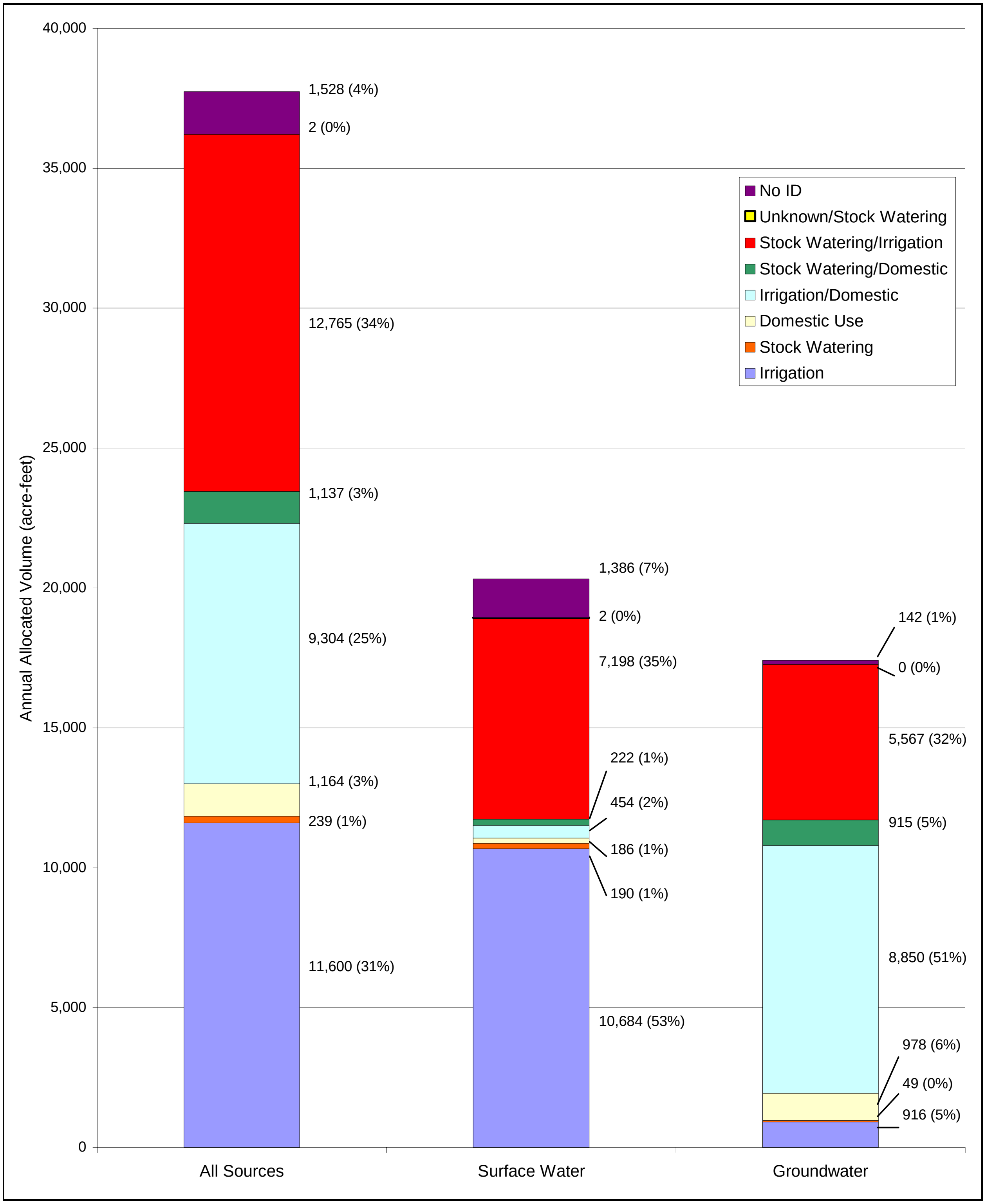


Figure 3-2. Distribution of Estimated Annual Volume Allocation for Claims by Intended Use

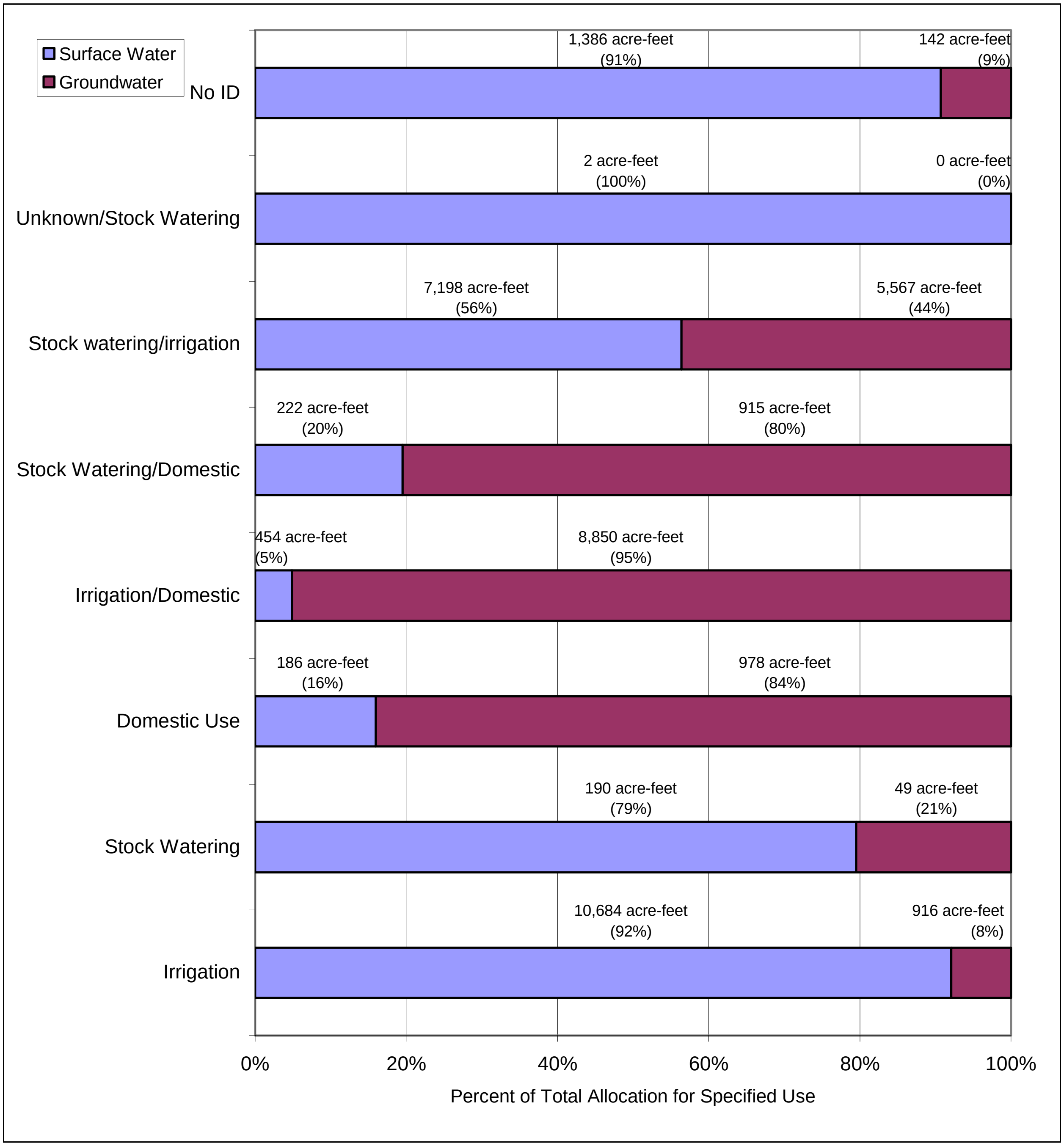


Figure 3-3. Distribution of Estimated Annual Volume Allocation for Claims by Water Source (Surface/Ground)

TABLE 3-4.
SUMMARY OF WRIA 54 PERMITS AND CERTIFICATES

	Number	Maximum Annual Withdrawal (acre-feet)
Surface Water		
Certificates	155	9,260
Permits	9	6,170
Groundwater		
Certificates	205	58,361
Permits	18	4,709
Total	387	78,500

Certificates

The certificates in WRIA 54 are held mostly by municipal purveyors (44 percent) and irrigators (39 percent) within the WRIA. The City of Spokane holds rights to approximately 35 percent, or 25,000 acre-feet per year, of the water allocated by certificates. Fairchild Air Force Base, the City of Medical Lake and Stevens County PUD each hold slightly less than 2 percent of the certificate volume allocation, each accounting for approximately 1,600 acre-feet per year. Irrigation use is spread out among many individual users, with the Spokane Hutterian Brethren one of the larger users.

Domestic multiple (3.9 percent), stock watering/irrigation (2.8 percent), and irrigation/domestic multiple (2.2 percent) account for other significant uses. A combination of other uses—none of which account for more than 1 percent—make up the remaining 8.1 percent. The raw certificates data can be found in Appendix D.

Permits

Permits account for 10,879 acre-feet per year, or 8 percent of the water rights within WRIA 54, excluding claims and exempt wells. Approximately 59 percent of the permit-allocated water is used for irrigation by a variety of individual users, the largest of which is the Spokane Hutterian Brethren. Stevens County PUD accounts for all of the municipal use of permitted water, 32 percent. The remaining 9 percent of the water is used for stock watering, environmental quality, and domestic uses. The raw permit data can be found in Appendix D.

New Applications

There are 37 new applications on file with the State of Washington, mostly submitted by individual users for irrigation and domestic use. Approximately 90 percent of the new applications list the source of the water as a well. Most of the applications do not have an annual use volume (Qa) associated with them. Detailed information on the new applications within WRIA 54 can be found in Appendix D.

Change Applications

As of the date of this assessment there are applications for a change in 33 water rights in WRIA 54 (see Appendix D for listing). One of the change applications appears to be a request for a change in a permit; two request changes to water right claims.

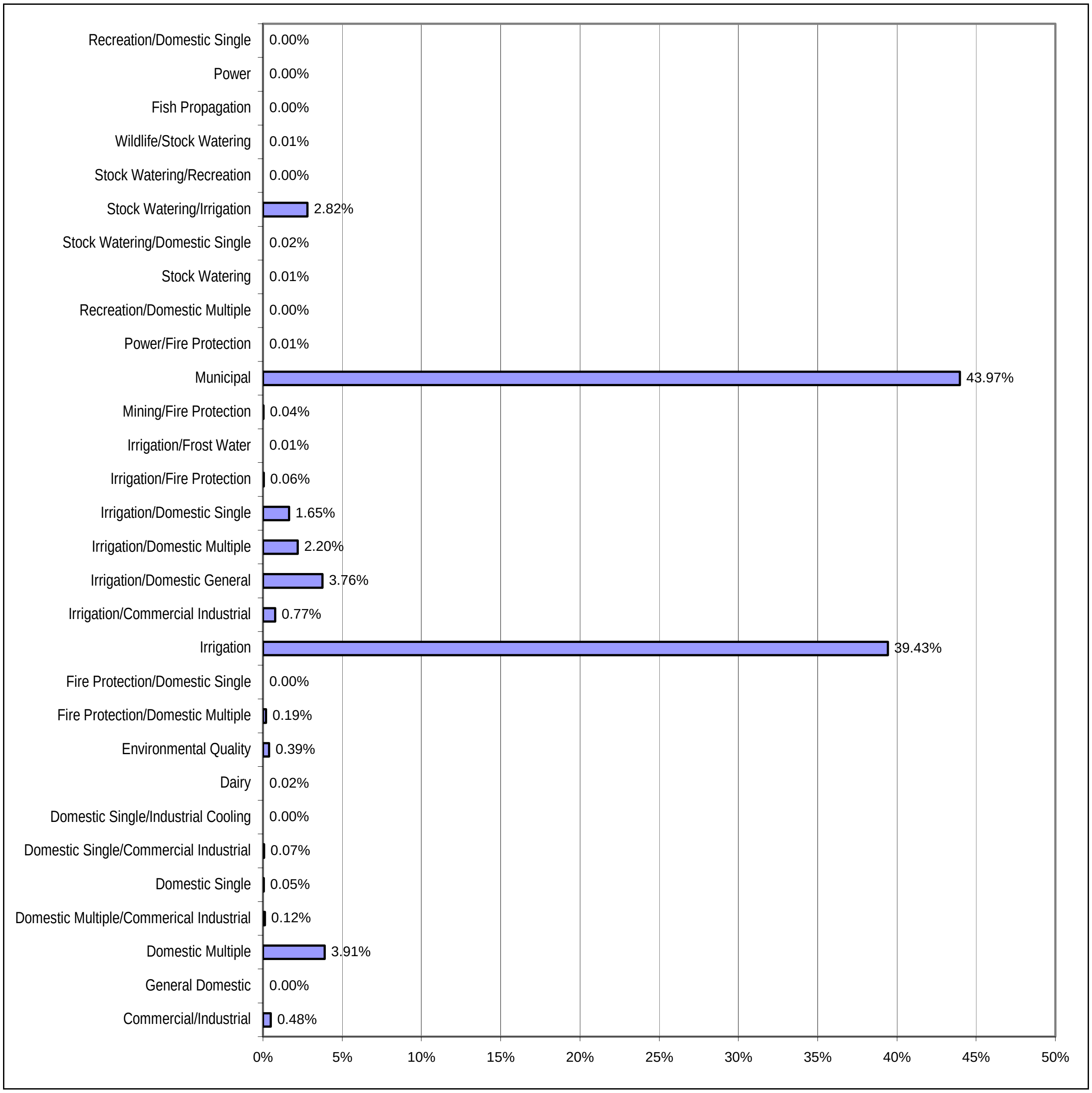


Figure 3-4. Distribution of Permits and Certificates Volume by Intended Use

Change applications cannot request an increase in the annual quantity of the water right; however, as a result of an investigation by the Department of Ecology or the Water Conservancy Board, the water right quantity can be reduced. Ecology has already investigated many of the change applications in WRIA 54. One water right was reduced from 10 cfs to 8 cfs during the change process.

Most change applications request a change in point of withdrawal, location of use, or purpose. The WRATS database is not clear about which kind of change was requested. It appears that 10 are for change or addition of purpose, eight, for change of point of withdrawal, and one, for both change of purpose and point of withdrawal. The type of change for the rest cannot be determined.

Chamokane Creek Adjudication

Water rights in the Chamokane Creek drainage were adjudicated in federal court, with a final order and judgment filed in 1979. The action was brought by the U.S. government on behalf of and as trustee for the Spokane Tribe to adjudicate the rights in and to the waters of Chamokane Creek and its tributaries, including the underlying groundwater. However the order does specify that groundwater withdrawals in the Upper Chamokane region have no impact upon the flow of Chamokane Creek because groundwater in the Upper Chamokane region is part of a separate aquifer.

The following is a summary of the Chamokane Creek adjudication. Except as noted, this information was obtained from federal court documents from U.S. v. Anderson et al. (Memorandum Opinion and Order, filed 7/23/79; Judgment, filed 9/12/79; Order Modifying the Minimum Flow Provisions of This Court's Memorandum Decision of July 23, 1979, filed 12/9/88; and Order Approving Water Master's Annual Report, Continuing Water Master's Service, Approving Compensation and Expense Agreement, and Addressing Additional Proceedings, filed 3/30/99 in the U.S. District Court, Eastern District of Washington):

- The Spokane Tribe is the beneficial owner of reserved water rights for irrigation as follows:
  - 23,694 acre-feet annually for irrigation of 7,898 acres; 8/18/1877 priority date
  - 1,686 acre-feet annually for irrigation of 526 acres; 1942-1945 priority dates (applies to specific land parcels)
- The Spokane Tribe owns reserved right to sufficient amount of water to preserve fishing in Chamokane Creek. This amount of water was originally specified to be 20 cfs flowing from Chamokane Falls into Lower Chamokane Creek, plus whatever additional flow is needed to maintain stream water temperature in Lower Chamokane Creek at 68ºF or less. This was modified by order on 12/9/88 to 24 cfs regardless of temperature. The priority date for this right is no later than 8/18/1877, the date of establishment of the Spokane Tribe Reservation, and could be determined to be earlier.
- The U.S. Department of Interior has confirmed a 10-cfs nonconsumptive water right from Spring Creek (tributary to Chamokane Creek) for fish propagation. This right has a 1942 priority date.
- Thirty-one Washington State-issued water rights were confirmed as well. All of these water rights have inferior priority dates to the bulk of the Spokane Tribe irrigation and all of the fishing rights for Chamokane Creek.
- All water rights were stated to have an effect on Chamokane Creek flow below the falls.
- The judgment decreed employment of a water master to regulate water users.
- The federal court retained jurisdiction in the case to allow for the tribe to apply for modification of the judgment as new information came available. The judgment has been modified at least twice, with additional minor adjustments as a result of the required annual water master report.
- Water for domestic use was not included since it was considered *de minimus* (insignificant) and sufficient water for such purposes always should be available.
- Based on the 1988 order that raised the required minimum flow in Lower Chamokane Creek to 24 cfs, regardless of temperature, water rights are regulated according to the following protocol:
  - Those with priority date on or before 9/13/88 (date of order) are subject to minimum flow of 24 cfs regardless of temperature.

  – All other water rights subsequent to 9/13/88 are subject to minimum flow of 27 cfs regardless of temperature.

  – Flows are to be determined by calculating the average of the daily average flows of the previous seven days.

  Historically, junior water users have been shut off twice based on flows dropping below the minimum flow requirements (Lylerla, 2006, written communication).

- A 1999 order amending the judgment closed the basin during irrigation season, stating that "no new appropriation of surface or ground water will be allowed during the irrigation season, 4/15/99 to 10/15/99." This order also stated that groundwater withdrawals would be subject to the same regulations as surface water.
- Most recently the court has ordered that a study be completed within the basin to determine the impact of new domestic, stock water and other exempt uses on the flow of Chamokane Creek. The State has requested funding for a portion of this study from the legislature (Lylerla, 2006, written communication).

Permit-Exempt Water Rights

Not all water rights are required to submit an application to acquire a permit and then certificate. The Groundwater Code allows for an exemption to the permitting requirements if the following criteria are met:

- Providing water for livestock (no gallon per day limit or acre restriction)
- Watering a non-commercial lawn or garden one-half acre in size or less (no gallon per day limit)
- Providing water for a single home or groups of homes (limited to 5,000 gallons per day)
- Providing water for industrial purposes, including irrigation (limited to 5,000 gallons per day but no acre limit.)

Since permit-exempt rights are not documented, the number of rights was estimated. Using the public water distribution boundaries of large purveyors within WRIA 54 and 2000 census data (see Figure 3-5), the population not serviced by public water distribution systems was identified. That population, approximately 9,200, was used to calculate an estimated number of wells and volume.

To provide an estimate of the number of wells in the WRIA, it was assumed that one well would service one equivalent residential unit (ERU) or 2.5 people. Using this assumption there are an estimated 3,600 exempt rights within the WRIA.

In most circumstances, exempt wells are allowed to withdraw a maximum of 5,000 gallons per day; however, since most exempt wells supply water to a single residential unit, assuming 5,000 gallons per day would tend to overestimate the actual water use. The Washington State Department of Health's *Water System Design Manual* states that the average day demand (ADD) in gallons per day per ERU can be calculated using the following formula:

ADD = (8,000/AAR) + 200

Where:

ADD = Average Day Demand (gallons per day/ERU)

AAR = Average Annual Rainfall (inches per year)

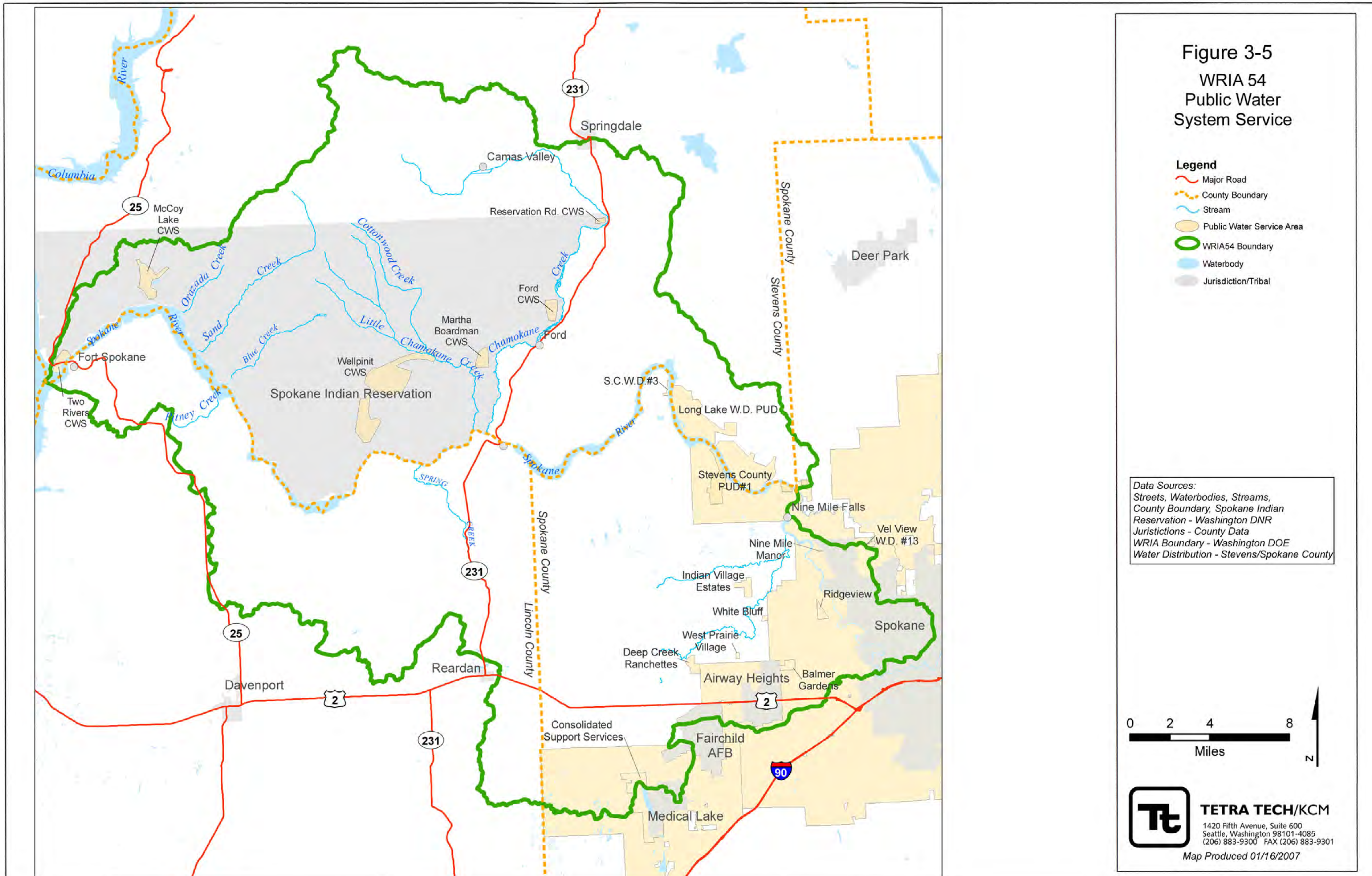


Figure 3-5
WRIA 54
Public Water
System Service

With an average annual rainfall of 15.8 inches, the ADD would be 706 gallons per day per ERU. The Department of Health also publishes the equation for calculating maximum-day demand (MDD), which it recommends using for a source that can meet or exceed the ADD. MDD is double the value of the ADD, therefore the MDD would be 1,412 gallons per day per ERU, or 515,000 gallons per year per ERU, or 1.6 acre-feet per year per ERU. To be conservative, the MDD was used to calculate the volume of exempt water rights. The exempt water right usage is estimated to be approximately 5,792 acre-feet annually. The detailed calculations can be found in Appendix D.

Illegal Water Use

Some entities in WRIA 54 may be using water with no authorization in either of the following ways:

- For uses that would require a water right
- Exceeding the authorized quantities for their permit or certificate, or permit-exempt well.

This assessment made no attempt to identify or quantify the magnitude of illegal water use as that determination could only be made through Ecology's enforcement authority.

Summary of Water Right Information

Water rights in WRIA 54 were tabulated as claims, permits/certificates, permit exempt wells and quantified federal rights. In terms of the number of potential rights, the breakdown between types of water rights is as follows:

- Water right claims: 1,723
- Permits/certificates: 387
- Permit-exempt wells: approximately 3,677
- Quantified federal rights (including Spokane Tribe): 12.

Because water right claims have yet to be validated, there is great uncertainty about the number of claims that should be considered as valid rights in the watershed planning process. The number of valid claims could be much less than the number of claims reported in the WRATS database. Without an adjudication, it is impossible to make a determination about the validity of these claims.

As an example of how many rights may be validated through an adjudication, we can look at results from the Deadman Creek (subbasin of WRIA 55) surface water adjudication completed in 1985. Both rights and claims were examined and either rejected or issued new certificates. The results shown in Table 3-5 give an idea of the percentage of rights and claims that might be validated in an adjudication.

There is also uncertainty regarding the number of permit-exempt wells. Some of the population included in this estimate may have a water source with a water right claim or certificate, and assumptions about the number of people per household may be inaccurate. The proportionately small number of permit/certificates is not reflected in the volume of water associated with each category of water right, however. As shown in Figure 3-6, the annual volume of water associated with permits/certificates (78,500 acre-feet/year) is almost twice the annual volume of water associated with claims (37,739 acre-feet/year).

TABLE 3-5.
DEADMAN CREEK SURFACE WATER ADJUDICATION RESULTS

	Count	Qi (cfs)[a]	Irrigated Area (acres)	Qa (acre-feet/year)
Adjudicated (relinquished) claims	192	n/a	790	2,370.0[b]
Relinquished certificates	84	41.06	681	1,275.5
Total – old claims and certificates	**276**	**41.06**	**1,471**	**3,645.5**
New certificates issued through adjudication	120	11.28	496	1,451.0
Percent old claims /certificates validated through adjudication	43.5%	27.5%	33.7%	39.8%

a. Qi = Maximum instantaneous flow
b. Adjudicated claims Qa based on an irrigation demand of 3 feet per acre.

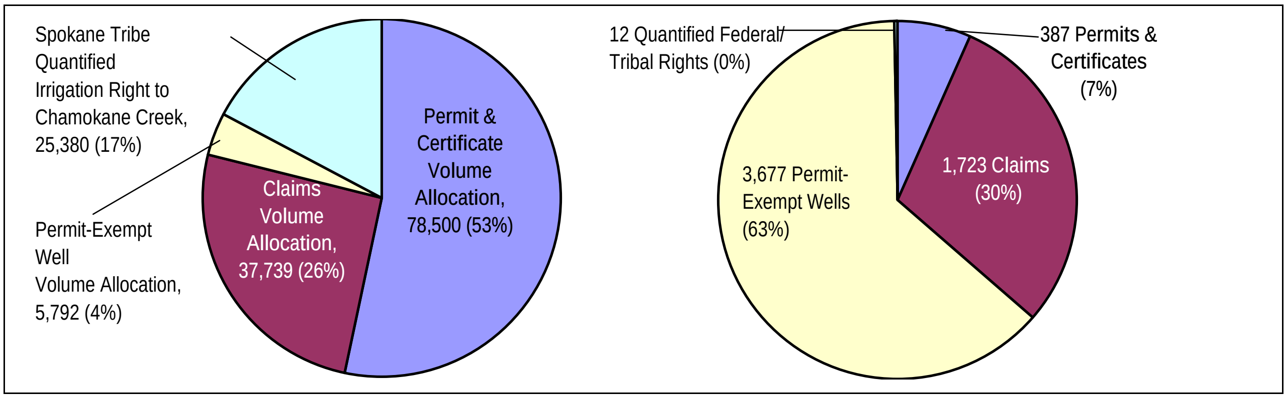


Figure 3-6. Summary of Water Rights by Allocated Annual Volume in Acre-Feet (left) and Number of Rights (right)

ESTIMATED CONSUMPTIVE WATER USE

While estimates of water right allocations help provide an understanding of potentially "committed water" and potential future water use in the WRIA, they are not an accurate indicator of actual current use, since many holders of water rights currently withdraw less than their allocated water right and some listed water rights may not be in use. A separate analysis was therefore performed to estimate actual current water use. Such water use evaluations sometimes distinguish between "consumptive" and "non-consumptive" water uses. Consumptive uses remove water permanently from its source, whereas non-consumptive uses, such as hydroelectric power generation, return all or most of the water to its source immediately after use. In WRIA 54, the non-consumptive uses are three hydroelectric power generation facilities owned and operated by Avista and two fish hatcheries along Chamokane Creek. All other water use is assumed to be consumptive.

Many of the larger permit, certificate and claim holders in the watershed meter their water use, and these data were used to estimate consumptive water use. Most of the data originate from public water system purveyors and can include use by municipalities, industrial facilities and commercial users. To segregate indoor uses from outdoor uses (primarily irrigation), the average withdrawal from November though

March was calculated and assumed to be the monthly indoor consumption. Subtracting this number from the total water use from April though October provided the outdoor use.

Group A Water Systems

The federal Safe Drinking Water Act (SDWA) of 1974, amended in 1986 and 1996, was created to protect public water system sources and ensure drinking water quality. The State of Washington holds the authority to implement the SDWA under the Washington Administrative Code (WAC), Title 246, Chapter 246-294. The act defines public water systems as having at least 15 connections and regularly serving a minimum of 25 people daily. These public systems are referred to as Group A systems in Washington and are managed by the Department of Health. The purpose of regulating Group A systems is to provide the public with safe and reliable drinking water consistent with the Washington State Board of Health drinking water regulations (246-291 WAC) and the water works operator certification regulations (246-292 WAC) (Washington State Legislature 2006). In the State of Washington there are 4,270 Group A systems (DOH 2001); in WRIA 54 there are 15 Group A community purveyors. In addition, there are six community water systems on the Spokane Indian Reservation; these are administered by EPA.

The federal regulations define two types of public water systems: community water systems and non-community water systems. Community water systems service the same people year-round and typically provide water to residents in cities, towns and mobile home parks. Non-community water systems do not service the same people year-round. There are two types of non-community water systems:

- Non-transient non-community water systems—These systems provide service to a relatively fixed set of users, but only for six to 12 months each year. Schools are primary examples of non-transient non-community water systems (EPA, 2006).
- Transient non-community water systems—These systems may service the same locations year-round but the service is to a changing set of users. Typical examples are rest areas, campgrounds and gas stations (EPA, 2006).

Group A Community Water Systems

Monthly data were collected for each of the community Group A water systems, shown in Figure 3-5. Figure 3-7 illustrates the water use by the community Group A purveyors. On average, 849 acre-feet per month are consumed for indoor uses; the remainder of the uses are outdoor uses, which accounts for approximately 55 percent of the water used in an average year. Irrigation is assumed to begin in April and continue until October, with a peak combined water use in August of approximately 3,876 acre-feet.


Typical Outdoor Domestic Water Use

The annual water use is approximately 10,156 acre-feet for indoor uses and 12,248 acre-feet for outdoor uses, which is an annual combined total use of 22,404 acre-feet. The City of Spokane is the largest Group A community user, providing approximately 70.3 percent of the total annual water consumed in the WRIA. Fairchild Air Force Base and Stevens County PUD are the next most significant users, at approximately 10.8 percent and 9.2 percent, respectively.

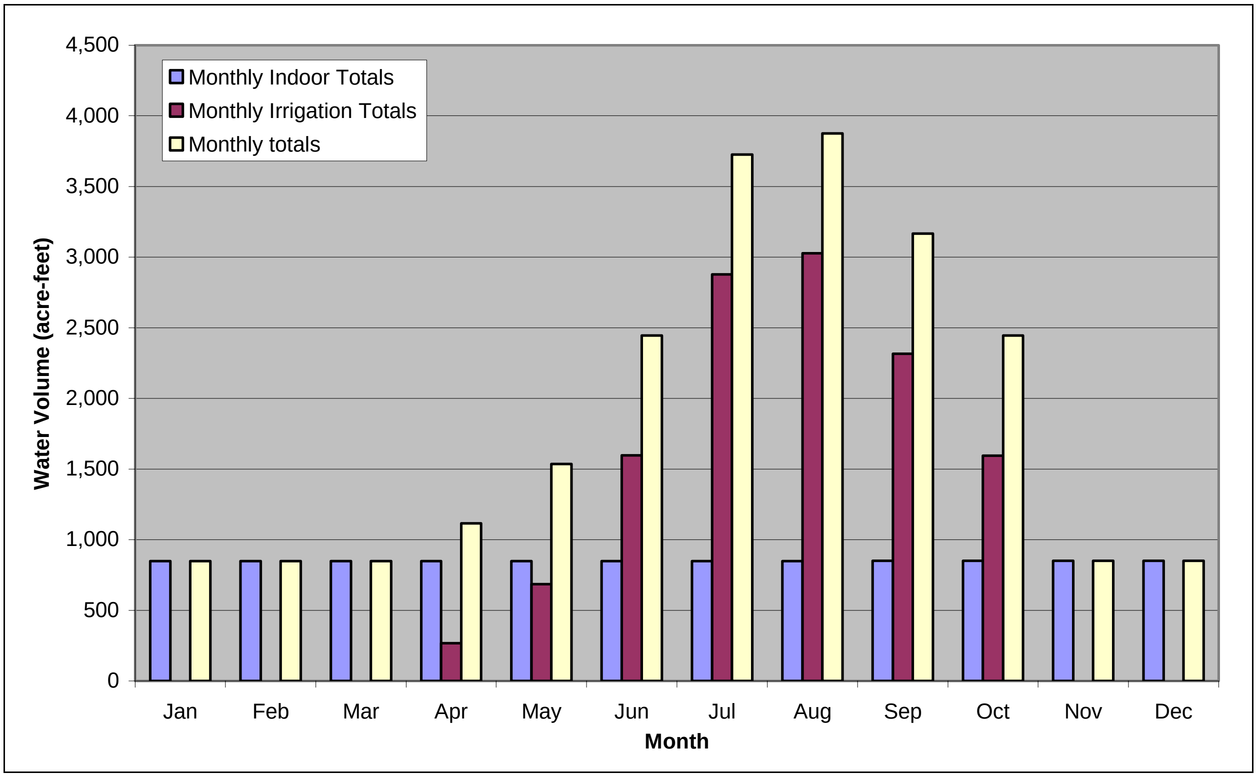


Figure 3-7. Community Group A Water Systems Estimated Consumptive Use

Airway Heights and Fairchild Air Force Base both have interties with the City of Spokane to provide water to their jurisdictions. Airway Heights has one intertie, which is used intermittently. In 1999 Airway Heights used 467 acre-feet of water from its intertie; in 2002, the intertie provided 138 acre-feet of water; and in 2003 the intertie provided 86 acre-feet. Fairchild Air Force Base has one intertie constructed in 2002, which provides water intermittently as required. The intertie provided 2.2 acre-feet in May 2002, 0.2 acre-feet in August 2003, 545 acre-feet over nine months in 2004 and 0.5 acre-feet in May 2005. Detailed data are available in Appendix E.

Group A Non-Community Water Systems

Monthly data were collected for each of the non-community Group A water systems. Figure 3-8 illustrates the water use within the non-community Group A purveyors. The total annual non-community Group A water use is approximately 398 acre-feet. About 83 percent of that water is used seasonally for irrigation or outdoor uses. The remainder is used for indoor uses, which tend to increase beginning in April and decrease again beginning in August. This is due to seasonal indoor use at small resorts or campgrounds. Detailed data are available in Appendix E.

Group B Water Systems

Group B systems are public water systems which meet the following requirements:

- Serve less than 15 residential services regardless of the number of people.
- Service, on average, less than 25 non-residents per day for 60 or more days within one calendar year.
- Service any number of people for less than 60 days within a calendar year.

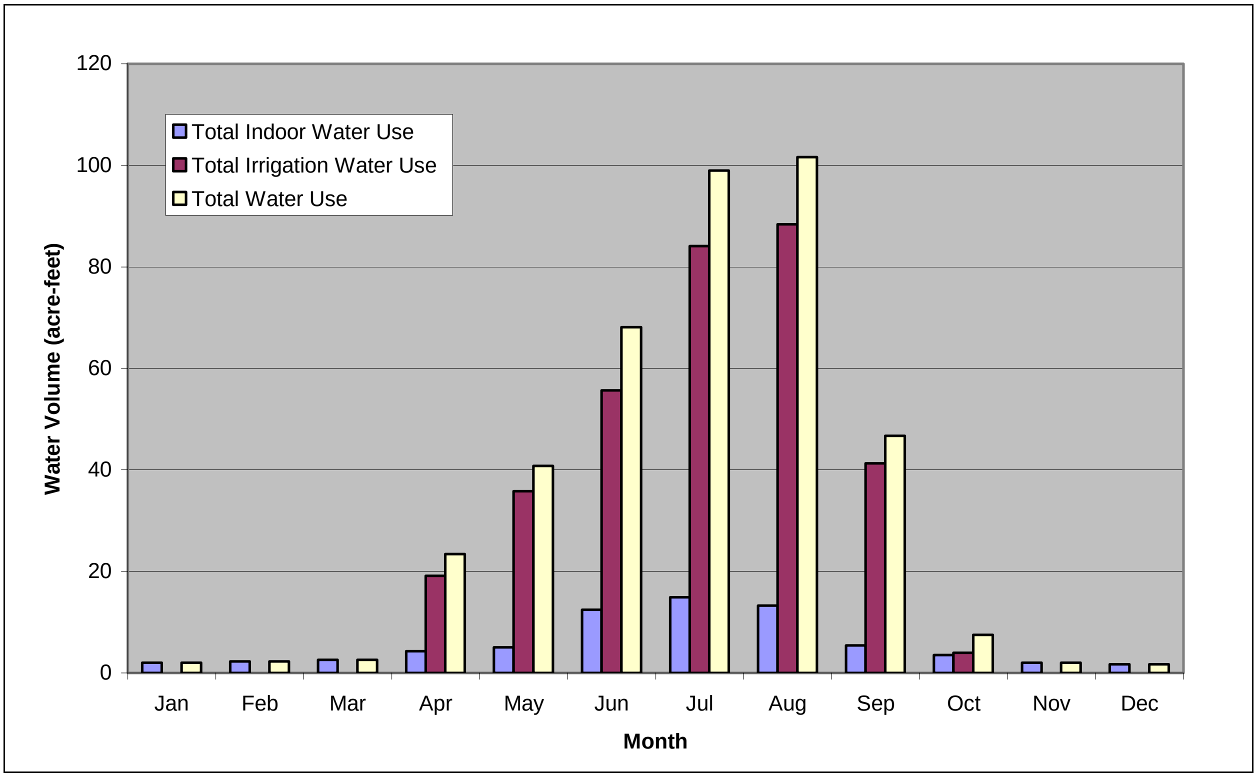


Figure 3-8. Non-Community Group A Water Systems Estimated Consumptive Use

These systems are not regulated by the SDWA but are regulated by the State of Washington and county health departments under the WAC Title 246 Chapter 246-291 Group B Public Water Systems. There are approximately 12,477 Group B systems located in the State of Washington (DOH, 2001) and approximately 100 in WRIA 54.

Most of the Group B systems in WRIA 54 are classified as community systems, and many may be using permit-exempt wells as a water source. Water service area boundaries are not provided for most of these systems.

Thirteen of the Group B systems in WRIA 54 are non-community, or industrial users. The following information about the largest of these users was available:

- The Ford Fish Hatchery provided water use data broken down into indoor use, outdoor use and use for fish rearing. The indoor and outdoor data are included with those of the other Group B users, but the fish rearing data represent an additional type of use that is nonconsumptive.
- Empire Cold Storage, which uses a large amount of water for making ice, provided only total water use data; these data were treated as an additional use and were not included in the evaluation of total Group B indoor and outdoor use.
- Nine Mile Falls Hydroelectric Dam provided monthly water use data for indoor use, outdoor use and use for bearing cleaning. The indoor and outdoor data are included with those of the other Group B users, but the bearing cleaning data represent an additional type of use.

These additional consumptive uses—ice making and bearing cleaning—total 8.3 acre-feet per year, which is 27 percent of the total consumptive Group B use in WRIA 54. The fish hatchery uses 5,714 acre-feet annually, although this is a nonconsumptive water use and was not included in the calculations.

The remaining 31.1 acre-feet of estimated Group B water use is broken down into indoor and outdoor use by month, as shown in Figure 3-9. Total annual outdoor use is about 28 acre-feet, and total annual indoor use is about 3.1 acre-feet per year.

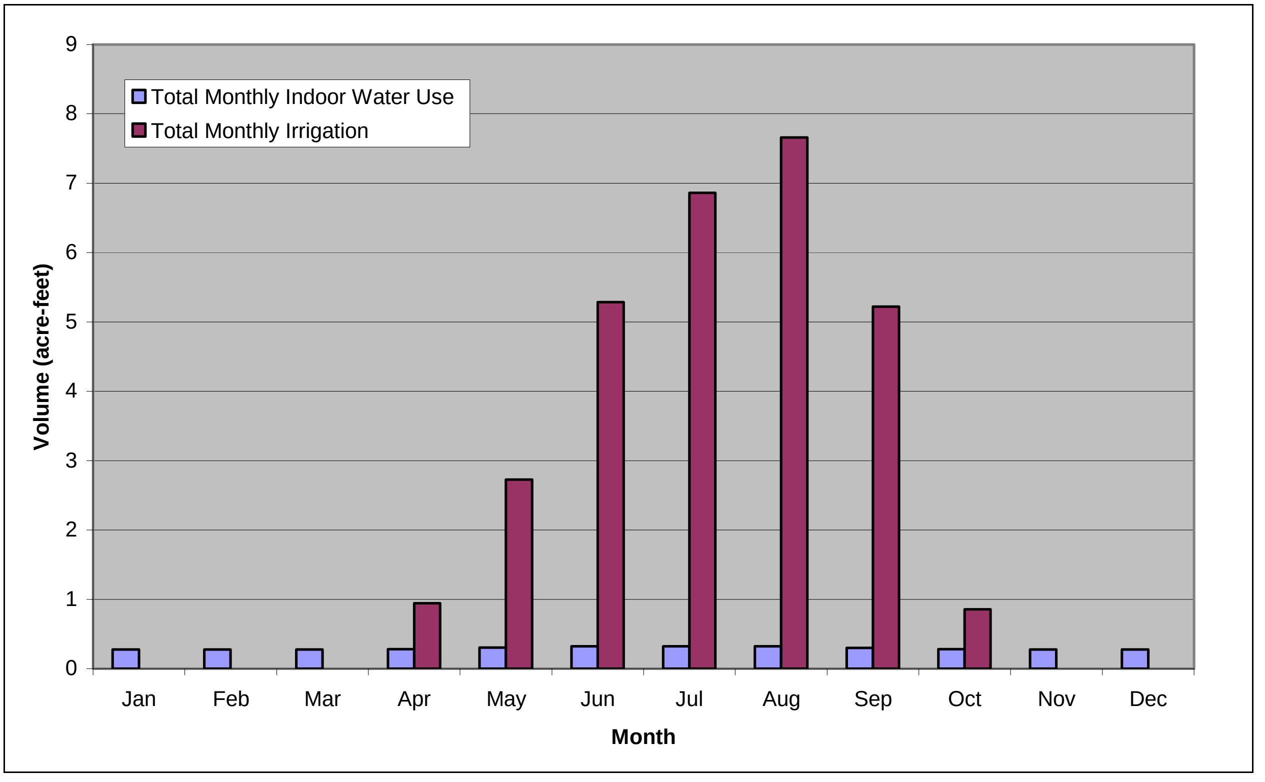


Figure 3-9. Group B Indoor and Outdoor Water Use Estimate

Agricultural Water Users

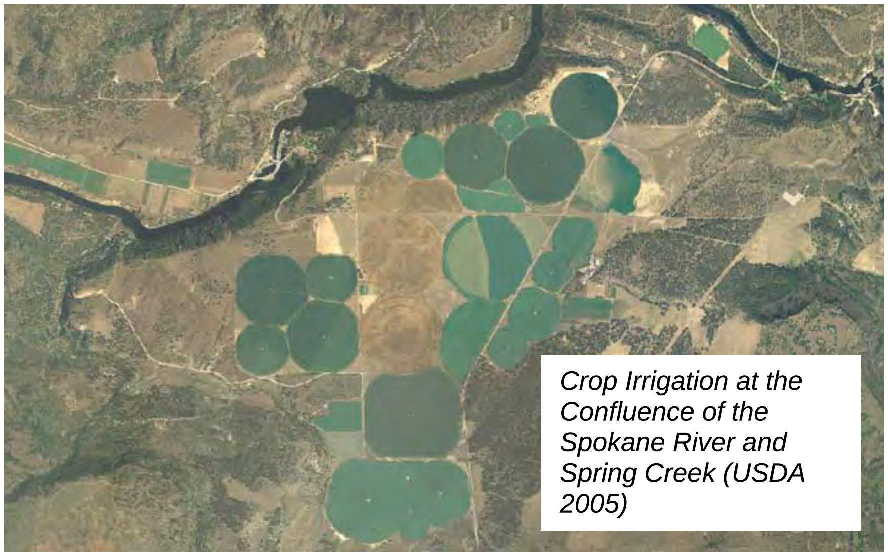
WRIA 54 currently is approximately 25 percent agricultural land use, which equals about 218,000 acres. Few water use data exist for agricultural water users, so water use estimates were extrapolated from previously recorded or observed rates of water application. Agricultural water use is divided into two primary activities: crop irrigation and livestock watering.

Crop Irrigation

Land use data for 1992 collected by the USGS identified approximately 200,000 acres of cropland within the watershed. Most of this area is dry land farming, which does not require irrigation. The 2002 Agricultural Census (USDA 2006) identifies 87,945 irrigated acres of agricultural land in Lincoln, Spokane, and Stevens Counties. About 8,205 irrigated acres are within WRIA 54; this was determined by multiplying the total irrigated acres in each county by the percentage of the county within WRIA 54, as shown in Table 3-6.

TABLE 3-6.
IRRIGATED AGRICULTURAL AREA

	Lincoln	Spokane	Stevens	**Total**
Total County Irrigated Area (acres)	55,544	14,466	17,935	**87,945**
Percent of County in WRIA 54	8.7	12.7	8.5	
Irrigated Area in WRIA 54 (acres)	4,847	1,835	1,523	**8,205**



Crop Irrigation at the Confluence of the Spokane River and Spring Creek (USDA 2005)

The volume of water used for irrigation was calculated by dividing the total area by the irrigation efficiency and multiplying it by the use for each crop in the WRIA. The result is an estimated 24,923 acre-feet of water consumed annually for crop production.

The data from the 2002 Agricultural Census likely do not include irrigated lands within the Spokane Reservation. The reservation rents most of its irrigated land to the Hutterian Brethren, one of the primary agriculturalists in WRIA 54. On the reservation the group irrigates approximately 1,000 acres, therefore using up to about 2,300 acre-feet annually.

The Hutterians have three additional active operations off the reservation where crops are irrigated for varying periods of time, with irrigation use ranging from 1.5 to 2.3 acre-feet per acre per year, depending on the growing season, soil type, and crop. The irrigation volume for these areas was derived from the agricultural census described above. The following information from the Hutterians provides a better understanding of the percentage of irrigation water that they use in WRIA 54 for operations off the reservation; detailed data are available in Appendix E:

- Little Falls Operation—Approximately 4,000 acre-feet annually
- Espinola Operation—Approximately 1,500 acre-feet annually
- West Plains Operation—Approximately 225 acre-feet annually

Livestock Watering

Cattle are the primary livestock in WRIA 54. Although other types of livestock are present, their populations are insignificant in terms of water use, with the exception of two horse farms.

According to the Washington State Department of Agriculture, there are 907 dairy cows in WRIA 54. A water use estimate of 65 gallons per day per animal is suggested by the Natural Resource Conservation Service and the Dairyman's Association. These assumptions produce a total volume of approximately 66 acre-feet of water use annually for dairy cattle watering.

Non-dairy cattle estimates were only available by county. To estimate the number of cattle in WRIA 54, the total number of cattle for each county was multiplied by the percentage of area of the county within the WRIA, as shown in Table 3-7. Water consumption estimates place non-dairy use at approximately 20 gallons per day per animal. Given this estimate, the total annual water consumption from non-dairy cattle is approximately 193 acre-feet.

TABLE 3-7.
NON-DIARY CATTLE POPULATION ESTIMATES

	Lincoln	Spokane	Stevens	**Total**
Total Number of Non-Dairy Cattle in County	25,500	25,500	37,000	**88,000**
Percent of County in WRIA 54	8.7	12.7	8.5	
Estimated Number of Non-Dairy Cattle in WRIA 54	2,219	3,239	3,145	**8,603**

Data provided for this assessment indicate that there are approximately 24 horses on two farms in WRIA 54. Water consumption is estimated at 14 gallons per day per horse, therefore annual estimates put water consumption at approximately 0.38 acre-feet. This accounts for less than 0.2 percent of the total livestock water use estimate, which is approximately 259 acre-feet per year. Non-dairy cattle make up about 75 percent of the total volume and dairy cattle consume the remaining 25 percent. Detailed data are available in Appendix E.

Other Consumptive Water Uses

Individual wells, which would have a permit-exempt right to water within WRIA 54, are not typically metered to track water usage. Water use from these wells was estimated to be the same as the estimated water right described previously in this chapter, or 5,792 acre-feet annually.

Water uses in WRIA 54 that would require a water right but do not fall under the Group A or B classification system or agricultural uses are associated primarily with seasonal irrigation of cemeteries. This use tends to occur only from April to October and consumes approximately 524 acre-feet annually.

Consumptive Use Summary

Figure 3-10 summarizes the estimated annual volume of water used for each category.

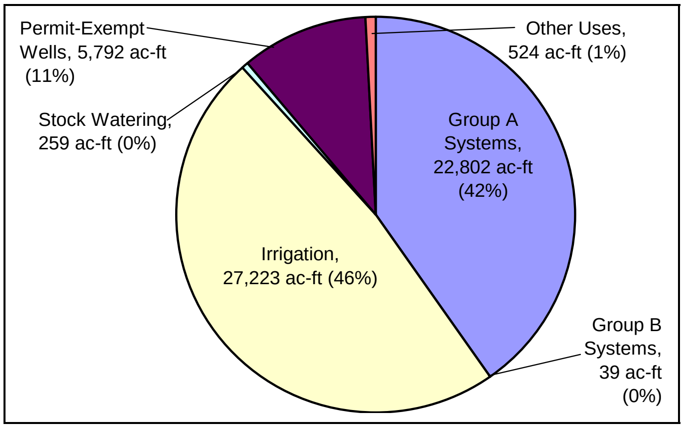


Figure 3-10. Estimated Annual Volume of Water Use in WRIA 54 by Category (acre-feet)

COMPARISON OF ESTIMATED USE TO ALLOCATED WATER RIGHTS

Water rights are often allocated at a higher rate of consumption than actual consumptive use. The water rights identified, documented and estimated in WRIA 54 total approximately 147,411 acre-feet per year as summarized in Table 3-8. The estimated consumptive use is approximately 56,639 acre-feet annually, as summarized in Table 3-9. Thus, approximately 62 percent of the water rights in WRIA 54 are not being used, based on the assumptions used in this analysis.

TABLE 3-8.
ESTIMATED TOTAL WATER RIGHTS ALLOCATED

Type of Water Right	Annual Volume Allocated (acre-feet)
Claims	37,739
Certificates	67,621
Permits	10,879
Quantified Federal/Tribe Reserved Rights	25,380
Permit-Exempt Water Rights	5,792
Total	**147,411**

TABLE 3-9.
ESTIMATED TOTAL CONSUMPTIVE WATER USE

Type of Consumptive Use	Annual Volume Used (acre-feet)
Group A Community Systems	22,404
Group A Non-Community Systems	398
Group B Systems (Indoor and Outdoor Uses)	31
Group B Systems (Additional Uses)	8
Crop Irrigation	27,223
Livestock Watering	259
Permit-Exempt Water Users	5,792
Other Consumptive Water Uses	524
Total	**56,639**

Among the WRIA 54 subbasins, the Airway Subbasin has the highest estimated annual allocation of water rights as well as the highest estimated annual water use, as shown in Table 3-10. The subbasins with the highest estimated allocations after Airway are Camas Valley, Ford, Deep Creek and Long Lake South. Three of the basins have estimated current water use that exceeds the annual allocation estimated in this analysis.

TABLE 3-10.
DISTRIBUTION OF WATER RIGHTS ALLOCATIONS AND WATER USE BY SUBBASIN

	Estimated Annual Volume Allocation (acre-feet)				Estimated Annual Use	
Subbasin	Claims	Permits/Certificates (Including Quantified Federal Reserved Rights)	Exempt	**Total**	Volume (acre-feet)	% of Estimated Allocation
Airway	7,898	36,359	774	**45,031**	22,242	49%
Camas Valley	8,982	13,423[a]	467	**22,872**	1,872	8%
Coulee	3,421	768	581	**4,770**	3,060	64%
Deep Creek	2,848	14,797	884	**18,529**	5,421	29%
Ford	3,862	14,583[a]	908	**19,353**	3,654	19%
Harker Canyon	881	860	154	**1,895**	3,613	191%
Little Chamokane	111	114	407	**632**	3,214	500%
Long Lake N	3,310	3,635	492	**7,437**	3,262	44%
Long Lake S.	1,817	15,763	350	**17,930**	2,633	15%
Orazada	280	208	250	**738**	680	92%
Pitney	700	1,534	114	**2,348**	2,477	105%
Sand Blue	219	1,216	209	**1,644**	621	38%
Spring Creek	3,409	620	202	**4,231**	3,883	92%
Total	**37,739**	**103,880**	**5,792**	**147,411**	**56,632**[b]	**38%**

a. Includes 12,690 acre-feet per year federal reserved right for irrigation owned by the Spokane Tribe. For estimating purposes, this right has been distributed equally between the Ford and Camas Valley subbasins.
b. Total use estimate differs from the total shown in Table 3-9 due to rounding differences.

The Cities of Spokane, Medical Lake and Reardan (which lies outside WRIA 54 but draws water from sources inside the WRIA) have their water supply wells and service areas split between multiple WRIAs, making it difficult to accurately determine water use in WRIA 54 for these systems. Medical Lake and Reardan both pump primarily from wells located in WRIA 54, but most of the water is used in WRIA 43 to the south. For these communities, the water use estimates are based on quantity pumped from these wells. The City of Spokane situation is much more complex; actual metered water use for customers in WRIA 54 was used to estimate water use from the City of Spokane water system.

CHAPTER 4.
WATER BALANCE

WATER BALANCE METHODOLOGY

A water balance is an inventory of water moving through a hydrologic system. Water balances vary widely in size and complexity, depending on the availability of data and the objectives of the analysis. They range from simple accountings of surface water transport across specific sites to watershed-scale simulations of hydrologic systems.

The purpose of the water balance for this Technical Assessment is to characterize water quantities associated with climate, surface water, groundwater, and net consumptive demand in WRIA 54. The water balance was designed to be appropriate for the available data and included the following estimates:

- Average monthly and annual precipitation and temperature
- Average monthly and annual evapotranspiration (the combined loss of water to evaporation and uptake by plants)
- Average monthly and annual stream flow entering and exiting the watershed
- Average annual groundwater flow entering and exiting the watershed
- Annual domestic and non-domestic net demand.

The water balance estimates the quantity of water entering and exiting WRIA 54 through various pathways. Components of the water balance were evaluated using monthly averages when available data allowed, and the monthly averages were totaled to estimate annual averages. The overall water balance is presented on an annual basis.

For a water balance analysis, basins are grouped into two categories: those that contain the headwaters of the primary drainage and those that do not. Precipitation is the main hydrologic input for basins that contain the primary drainage headwaters. The headwaters of the Spokane River, the primary drainage in WRIA 54, are not located within the WRIA, so inflow to the system contains significant surface water and groundwater components in addition to precipitation. A minor amount of water also is imported into the watershed via potable water and wastewater systems. The quantity of water entering WRIA 54, therefore, can be represented by the following:

Total Basin Inputs = SWI + GWI + PPT + IW

where:

SWI = Surface Water Inflow;

GWI = Groundwater Inflow; and

PPT = Precipitation;

IW = Imported Water

The quantity of water exiting the watershed was assumed to consist of the following components:

Total Basin Outputs = ET + ND + GWO + SWO

where:

ET = Evapotranspiration

ND = Net Demand (which consists of gross demand minus return flow)

GWO = Groundwater Outflow

SWO = Surface Water Outflow

In a basin where there is no change in storage over the time period of the analysis, total basin inputs equal total basin outputs.

WATER BALANCE COMPONENTS

Precipitation

Annual precipitation rates for the watershed were calculated from the precipitation distribution presented in Figure 4-1. The precipitation distribution is based on PRISM (Daly and Taylor, 1998), a statistical topographic model for mapping precipitation in mountainous terrain. PRISM incorporates available data from climate stations within and adjacent to the watershed.

The precipitation distribution was imported into a GIS to derive the average monthly and annual volume of precipitation for the WRIA 54 watershed. Average monthly precipitation volume estimates ranged from approximately 45,000 acre-feet (one acre foot is one foot of water over one acre) in November to 12,000 acre-feet in August. The annual volume was estimated to be 334,000 acre-feet. The results of the analysis are presented in Table 4-1.

TABLE 4-1.
MONTHLY AND ANNUAL PRECIPITATION INFLOW TO WRIA 54

Month	Average Precipitation Volume (acre-feet)
January	33,129
February	32,090
March	31,814
April	24,304
May	31,311
June	26,026
July	17,271
August	11,861
September	15,511
October	21,574
November	45,287
December	43,794
Annual Total	**333,972**

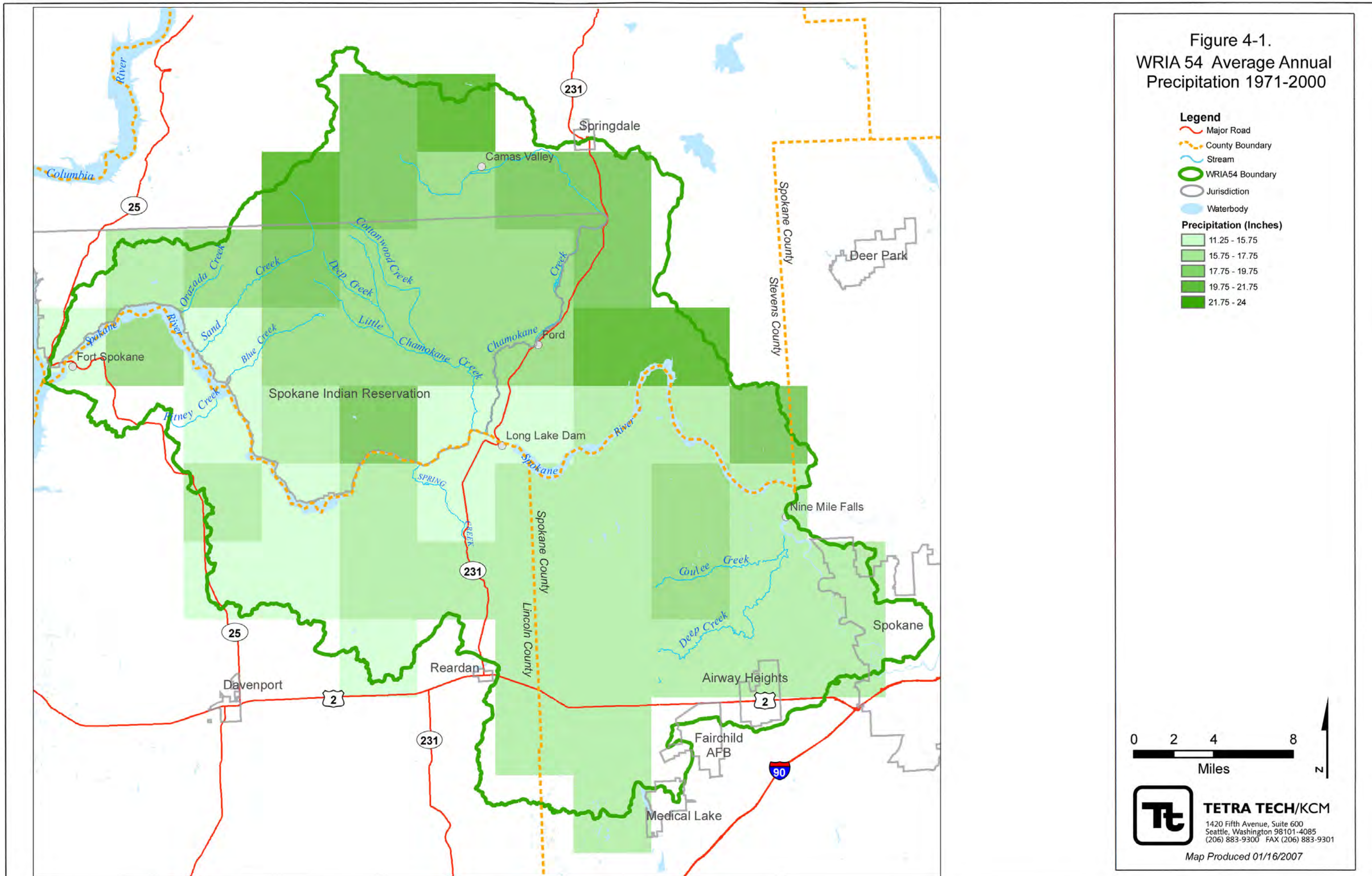


Figure 4-1.
WRIA 54 Average Annual Precipitation 1971-2000

Evapotranspiration

Land-Based

Land-based evapotranspiration for WRIA 54, the amount of water returned to the atmosphere from plants and soils through evaporation and vegetation transpiration for various land uses, was calculated using the Penman-Monteith energy balance model (Monteith, 1965). The Penman-Monteith method is based on a combination energy-mass balance equation that uses the difference between incoming and outgoing energy to estimate potential evapotranspiration. The equation uses standard meteorological data such as solar radiation, humidity, and wind speed. When detailed data were unavailable, representative average values for these parameters were used, or values were estimated from maximum and minimum monthly temperatures. Temperature data for WRIA 54 were obtained from PRISM (Daly and Taylor, 1998). The temperature distribution was imported into a GIS to derive maximum and minimum monthly temperatures for the watershed. The distributions of maximum and minimum monthly air temperature within WRIA 54 watershed are presented in Figures 4-2 and 4-3, respectively.

Designed for agricultural evapotranspiration estimates, the Penman-Monteith model initially estimates evapotranspiration for a reference crop (in this case, a uniform grass crop). Evapotranspiration is then estimated for specific crops based on plant-specific coefficients obtained from Allen and others (1998). The acreage associated with various crop types in WRIA 54 was calculated using agricultural census data for Spokane, Stevens, and Lincoln Counties, adjusted for the percentage of the counties located within WRIA 54. Evapotranspiration was estimated for 50 crop types including wheat, forage, barley, alfalfa hay, Kentucky blue grass seed, oats, canola, potatoes, and apples.

Land areas associated with non-agricultural land uses were estimated from the GIS distribution presented in Figure 2-15. Land uses included the following categories: Barren, commercial/industrial/transportation, forest, high-intensity residential, low-intensity residential, open land, open water, and wetland. Plant-specific coefficients for evapotranspiration estimates were chosen based on estimated land use. Barren-land evapotranspiration was estimated using coefficients for bare soil. Forest land was assumed to be uniformly covered with conifer trees and a corresponding conifer crop coefficient was used. Low-intensity residential land was assumed to be covered with turf. Evapotranspiration for open land was estimated using crop coefficients for range grasses. Coefficients for a reed swamp with moist soil were used to estimate wetland evapotranspiration. Commercial/industrial/transportation and high-intensity residential areas were assumed to be largely covered with impermeable, unvegetated surfaces and were not included in the evapotranspiration estimate. Open water surface evapotranspiration was estimated using pan evaporation data (see discussion below).

The use of plant-specific coefficients designed for agriculture to estimate evapotranspiration leads to an overestimate of evapotranspiration because it assumes a uniform, dense plant coverage for non-agricultural land uses. However, a better evapotranspiration estimate for non-agricultural lands would require more detailed land use data than were available for this study and more representative plant specific coefficients.

Average monthly evapotranspiration volume estimates for the entire WRIA ranged from approximately 760 acre-feet during December to 182,000 acre-feet in July. The annual volume was estimated to be approximately 881,000 acre-feet. Detailed estimates of land-based evapotranspiration for each land use evaluated are provided in Appendix F.

Surface Water Evaporation

Evaporation from surface waters is estimated based on the area of surface water in the study area and pan evaporation averages recorded at local climate stations. The total area of surface water in WRIA 54 was estimated to be 13,548 acres, using the project GIS. Monthly pan evaporation averages collected at the Spokane WSO (Weather Services Office) Airport climate station (Station No. 457938) were applied to this total area. This station has a period of record from 1889 to 2005. A standard correction factor of 0.75 was applied to the recorded monthly pan evaporation averages, based on recommendations from the Western Regional Climate Center and regional data presented in Schultz (1973). The resulting monthly surface water evaporation estimates range from zero in winter months to about 9,550 acre-feet in July. Annual surface water evaporation volume is estimated to be 41,000 acre-feet. Detailed surface water evaporation calculations are included in Appendix F.

Irrigation Evaporation Loss

The annual irrigation volume in WRIA 54 was estimated using area-weighted Agricultural Census Data for Lincoln, Spokane, and Stevens Counties and applying crop irrigation requirements to each crop type and associated acreages. This analysis yielded an irrigation volume of approximately 25,000 acre-feet per year (see Appendix F). Based on Washington Department of Ecology Water Resources Program Guidance GUID-1210, evaporation losses associated with agricultural irrigation systems (spray loss) range from 2 to 10 percent. Assuming a spray loss of 5 percent, a total of approximately 1,250 acre-feet of agricultural irrigation water is lost to evaporation each year in WRIA 54. It was assumed that this volume would be evenly distributed in each month when irrigation is applied (April through October).

Total Evapotranspiration

Table 4-2 summarizes the monthly and annual evapotranspiration loss from land-based uses, surface water and irrigation.

TABLE 4-2.
MONTHLY AND ANNUAL EVAPOTRANSPIRATION IN WRIA 54

	Average Evapotranspiration (acre-feet)			
Month	Land-Based	Surface Water	Irrigation	**Total**
January	955	0	0	**955**
February	1,671	0	0	**1,671**
March	43,676	0	0	**43,676**
April	74,305	3,946	179	**78,430**
May	142,245	6,156	179	**148,580**
June	167,862	7,257	179	**175,298**
July	182,054	9,551	179	**191,784**
August	128,501	8,654	179	**137,334**
September	82,693	5,428	179	**88,300**
October	40,797	0	179	**40,976**
November	15,447	0	0	**15,447**
December	764	0	0	**764**
Annual Total	**880,971**	**40,991**	**1,250**	**923,212**

Surface Water

Surface water inflow and outflow from WRIA 54 was estimated by analysis of stream flow data from available stream gauges and dam sites.

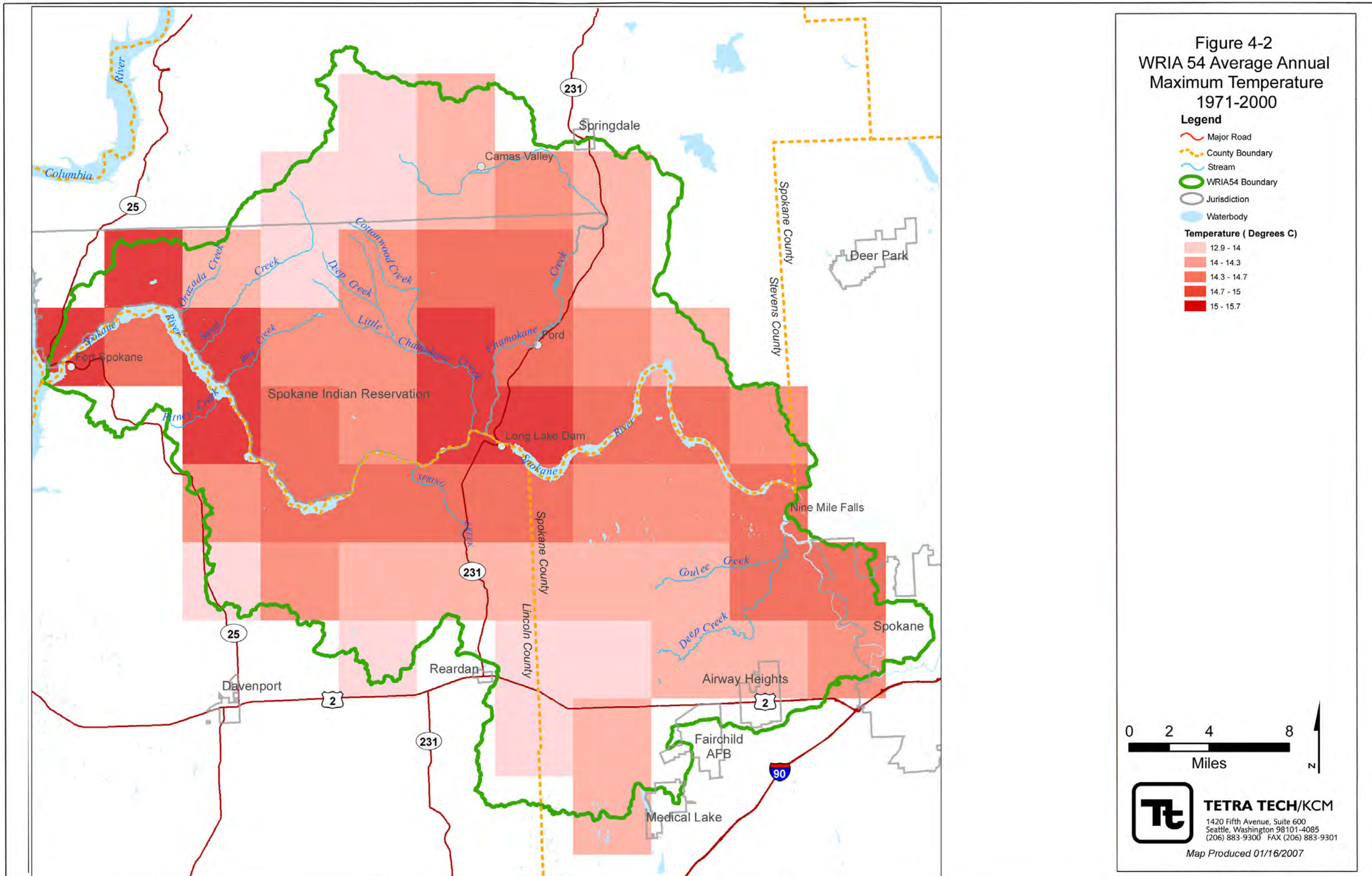


Figure 4-2
WRIA 54 Average Annual Maximum Temperature 1971-2000

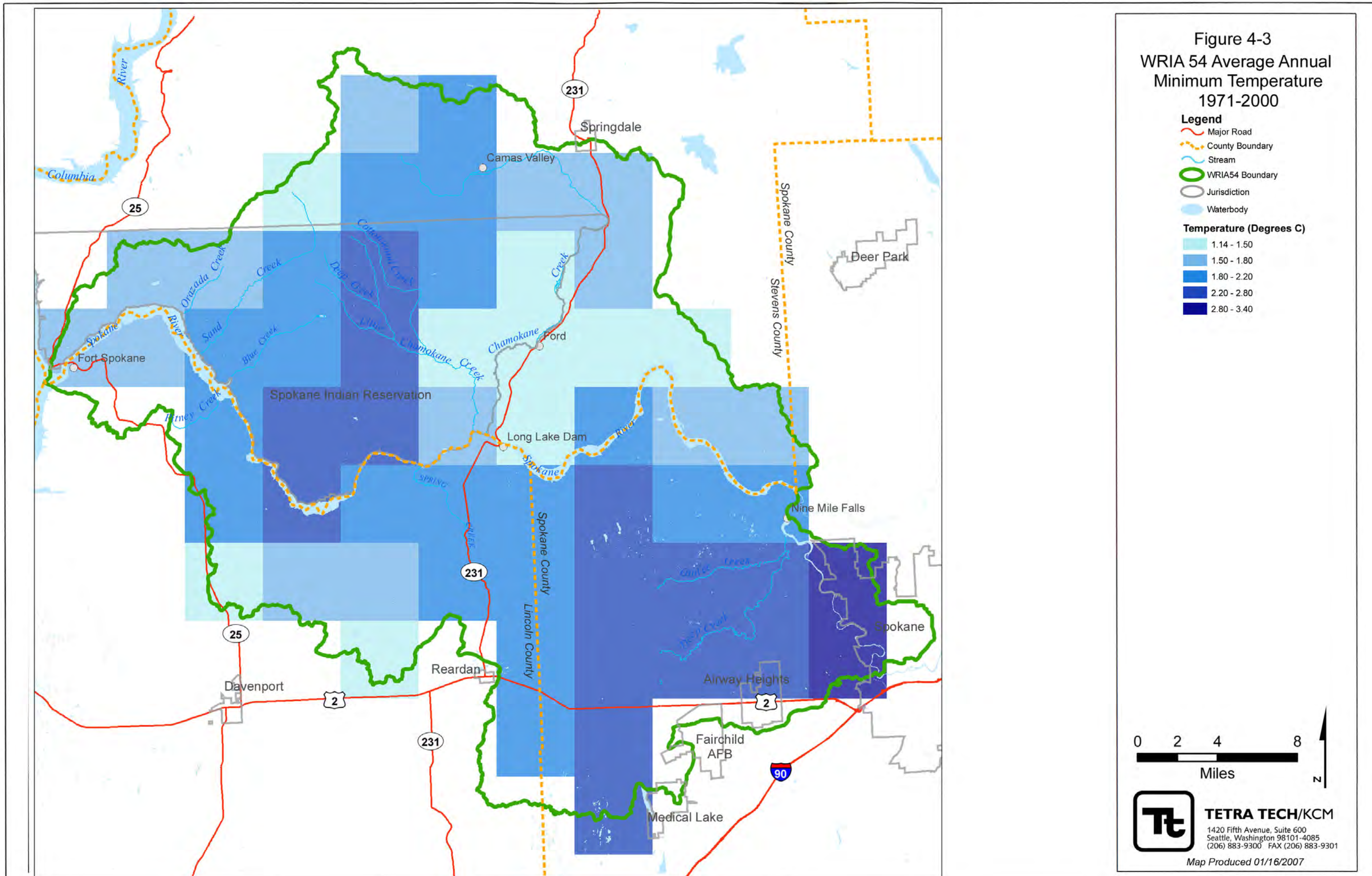


Figure 4-3
WRIA 54 Average Annual Minimum Temperature 1971-2000

Surface Water Inflow

Stream flow enters WRIA 54 in streams that do not originate in the WRIA. This includes the Spokane River, Latah (Hangman) Creek, and the Little Spokane River. Data from the following stream gauges were used to estimate surface water inflow, based on gauge location and sufficient period of record:

- Spokane River at Spokane, U.S. Geological Survey (USGS) Gage No. 12422500
- Latah (Hangman) Creek near Spokane River Confluence, USGS Gage No. 12424000
- Little Spokane River at Dartford, USGS Gage No. 12431000.

These measurement locations provide the best available data for surface water inflow, but they do not account for the impact of groundwater/surface water interaction between the stream gauges and the watershed boundaries. The stream flow volume entering the watershed ideally should be measured at the watershed boundaries. Drost and Seitz (1978) estimated an average inflow of 310 cubic feet per second (cfs) from the Spokane Valley/Rathdrum Prairie (SVRP) aquifer to the Little Spokane River between Dartford and the confluence with the Spokane River. This value was added to the data from the Little Spokane at Dartford gauge. Although the Little Spokane near Dartford gage is closer to the confluence of the Little Spokane River with the Spokane River than the Little Spokane at Dartford gage, flow data from the Little Spokane at Dartford gage were used due to its longer and more continuous record.

Average monthly stream flow was estimated based on historical stream flow data from these three gauges as modified to account for the contribution from the SVRP aquifer. Average monthly surface water inflow volume estimates ranged from 138,000 acre-feet in September to 1,161,000 acre-feet in May, with a total annual average of 5,503,000 acre-feet. Table 4-3 summarizes the results of the surface water inflow analysis.

TABLE 4-3.
MONTHLY AND ANNUAL SURFACE WATER INFLOW TO WRIA 54

	Average Surface Water Inflow (acre-feet)			
Month	Spokane River	Little Spokane River	Latah (Hangman) Creek	**Total**
January	336,768	36,770	17,708	**391,246**
February	350,218	39,987	22,770	**412,975**
March	511,454	55,031	35,970	**602,455**
April	841,924	55,755	37,309	**934,988**
May	1,090,790	44,640	25,579	**1,161,009**
June	652,165	33,977	15,531	**701,673**
July	208,320	29,207	10,145	**247,672**
August	107,050	27,178	8,116	**142,344**
September	103,180	26,598	8,152	**137,930**
October	132,506	28,653	9,592	**170,751**
November	194,579	29,752	11,306	**235,637**
December	315,739	33,757	14,696	**364,192**
Annual Total	**4,844,692**	**441,304**	**216,875**	**5,502,871**

Surface Water Outflow

The volume of stream flow exiting WRIA 54 should ideally be measured at the confluence of the Spokane and Columbia Rivers; but the backwater associated with Grand Coulee Dam precludes measurement at this location. The furthest downstream location where stream flow data with a significant period of record are available is at Little Falls Dam, about 30 river miles upstream from the confluence. Though this measurement location provides the best estimate for surface water outflow available with the current data set, its records do not account for contributions from groundwater/surface water interaction downstream of Little Falls Dam or tributaries that intersect the Spokane River downstream of Little Falls Dam which have not been monitored for stream flow. Of the tributaries that are located downstream of Little Falls Dam, only Blue, Sand, and Orazada Creeks had available stream flow data.

Average monthly stream flows were estimated for the Spokane River at Little Falls Dam and Blue Creek, Orazada Creek and Sand Creek based on historical stream flow data. Average monthly surface water outflow volume estimates ranged from 114,000 acre-feet in August to 932,000 acre-feet in April, with a total annual average of 5,280,000 acre-feet. Table 4-4 summarizes the results of the surface water outflow analysis.

TABLE 4-4.
MONTHLY AND ANNUAL SURFACE WATER OUTFLOW FROM WRIA 54

	Average Surface Water Outflow (acre-feet)		
Month	Spokane River at Little Falls Dam	Blue, Orazada, and Sand Creeks	**Total**
January	419,309	224	**419,533**
February	529,280	351	**529,631**
March	674,396	883	**675,279**
April	932,000	483	**932,483**
May	899,833	193	**900,026**
June	549,192	106	**549,298**
July	197,553	58	**197,611**
August	114,206	25	**114,231**
September	136,275	27	**136,302**
October	182,853	44	**182,897**
November	245,493	53	**245,546**
December	397,578	65	**397,643**
Annual Total	**5,277,968**	**2,512**	**5,280,480**

Groundwater

The boundaries of WRIA 54 are based primarily on surface topography and political considerations. They generally do not conform to the boundaries of aquifers that are partially or fully contained within the watershed. Therefore, groundwater flows across WRIA 54 boundaries based on local and regional hydraulic conditions. This analysis of groundwater inflow and outflow conditions incorporates flow through unconsolidated aquifers, such as the SVRP aquifer, and Columbia River Basalt Group (CRBG) aquifers, such as the Wanapum and Grande Ronde Basalt Formation aquifers. Because basement rock aquifers characteristically are of low porosity and permeability, groundwater inflow and outflow through these hydrogeologic units were assumed to be negligible.

Groundwater Inflow

Groundwater inflow to WRIA 54 occurs primarily through the following aquifers and watershed boundaries (see Figure 2-6 for aquifer locations):

- The SVRP aquifer along the southeast boundary
- The Latah (Hangman) Creek alluvial aquifer along the southeast boundary
- The Wanapum Basalt Formation aquifer along the south boundary
- The Grande Ronde Basalt Formation aquifer along the south boundary
- The Chamokane Valley aquifer along the north boundary.

SVRP and Latah (Hangman) Creek Aquifer Inflow

Estimates of groundwater inflow from the SVRP aquifer and Latah (Hangman) Creek alluvial aquifer were adapted from analyses performed by Bolke and Vaccaro (1981) and Drost and Seitz (1978), respectively, and summarized by Kahle et al. (2005). Groundwater inflow to WRIA 54 from the SVRP aquifer was estimated to be about 76,000 acre-feet per year, equivalent to the groundwater underflow out of the SVRP aquifer along the west boundary of the steady-state groundwater flow model developed by Bolke and Vaccaro (1981). Groundwater inflow to WRIA 54 from the Latah (Hangman) Creek alluvial aquifer was estimated to be about 10,900 acre-feet per year. Daily inflows were calculated assuming that inflow is constant year-round, and monthly estimates were developed from the daily inflow values based on the number of days in each month.

Wanapum, Grande Ronde and Chamokane Valley Inflows

For the Wanapum Basalt Formation, Grande Ronde Basalt Formation, and Chamokane Valley aquifers, groundwater inflow to the basin was calculated using the Darcy Equation:

$$Q = KA(dh/dl)$$

where:

Q = Groundwater Flow

K = Hydraulic Conductivity

A = Cross-Sectional Aquifer Area

dh/dl = Hydraulic Gradient

Values for hydraulic conductivity and hydraulic gradient were estimated for each aquifer based on available data. Hydrogeologic cross-sections were constructed perpendicular to interpreted groundwater flow direction at each groundwater inflow location for the purpose of estimating cross-sectional aquifer area. The equation gives daily flow rates, and monthly and annual estimates were developed assuming that the daily rate is constant year-round. Groundwater inflows were estimated to be about 8,200, 6,300, and 29,000 acre-feet per year from the Wanapum Basalt Formation, Grande Ronde Basalt Formation, and Chamokane Valley aquifers, respectively. Analytical inputs and detailed results of the analysis are provided in Appendix F.

Total Groundwater Inflows

Total groundwater inflow to WRIA 54 is estimated to be about 130,000 acre-feet per year. Table 4-5 summarizes the estimated groundwater inflows.

TABLE 4-5.
MONTHLY AND ANNUAL GROUNDWATER INFLOW TO WRIA 54

	Average Groundwater Inflow (acre-feet)				
Month	SVRP Aquifer	Latah (Hangman) Creek Alluvial Aquifer	Wanapum & Grande Ronde Basalt Formations	Chamokane Valley Aquifer	**Total**
January	6,456	922	1,235	2,456	**11,069**
February	5,831	833	1,116	2,218	**9,998**
March	6,456	922	1,235	2,456	**11,069**
April	6,248	893	1,195	2,377	**10,713**
May	6,456	922	1,235	2,456	**11,069**
June	6,248	893	1,195	2,377	**10,713**
July	6,456	922	1,235	2,456	**11,069**
August	6,456	922	1,235	2,456	**11,069**
September	6,248	893	1,195	2,377	**10,713**
October	6,456	922	1,235	2,456	**11,069**
November	6,248	893	1,195	2,377	**10,713**
December	6,456	922	1,235	2,456	**11,069**
Annual Total	**76,017**	**10,860**	**14,543**	**28,920**	**130,340**

Groundwater Outflow

For this water balance, it was assumed that groundwater outflow from WRIA 54 occurs primarily within the alluvial and CRBG aquifers near the Spokane River mouth and the downstream (west) boundary of the watershed. Groundwater outflow from the basin was calculated using the Darcy Equation, as described above. Analytical inputs and detailed results are provided in Appendix F. Groundwater outflows were estimated to be about 5,000 and 11,000 acre-feet per year from the basalt and sediment aquifers, respectively. Table 4-6 summarizes the results.

Imported Water

Imported water is water originating outside a watershed that is discharged or conveyed into the watershed. Water imported to WRIA 54 consists of two components:

- **City of Spokane wastewater from outside WRIA 54**—The City of Spokane sewer system conveys sewage collected within its sewer service area to the city's Wastewater Treatment Plant, which discharges into the Spokane River near Riverside State Park. Average monthly discharge was approximated from historical daily influent inflow data from the treatment plant. Figure 4-4 shows the recorded average, maximum, and minimum daily wastewater influent to the facility from January 1984 through December 2005.

**TABLE 4-6.
MONTHLY AND ANNUAL GROUNDWATER OUTFLOW FROM WRIA 54**

	Average Groundwater Outflow (acre-feet)		
	Basalt Aquifers	Alluvial Aquifers	**Total**
January	418	934	**1,352**
February	378	844	**1,222**
March	418	934	**1,352**
April	405	904	**1,309**
May	418	934	**1,352**
June	405	904	**1,309**
July	418	934	**1,352**
August	418	934	**1,352**
September	405	904	**1,309**
October	418	934	**1,352**
November	405	904	**1,309**
December	418	934	**1,352**
Average Annual	**4,922**	**11,000**	**15,922**

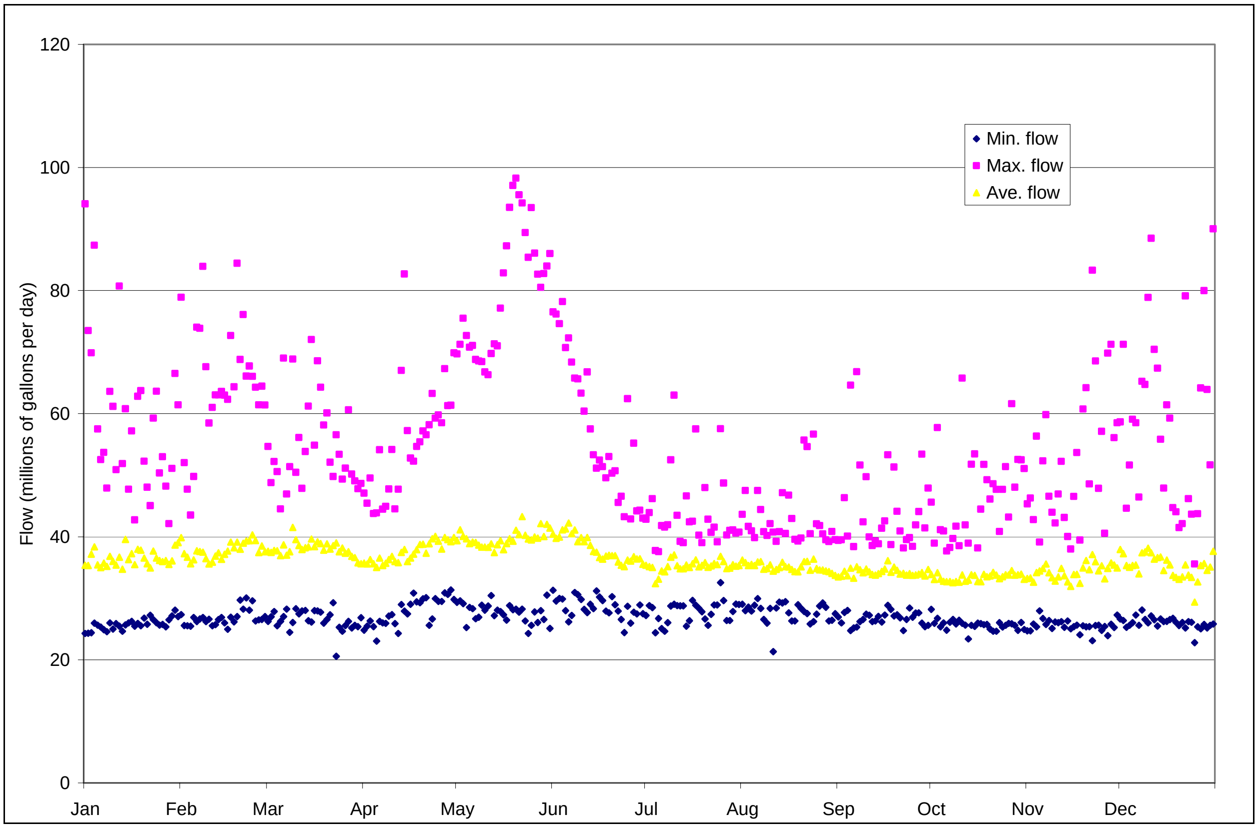


Figure 4-4. Primary Influent Flow to Wastewater Treatment Plant

The use of influent flow data is appropriate for this analysis because influent flows are monitored with greater precision than effluent flows; the retention time of water at the facility is less than one day; and the volume of solids removed during treatment is a small fraction of the total volume of influent wastewater. The City of Spokane sewer system serves a portion of WRIA 54, but no data were readily available to remove inflow from this area from the total inflow. Average monthly influent inflows ranged from about 3,800 acre-feet in May to 3,200 acre-feet in September, with an annual average of about 41,000 acre-feet.

- **Drinking water imported to Airway Heights and the Fairchild Air Force Base through interties with the City of Spokane municipal water system**—Chapter 3 cites water quantities for years in which Airway Heights and Fairchild Air Force Base interties were used to import Spokane municipal water. A monthly average for Airway Heights was estimated based on the three years of data presented. Fairchild Air Force Base imports Spokane municipal water only on rare emergency occasions, so a nominal monthly use of 0.06 acre-feet was used for this analysis.

Table 4-7 summarizes the estimated monthly and annual inflows from imported water.

TABLE 4-7.
MONTHLY AND ANNUAL INFLOW OF IMPORTED WATER TO WRIA 54

	Average Inflow of Imported Water (acre-feet)			
Month	City of Spokane Wastewater	Airway Heights Drinking Water	Fairchild Air Force Base Drinking Water	**Total**
January	3,470	19	0.06	**3,489**
February	3,245	19	0.06	**3,264**
March	3,618	19	0.06	**3,637**
April	3,447	19	0.06	**3,466**
May	3,777	19	0.06	**3,796**
June	3,508	19	0.06	**3,527**
July	3,352	19	0.06	**3,371**
August	3,337	19	0.06	**3,356**
September	3,152	19	0.06	**3,171**
October	3,178	19	0.06	**3,197**
November	3,155	19	0.06	**3,175**
December	3,*356*	19	0.06	**3,375**
Annual Total	**40,595**	**228**	**1**	**40,824**

Net Demand

Net demand is the difference between water removed from the basin for domestic, commercial and industrial uses and the water returned to the basin after it has been used. Net demand was estimated based on population information and data from the WRATS database (see Chapter 3). Water withdrawn for agricultural irrigation was not included in the net demand calculation because it is accounted for in the evapotranspiration component of the water balance.

Exempt Domestic Uses

Domestic annual water withdrawal was calculated by estimating the domestic exempt population, assuming 2.5 people per ERU (equivalent residential unit or one average household), and assuming a demand of 1.6 acre-feet/year per ERU (see Chapter 3 for a discussion of population and demand assumptions). Annual return flow was assumed to be 0.22 acre-feet per year per ERU, or 14 percent of the total demand, as recommended by the Washington Department of Health (USGS, 2003). The total domestic exempt net demand was estimated to be about 5,000 acre-feet; detailed calculations are included in Appendix F. The average monthly exempt domestic net demand was estimated by multiplying the total annual exempt net demand by the monthly fraction of total annual net demand for the City of Spokane.

Stock Watering

In Chapter 3 stock watering was estimated at 259 acre-feet/year. Assuming that demand is constant throughout the year, the monthly average net demand for stock watering is 22 acre-feet. A return flow from stock watering to the basin was not estimated.

Group A and B Systems

Net demand for Group A and Group B water systems in WRIA 54 was estimated from the total demand estimates developed in Chapter 3 by applying the following assumptions:

- For indoor water use, the ratio of return flow to total demand was assumed to be the same as for exempt domestic uses (14 percent) because Group A and B indoor water is used for similar purposes to the exempt domestic uses.
- Irrigation (outdoor) water was assumed to be completely removed from the watershed (no return flow).
- Of the three Group B commercial demands that do not fall into the indoor or irrigation water use categories, the Ford Hatchery and Nine Mile Falls hydroelectric demands were assumed to return all of their water to the watershed.
- The other Group B commercial demand that does not fall into the indoor or irrigation categories, Empire Cold Storage and Frosty Ice, was assumed to be completely removed from the watershed (no return flow).
- The City of Spokane, the City of Airway Heights and Fairchild Air Force Base indoor demands were not included in the Group A municipal net demand calculation because the return flows were already accounted for in the imported wastewater input to the water balance. Instead, the Spokane, Airway Heights, and Fairchild Air Force Base indoor demands were added directly to the total net demand of the remaining Group A municipal systems. The irrigation demands for Spokane, Airway Heights, and Fairchild Air Force Base were included in the total net demand calculation.

The resulting average annual net demand for Group A and Group B systems is 20,728 acre-feet. Detailed results of net demand calculations for Group A and B systems are included in Appendix F.

Total Net Demand

Table 4-8 summarizes the estimated total net demand for water in WRIA 54.

TABLE 4-8.
AVERAGE ANNUAL NET
WATER DEMAND IN WRIA 54

	Average Annual Net Demand (acre-feet)
Exempt Domestic Use	4,983
Stock Watering	259
Group A and B Systems	20,728
Total	**25,970**

Exported Water

Exported water is water originating inside a watershed that is discharged or conveyed outside the watershed. Within WRIA 54, water is exported from the watershed by the Cities of Reardan and Medical Lake. These municipalities operate water supply wells located within WRIA 54 that produce groundwater that is transmitted and consumed outside of watershed boundaries. Average monthly flows were calculated based on water use data for these wells presented in Chapter 3, and are summarized in Table 1 of Appendix F. Return flow to WRIA 54 from these exported water uses was assumed to be negligible.

WATER BALANCE SUMMARY

WRIA-Wide Total

The annual water balance for the WRIA 54 watershed is summarized in Table 4-9. Total estimated outputs (6,246,000 acre-feet) in WRIA 54 exceed inputs (6,008,000 acre-feet) by approximately 238,000 acre-feet per year, or about 4 percent of the estimated input. This difference is within the anticipated error of the water balance calculations and does not reflect an annual net decrease in storage. Based on previous experience constructing water balances, the expected error of the water balance is between 10 and 40 percent. Table 4-10 summarizes methodology and data sources, and identifies possible error in components of the WRIA 54 water balance.

Subbasin Water Balances

Water balances were constructed for each of the subbasins in WRIA 54. Each subbasin water balance addresses the same set of inflows and outflows as the WRIA-wide water balance. Tables 8a through 8m in Appendix F summarize the water balances for each subbasin. The subbasin water balances have more frequent data gaps and are subject to greater uncertainties than the WRIA-wide water balance, as evidenced by the much larger percent differences between subbasin inflows and outflows. Surface water outflows from the subbasins are generally not known due to the lack of stream gauges along most of the tributaries to the Lower Spokane River. For many of the subbasins, the surface water inflow is zero because all streams within the subbasin have their headwaters within the subbasin. Groundwater inflows and outflows, especially between subbasins, are difficult to resolve with the available subsurface geologic and hydrogeologic data. Inflows and outflows besides groundwater and surface water were determined using data and assumptions similar to those used in the WRIA-wide water balance.

**TABLE 4-9.
WATER BALANCE SUMMARY**

	Average Inflow (acre-feet)				
	Surface Water Inflow	Groundwater Inflow	Precipitation	Imported Water (Wastewater)	**Total**
January	391,246	11,069	33,129	3,489	**438,934**
February	412,975	9,998	32,090	3,264	**458,327**
March	602,455	11,069	31,814	3,637	**648,977**
April	934,988	10,713	24,304	3,466	**973,471**
May	1,161,009	11,069	31,311	3,796	**1,207,186**
June	701,673	10,713	26,026	3,527	**741,939**
July	247,672	11,069	17,271	3,371	**279,384**
August	142,344	11,069	11,861	3,356	**168,631**
September	137,930	10,713	15,511	3,171	**167,325**
October	170,751	11,069	21,574	3,197	**206,592**
November	235,637	10,713	45,287	3,175	**294,811**
December	364,192	11,069	43,794	3,375	**422,430**
Source Total	**5,502,871**	**130,340**	**333,972**	**40,825**	**6,008,006**
% of WRIA Total	**91.6%**	**2.2%**	**5.5%**	**0.7%**	**100%**

	Average Outflow (acre-feet)					
	Surface Water Outflow	Groundwater Outflow	Evapotranspiration	Net Demand	Exported Water	**Total**
January	419,534	1,352	955	630	27	**422,498**
February	529,630	1,221	1,671	630	12	**533,164**
March	675,279	1,352	43,676	578	4	**720,889**
April	932,483	1,309	78,430	1,545	30	**1,013,797**
May	900,027	1,352	148,579	2,976	43	**1,052,977**
June	549,298	1,309	175,297	4,157	6	**730,066**
July	197,612	1,352	191,784	5,312	30	**396,089**
August	114,231	1,352	137,333	4,994	44	**257,953**
September	136,302	1,309	88,300	2,901	17	**228,828**
October	182,897	1,352	40,976	1,167	23	**226,415**
November	245,546	1,309	15,447	579	18	**262,900**
December	397,643	1,352	764	501	12	**400,272**
Source Total	**5,280,479**	**15,922**	**923,212**	**25,970**	**267**	**6,245,849**
% of WRIA Total	**84.5%**	**0.3%**	**14.8**	**0.4%**	**0.0%**	
				Difference from Inflow		**- 237,843**
				% Difference from Inflow		**4.0**

**TABLE 4-10.
SUMMARY OF WATER BALANCE METHODOLOGY AND ESTIMATED ERROR**

Component	Summary
Inflows	
Precipitation	• Volumes based on analysis of PRISM, a statistical topographic model. • Based on periods of record (POR) of adjacent climate stations. • Comprises about 6 percent of annual inflow to watershed. • Estimated 10 percent error for annual data.
Surface Water Inflow	• Volumes based on stream flow data for the Spokane River (POR 1891 to 2006), Latah (Hangman) Creek (POR 1948 to 2004), and the Little Spokane River (POR 1929 to 2006). • Comprises about 92 percent of annual inflow to watershed. • Estimated 10 percent error for annual data.
Groundwater Inflow	• Volumes for the SVRP and Latah (Hangman) Creek aquifers adapted from prior analyses. • Volumes for the Wanapum, Grande Ronde, and Chamokane Valley aquifers based on a Darcy's Law-based analysis. • Comprises about 2 percent of annual inflow to watershed. • Estimated error for annual data could exceed 100 percent.
Imported Water	• Volumes based on estimates provided by the city of Spokane (POR 1984 to 2005), the city of Airway Heights (POR 1999, 2002, and 2003), and Fairchild Air Force Base (POR 2003 to 2005). • Comprises about 0.1 percent of annual inflow to watershed. • Estimated 50 percent error for annual data.
Outflows	
Surface Water Outflow	• Volumes based on stream flow data for the Spokane River (POR 1891 to 2006), Blue Creek (POR 1984 to 2004), Orazada (POR 1994 to 1996), and Sand (POR 1994 to 2006). • Comprises about 85 percent of annual inflow to watershed. • Estimated 20 percent error for annual data.
Land-Based Evapotranspiration	• Volumes based on a Penman-Monteith energy balance model. • Used temperature data from PRISM, agricultural census data, land-use data, and crop- and plant-specific evapotranspiration coefficients. • Based on POR of adjacent climate stations. • Comprises about 14 percent of annual outflow from watershed. • Estimated 20 percent error for annual data.
Surface Water Evaporation	• Volumes based on GIS analysis of surface water area, pan evaporation for the Spokane WSO Airport climate station, and a correction factor. • Based on a POR of 1889 to 2005. • Comprises about 0.6 percent of annual outflow from watershed. • Estimated 20 percent error for annual data.

TABLE 4-10 (continued).
SUMMARY OF WATER BALANCE METHODOLOGY AND ESTIMATED ERROR

Component	Summary
Outflows (continued)	
Irrigation Evaporation Loss	• Volumes based on area-weighted Agricultural Census Data , crop irrigation requirements and a standard spray loss coefficient. • Comprises less than 0.1 percent of annual outflow from watershed. • Estimated 50 percent error for annual data.
Groundwater Outflow	• Volumes based on a Darcy's Law-based analysis. • Comprises about 0.2 percent of annual inflow to watershed. • Estimated error for annual data could exceed 100 percent.
Net Demand	• Volumes based on estimates for domestic water use, stock watering, Group A and Group B use. • Return flows for domestic, Group A, and Group B uses were subtracted from gross use estimates to derive net demand. • Comprises about 0.4 percent of annual outflow from watershed. • Estimated 50 percent error for annual data.

Note: A quantitatively rigorous error analysis was not performed to derive the error estimates provided in this table. The error estimates were developed based on an evaluation of source data, experience with similar analyses, and professional judgment.

SIMPLIFYING ASSUMPTIONS

A water balance provides a simple evaluation of the relative influence of an existing or proposed water use on the overall water resources of a watershed. The following simplifying assumptions were used to generate this water balance:

- The watershed hydrology components were based on existing, incomplete data. The simplifying assumptions used to develop estimates for each of the watershed components apply to the water balance assessment.
- Water balances are not adequate to evaluate the potential influence of an increase in groundwater use for watersheds with complex hydrology or large groundwater use. This is because the impact of groundwater use is dependent upon aquifer hydraulics, spatial and temporal characteristics, and the capture of natural discharge; water balances cannot be used to accurately evaluate any of these factors (Bredehoeft 1997, Sophocleous, 1997; Bredehoeft et al., 1982).
- Steady-state (static) conditions are assumed to be an accurate representation of the hydrologic system in the watershed. In reality, watersheds are transient systems that are dynamically balanced between water input and output. Watersheds with significant consumptive use and complex watershed hydrology should be evaluated as transient systems.
- The groundwater flow system boundaries are complex, and the groundwater boundaries may not be identical to the surface water boundaries for many of the subbasins.
- Groundwater inflow and outflow from bedrock aquifers were assumed to be negligible.

- Water balances are only valid to describe existing conditions if sufficient data are available. Water balances are widely recognized as inappropriate for predictive analysis due to the simplifying assumptions and the inability of the method to predict changes in hydrologic systems (Bredehoeft et al., 1982; Sokolov and Chapman, 1974). For this investigation, this water balance should be used as a screening tool to identify hydrogeologic data gaps.

DATA GAPS

The water balance was developed using the best available data, but existing hydrologic and hydrogeologic data for WRIA 54 are incomplete. Table 4-10 summarizes the methodology and data sources used for this water balance to provide an indication of the degree of confidence for individual water balance components. The following data limitations affect the precision of this water balance analysis:

- The lack of a gauge on the Little Spokane River near the confluence with the Spokane River leads to a poorly defined Little Spokane River inflow component in the water balance.
- Tributaries to the Spokane River except the Little Spokane River, Latah (Hangman) Creek and Blue Creek do not have flow measurements for extended time periods.
- SVRP aquifer groundwater inflow to WRIA 54 should be reevaluated when the USGS bi-state study is completed.
- Groundwater inflows at the WRIA 54 boundary from underflow at Latah (Hangman) Creek, the Chamokane Valley aquifer, the basalt aquifers, and the bedrock aquifers require further detailed field and modeling studies to be determined accurately. A similar study should be performed on groundwater outflow at the Spokane River mouth.
- Discharge of the Spokane River into the Columbia River has not been measured.
- Precipitation inputs should be reevaluated with 800-meter resolution PRISM data that were published near the completion of this technical assessment.
- Previous hydrogeologic studies within WRIA 54 have focused on the SVRP aquifer and CRBG and paleochannel aquifers in the West Plains area. In the rest of the watershed, the hydrogeology is largely undefined. Data used to estimate aquifer thickness and extent, hydraulic conductivity, and hydraulic gradient for the bedrock and sedimentary aquifer were limited to information provided in a relatively small number of domestic water well reports, boring logs, and regional and local studies.
- Groundwater/surface water interaction is not well defined downstream of Lake Spokane (Long Lake).
- The coarse scale and general nature of descriptions for non-agricultural land use data can lead to errors in evapotranspiration estimates and an overestimate for total evapotranspiration.
- Population estimates were derived by summing census blocks located completely or partially within the watershed, likely resulting in overestimation.
- The calculation of total commercial or industrial water right allocations did not incorporate values for water right certificates, permits or claims that did not have a quantity associated with them in the source databases.
- The water balance was completed at a relatively coarse spatial scale. Evaluation of the impact of a concentration of high consumptive water use rates in a localized area would require more detailed evaluation.
- The water balance was completed by assuming steady-state conditions and did not evaluate potential impacts on aquifer storage.

CHAPTER 5.
FUTURE WATER DEMAND

Population, urban development, and commercial/industrial activities in WRIA 54 are expected to increase over the next 20 years, bringing an increased water supply demand. Although millions of acre-feet of water flow in and out of WRIA 54 annually, as described in Chapter 4, the water resources available to meet new human water demand are limited. These resources are also needed to maintain the volume of aquifers, base flows in streams, and the ecological character of the watershed. They will need to be carefully managed to provide satisfactory water supply for all future needs.

ESTIMATED FUTURE WATER USE

Current annual water use is approximately 57,000 acre-feet, with about 28,000 acre-feet representing urban and domestic uses, Group A, Group B and self-supplied users. The remaining 29,000 acre-feet is used for agriculture and livestock. Current water rights established by permits and certificates in the WRIA account for about 147,000 acre-feet.

The demand for water to serve agriculture and livestock uses is not expected to increase substantially for two reasons. First, most farmable land is already under cultivation. Second, the trend in agricultural water use is toward more efficient use of water through improved irrigation systems and practices.

Future water demand to serve the anticipated population growth was calculated by extrapolating the per capita water consumption rate determined in Chapter 3 to the anticipated future population. In 2000 (the most recent census available) approximately 89,500 people were living in WRIA 54; most of that population were located in the eastern portion of the watershed in Spokane and Stevens Counties. This population used an estimated 320 gallons per capita per day of water, based on an assumed 2.5 residents per ERU and the Washington State Department of Health Water System Design Manual’s recommended design value of 800 gallons per ERU.

By 2025, population is likely to increase by 37 percent, with an expected WRIA 54 population of approximately 122,300 (see Table 2-8). If the per capita demand does not change, then the domestic water use in 2025 would be approximately 44,000 acre-feet annually, a 57 percent increase. The Hutterian Brethren expect a growth in agricultural irrigation of approximately 9,000 acre-feet over the next 20 years for their operations on the Spokane Reservation and at West Plains and Long Lake. Even with this growth, it is expected that the loss of other irrigated agricultural lands to development and other uses would maintain agricultural water use at roughly the current level of 27,000 acre-feet; therefore, the total estimated water demand for 2025 will about 71,000 acre-feet.

Future needs for commercial/industrial activities are included in the per capita consumption rate. None of the WRIA 54 water purveyors have identified a projected need for commercial/industrial customers separate from their bulk projections. Since the water needed for these types of activities varies greatly with the type of industry, it is impossible to know at this time what that might be.

Table 5-1 identifies the current annual volume for Group A municipal purveyors and the projected 20-year volume taken from each purveyor’s water system plan.

TABLE 5-1.
20-YEAR FUTURE WATER NEEDS PREDICTION

	Annual Water Volume (acre-feet)		Increase	
Jurisdiction	Current	Projected 20-Year	(acre-feet)	(%)
Airway Heights	1,136	2,149	1,013	89.2%
Medical Lake	610	857	247	40.5%
Fairchild Air Force Base	3,017	3,360	343	11.4%
Stevens County PUD LUD 4&6	1,792	2,638	846	47.2%
Stevens County PUD LUD 5	116	142	26	22.4%
Stevens County PUD LUD 18	267	286	19	7.1%
Stevens County PUD LUD 22	6	31	25	416.7%

INCHOATE WATER RIGHTS

Inchoate water rights are the portions of municipal rights that are not currently utilized but available for use as the municipality grows. The estimated inchoate rights for WRIA 54 municipalities, excluding the City of Spokane because it is not WRIA 54-specific, are presented in Table 5-2, along with the projected 20-year annual volume increase derived from Table 5-1.

TABLE 5-2.
ESTIMATED INCHOATE RIGHTS FOR WRIA 54

	Annual Water Volume (acre-feet)		Inchoate Rights Remaining (acre-feet/year)	% of Inchoate Rights Used by 20-Year Increase
Jurisdiction	Current Inchoate Rights	20-Year Increase in Demand[a]		
Airway Heights	489	1,013	-524	207.2%
Medical Lake	3,700	247	3,453	6.7%
Fairchild Air Force Base	1,473	343	1,130	23.3%
Stevens County PUD LUD 4&6	892	846	46	94.8%
Stevens County PUD LUD 5	1,000	26	974	2.6%
Stevens County PUD LUD 18	-873[b]	19	-892	—
Stevens County PUD LUD 22[c]	—	25	—	—
Total[d]	**6,681**	**2,494**	**4,187**	**37.3%**

a. 20-year demand increase taken from Table 5-1.
b. Negative value for inchoate right indicates current use exceeds current right.
c. No data available on annual volume associated with Stevens County PUD LUD 22 inchoate rights.
d. Totals exclude Stevens County PUD LUD 22 because of lack of data on annual volume of inchoate rights.

This information illustrates the capacity of each of these water purveyors to provide water to anticipated new customers with current water rights. At this time, the City of Airway Heights, Stevens County PUD LUD 4&6 and Stevens County PUD LUD 18 do not hold sufficient water rights to serve their anticipated growth. The other purveyors do not show a similar deficit, but this situation could change if unanticipated growth or a large new industrial user were to locate within their service area.

It must be recognized that utilizing the inchoate rights held by municipal purveyors could place additional stresses on natural resources because they would use water that is presently reserved but not being physically used. Purveyors that fully use their inchoate rights may need to acquire additional water rights. If additional water rights cannot be acquired, municipalities may have to depend on purchasing water through interties from other municipalities with existing inchoate rights. Relying on interties for additional water demand places a community at risk if the provider of the intertie requires that water for its own uses.

FEDERAL AND TRIBAL RESERVED WATER RIGHTS

Like inchoate rights, federal and Tribal reserved water rights are not subject to continuous use provisions. Spokane Tribal rights for the waters of Chamokane Creek have been quantified in federal court as discussed in Chapter 3. The Spokane Tribe and U.S. government could assert reserved rights to other waters within WRIA 54 associated with fulfilling the needs of the lands held by these entities.

WATER CONSERVATION

Water conservation is a critical component of meeting existing and future water needs, including in-stream and out-of-stream uses. Water conservation measures include anything that reduces the amount of water needed to meet water supply uses. Conservation measures entail changing practices and improving system efficiencies to reduce water demand, preserve natural resources and inchoate rights, and accommodate future development opportunities. Water conservation best management practices that can reduce demand include reducing irrigation, changing landscaping materials, minimizing leaks and systems inefficiencies, and reusing or recycling water. An important finding of this Technical Assessment is that the use of water for irrigation, including commercial and residential landscaping, far exceeds water used for other purposes (Figures 3-7, 3-8, and 3-9). Therefore, conservation measures targeted to reducing water for landscaping and irrigation are likely to produce significant water savings.

In WRIA 54, Group A purveyors—Airway Heights, Fairchild Air Force Base, Medical Lake, the City of Spokane, and Stevens County—have developed water conservation plans as part of their water system management plans. A copy of the water conservation sections for these plans is provided in Appendix G.

Airway Heights

Airway Heights has set a goal to reduce water consumption by 5 percent, although a detailed schedule is not provided in the plan. Currently Airway Heights is meeting requirements to meter wells and to check for inconsistencies in the data. The City is also providing public education on water conservation methods and providing customer assistance. Airway Heights is not currently providing incentives to encourage water conservation. A more detailed look at Airway Heights water conservation actions can be found in an excerpt of the water system plan found in Appendix G.

Fairchild Air Force Base

Fairchild Air Force Base is working under a directive to implement four water conservation measures:

- Implement public information and education programs.
- Audit distribution systems to identify leaks and repair needs.
- Upgrade boiler/steam systems.

- Identify miscellaneous high water using processes.

Most of these measures were completed by 2002, and the only ongoing measure identified in the plan is to implement public information and education programs. An existing program to convert manual above-ground irrigation systems to an automatic underground setup is improving water efficiency. This program may be expanded by adding a precipitation-based irrigation system instead of a timer-based system.

A goal for water use reduction was not identified, but between 1989 and 2000 the water demand on Fairchild AFB has not increased, even though the irrigated area has increased by 60 percent. A more detailed look at the conservation practices being conducted at Fairchild AFB can be found in Chapter 4 of the base's water system plan in Appendix G.

Medical Lake

Medical Lake is metering all facilities and reviewing the meters to identify problems within the system. Medical Lake estimates that this has resulted in a two-percent saving in water use. A new wastewater treatment and reuse facility has been constructed, which treats two-thirds of the wastewater to reuse standards and diverts it to West Medical Lake. A portion of the treated water is used for irrigating the wastewater treatment plant facilities. A more detailed look at Medical Lake's water conservation actions can be found in an excerpt of the water system plan found in Appendix G.

City of Spokane

The City of Spokane's objective is to limit the growth of peak-day demand to allow existing resources to supply a growing number of customers. Almost all of the City's consumption is metered, with the exception of fire hydrants and some fire lines. Meters and data are checked to identify failing meters or problems in the system. The City has had a leak detection system in place since the 1970s. The City is also involved in a combined effort to promote water conservation. A more detailed look at the City of Spokane's water conservation actions can be found in an excerpt of the water system plan found in Appendix G.

Stevens County Public Utility District

Stevens County Public Utility District (PUD) has established a goal to provide all PUD customers with the knowledge and incentives to use water wisely and reduce wasteful water use practices. Stevens County PUD provides public education materials to residents as well as limited technical assistance for water conservation measures. Sources and service are metered and monitored, and a program is in place to identify unaccounted water. The PUD has worked on a reduced lawn watering demonstration project in the Suncrest system and experimented with changing water rates to promote water conservation. No specific reduction goals in terms of a percentage or volume of saving are provided in the plan. A more detailed look at Stevens County PUD's water conservation actions can be found in an excerpt of the water system plan found in Appendix G.

CHAPTER 6.
WATER QUALITY

Water quality in WRIA 54 is threatened by increasing development and urbanization in the eastern portions of the WRIA, mining and logging operations, and poor-quality waters discharging from other WRIAs. Based on the scope of work for this Level 1 Assessment, the following discussion summarizes the issues and efforts related to state regulatory efforts to develop water cleanup plans, also known as total maximum daily loads (TMDLs), for the Spokane River system. Many additional water quality problems, issues, and concerns exist in WRIA 54; assessment of these will be accomplished through the WRIA 54 supplemental water quality grant.

REGULATORY REQUIREMENTS

The State of Washington is required by the federal Clean Water Act to have a set of standards for water quality. These standards are in two forms:

- Standards for designated uses are based on the intended uses of the water body, such as recreation, water supply, irrigation, fisheries, and habitat.
- Numerical-value standards establish levels for water quality parameters to which water quality samples can be compared. Typically these numbers reflect conditions that are favorable to meeting designated uses.

Threatened Water Quality Standards

There are many water quality threats to the water bodies within WRIA 54. Some pollutants exceed water quality standards, while others are expected to exceed state water quality standards in the near future. The threats to water quality standards identified in WRIA 54 include:

- Spokane River—Dissolved oxygen, phosphorus, zinc, chromium, lead, fecal coliform, total dissolved gas, and polychlorinated biphenyls (PCBs)
- Lake Spokane (Long Lake)—PCBs, dissolved oxygen, invasive toxic species, 2,3,7,8-TCDD, 4,4’-DDD, 4,4’-DDE, DDT, Aldrin, Chlordane, Dieldrin, Endrin, fecal coliform, total phosphorus, and zinc
- Blue Creek—Lead
- Knight Lake, Horseshoe Lake—Total phosphorus
- Lower Spokane River arm of Lake Roosevelt—Temperature, pH, fecal coliform.

Impaired Water Quality Standards

When water quality standards in waters of the state are not met, then the Clean Water Act, under Section 303(d), requires that the water body be identified as “impaired.” To address the impairment of the water body, a TMDL must be established to set limits for the loading of pollutants impairing the water body. Figure 6-1 shows that most current 303(d) impaired listings for WRIA 54 are along the Spokane River and Lake Spokane (Long Lake). Under federal law, Ecology will be required to develop water cleanup plans (TMDLs) for all of these impairments unless the problem is resolved through earlier corrective actions. Water cleanup plans that are complete or are currently being developed for the Spokane River are discussed in the following sections.

SPOKANE RIVER/LAKE SPOKANE DISSOLVED OXYGEN TMDL

The Spokane River and Lake Spokane (Long Lake) are impaired for dissolved oxygen. Dissolved oxygen (DO) is gaseous oxygen that is dissolved in the water. DO is replenished via interaction between the water and the atmosphere, turbulent water, and transpiration of aquatic vegetation. DO levels in the Spokane River should naturally be around or above 8 milligrams per liter (mg/l)

DO can dissipate as water becomes stagnant or warm, or as organic materials such as aquatic plants begin to decompose, during which process bacteria consume the DO available in the water. The amount of oxygen consumed by bacteria in breaking down organic materials is called the biochemical oxygen demand (BOD). The higher the BOD, the more oxygen is being consumed. Nutrients such as phosphorus and nitrogen support the growth of organic materials in the water, thus leading to increased BOD.

DO levels in the Spokane River have been among the most significant water quality issues in WRIA 54, and Ecology is preparing TMDL limits for nutrients entering the Spokane River system to help ensure that the river meets state and Spokane Tribal water quality standards. In 2004 Ecology published two documents related to the TMDL effort: *Spokane River and Lake Spokane (Long Lake) Pollutant Loading Assessment for Protecting Dissolved Oxygen* and *Draft Total Maximum Daily Load to Restore and Maintain Dissolved Oxygen in the Spokane River and Lake Spokane (Long Lake)*.

Over the last 30 years, phosphorus loading into the Spokane River has occurred from point sources, such as pipes discharging directly to the river, as well as non-point sources, such as stormwater runoff flowing over impervious surfaces to the river. Historically this has resulted in algal blooms in Lake Spokane (Long Lake), which increase the BOD and decrease DO, particularly during the summer. The following have been identified as the key sources of nutrients to the Spokane River system:

- The City of Spokane Advanced Wastewater Treatment Plant removes much of the material that decreases oxygen in the water when it degrades; however, some of its discharge still contains oxygen-consuming materials. This facility is the only one in the WRIA with a National Pollutant Discharge Elimination System (NPDES) permit to discharge oxygen-consuming substances and nutrients to the river.
- Studies have found that Deep and Coulee Creeks, within WRIA 54, and Latah (Hangman) Creek and the Little Spokane River, discharging to WRIA 54, provide significant amounts of nutrients to the Spokane River.
- The Spokane Valley-Rathdrum Prairie aquifer has been found to affect dissolved oxygen levels in the Spokane River.
- Some non-point sources remain along the Spokane River, although most stormwater and combined sewer overflows were removed over the last 15 to 20 years.

Each of these potential nutrient sources is discussed below.

City of Spokane Advanced Wastewater Treatment Plant

Prior to 1978, the Spokane wastewater treatment plant was a significant source of oxygen-depleting effluent in the Spokane River. In 1978, the plant was converted to an advanced wastewater treatment plant, which added secondary treatment capable of removing 85 percent of the phosphorus. A 1985 study discussed in Cusimano (2004) found that total phosphorus concentrations continue to increase downstream of the Spokane treatment plant. A Department of Ecology study conducted in 2000 confirmed an increase in total phosphorus immediately downstream of the Spokane plant. The plant also has been identified, along with the Spokane Valley-Rathdrum Prairie aquifer, as the primary source of nitrogen in the watershed (Cusimano 2004).

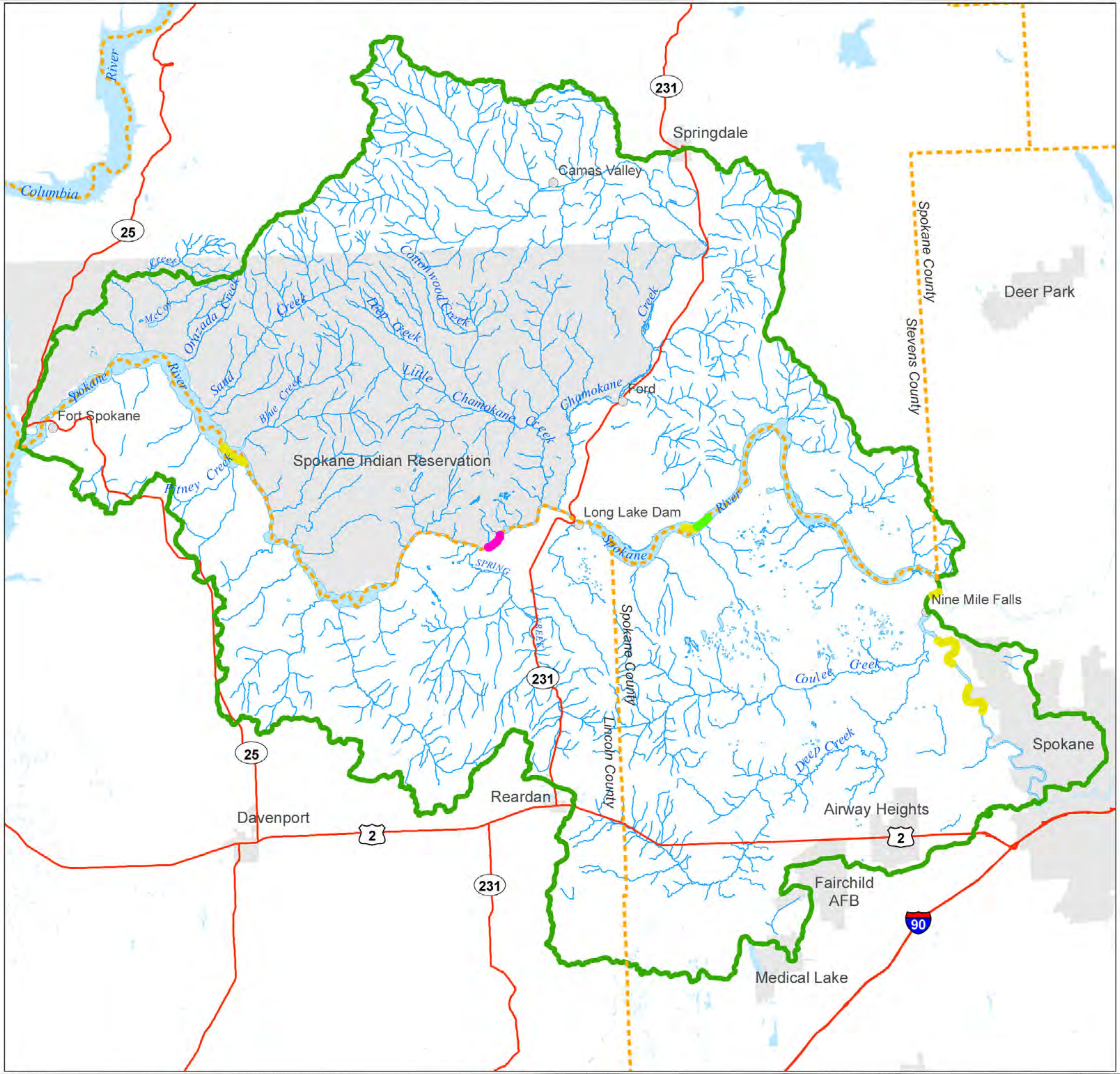


Figure 6-1
WRIA 54
Department of Ecology
Category 5 303D Listings

Legend

303D Listing
- Dissolved oxygen
- Total Dissolved Gas
- Total PCBs
- Major Road
- County Boundary
- Stream
- WRIA54 Boundary
- Unincorporated Area
- Waterbody
- Jurisdiction

Data Sources:
Streets, Waterbodies, Streams, County Boundary, Spokane Indian Reservation - Washington DNR
Juristictions - County Data
WRIA Boundary - Washington DOE
Populated Places - USGS
303D Locations - WA DOE

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Miles

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Map Produced 01/16/2007

Tributaries

The Spokane River tributaries with the greatest influence on water quality are Latah (Hangman) Creek, the Little Spokane River, Deep Creek and Coulee Creek. All of these tributaries discharge drainage from developed or developing areas, which may contribute nutrients to the river system.

Tributaries Outside WRIA 54

Latah (Hangman) Creek and the Little Spokane River have both been recorded as having higher concentrations of nutrients than found in the Spokane River at the Washington-Idaho state line. The levels are elevated predominantly from January through April. The elevated nutrients coincide with the period of elevated levels of total suspended solids and high turbidity, which extends from January to March (Cusimano 2004). It appears that both of these water bodies receive significant amounts of sediment, likely through erosion, which may result in high levels of sediment oxygen demand as a result of the nutrients and organics attached to the soil particles. Additionally, Latah (Hangman) Creek receives discharges from several small seasonal treatment facilities in its drainage area, while the Little Spokane River receives discharges from the Washington Department of Fish and Wildlife Spokane Fish Hatchery and from the groundwater pump and treat system of the Colbert Landfill superfund site.

One ameliorating condition for the nutrient discharges from Latah (Hangman) Creek and the Little Spokane River is that the timing does not coincide with the critical season, June through October, when nutrient loading and algal growth peak (Cusimano 2004). However, this does not reduce the overall impact of the nutrients delivered to the main stem Spokane River from these tributaries.

Tributaries in WRIA 54

Coulee and Deep Creeks are sources of oxygen-consuming substances and nutrients. Likely sources include the City of Medical Lake wastewater treatment plant discharge, a portion of which is discharged to the Deep Creek subbasin, as well as failing septic systems, fertilizers, stormwater, and other common urban and domestic sources. Current loading levels from the Medical Lake treatment plant have been reported as insufficient to impact the Spokane River. Additional development expected in these subbasins could increase the nutrient load to the creeks and to the Spokane River.

Chamokane, Little Chamokane, Mill, and Spring Creeks are also likely to have suspended sediment problems, particularly during spring runoff, when their water appears deep brown (B. Crossley, personal communication).

Spokane Valley-Rathdrum Prairie Aquifer

The Spokane Valley-Rathdrum Prairie aquifer, as discussed in Chapter 2, is a very permeable unconfined aquifer with high infiltration rates. As a result, the water quality in the aquifer is susceptible to non-point source pollution from irrigation, on-site waste disposal systems, and stormwater. The losing reaches of the Spokane River upstream of WRIA 54 may add additional nutrients to the groundwater as potentially nutrient-rich waters leave the Spokane system and enter the aquifer, only to be discharged back to the Spokane River downstream (Cusimano 2004). The aquifer has been identified, along with the Spokane wastewater treatment plant, as the primary source of nitrogen in the watershed (Cusimano 2004)

Point and Non-Point Discharges

Historically, combined sewer overflows (CSOs) and stormwater discharges added nutrients to the Spokane River, which affected DO. In the last 25 years, the City of Spokane has separated combined sewers and developed controls to reduce stormwater runoff. Currently, the City’s CSO discharges have been identified as insufficient to impact the water quality of the river or lake system significantly (Cusimano 2004).

SPOKANE RIVER DISSOLVED METALS TMDL

This study, which was completed in 1999, determined that the primary source of metal contamination in the Spokane River is upstream mining areas in the State of Idaho. The implementation plan calls for continued cleanup of these mining areas as well as of beaches along the Spokane River where contaminated sediments have accumulated.

SPOKANE RIVER POLYCHLORINATED BIPHENYLS TMDL

Spokane River and Lake Spokane (Long Lake) violate the water quality standards for PCBs in several locations. In the past, PCBs were used for numerous commercial and industrial purposes, including as coolants and lubricants in electrical equipment, such as transformers and capacitors, and in other products such as plasticizers, paint additives, adhesives and hydraulic fluids. The use of PCBs was banned in the U.S. in 1977 because of their health hazards.

The main health concern associated with PCBs is consumption of contaminated fish. The TMDL process for the Spokane River is just beginning, with a problem assessment study to examine the levels of PCBs in the Spokane River and to determine possible sources. Results from this study show increasing levels of PCBs in the river moving downstream from the Idaho border to Lake Spokane (Long Lake) Dam. The next step is to identify specific sources and develop plans to stop their release into the river. Some cleanup work is already underway to remove contaminated sediments above Upriver Dam.

LAKE SPOKANE (LONG LAKE) TOTAL PHOSPHORUS TMDL

The Lake Spokane (Long Lake) Total Phosphorus TMDL was approved in 1992 to address nutrient enrichment in Lake Spokane (Long Lake). This study, which placed initial controls on phosphorus loading to the Spokane River system, will be superceded by the Spokane River Total Maximum Daily Load (TMDL) to restore and maintain dissolved oxygen in the Spokane River and Lake Spokane (Long Lake).

CHAPTER 7.
CONCLUSIONS

This report represents the first comprehensive water resources data compilation and assessment for WRIA 54. The conclusions of this work are presented below, organized by report chapter.

WATERSHED CHARACTERISTICS

Much water-resource information exists for the main stem Spokane River throughout WRIA 54, but very little exists for most of the tributaries, such as Deep and Coulee Creeks, Spring Creek, and Mill Creek. While the main stem Spokane River is by far the largest surface water body in the WRIA and therefore may warrant much focus, it will be impossible to comprehensively manage the watershed without better data for the tributary subbasins. This need is particularly acute in the Deep Creek, Coulee Creek, Airway and Long Lake North subbasins, where development pressure is rapidly changing the character of the areas.

Based on available data, it appears that the SVRP aquifer is a significant source of flow for the Spokane River in WRIA 54. It follows that the WRIA 54 planning unit will have a keen interest in the quality and quantity of water in the SVRP aquifer that discharges into the Spokane River between Latah (Hangman) Creek and Nine Mile Falls Dam.

A number of groundwater aquifers warrant further investigative studies, as they either hold promise for water supply purposes or appear to be already over utilized in areas. The characteristics of most of these aquifers within the watershed are not currently well-understood. These include the Columbia River Basalt Group aquifers (Wanapum and Grande Ronde) that are present in most of the southern portion of the WRIA (south of the Spokane River), the paleochannel aquifers, and the Lower Chamokane Valley Aquifer.

Groundwater/surface water interaction is a dynamic component of the intra-basin water balance throughout WRIA 54. This exchange of water is not well understood below Lake Spokane (Long Lake) on the Spokane River, and even less well documented in tributary subbasins. Hydraulic continuity between the Upper Chamokane Valley Aquifer and Chamokane Creek, is believed to be significant, based on historical observations of water levels, stream flow and water well pumping.

The subbasin delineations used in this document, drawn from the Washington Department of Natural Resources Watershed Administrative Unit designations, may not be a logical breakdown for planning purposes in all cases. For example, it is likely that groundwater flow in CRBG aquifers does not follow subbasin boundaries. Further groundwater-related investigations should consider alternate study area delineations.

The Airway subbasin is an example of a subbasin delineation that may need to be revised as watershed planning continues in WRIA 54. This subbasin covers a very diverse area, including portions of the City of Spokane (some of the most densely populated portions of the WRIA) as well as rural areas north and west of the City of Airway Heights. This subbasin also includes very distinct regions from a water resources perspective, with the SVRP aquifer and Spokane River dominating the eastern portion of the subbasin and the CRBG aquifers, paleochannel aquifers and Deep Creek drainage dominating the western portion.

The Cities of Spokane, Medical Lake and Reardan lie only partially in WRIA 54. This Level 1 Assessment attempted to accurately portray the water rights and water use for these cities as they pertain to WRIA 54. Inter-WRIA planning would benefit these communities, in order to ensure that consistency and a regional viewpoint are reflected in WRIA 54 Watershed Plan recommendations that affect these jurisdictions.

WATER RIGHTS AND WATER USE

Water right claims dominate the recorded water documents in WRIA 54, and uncertainty about the true quantity of water appropriated through these claims restricts the ability to effectively manage water resources in WRIA 54. The understanding of the probable appropriation could be refined through additional targeted studies, but only an adjudication can actually validate these potential appropriations. The first targeted studies we recommend are the following:

- Investigate the largest claims to evaluate the likelihood that they are actively being used, and if so, the nature of the use.
- Further investigate potential duplicate claims to establish greater confidence that they can be removed from water-rights calculations.
- Because so many of the claims are to groundwater for small quantities, it is likely that many of these serve single domestic needs. The estimates for permit-exempt wells in this document may overlap significantly with this category of claims. A study to evaluate the magnitude of this overlap would help refine the understanding of this potential appropriation.

A very large (25,680 acre-foot per year) irrigation water right is held by the Spokane Tribe for Chamokane Creek and its tributaries and portions of the underlying groundwater. This right was quantified through a federal adjudication, which also granted the tribe rights to a minimum 24 cfs flow for fish habitat in Chamokane Creek.

The estimates presented for permit-exempt wells are based on standard methods using population, water right, and public water system service area data. These estimates are likely to be fairly accurate, but because there is almost no information to verify the location and use of these wells, it is impossible to evaluate the true impacts of permit-exempt wells. For exempt wells that are simply providing water to one home, the individual impact is not likely to be significant. Significant impacts may be occurring where exempt wells provide significant water for agricultural or industrial purposes, for multiple homes, or where there is a high density of permit exempt wells.

Estimated actual water use exceeded potential water right appropriations in three subbasins: Harker Canyon, Little Chamokane, and Pitney. The reason for this should be evaluated further, and may be the result of transfer of water between subbasins (a water right in one subbasin with actual use in a different subbasin). In some heavily populated subbasins, actual current water use that exceeds current allocated withdrawals may not be identified in this analysis if the estimates of allocated withdrawal include inchoate water rights (currently unused portions of water rights) held by municipal water purveyors in those subbasins.

WATER BALANCE

A frequent objective of incorporating a water balance into watershed planning efforts is to understand the magnitude of each of the water balance components (precipitation, surface water inflow, net demand, etc.) and to identify where surpluses and deficits exist, both spatially throughout the watershed, and seasonally throughout the year. In actual practice, a water balance that spans such a large planning area as WRIA 54 has limited utility for water-resource allocation management, but it does provide useful information for general planning, education, and targeting further detailed work efforts.

In terms of annual water volume, the flow of the Spokane River dominates the WRIA 54 water balance and, because of frequent measurements and a relatively long period of record, is relatively well understood. The other water balance components are smaller in volume than surface water flow, but also are significant with respect to water resource management. For example, water balance components such as groundwater flow and net demand could be critical factors in water resource management at the basin and particularly subbasin level. These components are among the least understood at this time.

The water balance performed for this report allowed for the identification of gaps in the current understanding of hydrologic processes within the watershed. Many of these are summarized in the below *Data Gaps* section.

WATER AVAILABILITY

One of the primary goals of watershed planning is to estimate the amount of water available for future allocation in the watershed. In WRIA 54, gaps in the existing data set limit the understanding of watershed hydrology and make a comprehensive determination of water availability difficult. Water availability considerations for WRIA 54 include the following:

- Surface water could be available for future allocation from the Lower Spokane River. This determination will depend upon, among other factors, the in-stream flow analysis currently being performed for the WRIA 54 Planning Unit.
- Surface water could possibly be available for future allocation from tributaries of the Lower Spokane River if further investigation and analysis show that it could be done with no negative impact. Stream flow data are currently not available for most of the tributaries and would be necessary before allocations are feasible. Though a number of these tributaries are intermittent (do not flow continuously throughout the year), continuous supply could be achieved by implementing water storage projects. This determination also will depend upon, among other factors, the in-stream flow analysis currently being performed for the WRIA 54 Planning Unit.
- The paleochannel aquifers appear to be a relatively promising source for additional groundwater allocation. A review of existing data suggests that these aquifers are relatively transmissive and currently stable with regard to long-term groundwater elevation. Based on the relatively low number of wells currently pumping from paleochannel aquifers and the limited capture zone anticipated, well interference issues likely would be less extensive than in CRBG aquifers.
- The CRBG aquifers in the West Plains area appear to have significant existing groundwater mining and well interference issues, suggesting that these aquifers could be over-allocated in the West Plains area. Additional allocation of this resource should be limited until the impact of future allocation is evaluated by groundwater flow modeling.
- Groundwater elevation data associated with CRBG aquifers in the southwest portion of WRIA 54 are limited. However, based on the current distribution of wells in the basin and aquifer hydraulic characteristics, there could be opportunity for significant additional withdrawal in this area.
- The SVRP Aquifer is highly transmissive and an important source of water throughout the region. Further use of this resource in WRIA 54 will depend on the results of the ongoing

U.S. Geological Survey bi-state investigation, ongoing and planned water right adjudication efforts, and in-stream flow analysis for the Lower Spokane River.

- The basement rock aquifers are of limited permeability, and associated well yields generally will be low. The aquifers generally are reliable only for low-volume domestic use.

FUTURE WATER NEEDS

Future consumptive water needs, which are anticipated to be primarily for domestic supply (this includes associated commercial/industrial uses), are expected to increase by approximately 57 percent by 2025, based on WRIA 54 growth projections. This increase will likely be focused in two areas—the West Plains region of Spokane County and near the Spokane River downstream from the City of Spokane —making the likely actual increase in water demand more in those two areas. Some of these areas are in established water service areas, but existing purveyor systems may not be fully built at this point. Other parts of these growth areas are not in established water service areas (see Figure 7-1).

Municipal purveyors hold inchoate water rights that will help meet this future demand. The magnitude of inchoate rights differs among purveyors, however, and may not be matched to where actual growth in water demand will occur. This should be approached as a regional issue through a coordinated planning effort.

Water conservation is an important component in meeting current and future water supply needs. All municipal purveyors currently have conservation programs described in their water system plans; implementation of these programs, as well as additional conservation activities, will produce significant water savings. Because outdoor water use (residential, commercial, and agricultural irrigation) is such a large component of water use in WRIA 54, conservation efforts targeted to reducing outdoor water use will be most fruitful. For example, outdoor water use accounts for approximately three-quarters of the water consumed by the Group A and Group B systems alone in WRIA 54.

Water needs for in-stream flow are being evaluated through the WRIA 54/57 Instream Flow Study currently being conducted by the Tetra Tech project team. Results of the instream flow study will help quantify stream flow requirements for fish in the main stem Spokane River, Deep Creek, Coulee Creek, Little Chamokane Creek, and Lower Spring Creek. These results will be integrated with other in-stream flow needs and technical assessment results by the planning unit as they develop the WRIA 54 Watershed Plan.

WATER QUALITY

The water quality information provided with this Level 1 assessment is limited to a brief summary of water quality information primarily related to the Spokane River Dissolved Oxygen TMDL. The planning unit intends to undertake additional water quality assessment work under a separate project, funded through a supplemental grant from the Department of Ecology.

Water quality impairments caused by excess nutrients (contributing to low dissolved oxygen levels), metals, and PCBs have been identified in WRIA 54, and Ecology is currently addressing these impairments through development and implementation of Total Maximum Daily Load (TMDL), or Water Cleanup Plans. The excess nutrients and low dissolved oxygen may be related to stream flow levels.

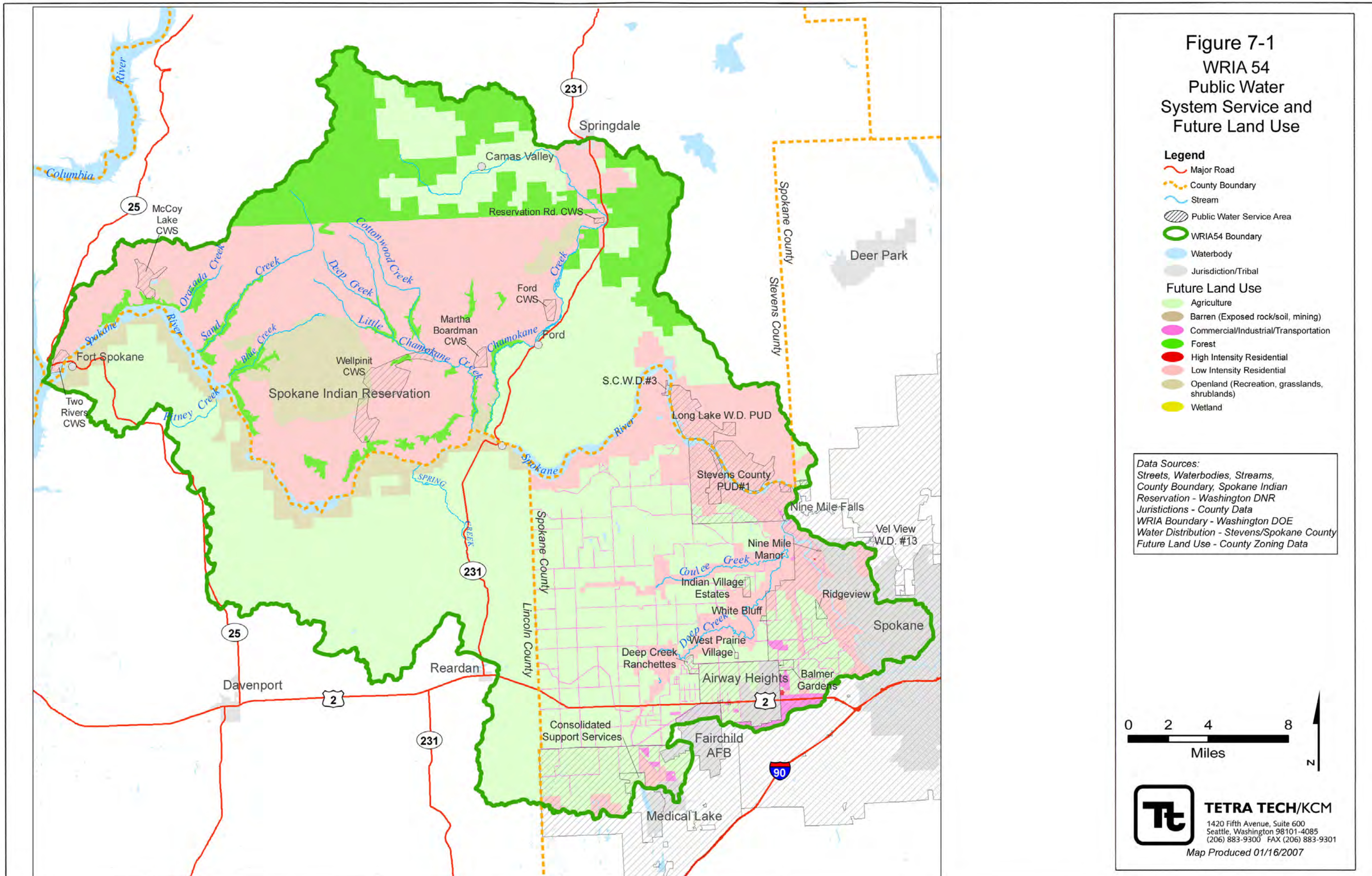

Figure 7-1
WRIA 54
Public Water System Service and Future Land Use

DATA GAPS

Data gaps that were identified during the technical assessment limit our understanding of hydrologic processes within WRIA 54 and could hinder future water resource management efforts. These include the following:

- Stream Flow
  - With the exception of the Little Spokane River, Latah (Hangman) Creek, and Blue Creek, stream flow data for tributaries to the Spokane River are limited. This limits the understanding of hydrologic processes on a subbasin scale.
  - The amount of surface water entering WRIA 54 from the Little Spokane River is poorly defined because a stream gauge is not located near the Spokane River confluence.
  - The amount of surface water exiting the watershed in the Spokane River cannot be accurately estimated because a backwater portion of the river varies with Lake Roosevelt pool elevation that extends a significant distance into the watershed.
  - Groundwater/surface water interaction is not well defined downstream of Lake Spokane (Long Lake); it could have a significant impact on the watershed-scale water balance.
- Groundwater
  - Previous estimates regarding SVRP discharge to the Spokane River in WRIA 54 are conflicting in the literature and should be reevaluated when the USGS bi-state study is completed.
  - The amount of groundwater entering and exiting the watershed through various aquifers was estimated from existing information and is of limited precision. Accurately delineating groundwater flow on a watershed scale is a massive undertaking. Targeted groundwater studies should be considered by prioritizing aquifers with significant water resource management challenges.
  - Previous hydrogeologic studies in WRIA 54 have focused primarily on the SVRP aquifer and CRBG and paleochannel aquifers within the West Plains area. In the rest of the watershed, the hydrogeology is largely undefined. Data used to estimate aquifer thickness and extent, hydraulic conductivity, and hydraulic gradient for the bedrock and sedimentary aquifer were limited to information provided in a relatively small number of domestic water well reports, boring logs, and regional and local studies.
- Climate
  - Precipitation inputs should be reevaluated with 800-meter resolution PRISM data that were published near the completion of this technical assessment.
  - The coarse scale and the general nature of descriptions for non-agricultural land use data could lead to errors in evapotranspiration estimates and an overestimate for total evapotranspiration.
- Net Demand
  - Population estimates were derived by including all census blocks completely or partially located within the watershed, likely resulting in overestimation.
  - The calculation of total commercial or industrial water right allocations did not incorporate values for water right certificates, permits or claims that did not have a quantity associated with them in the source databases.

Addressing all of these data gaps would be a time-consuming and expensive task that may not be necessary to achieve the water management goals of the WRIA 54 Planning Unit. Targeted investigations that increase understanding of specific subbasins or components of the watershed water balance could provide more short- and long-term benefit.

MODELING CONSIDERATIONS

The construction of a comprehensive hydrologic model (such as the model developed for WRIA 55/57) that encompasses all of the WRIA 54 basin would be a major undertaking and should be initiated only after careful examination of the potential benefits and probable cost. This type of model can be a planning tool to determine the potential impact of future water resource allocations on existing water rights, stream flow, etc. Because of the data gaps identified in the water balance analysis, a significant data acquisition effort would be required before a comprehensive hydrologic model could be constructed for WRIA 54. Significant data collection would be required in portions of the watershed that have relatively limited water resource allocation issues at this time.

It is our opinion that modeling resources would be better spent concentrating investigative efforts in key areas within the watershed that are not addressed by previous and ongoing modeling efforts. A targeted model that likely would provide significant water resource planning benefit for the cost would be a groundwater flow model that encompasses the West Plains area. Such a model could achieve the following objectives:

- Characterization of the extent of groundwater mining in CRBG aquifers under existing conditions and various future scenarios
- Estimation of the groundwater resource potential of the paleochannel aquifers
- Evaluation of the hydraulic connection between the CRBG and paleochannel aquifers
- Estimation of the diminishment or augmentation of groundwater discharge (to the Spokane River and/or its tributaries) as a function of well discharge and development scenarios
- Evaluation of the potential for successful aquifer storage and recovery projects within CRBG and/or paleochannel aquifers.

Alternatively, a larger model grid could be developed to evaluate the groundwater resource potential within the CRBG that includes the southwest portion of WRIA 54 in addition to the West Plains area.

The Spokane Tribe has obtained funding to potentially run the CEQUAL water quality model for the Spokane Arm of Lake Roosevelt, in order to understand the impacts of flow on water quality. This work could be used to further address in-stream flow needs in the non-free-flowing reaches of the Lower Spokane River.

REFERENCES

Allan, R.G., L.S. Pereira, D. Raes, and M. Smith. 1998. Crop evapotranspiration - Guidelines for Computing Crop Water Requirements: United Nations, Food and Agricultural Organization Irrigation and Drainage Paper 56, Rome.

Anderson, K.E. 1951. Geology and Ground-Water Resources of the Rathdrum Prairie Project and Contiguous Area, Idaho-Washington: U.S. Bureau of Reclamation, Kalispell Planning Office, 39 p., 3 pls.

Atwater, B.F. 1986. Pleistocene Glacial-Lake Deposits of the Sanpoil River Valley, Northeastern Washington: U.S. Geological Survey Bulletin 1661, 39 p.

Bolke, E.L. and J.J. Vaccaro. 1981. Digital-Model Simulation of the Hydrologic Flow System, with Emphasis on Ground Water, in the Spokane Valley, Washington and Idaho: U.S. Geological Survey Open-file Report 80-1300, 43 p.

Bredehoeft, J. 1997. Safe Yield and the Water Budget Myth. Ground Water, 35(6):929.

Bredehoeft, J.D., S.S. Papadopulos and H.H. Cooper. 1982. Groundwater: The Water Budget Myth. in Scientific Basis of Water Management, National Academy of Sciences Studies in Geophysics, pg. 51-57.

Bretz, J.H. 1930. Lake Missoula and the Spokane Floods: Geological Society of America Bulletin 41, 92-93.

Broom, H.C. 1951. Gaging Station Records in Spokane River Basin, Washington, from Post Falls, Idaho, to Long Lake, Washington, Including Little Spokane River, Water Years 1948 to 1950: U.S. Geological Survey Open-File Report, 29 p.

Buchanan, J.P. 1992. Hydrogeologic Considerations for the Location of Municipal Water Supply Well Number 6, Cheney, Washington: Report by J.P. Buchanan for the Department of Public Works, City of Cheney, Wash., June, various pages.

Buchanan, J.P., Wozniewicz, JV., and R.H. Lambeth. 1988. Hydrogeology of the Chamokane Valley Aquifer System: Department of Geology, Eastern Washington University, Cheney, WA.

Bureau of Reclamation. 1956. Spokane Valley Project, Washington-Water Supply and Requirements Appendix to Regional Director’s Report: Spokane, Upper Columbia Development Area. January 1956. 110 p.

CH2M Hill. 1998. City of Spokane Wellhead Protection Program Phase I-Technical assessment: CH2M Hill report for the City of Spokane Wellhead Protection Program. 2 vols., variously paged, 12 appendixes.

CH2M Hill. 1998. Hydrogeologic and Geotechnical Report, Draft Environmental Impact Statement, Graham Road Recycling and Disposal Facility Expansion, Appendix E: Spokane, WA; 1998.

CH2M Hill. 2000a, Spokane Aquifer Joint Board Wellhead Protection Program, Management Plan and Report Appendix: CH2M Hill report for the Spokane Aquifer Joint Board, 3 vols., variously paged, 24 appendixes.

Conners, J.A. 1976. Quaternary History of NORTHERN IDAHO and Adjacent Areas: Moscow, Idaho, University of Idaho, Ph.D. dissertation, 504 p.

Crossley, B. personal communication. 2006. Spokane Tribe Department of Natural Resources, Water Resources.

Crosthwaite, E.G., McQueen, I.S., and Nace, R.L. 1970. Interchange of Ground Water and Surface Water, in Nace, R.L., McQueen, I.S., Crosthwaite, E.G., and Pluhowski, E.J. Water Resources of the Spokane-Coeur d'Alene River Basin with Emphasis on the Spokane-Rathdrum Lowlands, Idaho-Washington: Boise, draft report, P. 212-235.

Deobald, W.B., and J.P. Buchanan. 1995. Hydrogeology of the West Plains area of Spokane, County, Washington: Department of Geology, Eastern Washington University, Cheney, WA.

DOH. 2001. Drinking Water Program Overview.

Donaldson, N.C., and J.T. DeFrancesco. 1982. Soil Survey of Stevens County, Washington: U.S. Department of Agriculture, Soil Conservation Service, in cooperation with the Forest Service U.S. Department of the Interior, Bureau of Indian Affairs, Washington State Department of Natural Resources, and Washington State University Agricultural Research Center, 459 p.

Donaldson, N.C., and L.D. Giese. 1968. Soil Survey of Spokane County, Washington: U.S. Department of Agriculture, Soil Conservation Service, in cooperation with the Washington Agricultural Experiment Station. 143 p.

Drost, B.W., and H.R. Seitz. 1978. Spokane Valley-Rathdrum Prairie aquifer, Washington and Idaho: U.S. Geological Survey Open-File Report 77-289. 79 p.

Ecology. 2006. Frequently Asked Questions about Water Right Claims. Washington Department of Ecology.

Ecology. 2006. http//www.ecy.wa.gov/programs/wr/rights/water-right-home.html. Washington State Department of Ecology web page.

Ecology. 2006a. Washington Department of Ecology Web Site. Accessed February 28, 2006 http://www.ecy.wa.gov/apps/watersheds/planning/54.html

Ecology. 2006b. Washington Department of Ecology Web Site. Accessed February 28, 2006. http://www.ecy.wa.gov/services/gis/maps/wria/wria.htm

Ecology. 2006c. Washington Department of Ecology Web Site. Accessed March 1, 2006. http://www.ecy.wa.gov/watershed/misc/background.html

EPA. 2006. http://www.epa.gov/safewater/sdwa/30th/factsheets/understand.html. U.S. Environmental Protection Agency web page.

GeoEngineers, Inc. 2003. Report, Hydrogeologic Evaluation, City of Airway Heights, Airway Heights, Washington: Spokane, Washington, 26 p.

GeoEngineers, Inc. 2004a. Report, Boundary Evaluation, West Plains High-Risk Drainage Area, Spokane County, Washington: Spokane, Washington, 26 p.

GeoEngineers, Inc. 2004b. Report, Water Resource Evaluation, City of Airway Heights, Airway Heights, Washington: Spokane, Washington, 261 p.

Golder Associates, Inc. 2003. Little Spokane (WRIA 55) and Middle Spokane (WRIA 57) Watershed Planning, Phase II – Level 1 Assessment, Data Compilation and Preliminary Analysis. Redmond, Washington.

Golder Associates, Inc. 2004. Final Report to the Little and Middle Spokane Watershed WRIA 55 and 57 Planning Unit, Level 2 Technical Assessment-Watershed Simulation Model: Seattle, Golder Associates, Inc., prepared under Grant no. 9800300, from the Washington Department of Ecology, February 14, 2004. 51 p., 4 appendixes.

Griggs, A.B. 1976. The Columbia river Basalt Group in the Spokane quadrangle, Washington, Idaho, and Montana: US. Geological survey Bulletin 1413, 39 p.;

Hortness, J.E., and J.J. Covert. 2005. Streamflow Trends in the Spokane River and Tributaries, Spokane Valley/Rathdrum Prairie, Idaho and Washington: U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia, 17 p.

James, L.G., J.M. Erpenbeck, D.L. Bassett, and J.E. Middleton. 2001. Irrigation Requirements for Washington, Part 1: Estimates for 39 Crops, Cooperative Extension, Washington State University, 31 p.

Kahle, S.C., Caldwell, R.R. and J.R. Bartolino. 2005. Compilation of Geologic, Hydrologic, and Ground-Water Flow Modeling Information for the Spokane Valley—Rathdrum Prairie Aquifer, Spokane County, Washington, and Bonner and Kootenai Counties, Idaho: U.S. Geological Survey, Scientific Investigations Report 2005–5227; 64 p.

Kimbrough, R.A., G.P. Ruppert, W.D. Wiggins, and R.R. Smith. 2004. Water Resources Data-Washington Water Year 2004, U.S. Geological Survey Water Data Report WA-04-1, U.S. Department of the Interior.

Kimbrough, R.A., G.P. Ruppert, W.D. Wiggins, R.R. Smith, and D.L. Kresch. 2005. Water Resources Data-Washington Water Year 2005: U.S. Geological Survey Water Data Report WA-05-1, U.S. Department of the Interior.

Lane, R.C., and K.J. Whiteman. 1989. Ground-water levels, spring 1985, and ground-water level changes, spring 1983 to spring 1985, in three basalt units underlying the Columbia Plateau, Washington and Oregon: U.S. Geological Survey Water Resources Investigations 88-4018, 4 Sheets.

Lenz, A.T. 1950. Return Flow Rathdrum Prairie Project: Memorandum dated September 1, 1950, Exhibit E, in, Bureau of Reclamation, 1950, Irrigation Water Requirements, Seepage Losses and Return Flows, Rathdrum Prairie Project, Spokane River Basin, Idaho-Washington: Boise, Bureau of Reclamation, Hydrologic Studies Office, Region I, December 20, 1950, p. E1-E16, 12 figs.

Lylerla, Jim. Personal communication. 2006. Washington State Department of Ecology.

Matt, V.J. and J.P. Buchanan. 1993. Aquifer Systems on the Spokane Indian Reservation. Upper Columbia United Tribes Fisheries Center, Fisheries Technical Report Number 37, 107 p.

Monteith, J.L. 1965. Evaporation and the Environment: Symposium of the Society of Exploratory Biology, 19, 205-234.

National Resource Conservation Service. 1996. National Soil Survey Handbook, Title 430-V.: U.S. GPO Printing Office, Washington D.C.

NOAA. 2006. http://www.wrh.noaa.gov/otx/spokane.php. National Oceanic and Atmospheric Administration web page. Accessed April 3, 2006.

Patmount, C.R., Pelletier, G.J., and Harper, M.E. 1985. Phosphorus Attenuation in the Spokane River: Prepared for the Washington Department of Ecology: Seattle, Wash., Harper-Owes, 144 p, available online at http://www.ecy.wa.gov/pubs/85e28.pdf.

Pelton, T. personal communication. 2006. City of Spokane Wastewater Management Department.

Pharris, J., Wilson, M.S., and Reichman, A. 2002. Federal and Indian Reserved Water Rights, A report to the Washington State Legislature by the Office of the Attorney General. 31 p.

Robinson, J.D. 1991. Stratigraphy and Sedimentology of the Latah Formation, Spokane County, Washington: Department of Geology, Eastern Washington University, Cheney, WA.

SAIC, Inc. 1998. Remedial Investigation/Feasibility Study, Site Characterization Summary, Priority 1 Sites, Fairchild AFB, Washington. Prepared for the USAF, Human Systems Division, Brooks AFB, Texas.

SCAS. 2006. http://www.ocs.oregonstate.edu/prism/faq.phtml#anchor536367. Web page accessed April 4, 2006

Schultz, E.F. 1973. Problems in Applied Hydrology. Water Resources Publications: Littleton, Colorado, 501 p.

Sophocleous, M. 1997. Managing Water Resources Systems: Why “Safe Yield” is not Sustainable. Ground Water 35(4):563.

Stevens County Conservation District. 2000. Chamokane Creek Watershed Management Plan. 116 pp.

Stockinger, G. personal communication. 2006. Avista Corporation

Stockman, D.D. 1981. Soil Survey of Lincoln County. U.S. Department of Agriculture, Soil Conservation Service, in cooperation with Washington State University Agricultural Research Center, 167 p.

Taubeneck, W.H. 1970. Dikes of Columbia River Basalt in Northeastern Oregon, Western Idaho, and Southeastern Washington. Columbia River Basalt Symposium, 2d. Cheney, WA, 1969, Proc., p. 73-76.

U.S. Department of Agriculture. 2002 Census of Agriculture. U.S. Department of Agriculture

U.S. Geological Survey. 2003. http://sagemap.wr.usgs.gov/ftp/washington/DNR/wau.htm, March 20 2003. Web paged accessed March 7, 2006.

U.S. Geological Survey. 2003. Water Resources of the Ground-Water System in the Unconsolidated Deposits of the Colville River Watershed, Stevens County, Washington. Water Resources Investigations Report 03-4128.

U.S. Geological Survey. 2006. National Water Information System Website: U.S. Department of the Interior, Reston, Virginia

Waitt, R.B., Jr., and R.M. Thorson. 1983. The Cordilleran Ice Sheet in Washington, Idaho, and Montana, in Wright, H.E., and Porter, S.C., eds., Late-Quaternary environments of the United States, v. 1.: Minneapolis, University of Minnesota Press, p. 53-70;

Washington State Legislature. 2006. http://apps.leg.wa.gov/WAC/default.aspx?cite=246. Web page accessed June 6, 2006.

Washington State Legislature. 2006. Web Site. http://www1.leg.wa.gov/legislature/ Accessed March 1, 2006.

Whiteman, K.J., J.J. Vaccaro, J.B. Gonthier, and H.H. Bauer. The Hydrogeologic Framework and Geochemistry of the Columbia Plateau Aquifer System, Washington, Oregon, and Idaho: U.S. Geological Survey Professional Paper 1413-B, U.S. Department of the Interior, Reston, VA; 1994.