Water Resource Inventory Area 54 (Lower Spokane) Watershed Plan

Multi-Purpose Water Storage Assessment

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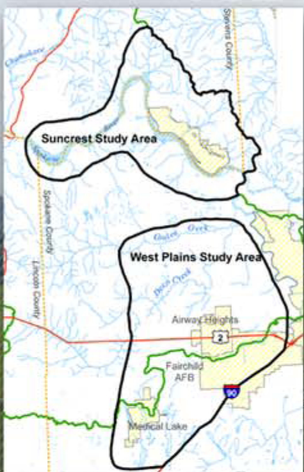

Prepared for

WRIA 54 Watershed Planning Unit

Lead Agency:

Spokane County

Ecology Grant No. G0700115

May 2007

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***Lead Agency:* Spokane County**

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WRIA 54 Planning Unit
WATER RESOURCE INVENTORY AREA 54 (LOWER SPOKANE) MULTI-PURPOSE WATER STORAGE ASSESSMENT

DRAFT

MAY 2007

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Project #3640028

WRIA 54 Planning Unit
Water Resource Inventory Area 54
Multi-Purpose Water Storage Assessment

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CHAPTER 1.
INTRODUCTION

This Multi-Purpose Water Storage Assessment is a comprehensive review of the current storage and potential future storage opportunities in 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 Washington's Watershed Management Act (Revised Code of Washington 90.82), also known as a "2514 Watershed Plan." This report summarizes a survey-level study to examine multi-purpose water storage options that could be part of meeting the future needs of domestic, agricultural, and commercial/industrial uses.

WATERSHED MANAGEMENT PLAN

The Multi-Purpose Water Storage Assessment is part of 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 WPU. The planning group will use the data assembled for this assessment to make recommendations for water storage for future human consumption needs. These recommendations will be outlined in a watershed plan for WRIA 54, to be completed by 2009.

Phase 1 of the planning effort—organization of the WRIA 54 planning unit is complete. This phase developed a mission statement and established goals, objectives, and the scope of work for Phase 2. Phase 2 Level 1 of the planning effort—data compilation and technical assessment (Tetra Tech, 2007)—is also complete; other aspects of Phase 2 are still ongoing. Phase 2 Level 1 consisted of collecting and analyzing water and geographical data in the WRIA including the following:

- Creating a water balance:
  - Gathering flow data for all rivers and tributaries
  - Characterizing and detailing groundwater aquifer availability and interaction with surface flow
  - Assembling water use and water rights data
- Studying population and land use distribution.

Conclusions from the Level 1 study helped to identify potential future water sources and areas of limited water resources. The continuing Phase 2 work includes instream flow and water quality studies. The final phase of the watershed plan, Phase 3, will recommend and identify alternative solutions for future management of the basin. The watershed plan will include all study phases.

MULTI-PURPOSE WATER STORAGE ASSESSMENT OBJECTIVES

The objectives of the Multi-Purpose Water Storage Assessment are as follows:

- Identify the types of storage projects that would be useful in the watershed, given the current and future water supply and demand.
- Assess the full range of storage alternatives and identify potential locations for off-channel storage, instream storage, underground storage, and enlargement or enhancement of existing storage. Both large- and small-scale storage options should be considered.

- Include an inventory and assessment of the water storage infrastructure needs, including public and private water systems and irrigation systems.
- Consider how to balance the full range of potential uses for stored water.
- Identify potential environmental effects associated with each storage alternative.

These objectives were met through this Multi-Purpose Water Storage Assessment which is comprised of two elements:

- WRIA-wide screening for water storage needs and opportunities.
- Conceptual evaluation of water storage alternatives in two areas of the WRIA.

The WRIA-wide screening provides an overview of the full range of possible water storage projects. These projects include structural and nonstructural projects, surface water and groundwater projects, and projects that are both large and small in scale.

The Multi-Purpose Water Storage Group, a subcommittee of the WRIA 54 Planning Unit selected two special study areas to be the focus for more detailed water storage assessment:

- The West Plains, a rapidly urbanizing region on the uplands west of Spokane
- Suncrest area, defined as the region along the Spokane River and Lake Spokane (Long Lake) downstream from Spokane.

Following initial screening and a review of future water needs, the Multi-Purpose Water Storage Group directed this study to focus primarily on the West Plains Study Area rather than Suncrest, because of the declining water level and critical water need situation on the West Plains.

WRIA 54 WATERSHED CHARACTERISTICS

WRIA 54, an 885-square-mile watershed in eastern Washington, encompasses portions of the City of Spokane, Spokane County, Stevens County, Lincoln County, and 90 percent of the Spokane Indian Reservation (see Figure 1-1). The watershed consists of 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 the Spokane River, which flows east to west through the middle of WRIA 54.

The Spokane River enters WRIA 54 at the confluence with Latah (Hangman) Creek and exits WRIA 54 at the river's mouth, where it drains to the Columbia River. The main stem of the Spokane River is by far the largest surface water body in the WRIA. The most important aquifer in the region is the SVRP Aquifer, a small part of which extends into the southeast corner of WRIA 54. This aquifer is a major water supply source for direct groundwater pumping and recharge of the Spokane River. One of the more significant points of groundwater discharge from the Spokane Valley Rathdrum Prairie (SVRP) Aquifer to the Spokane River appears to be between Latah (Hangman) Creek and the Nine Mile Falls.

Much of WRIA 54 is underlain by basalt deposits that are hundreds to thousands of feet thick. This formation is known as the Columbia River Basalt Group (CRBG). Much of the CRBG has stacked, confined aquifers and relatively high well yields. Groundwater also occurs in the fractured or weathered zones of basement rocks underlying parts of the CRBG, and in 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 sediment and CRBG aquifers are not available. The permeability, transmissivity, and storage properties of the basement rock aquifers generally are low, making them only suitable for small water supply needs.

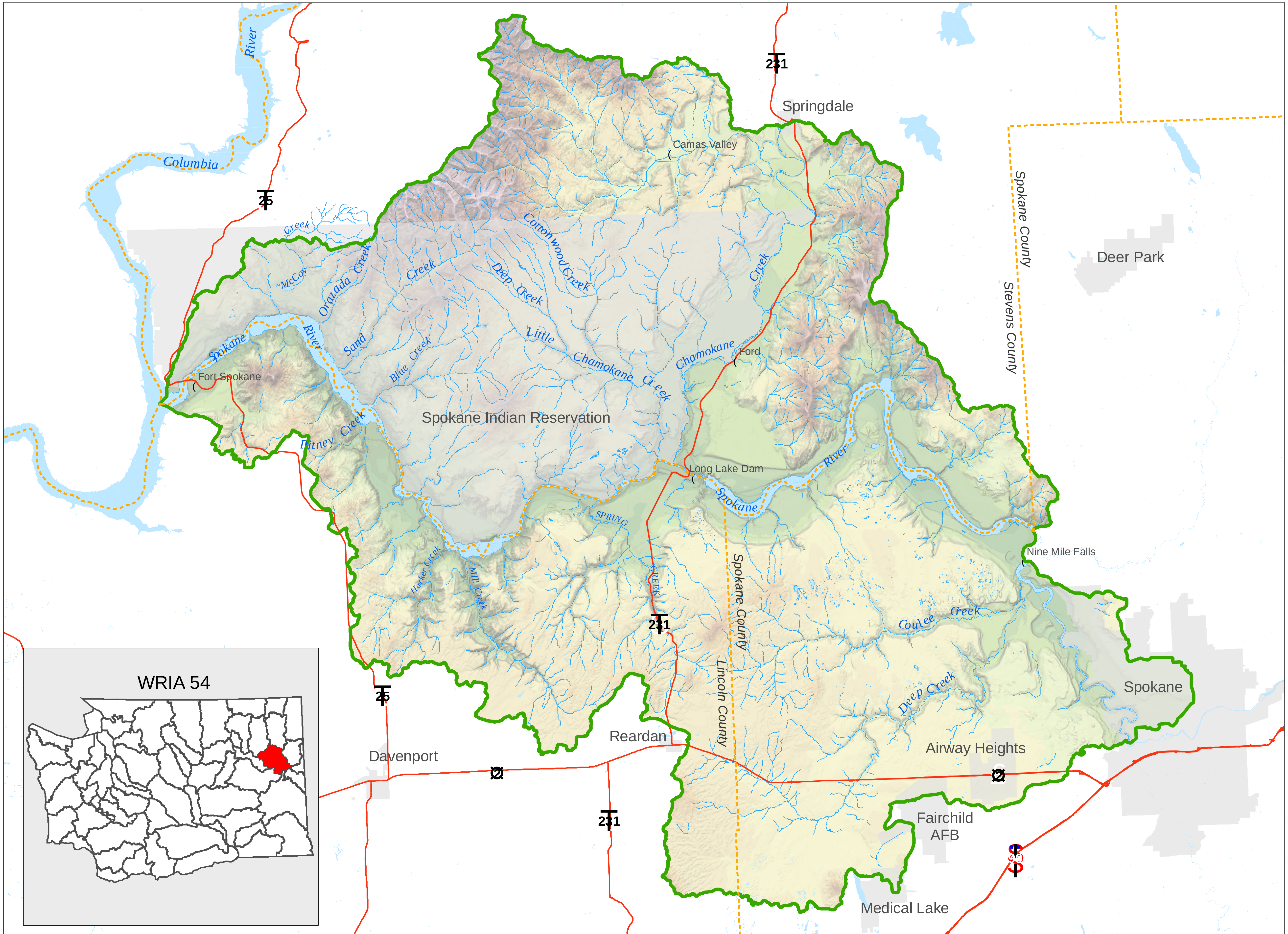

Figure 1-1
WRIA 54 General Site Map

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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Map Produced 1/16/2007

Most of WRIA 54 is rural and the population is dispersed across a large area. The year 2000 population of WRIA 54 was 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.

Future consumptive water needs, which are anticipated to be primarily for domestic supply, are expected to increase by approximately 33 percent by 2025, based on WRIA 54 growth projections. As determined in the Phase 2 Level 1 study, there is sufficient water in most areas to meet water needs into the future with existing sources. However, groundwater level declines in CRBG aquifers in the area known as “the West Plains”- west of Spokane and including Airway Heights, Fairchild AFB, and Medical Lake has led to concern about the ability to provide for water needs in this region.

SPECIAL STUDY AREAS

The Phase 2 Level 1 work concluded that the major population growth will likely be focused in two areas—the West Plains and Suncrest regions (see Figure 1-2)—making the likely actual increase in water demand more in those two areas. In the Chamokane Creek area, on the other hand, population growth is not expected to be significant, but the area’s growth is stifled by lack of access to water rights. Many municipal purveyors hold inchoate water rights (rights that are not currently fully used) that may help meet future demand in WRIA 54. The magnitude of inchoate rights differs among purveyors, however, and is not necessarily matched to where actual growth in water demand will occur.

The Multi-Purpose Water Storage Assessment consists of a WRIA-wide screening to identify feasible water storage needs and opportunities for all of WRIA 54, as well as conceptual evaluations of water storage alternatives for the West Plains, Suncrest and Chamokane Creek areas. The West Plains area lies just west of the City Spokane and includes Fairchild Air Force Base (AFB) and the Cities of Airway Heights and Medical Lake. The Suncrest area lies along Long Lake northwest of the City of Spokane. The Chamokane Creek drains from the north to empty into the Spokane River just west of Long Lake Dam.

COLUMBIA RIVER INITIATIVE

The Columbia River Basin is affected by a variety of water resource management problems that limit the availability of water for human consumption, agriculture, and instream flows. Hundreds of water rights for new diversions have been submitted and some have been pending for over a decade. The Washington State Legislature determined that a priority for water management in the Columbia River Basin is the development of new water supplies, and in 2006 the Legislature enacted the Columbia River Water Management Act (subsequently codified as Chapter 90.90 in the Revised Code of Washington (RCW)). The act provides funding for storage and conservation measures in order to meet the economic and community development needs of people and the stream flow needs of fish. Money may be used to “assess, plan, and develop new storage, improve or alter operations of existing storage facilities, implement conservation projects, or any other actions designed to provide access to new water supplies within the Columbia River basin for both instream and out-of-stream uses” (Chapter 90.90 RCW). In the first year, $6 million is provided solely for feasibility studies related to off-stream storage projects and $10 million is available to begin implementation of the program. A new appropriator of water has 15 years to develop and put the water to beneficial use.

Although WRIA 54 lies in the Columbia River Basin, it is not eligible for new water right applications under this new funding because the law requires the point of withdrawal to be within a mile of the main stem of the Columbia River. Water supply projects in the tributaries to the Columbia River such as the

Spokane River, on the other hand, are allowed to submit for funding. These projects would be eligible if they are creating new storage capacity that can subsequently supply water to the Columbia River. One third of the newly created storage must be used for Columbia River instream flows and cannot be used in the tributary subbasin.

RELATED MULTI-PURPOSE WATER STORAGE ASSESSMENTS

Separate watershed management plans were created for the other WRIAs in the Spokane River drainage basin (WRIAs 55, 56, and 57). WRIA 57 consists of the portions of the drainage basin of the Spokane River upstream of the confluence with Hangman Creek and within Washington State. WRIA 55 includes the Little Spokane River. WRIA 56 is the portion of the Hangman Creek drainage basin in Washington.

The Multi-Purpose Water Storage Assessment for WRIAs 55 and 57 was a joint effort and investigated storage alternatives to enhance existing stream flow and prevent future decreases in low summer flows that could occur with increased water use and supply reliability. The assessment was completed in two phases: an initial broad assessment of potential storage options in the WRIAs; and a focused assessment of three specific storage options:

- Aquifer storage and recovery (ASR) in the lower Little Spokane Watershed (WRIA 55)—Using the SVRP as a source of water and the Lower Sand and Gravel Aquifer in the vicinity of the confluence of Deadman Creek and the Little Spokane River as the receiving water body. The qualities of the source and receiving waters appear compatible. The aquifer is confined and well bounded but the degree of hydraulic conductivity between this portion of the aquifer and the rest of the SVRP is the primary variable of least confidence.
- Surface storage on Beaver and Buck Creeks—These potential new reservoirs would be used to retain peak flows to release for summer stream flow augmentation and potentially benefit junior water right and/or inchoate water right holders. The balance between these two objectives, and additional studies of environmental impact would be critical if this option were to be pursued.
- Restoration of the Saltese Flats, with a focus on using the Flats as discharge site for reclaimed water—Restoration is expected to provide a significant increase in habitat. However, existing data is insufficient to confidently define the rate of recharge through the Flats and the extent of hydraulic connectivity with the Spokane Valley-Rathdrum Prairie (SVRP) Aquifer. The Flats appear to have a wide range of restoration options, in terms of size and configuration. To maximize the available opportunities, it will be necessary to coordinate with several interested agencies and objectives.

The Multi-Purpose Water Storage Assessment for WRIA 56 identified a range of possible water storage options, and several options were selected for evaluation in greater detail:

- Stream flow augmentation with groundwater at four sites—Before implementation, pilot tests would need to be conducted and water levels monitored. The program could be sustainable if the augmentation rate is a negligible amount of total groundwater recharge.
- Two wetland complexes identified for restoration and water storage—The restoration could increase soil moisture and attenuate high flows. The exact amount of water storage that could be provided is still unknown.
- Designing and building catchment basins—Catchment basins are shallow excavations (less than 4 feet deep) in areas near streams and are designed to capture surface water runoff and allow it to infiltrate to groundwater.

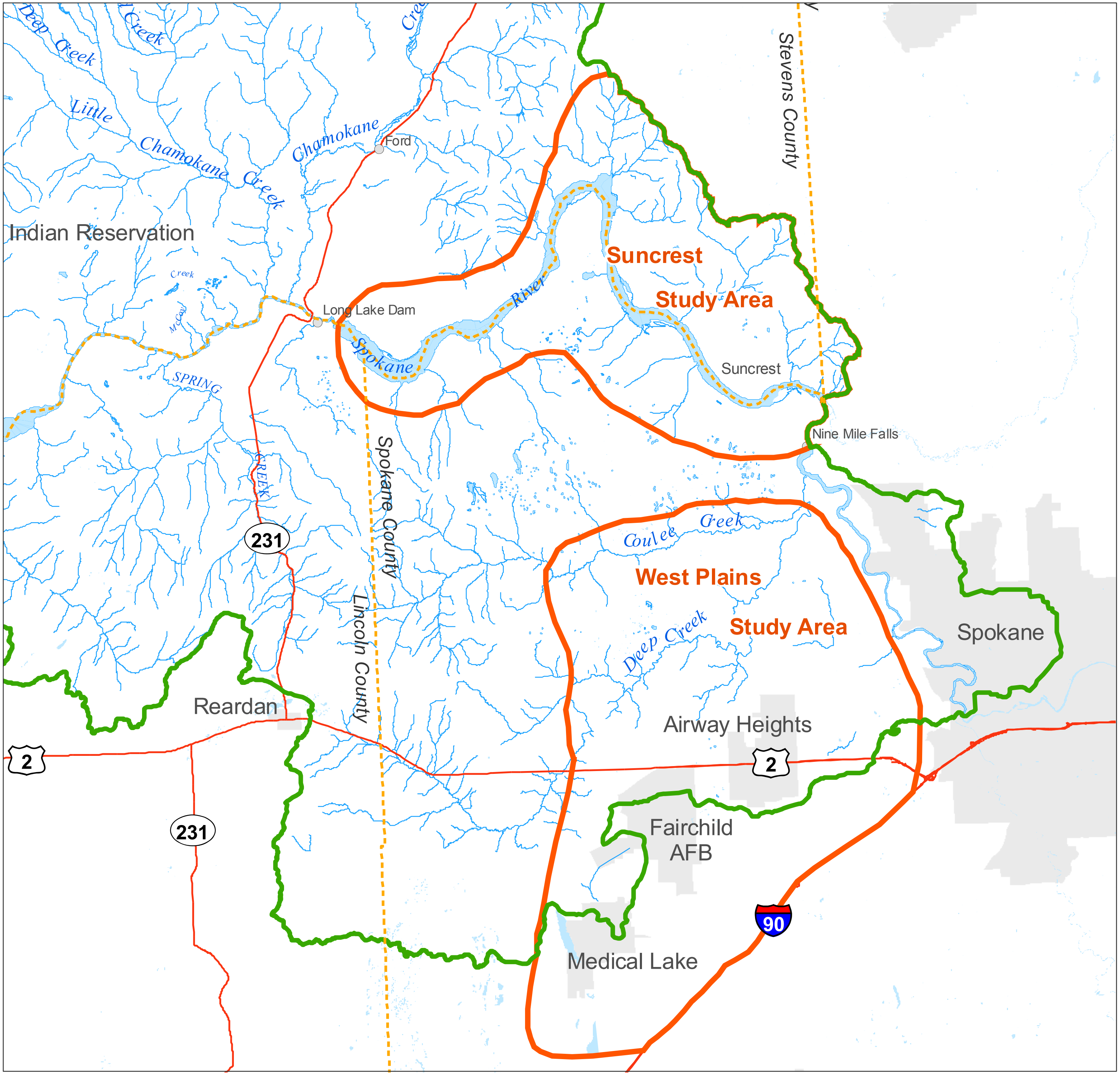

Figure 1-2

Water Storage Assessment Study Areas

Legend

- Major Road
- County Boundary
- Stream
- WRIA54 Boundary
- Study Area Boundary
- Unincorporated Area
- Waterbody
- Jurisdiction

Data Sources:
Streets, Waterbodies, Streams, County Boundary, Spokane Indian Reservation - Washington DNR
Juristictions - County Data
WRIA Boundary - Washington DOE
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Map Produced 05/16/2007

- Two potential new dam sites—One of these sites is near the town of Spangle and the other is on Smith Creek.

No one storage option will completely satisfy the wide range of physiographic features and needs of the Hangman watershed, so multiple options are likely the most appropriate water storage solution. The most cost-effective options for augmenting stream flow are the stream flow augmentation with groundwater option and wetland restoration. However, these options will only enhance flows in the lower and middle portions of the WRIA. The only options that provide stream flow augmentation to all areas of the WRIA are the catchment basins in the upper watershed and Smith Creek Dam development.

CHAPTER 2.
WRIA-WIDE SURVEY

This WRIA-wide study assesses a range of storage-related projects that warrant further consideration and was based on a review of existing information. No new analyses were conducted for this report, so the level of detail for projects identified in this report depended on the information available. In some instances, projects would require considerably more investigation before a final determination could be made as to their feasibility.

Water storage opportunities can be placed into two categories: structural and nonstructural. Structural alternatives involve physical modifications at a specific site and nonstructural alternatives derive their benefit from policies, studies or other activities that involve no physical alteration or construction. Nonstructural alternatives may not immediately or directly create water storage, but they help restore and maintain base flows and/or address water needs through a new or alternative approach. Depending on the volume of the potential water storage, the opportunities may also be classified as large-scale or small-scale.

The following structural alternatives were assessed for WRIA 54:

- Enhanced surface storage
  - Instream reservoirs and impoundments
  - Off-channel reservoirs
  - Natural lakes
  - Wetlands
  - Beaver ponds
  - Balancing basins
- Enhanced surface water recharge to groundwater
  - Aquifer storage and recovery
  - Direct injection to groundwater without recovery
  - Farm field flooding
  - Distributed small-scale catchment basins
  - Stormwater infiltration, including low-impact development
- Direct pumping to surface water
- Reclaimed water use
- Increased connectivity.

The following nonstructural alternatives were assessed for WRIA 54:

- Water conservation policies and projects
- Water rights transfers.

The broad initial list of prospective project types was pared down based on criteria and input from the WRIA 54 Multi-Purpose Water Storage Group.

STRUCTURAL ALTERNATIVES

Enhanced Surface Storage

Instream Reservoirs and Impoundments

The most traditional types of water storage are instream impoundments (dams) and reservoirs. While most large dam sites in WRIA 54 have been used, there is potential for smaller new dams or modification of existing dams to store more water. Water storage can also be increased by modifying the management and operational procedures of existing dams.

The advantages and disadvantages of modifying existing instream impoundments are as follows:

- Advantages:
  - Lower construction and operation costs than for new impoundments
  - Less additional land required than for new impoundments
- Disadvantages:
  - Reduced flows available for power generation during some parts of the year
  - Structural modifications of dams may be required
  - Permitting requirements
  - Flooding of additional land area.

The advantages and disadvantages of constructing new instream impoundments are as follows:

- Advantages:
  - Potential for larger gains in storage than through modification of existing impoundments
  - Availability of water in areas without prior access to stored water
  - Well-controlled rate of release
- Disadvantages:
  - Complex and contentious locating and permitting process
  - Limited potential sites
  - Sedimentation reducing storage capacity of impoundment over time
  - High construction, operation, and maintenance costs
  - Increased loss of water to evaporation and infiltration
  - Potential for increase in water temperature adversely affecting aquatic ecosystems.

Off-Channel Reservoirs

Off-channel reservoirs differ from instream reservoirs because they are constructed away from the river channel that supplies water to the reservoir. These tend to be much smaller than instream projects. Examples of off-channel reservoirs in WRIA 54 include Group A system storage tanks and off-channel water supply reservoirs. Options for increasing storage in off-channel reservoirs include structural and management modifications of existing reservoirs as well as construction of new reservoirs. Advantages of off-channel reservoirs include the following:

- Increased flexibility in locating reservoir
- Reduced impact on river channel supplying water
- Reduced loss of water to evaporation or infiltration if reservoir is lined or covered
- Reservoir can be sited close to water needs
- Flexible sizing based on local water needs.

Disadvantages of off-channel reservoirs include the following:

- Water must be conveyed to the reservoir to fill it
- High construction, operation, and maintenance costs
- Location and permitting issues
- Intensive land use
- Evaporation or infiltration losses if the reservoir is uncovered or unlined.

Natural Lakes

Reservoir lakes are designed to hold significant amounts of water, but naturally occurring lakes also control large volumes of water. Like a reservoir, natural lakes can be modified through the use of impoundments to increase the volume of water that can be stored. Advantages to increasing natural lake storage include the following:

- Pre-existing storage area
- Relatively low cost.

Disadvantages include the following:

- Sedimentation
- Damage to existing lake and wetland habitat
- Permitting issues
- Impacts on adjacent properties.

Wetlands

Wetlands are lands that are inundated or saturated by surface water or groundwater often enough to have dominant vegetation types that are adapted for saturated soil conditions. Using existing wetlands for storage has many of the same advantages as using a natural lake for storage. Wetland storage can also be increased by use of impoundments. Additional wetlands can also be created by restoring previously drained wetland areas. Restoring historical wetlands offers the additional benefit of restoring wetland habitat. Water stored in a wetland can be released into streams during low flow periods or, depending on the soil type, simply infiltrate into the ground, recharging an underlying aquifer. The ability of wetlands to remove sediment and nutrients from water increases instream water quality.

Wetlands offer many environmental benefits compared to the other storage options. Key advantages of using wetlands as storage include the following:

- Nutrient and sediment removal, improving water quality

- Pre-existing, partially flooded sites
- Improved wildlife habitat
- Low cost.

Key disadvantages of using wetlands as storage include the following:

- Poor control of water release rate
- Potential increased water temperature
- Relatively small water storage volumes.
- Relatively low cost
- Creation of temporary wetland habitat.

Beaver Ponds

As beavers create dams along streams for their own purposes, they can also enhance water storage within a watershed. Beaver dams flood low-lying areas upstream of the dam, creating wetlands. The wetlands store water, increasing water residence times within the watershed. The water stored in wetlands can also infiltrate to recharge groundwater. Wetlands created by beavers trap sediment and remove nutrients improving surface water quality. The flooding created by beaver dams, however, can also damage human-made structures such as roads and agricultural fields. For this reason, promoting beaver activity to increase water storage should only be attempted in parts of the watershed where there is little human activity or development. Advantages of beaver dams include the following:

- Low cost
- Creation of new wetland habitat
- Improvements in water quality.

Natural storage options that have environmental benefits are often preferable, but beaver ponds also have disadvantages as storage opportunities, including the following:

- Relatively small amounts of water stored
- Stored water not directly available for human use
- Limited areas where beaver activity can be enhanced are typically far from the highest water needs.

Balancing Basins

Balancing basins are shallow excavations that retain water for later release to streams to augment flow during low-flow periods. Infiltration is not a goal of balancing basins, so they can be used where soil or aquifer characteristics are not favorable for infiltration, such as areas with high clay percentages in the soils or areas with bedrock near the surface. The advantages include the following:

- Relatively low cost
- Small-scale projects that require little land area

Disadvantages include the following:

- Low amount of water captured
- Subject to sedimentation

- Potential for water loss by evaporation.

Enhanced Surface Water Recharge to Groundwater

The purpose of enhanced surface water recharge to groundwater is to raise groundwater levels and increase the residence time of water in the watershed. This goal can be accomplished through a variety of methods. Infiltration ponds can be used to capture overland flow before it enters streams to allow it to infiltrate into the ground. Infiltration galleries are layers of gravel placed underground containing perforated piping connected to water collection structures at the surface. Conduits direct water into the perforated piping, which then passes into the gravel layer and recharges groundwater. Infiltration galleries work best in sand and gravel aquifers. The following sections describe methods of enhancing surface water recharge to groundwater.

Aquifer Storage and Recovery

Aquifer storage and recovery **(**ASR) is a relatively new technology involving the artificial storage of water in an underground geological formation through injection, surface spreading or infiltration, with subsequent withdrawal and use of the stored water. In most large-scale ASR projects, water is pumped via wells directly into an aquifer during periods of high water availability. Water is then recovered from the aquifer when it is needed by pumping the water from the injection well or other suitably located well. The aquifer essentially functions as a water bank. Deposits are made in times of surplus, typically during the rainy season, and withdrawals occur when available water falls short of demand. ASR can be especially beneficial in areas where water availability is limited on a seasonal basis.

Aquifer storage and recovery has the advantage of reduced evaporation losses, compared to water storage in open reservoirs. Appropriate locations for ASR are limited to areas with aquifers capable of high injection and withdrawal rates. ASR projects are technically challenging and relatively expensive. Care must be taken to ensure that water injected into the aquifer is clean to avoid contamination of the aquifer. Key advantages of this technology include the following:

- Reduced evaporation losses compared to open water reservoirs
- Protection of stored water from runoff contamination
- Minimal damage to the surface environment
- Small land area requirements.

Key disadvantages include the following:

- Potentially technically complex to implement
- Relatively expensive to implement and operate
- High quality standards for injected water often require water treatment prior to injection
- Specific aquifer characteristics required
- Extensive site evaluation required.

Direct Injection to Groundwater without Recovery

Direct injection to groundwater is similar to ASR except that water injected into the aquifer is not removed directly from the aquifer for use but is allowed to raise the groundwater levels. By injecting water into the aquifer rather than letting it flow in a stream channel, the residence time of the water in the watershed is increased. The purpose of direct injection without recovery would be to allow the injected water to augment stream flow during low flow periods. This technology is therefore best suited in locations close to streams and for aquifers where the discharge path to the stream is well understood. The best understood aquifers tend to be sand and gravel aquifers as opposed to fractured rock aquifers in which groundwater flow paths are more difficult to predict. The advantages and disadvantages are similar to ASR but the additional disadvantages include the following:

- Difficulty in predicting groundwater flow paths
- Difficulty in predicting discharge rates to the target stream.

Farm Field Flooding

Farm fields with nearby streams can be flooded during periods of high stream flow when the fields are lying fallow. Spreading stream water over fields allows the water to infiltrate and recharge underlying aquifers. This technique works best for fields consisting of soils with high infiltration rates above unconfined aquifers. Water that recharges underlying aquifers can be recovered from the aquifer later or allowed to discharge to streams to augment flows during low flow periods. Advantages of flooding fields to recharge groundwater include the following:

- Nutrient and sediment removal, improving water quality
- Pre-existing sites
- Low cost.

Farm field flooding has many of the same advantages as wetland storage but has additional drawbacks that include the following:

- Significant land area requirements
- Decreased agricultural production
- Alteration of riparian habitat
- Summer storage unavailable
- Requires specific soil and aquifer characteristics
- Potential leaching of agricultural chemicals into the groundwater system.

Distributed Small-Scale Catchment Basins

Small-scale catchment basins are shallow excavations (less than 4 feet deep) in areas adjacent to or near streams. Catchment basins are designed to capture surface water runoff from adjacent hillsides and allow it to infiltrate to groundwater. Because of their ability to trap sediment in addition to water, catchment basins work best in areas of low sediment yield. The advantages include the following:

- Relatively low cost
- Small-scale projects that require little land area

Disadvantages include the following:

- Low amount of water captured
- Sedimentation
- High infiltration rate soils required.

Stormwater Infiltration

Instead of allowing stormwater to enter a municipal sewer system, stormwater can be allowed to infiltrate into the ground, recharging local aquifers. Stormwater infiltration is best used in developed areas with large amounts of impervious surfaces that generate runoff. It helps maintain the natural hydrology of developing areas and is better than the traditional capture, piping and conveyance of stormwater. Low Impact Development (LID) has emerged as a highly effective and attractive approach to controlling stormwater pollution and protecting developing watersheds and already urbanized communities throughout the country. LID is a good onsite method for managing stormwater. LID uses vegetation and small-scale hydrologic controls (structures such as infiltration basins, infiltration galleries and dry wells) to capture, treat, store and infiltrate runoff on-site. Several LID practices and principles, particularly the source control approach and the use of micro-scale integrated management practices have the potential to work effectively as stormwater quality retrofits in existing ultra urban areas as well.

In some cases onsite management of stormwater in infeasible and so managing stormwater on a regional level is preferred. Regional stormwater management planning addresses water quality and water quantity issues on a watershed basis. Regional stormwater management plans aim to minimize flooding, eliminate nonpoint source pollution, and assist municipalities and developments in better managing their stormwater. Allows for focusing on issues for an entire watershed and how each municipalities' actions impact other municipalities.

The benefits of using stormwater infiltration include the following:

- Relatively inexpensive
- Low land use requirements
- Reduced stormwater load on sewage systems.

The major shortcoming for stormwater infiltration is the potential for groundwater contamination from material rinsed from roads or other developed areas. In addition, it may not be feasible in areas where soil infiltration rates are low.

Direct Pumping to Surface Water

Direct pumping of groundwater to surface water would be used to augment stream flow during low flow periods. Augmenting stream flow during critical periods could reduce the chance that instream water rights would be cut off for more junior water users. Groundwater could also be pumped to lakes, ponds, or wetlands to maintain water levels in those surface water bodies. Advantages of direct pumping of groundwater to surface water include the following:

- High water quality and low sediment load of water added to stream
- Consistent water levels maintained in surface water bodies
- Minimal additional land used, compared to other water storage options.

Disadvantages of direct pumping of groundwater to surface water include the following:

- Expense of construction and operation of groundwater wells and pumps
- High productivity aquifer required for well
- Potential impact on groundwater levels in aquifer.

Reclaimed Water Use

Reclaimed water is effluent derived in any part from sewage from a wastewater treatment system that has been adequately treated so that it is no longer considered wastewater and is suitable for a beneficial use that would not otherwise occur. Water reuse is the use of reclaimed water. The use of reclaimed water reduces the need for new water supplies. Although reclaimed water cannot be used in all situations it may be used in several types of irrigation, supplementing groundwater, and recharging wetlands. The major advantage of using reclaimed water is that it frees up existing water supplies for potable uses. The drawbacks to using reclaimed water are as follows:

- Difficulty in gaining public acceptance because it is a new technology
- Potential storage issues
- Additional costs and safety concerns (need for separate pipe system).

Increased Connectivity

Increased connectivity involves physically connecting water purveyors via pipelines. Simply using the existing water more effectively could delay the need for additional physical storage or new water sources for a long time. Several areas are already connected via interties, both for emergencies and for regular use. Increasing the ease of moving water among systems could allow for current water storage volumes to serve a much wider area. Benefits include the following:

- Easy technology
- Beneficial use of inchoate water rights.

Potential problems with increased connectivity include the following:

- Still need enough water rights
- Cooperative arrangements and pricing need to be negotiated between participants.

NONSTRUCTURAL ALTERNATIVES

Water Conservation

Water conservation is a critical component of meeting existing and future water needs, including instream and out-of-stream uses. Increased conservation reduces the amount of water being withdrawn from surface water and groundwater sources, leading to reduced impact on water supply sources. Using water efficiently is particularly important during summer months when rainfall is scarce and customer demand is high. The most beneficial reason for water conservation is that existing water resources can be extended for many more users and into the future. The only potential drawback to some conservation techniques is requiring widespread public participation.

Water Rights Transfers

The growing demand on water resources and the difficulty in securing new water rights have shifted the emphasis from appropriation of new rights to reallocation of existing water supplies to new uses. Water rights transfers are the buying and selling of water rights among users. Often, one user in an area has a significant amount of inchoate water rights while another user is in need of water. Transferring water rights is closely tied with increased connectivity, because the transferred water right must come from the "same body of water" and often this water must be piped once it is pumped. The additional disadvantages of transferring water rights and not just increasing connectivity are that the applicants must prove the following to the Washington Department of Ecology:

- The existing water right is valid.
- Changing location will not impair existing rights.
- The requested change is in the public interest (groundwater rights only).
- The intended purpose of the use is beneficial.

CHAPTER 3.
STUDY AREAS OVERVIEW

The West Plains and Suncrest regions were identified in the Phase 2 Level 1 Assessment as regions where future water needs may strain ability to provide water, due to a variety of physical, natural resource and environmental factors. Both of these regions are experiencing significant urban/suburban development associated with their proximity to the City of Spokane and could benefit from additional storage opportunities.

Washington's Growth Management Act (GMA), adopted in 1990 to balance the needs of economic development and environmental preservation, established Urban Growth Areas (UGAs) as areas where growth is to be encouraged and can be supported with adequate facilities, such as sewer and water. UGAs are created to accommodate growth in a cost-effective manner. The West Plains and Suncrest study areas encompass most of the proposed UGAs (Figure 3-1). Spokane County did not propose expansion of UGAs in 2006, but it will likely review expansion plans in 2007 (Capital Facilities Plan, 2007).

The West Plains and Suncrest areas are both predicted to change dramatically in the next 20 years. The distribution of current land use is shown Figure 3-2. Current land use data was acquired from the U.S. Geological Survey (USGS) and was developed based on aerial photos taken in 1992. Although these photos are 15 years old they are the most current land use data available. Future land uses were determined based on zoning designations. The zoning data represents a conceptual idea of buildout conditions, rather than projections of growth that is actually expected to occur.

Figures 3-3 through 3-6 show the land use breakdown for current and future use in West Plains and Suncrest. According to the projections, current forest cover and open land cover in the West Plains area will be taken over by growing agriculture, low-intensity residential and commercial/industrial areas. A similar trend is predicted for the Suncrest area, but with an even greater growth in low-intensity residential land use.

Water storage opportunities in the Chamokane Creek drainage are also presented as a distinct study area. While not designated as a special study area, the Chamokane Creek drainage has been recognized in the Phase 2 Level 1 Assessment and by the Planning Unit as an area where lack of access to water is impacting the local community.

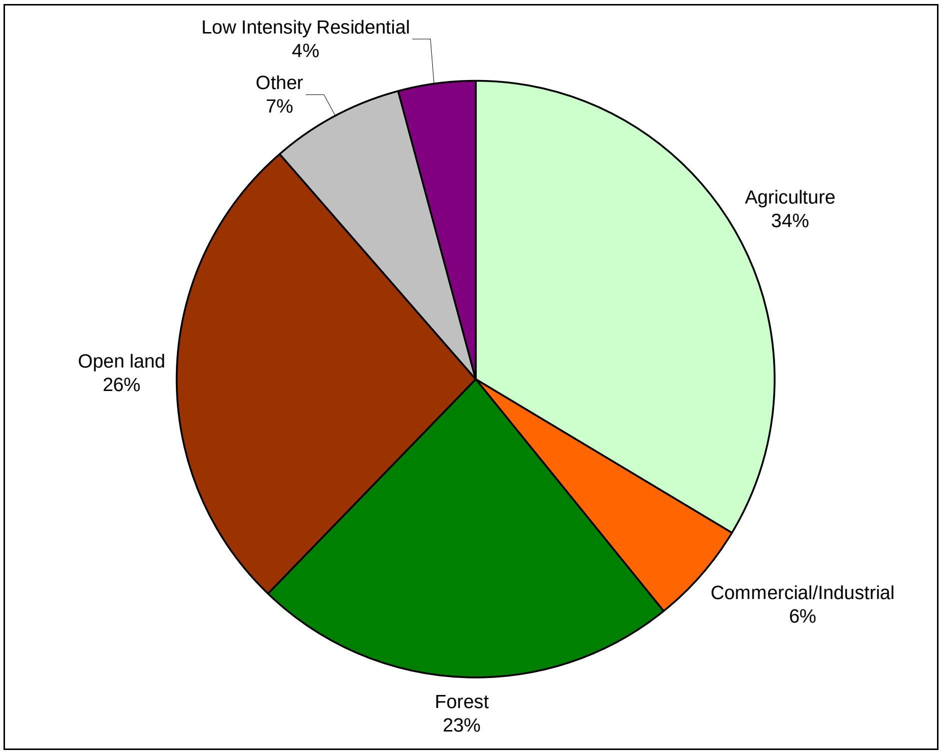

Figure 3-3. West Plains Current Land Use

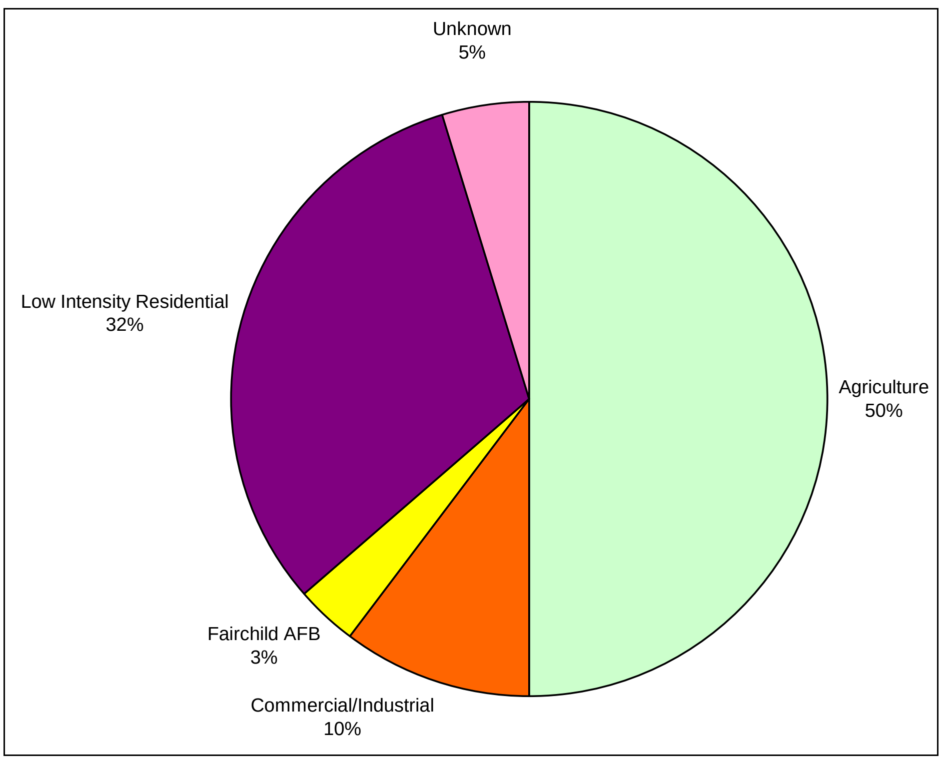

Figure 3-4. West Plains Future Land Use Zoning

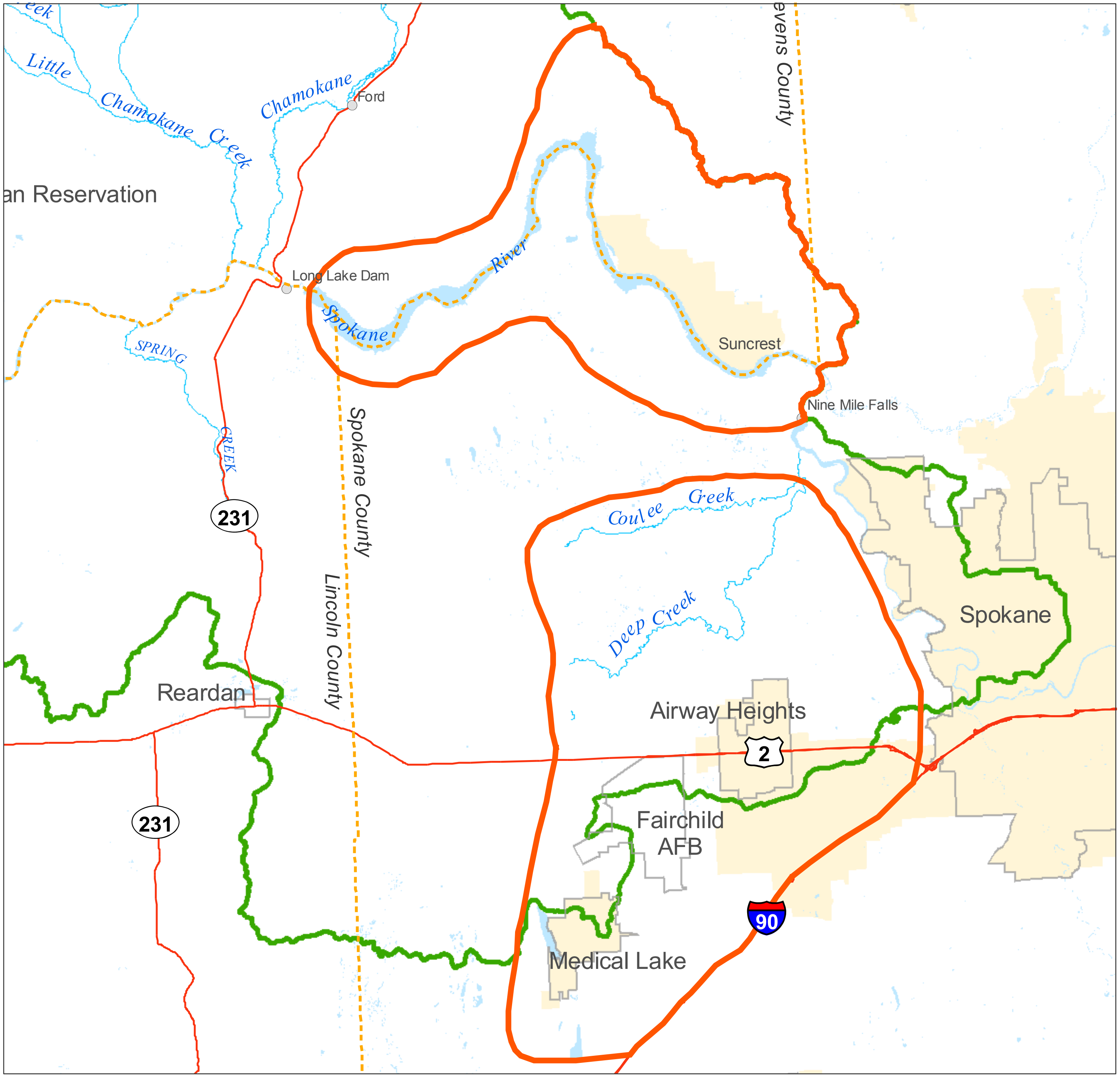

Figure 3-1
Suncrest and West Plains Urban Growth Boundaries

Legend
- Major Road
- County Boundary
- Stream
- WRIA54 Boundary
- Study Area Boundary
- Juristiction
- Waterbody
- Urban Growth Boundary

Data Sources:
Streets, Waterbodies, Streams, County Boundary, Spokane Indian Reservation - Washington DNR
Juristictions - County Data
WRIA Boundary - Washington DOE
Current Land Use - 1992 NLCD

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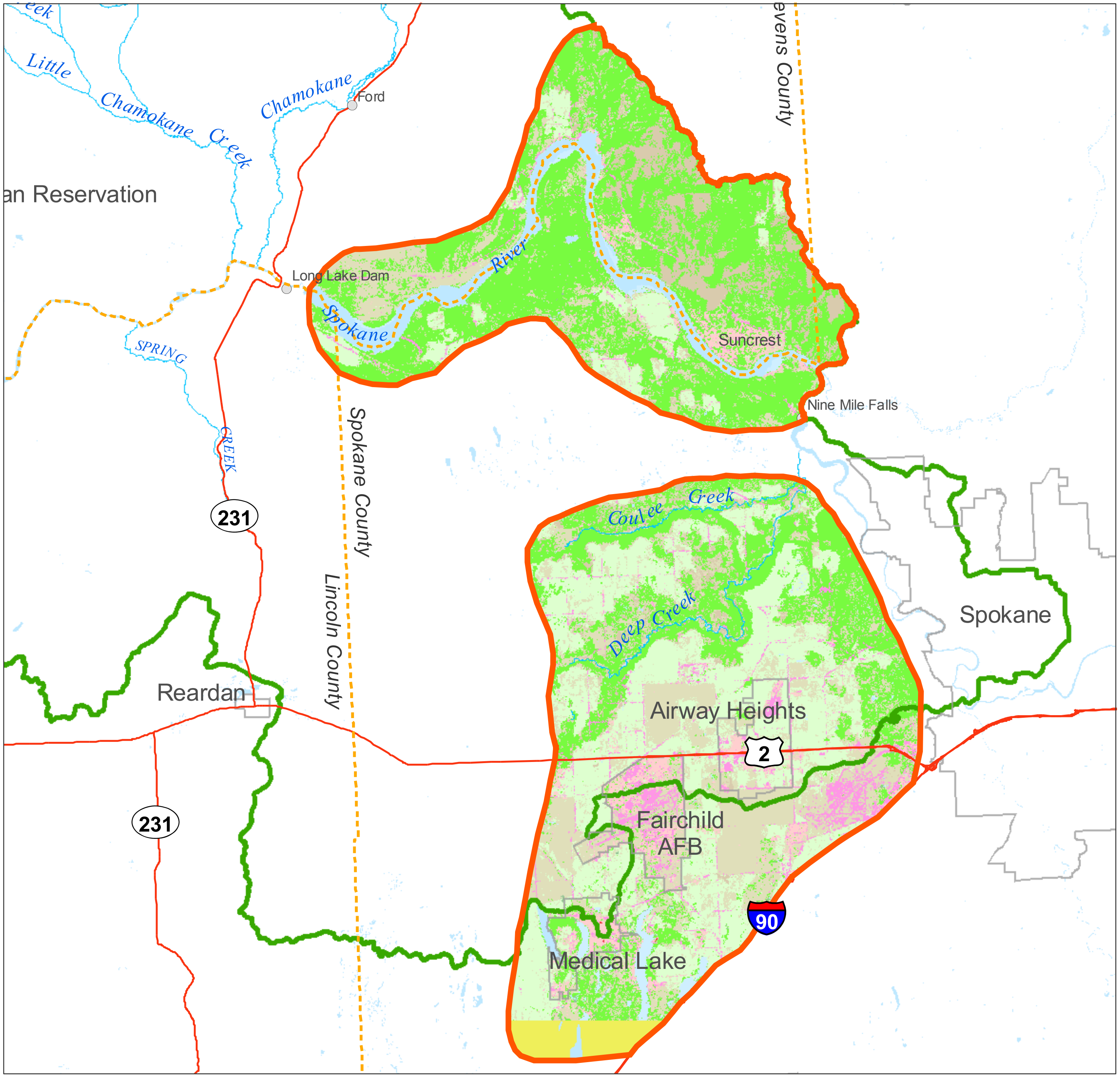

Figure 3-2

Suncrest and West Plains Current Land Use, Land Cover

Legend

- Major Road
- County Boundary
- Stream
- WRIA54 Boundary
- Study Area Boundary
- Juristiction
- Waterbody

Current Landuse

- Agriculture
- Barren (Exposed rock/soil, mining)
- Commercial/Industrial/Transportation
- Forest
- High Intensity Residential
- Low Intensity Residential
- Openland (Recreation, grasslands, shrublands)
- Wetland
- Unknown

Data Sources:
Streets, Waterbodies, Streams, County Boundary, Spokane Indian Reservation - Washington DNR
Juristictions - County Data
WRIA Boundary - Washington DOE
Current Land Use - 1992 NLCD

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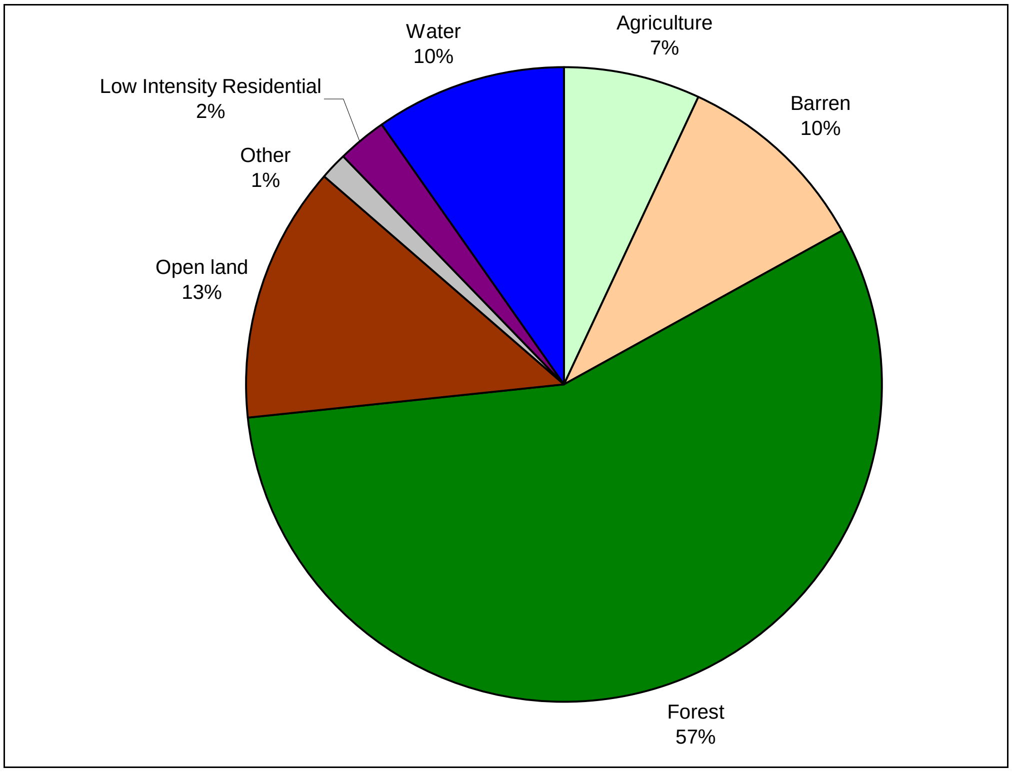

Figure 3-5. Suncrest Current Land Use

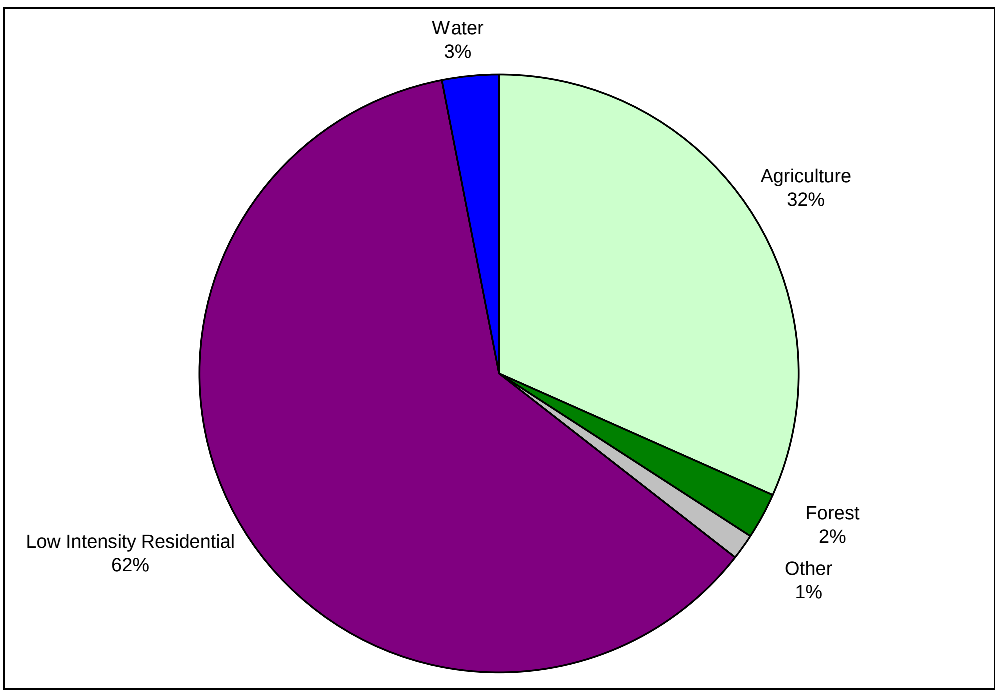

Figure 3-6. Suncrest Future Land Use Zoning

CHAPTER 4.
WEST PLAINS STUDY AREA

STUDY AREA DESCRIPTION

The West Plains area lies west of the City of Spokane and includes the City of Airway Heights, the City of Medical Lake, and Fairchild AFB. It is an arid region situated west of the SVRP aquifer. The West Plains aquifer system includes local sand and gravel aquifers deposited within paleochannels and regional basalt aquifers associated with the Columbia River Basalt Group. The primarily source of recharge to West Plains aquifers is precipitation and snowmelt (15 to 19 inches of precipitation annually). The long-term monitoring of static groundwater levels generally has not been performed within area wells, therefore conclusive evidence regarding trends in aquifer levels are not available. However, the Washington State Department of Ecology has concluded, using pumping data from several area wells, that groundwater levels within the CRBG aquifers are declining in some areas of the West Plains. The declines ranged from about 15 feet in a Medical Lake well between 2001 and 2003 to about 120 feet in a Four Lakes well between 1997 and 2005. Aquifer testing data also suggests that well interference occurs between some of the area's municipal wells.

The population in the study area was estimated from 2000 census block information. The population of all U.S. Census tracks whose center is inside the study area boundary was included in the estimate. The West Plains study area is estimated to have a population of 19,528. The Cities of Airway Heights and Medical Lake are becoming more urbanized and experiencing a population boom. The region is also experiencing growth along Coulee and Deep Creek. Fairfield AFB, in contrast, has recently been experiencing a population decrease. Twelve percent of the population in West Plains do not have water service. Figure 4-1 shows the locations of the major water purveyors in the study area.

The Spokane County Comprehensive Plan has designations for new UGAs. Each city in Spokane County has adopted its own GMA Comprehensive Plan and these plans provide a greater level of detail. The significant growth areas in Spokane County are surrounding the City of Spokane. The largest growth area is an expansion south and east of Airway Heights. The new UGA connects the urban areas of Airway Heights and the City of Spokane. Airway Heights also has additional small UGAs on the north and west of the city. The City of Medical Lake area has two small areas of growth—one the north and one on the southwest. The total UGA in the West Plains study area is approximately 15,000 acres (23 square miles).

ANALYSIS APPROACH

Water Rights

The State of Washington maintains a database of all water rights in the state. The Water Rights Application Tracking System (WRATS) provides summary information on each right. The summary data in the WRATS are often incomplete, and duplications and errors are common. Information contained in the WRATS database often disagrees with the water rights information provided by water purveyors in their water system plans. The water rights information presented in this report was screened for duplicate records and obvious anomalies.

Current Water Use

While estimates of water right allocations 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. In many cases, water rights are allocated at a higher rate of consumption than actual use.

Most of the water use data in this report originated and was extracted from the purveyors' water system plans. Group A purveyors are required to submit a water system plan to the Department of Health (DOH) only every six years, so some of the information contained in them is somewhat dated.

WATER RIGHTS AND CURRENT WATER USE

Groundwater aquifers supply nearly all water used for domestic purposes in Spokane County. The City of Spokane pumps all of its water from the SVRP. The City not only provides water for itself but also provides a significant amount of water for adjoining purveyors through pipeline interties (Figure 4-2). Interties provide the opportunity for the transfer of water from one water system to another. The intertie can be used for a permanent water supply; to supplement limited supply capacity of a neighboring purveyor; to provide water to an area that has limited storage capacity; to provide water to meet a peak or fire demand; or to provide for emergency service, such as an equipment failure.

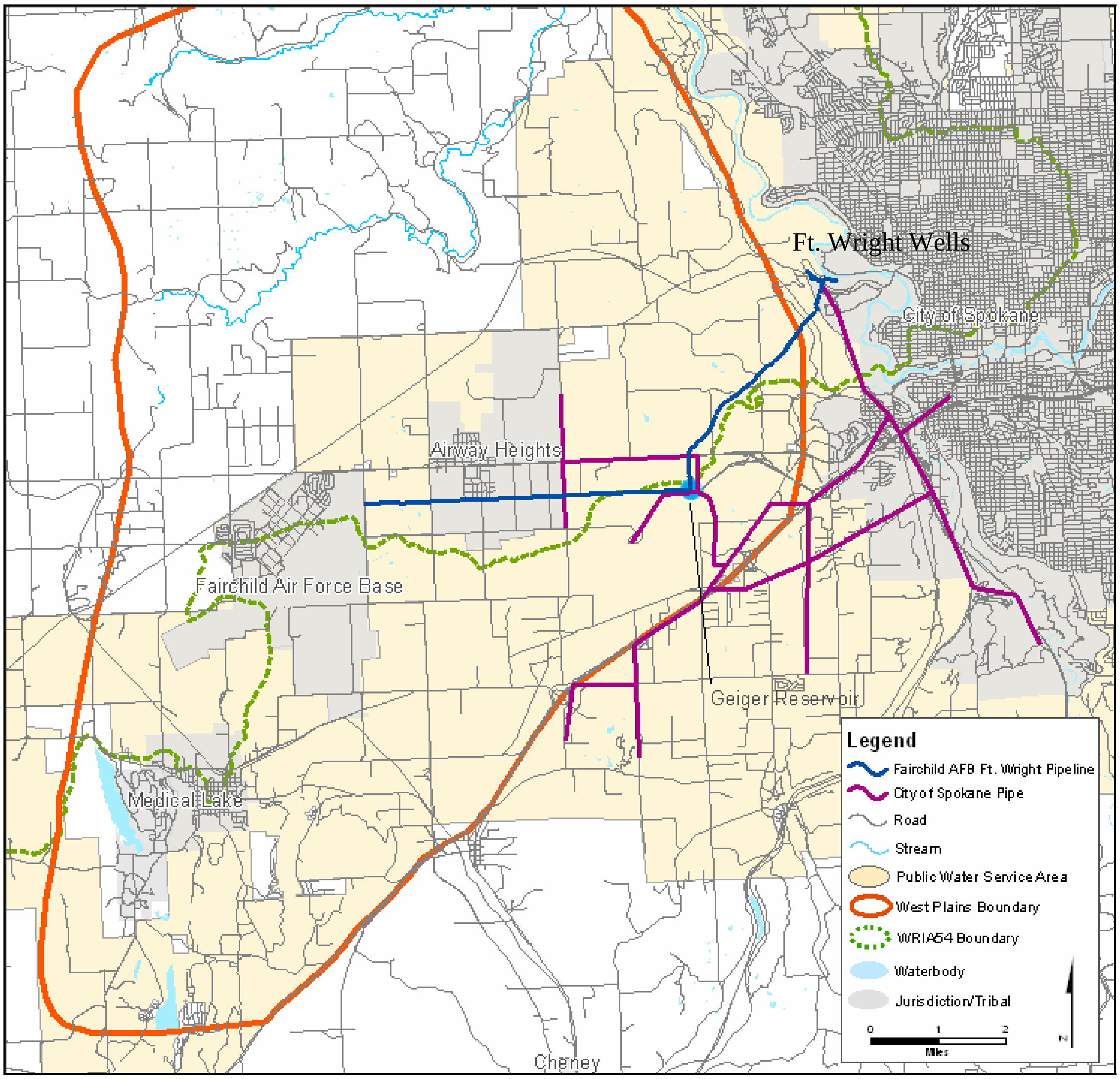

Figure 4-2. Fairchild AFB Fort Wright Pipeline and City of Spokane Pipelines

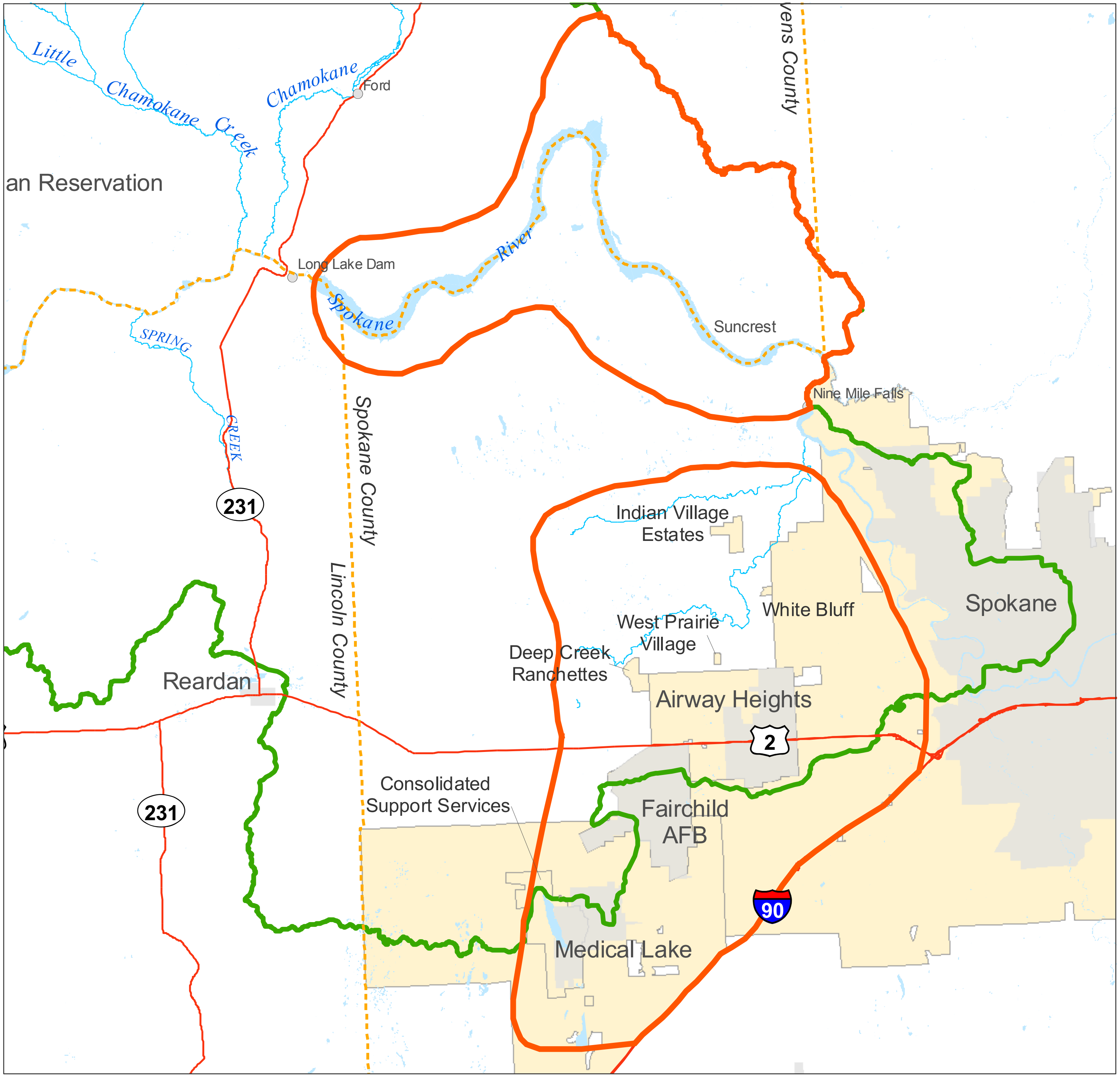

Figure 4-1

West Plains Public Water System Service

Legend

- Major Road
- County Boundary
- Stream
- Public Water Service Area
- WRIA54 Boundary
- Waterbody
- Jurisdiction/Tribal

Data Sources:
Streets, Waterbodies, Streams, County Boundary, Spokane Indian Reservation - Washington DNR
Juristictions - County Data
WRIA Boundary - Washington DOE
Water Distribution - Stevens/Spokane County

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Map Produced 05/16/2007

Water Purveyors

Spokane County does not own or operate public water systems. The County's role is to coordinate with water purveyors to ensure that their actions are consistent with land use plans, service areas, and health regulations. Part of that responsibility includes preparation of a coordinated water system plan. Water purveyors provide water to the majority of people in the study area (88 percent). A portion of the study area is served by the City of Spokane but that segment is not included.

Fairchild AFB

Fairchild AFB has been an Air Force base since 1942. The base is an incorporated UGA with approximately 2,235 connections. Its primary wellfield, Fort Wright, is located outside the study area along the Spokane River, just north of Spokane Falls Community College and 12 miles northeast of the base's central treatment and distribution facility. Fairchild AFB also has an on-base well (Well #2) located at the extreme southeast corner of the base. The yield on this well has been declining due to increased pumping from other users. The base has another well outside of WRIA 54 that does not withdraw water from the SVRP aquifer; this well pumps during high demand times in the summer only.

A 16-inch pipeline connects the Fort Wright wells to the base via the Geiger Reservoir (Figure 4-2). Although the water from Fort Wright has proven to be economical and of high quality, Fairchild AFB does not want to solely rely on this 53-year old transmission line and wants more redundancy in its water supply system. This 11.5-mile pipeline will need to be replaced soon due to age, leaks, and inadequate size for larger flows. One option is to simply replace the pipeline in its current alignment. In the 2004 report *Analysis of Water Supply Options* (URS, 2004), Fairchild AFB investigated alternatives for new interties to the City of Spokane water system to supply its water in lieu of the existing pipeline. An intertie at Geiger Reservoir built in 2002 already allows for emergency water supply from Spokane, but that intertie relies on the 7 miles of the old transmission line between the reservoir and the base. The base assessed two new intertie alignments: one running from the City's supply main on Hayford Road near Airway Heights to the base parallel to the current pipeline; and one beginning at Mallen Road and I-90 (southwest of the City of Spokane) and running to the base. The investigations concluded that the Mallen Road intertie is preferable to the Hayford Road intertie. The Mallen Road intertie would provide emergency water to Fairchild AFB and could also be used by the Cities of Spokane and Airway Heights to expand their water supply systems.

The water demand on the base has been declining over time, partly due to a population decline and partly due to improved conservation and repairs. An aggressive leak detection and repair campaign was undertaken in 1999 that fixed leaks in excess of 200,000 gallons per day.

Fairchild AFB currently holds water rights for its wells at the main base and at White Bluff. The White Bluff certificate is for 50 gallons per minute (gpm) and 80 acre-feet per year. They also submitted applications under Claim Numbers 112892, 11893, 11894 and 11895 to change the place of use, change the purpose of use, and integrate three of their wells.

Fairchild AFB has applied for one water right (6,200 gpm) to cover the three of their wells located near the Spokane River. In 1997, at the time of filing, Fairchild AFB claimed a total of 5,900 gallons per minute or 8,386 acre-feet per year from four wells. The present use under these claims, however, is only 2,457 acre-feet per year. Currently the base's average annual maximum water use is 3,368 acre-feet, including water purchased and transferred via the Geiger intertie from the City of Spokane.

Airway Heights

The City of Airway Heights is 6 miles west of the City of Spokane and was incorporated in 1955. It gained its name from its proximity to Fairchild AFB and the Spokane International Airport. The population in 2000 was 4,500 people but it is growing rapidly.

Airway Heights has five wells of its own in addition to its intertie to the City of Spokane water system. Airway Heights purchased the Parkwest industrial well in 2002 to supplement its water because of a shortage of water rights and water capacity. Airway Heights had three additional wells but they are not in use due to an operational problem, a water quality issue, and lack of water, respectively. The intertie is used extensively to supplement demands that the Airway Heights water system cannot support. The water system has 986 connections. Currently the average annual maximum water use is 1,233 acre-feet, including water purchased and transferred from the City of Spokane.

There is a small discrepancy between the WRATS and the water system plan as to the quantity of water rights. According to WRATS, the City has a maximum allowable pumping of 2,328 acre-feet per year, 224 acre-feet more than cataloged in the water system plan.

Consolidated Support Services and Medical Lake

The Consolidated Support Services (CSS) service area lies entirely within the City of Medical Lake service area. CSS is responsible for serving water to several state-owned facilities in the service area. Water source, storage, and transmission facilities are jointly owned with the City of Medical Lake. Medical Lake operates and maintains its distribution system separately. The joint source facilities consist of three wells, all located 2 to 3 miles west of the area. In 1995 Medical Lake drilled a new well east of the City for its sole use. CSS and Medical Lake have 1,214 and 1,165 connections, respectively. Historically, Medical Lake has used approximately 40 percent of the water pumped by the CSS wells.

Medical Lake also provides a small percentage of water to the Strathview Water District, which is solely dependent on the City of Medical Lake due to Strathview’s water quality and quantity issues. Four Lakes Water District #10, located just south of I-90 outside of the study area, is proposing to construct an emergency water intertie connecting its well to the City of Medical Lake well. The Four Lakes Water District #10 well is located 6,800 feet south of the City of Medical Lake well, inside the study area. The water could be transferred in either direction if one entity was in need of water and the other has additional water available. Medical Lake does not have an intertie with the City of Spokane, but would like to have one as soon as the necessary piping is available to make it possible.

Medical Lake also has a reclaimed water facility. Using reclaimed water reduces the demand on the limited water resources. The City replaced its wastewater treatment facultative lagoon plant with a water reclamation facility in 2001. The Class A reclaimed water is discharged to West Medical Lake to maintain water levels for recreation and to the Deep Creek tributary. As flows increase, the City of Medical Lake anticipates expanding reclaimed water use to irrigate city parks and urban landscaping.

There is a discrepancy between the WRATS and the Medical Lake water system plan as to the number of water right permits and certificates; the water plan contains an additional permit and certificate not documented in the WRATS. For the joint system portion, the water system plan accounts for a maximum allowed annual withdrawal of 5,600 acre-feet per year. The additional Medical Lake well has an additional allowable 800 acre-feet per year. The system has a maximum average annual water use of 1,098 acre-feet, significantly less than the water right. The most recent pumping data available is from 1998 and water needs could have increased with population growth in the last 10 years.

Small Group A Water Systems

The other Group A purveyors in West Plains are considerably smaller water users than Airway Heights, Medical Lake/CSS, and Fairchild AFB. These systems pump their own groundwater and do not have connections to the City of Spokane:

- Deep Creek Ranchettes is a small housing community of 141 people located on the northwest corner of Airway Heights. The community has a certificate for 50 acre-feet per year and its maximum annual consumption is 56 acre-feet per year. The system uses two year-round wells and an additional small well for summer-only use.
- Indian Village Estates is located in the north end of West Plains and has 32 connections. The community has three wells. The WRATS only lists one of the two certificates. The certificates allow maximum annual withdrawals of 36 and 29 acre-feet per year; the maximum annual consumption is 25 acre-feet per year.
- West Prairie Village is located 2 miles north of Airway Heights and serves water to 105 mobile homes. The community has two wells and is in the process of building a third because of decreased pumping rates in the original two wells over the last few years. Since 2003, West Prairie Village has had to truck water from the City of Spokane to meet summer water needs. The WRATS lists one permit for a maximum annual withdrawal of 63 acre-feet per year and the water system plan shows one certificate for 66 acre-feet per year. The maximum annual consumption is 35 acre-feet per year.
- Fairchild Mobile Home Park lies on the northeast corner of the Fairchild AFB. Three wells serve 56 connections at the mobile home park. The community has not yet written a water system plan. The WRATS shows one permit for a maximum annual withdrawal of 48 acre-feet per year; the maximum annual consumption is 14 acre-feet per year.

Other Water Systems and Users

While Group A municipal systems are the largest water uses in the study area, other waters systems are also growing and using potentially significant amounts of water. These other users include small communities and companies. Most of the Group B systems in the study area are classified as community systems and may be using permit-exempt wells as a water source. Water service boundaries are not provided for most of these systems.

Water Purveyors' Current Water Use Summary

Inchoate water is the amount of water not used from a water right (i.e. the difference between the maximum allowable annual withdrawal and the maximum annual withdrawal). Tables 4-1 and 4-2 summarize the water rights and inchoate water in the West Plains study area. The estimated total consumptive use in West Plains is 5,829 acre-feet annually, about half of the water rights, based on the assumptions used in this analysis. The remaining inchoate water rights can potentially available for water right transfers.

Table 4-1.
Water Rights Summary

Water Purveyor	Water Right Type	Maximum Annual Withdrawal (acre-feet)
Airway Heights	Certificate	102
	Certificate	800
	Certificate	224
	Permit	1,200
Deep Creek Ranchettes	Certificate	50
Fairchild AFB	Certificate	80
	Claim	1,545
	Claim	3,130
	Claim	2,164
	Claim/change	1,545
Fairchild Mobile Home Park	Permit	48
Indian Village Estates	Certificate	36
	Certificate	29
Medical Lake and CSS	Certificate	800
	Certificate	1,600
	Certificate	1,600
	Permit	2,400
West Prairie Village	Certificate	63
	Permit	66

TABLE 4-2.
INCHOATE WATER

Water Purveyor	Maximum Annual Withdrawal [a] (Acre-feet)	Water Rights (Acre-feet)	Inchoate Water (Acre-feet)
Airway Heights	1,233	2,328	1,095
Deep Creek Ranchettes	56	50	-7
Fairchild AFB	3,368	8,464[b]	5,096
Fairchild MHP	14	48	34
Indian Village Estates	25	65	40
Medical Lake +CSS	1,098	6,400	5,302
West Prairie Village	35	129	94
Total	**5,829**	**17,484**	**11,654**

a. Data compiled from water system plans
b. Includes claims

Exempt Water Use

Not all water uses are required to submit an application. The Groundwater Code allows for an exception to the permitting requirements if the user is providing water for livestock, watering a non-commercial lawn or garden one-half acre in size or less, providing water for a single home or groups of homes (limited to 5,000 gallons per day), or providing water for industrial purposes, including irrigation (limited to 5,000 gallons per day). Since permit-exempt water rights are not documented, the number of water rights was estimated. Using the public water distribution boundaries of large purveyors within WRIA 54 and 2000 census data, the population not serviced by public water distribution systems was identified. That population 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. 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. Using the Washington State Department of Health's *Water System Design Manual*, an estimate of 1.6 acre-feet per year per ERU was chosen. The domestic exempt water demand in West Plains is 1,264 acre feet.

FUTURE WATER USE

Future consumptive water needs, which are anticipated to be primarily for domestic supply, are expected to increase in the future. Future population estimates at local scales were not available. Forecasts for Spokane County's transportation analysis zones (TAZ) project the number of future housing units. An estimate of future population can be calculated using an assumption of 2.5 people per housing unit. Figure 4-3 displays the population growth based on the TAZ housing estimates; the projected population for 2030 using this approach is about 31,000.

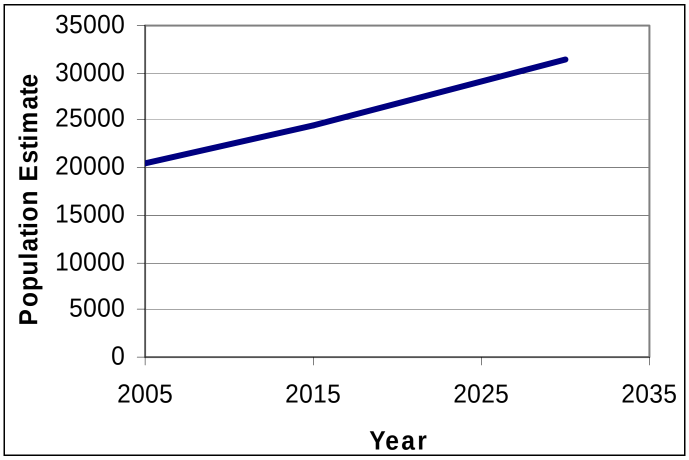

Figure 4-3. West Plains Population Growth Estimates

Using the current population of 19,528 and the current West Plains annual water use of 5,830 acre-feet annually, a per person estimate of 0.3 acre-feet annually (266 gallons per person per day) was calculated. This is a reasonable estimate because the estimate for the Columbia River Basin in the 2006 *Water Supply Inventory and Long-Term Water Supply and Demand Forecast Legislative Report* is 170 gallons per person per day, with a range of 92 to 300 gallons per person per day. The estimate of 0.3 acre-feet per person per year yields a water use for 2030 of 9,350 acre-feet, a 60-percent increase from the current water use.

STRUCTURAL WATER STORAGE OPPORTUNITIES

Only some of the structural project categories discussed as WRIA-wide opportunities in Chapter 2 are appropriate for West Plains. Instream reservoirs and impoundments (modified or new), natural lakes, balancing basins, and beaver dams were removed as alternatives because West Plains has no viable project sites. Direct pumping to surface water was not examined further because augmenting surface water does not solve the problem of water storage for human consumption. Farm-field flooding and small-scale catchment basins were removed from consideration because the water storage volumes would be quite small. Small-scale catchment basins may also just be used as a method for urban or rural stormwater infiltration.

Large-scale structural opportunities for West Plains include increased connectivity and ASR. Depending on the project site, there may be opportunities for direct injection to groundwater, enhanced surface water recharge to groundwater, stormwater infiltration, and water reuse. The small-scale structural alternatives examined in the assessment include off-channel reservoirs and wetland restoration.

Increased Connectivity

Increased connectivity in the study area could be an alternative to increasing water storage volumes. Currently, some water purveyors have significant amounts of inchoate water rights. Additional infrastructure may need to be constructed to share this water and have this option be viable. At present, the City of Spokane is hydraulically connected to the City of Airway Heights and to Fairchild AFB.

Due to the low population densities, it does not make sense to create pipeline interties to the northern portion of the study area. However, decreasing the dependency of the larger entities such as Medical Lake, Airway Heights, or Fairchild AFB on the basalt aquifer through increased connectivity would help relieve the pressure on regional aquifers and thus increasing the productivity of the aquifers for some of the smaller users. The following alternatives for increasing connectivity were reviewed for this report:

- Alternative 1: Fairchild AFB abandons Fort Wright infrastructure, sells the water rights for the Fort Wright wells to the City of Spokane, and purchases water from the City via the Mallen Road intertie, which is shown in Figure 4-4. Costs include construction of the Mallen Road intertie- $6.8 Million.
- Alternative 2: Fairchild AFB sells the water rights for the Fort Wright wells to the City of Spokane and purchases water from the City via the Mallen intertie, while keeping the existing transmission line from Fort Wright available for emergency water supply. Costs include construction of the Mallen Road intertie and replacing the Fort Wright pipeline- $19.2 Million.
- Alternative 3: Medical Lake builds a 12-inch intertie to connect to the City of Spokane, as shown in Figure 4-5. The intertie would also connect at Mallen Road or could be built in combination with the Mallen Road intertie to Fairchild AFB and split off where the Fairchild pipeline turns north. This intertie could be used for all water needs or just provide water in emergency situations. Costs include construction of the Medical Lake intertie- $3.1 Million.
- Alternative 4: Fairchild AFB sells water rights and infrastructure to the City of Airway Heights and purchases water from the City through a short intertie connecting the Fort Wright pipeline to the Airway Heights water system. Costs include replacing the Fort Wright pipeline and constructing the new connection to the City of Airway Heights- $11.1 Million.

The cost estimates are based on Fairchild AFB's cost estimates in the *Analysis of Water Supply Options* (URS, 2004). No operation and maintenance costs are included.

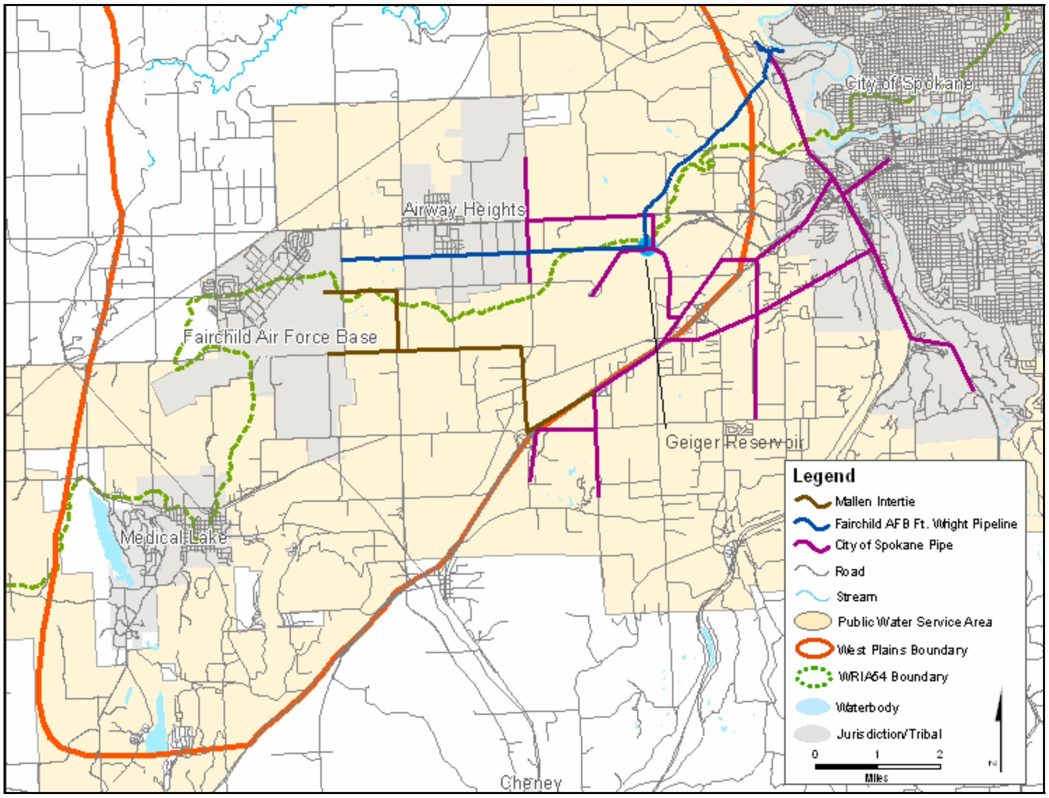

Figure 4-4. Mallen Road Intertie to Fairchild AFB

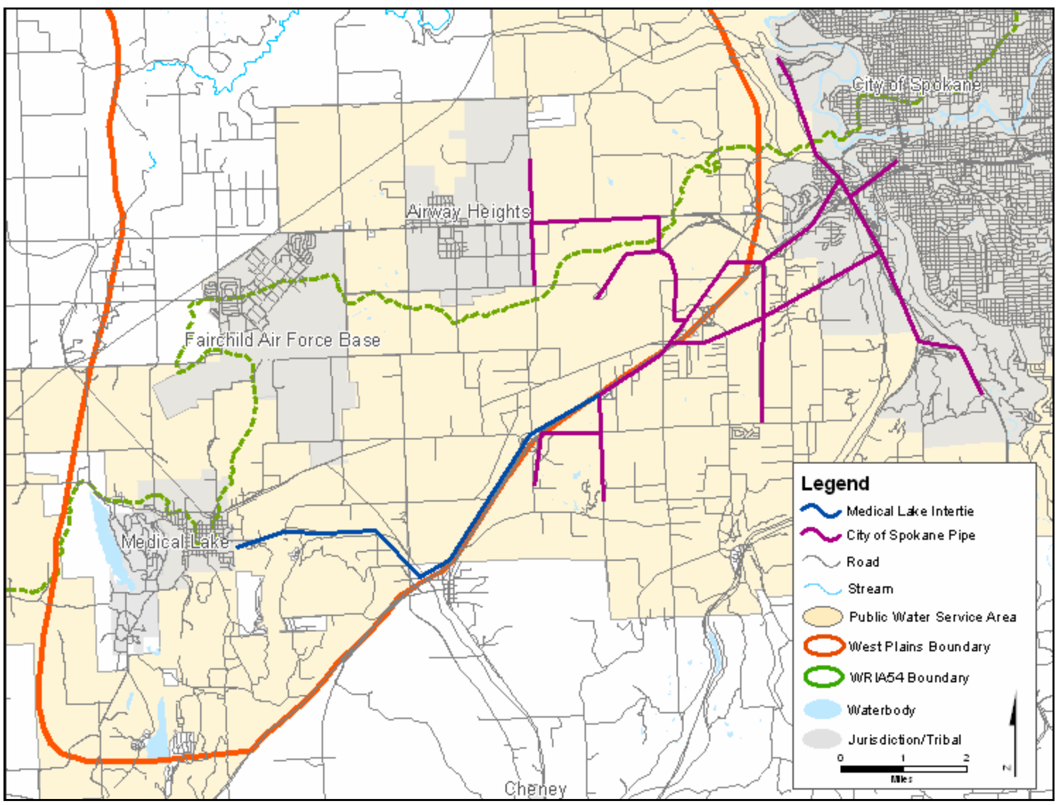

Figure 4-5. Potential Site for Medical Lake Intertie from City of Spokane

Enhanced Surface Water Recharge to Groundwater

Aquifer Storage and Recovery

Required Analyses

Aquifer storage and recovery is a relatively new and effective technology but areas where ASR projects can be implemented are limited. The following analyses must be conducted by the applicant for any proposed ASR project; the studies are reviewed by Ecology before a permit may be issued:

- A hydrogeologic analysis is the primary analysis to be conducted in conjunction with a proposed ASR project. It includes the development of a conceptual hydrogeologic model that identifies general geological and hydrogeological conditions in the project area. This would identify such features as geologic materials and their thicknesses, structural information such as faults, fractures or synclines, and other relevant information describing the general geologic setting. General groundwater information should be part of this analysis as well, including such elements as the water-bearing units and their hydraulic properties, the general groundwater flow system, and any groundwater boundaries. The size of a proposed ASR project will have a bearing on the level of detail needed and the amount of investigation required to ascertain its feasibility. Larger and more complex projects may require considerably more study, including the development of computer models. A pilot phase must be designed in order to validate the conceptual model.
- An operational analysis describes how the completed project would function. This analysis includes the major elements of the project operation such as the means of recharge (e.g. injection well or spreading basin), the location, number and capacity of proposed recharge facilities, the source water quality and the means of treatment and disinfection of the source and recovered waters, the timing of recharge operations and the use of the stored water, and the rates of recharge and recovery. A water right is required for the source water and the user must apply for a reservoir permit before undertaking an ASR project.
- An environmental analysis describes probable and potential environmental effects from the ASR project. Possible effects identified in the conceptual model are assessed, including changes to local water bodies such as wetlands, changes to water levels and water quality in nearby wells, changes in slope stability, and subsidence or ground heave. Some of this analysis can be conducted as part of preparing an environmental checklist or environmental impact statement to comply with the State Environmental Policy Act (SEPA).
- A legal analysis assesses the significance of any potential legal issues associated with a proposed project, including identification of any wells in the aquifer and water rights connected with them. It also addresses any changes necessary to the ASR proponent’s water rights to cover the project, including changes to water rights for the source waters, and any legal issues associated land use activities, land ownership, and adverse environmental effects.

  Most ASR projects already are operating under one or more water rights, so new water rights are usually not an issue. For existing rights, the state has considered whether storage must be added as a new “purpose of use” for the source waters if it was not part of the original water right. The Attorney General’s office advised Ecology that, in itself, storage is not a purpose of use of water. Rather, it is merely a means to provide water for the true purposes of use identified in the permit.

Potential ASR Locations

The area between Airway Heights and Medical Lake is a potential location for an ASR project in the West Plains study area. The exact location would take into consideration factors such as the aquifer properties, the distance to the injection water source, the depth to the target aquifer, the proximity to other wells, and the availability of land for injection facilities. The discussion below addresses the factors that would be important in implementing any ASR project in West Plains.

In the West Plains area, basalt and “paleochannel” aquifers are the primary aquifers that can be considered for ASR projects:

- The basalt aquifers in West Plains are contained within two members of the Columbia River Basalt Group: the younger Wanapum Basalt and the older Grand Ronde Basalt. Each member consists of multiple lava flows. Water flows most easily within the broken “vesicular” layers between flows. About 90 to 95 percent of the volume of the basalts consist of lower transmissivity “entablature” and “colonnade” portions, where water moves through interconnected, vertical fractures (Whiteman et al., 1994). The flows are locally inter-layered with sedimentary deposits, yielding multiple stacked aquifers that are confined or semi-confined. Figure 4-6 shows the distribution of the basalt aquifers in the West Plains. Department of Ecology data suggests that water levels are declining in one or more basalt aquifers in West Plains. This has created concern that basalt aquifer recharge is not compensating for groundwater withdrawal in this area.
- The paleochannel aquifers are sand and gravel aquifers that formed in drainage channels eroded into the Wanapum and Grande Ronde Basalts. The approximate locations of three paleochannel aquifers in the West Plains are shown in Figure 4-6. The paleochannels cut through most of the Wanapum Basalt and, in some locations, into the upper layers of the Grande Ronde Basalt. Studies suggest that water from the basalt aquifers drain into and provide the primary source of recharge to the paleochannel aquifers. Recent unpublished aquifer testing by GeoEngineers, Inc. suggest that the westernmost paleochannel shown in Figure 4-6 aquifer is very transmissive.

ASR projects are commonly installed in confined aquifers, though they have been successfully created in unconfined aquifers. Confined aquifers have the benefit of reduced exposure to contamination from surface water infiltration. A possible objective of an ASR project is to build a groundwater “mound” around the point of injection or infiltration. The injected water displaces pre-existing water in the aquifer, creating a zone of stored water around the injection well. The injected water is later recovered by pumping from the injection well or a different recovery well. Recovery of injected water is affected by mixing of injected water with native water in the aquifer and migration of injected water due to groundwater gradients. Where the native groundwater is of drinking quality, mixing of injection water with the native groundwater is not a high concern.

Key factors to consider in selecting a target aquifer for ASR include the aquifer’s “storativity” and “transmissivity.” Storativity is defined as “the volume of water that a permeable unit will absorb or expel from storage per unit surface area per unit of change in head” (Fetter, 1994). For ASR, a high storativity is desirable so that more water can be stored with a give volume of aquifer material. Transmissivity is “a measure of the amount of water that can be transmitted horizontally through a unit width [of an aquifer] by the full saturated thickness of the aquifer under a hydraulic gradient of 1” (Fetter, 1994). Depending on project objectives, the transmissivity of a subject aquifer can be too low or too high for successful ASR project operation. A higher transmissivity facilitates injection of water into the target aquifer. Highly transmissive aquifers with high hydraulic gradients, however, tend to disperse injection water, making construction of a groundwater mound through ASR difficult.

Table 4-3 summarizes findings of the limited hydrogeologic studies of the aquifers in West Plains. The westernmost paleochannel aquifer has a higher storativity than basalt aquifers in the locations studied. This is typical for sand and gravel aquifers versus the basalt aquifers, which store water predominantly in fractures. Storativity is higher in the Wanapum basalt aquifer than in the Grande Ronde basalt aquifer in the studied wells. Transmissivity of the paleochannel aquifers is relatively high, and transmissivity of the Wanapum basalt is moderate. No transmissivity data for the Grande Ronde basalt aquifer specific to the West Plain was identified for this study.

**TABLE 4-3.
AQUIFER HYDRAULIC CHARACTERISTICS**

Aquifer	Location	Storativity (unitless)	Transmissivity (square feet per day)	Source
Wanapum Basalt	Near Graham Road Recycling and Disposal Facility near Medical Lake	0.000009 to 0.00006	0.02 to 1,100	CH2M-Hill, 1998
	Columbia Plateau, General	0.0000018 to 0.000099 0.000032 median value	NA	Whiteman et al., 1994
	Fairchild AFB	0.0000177 0.00016 0.00055	16.7 20.9 4.8	Halliburton NUS environmental Corporation, 1993
Grande Ronde	Columbia Plateau, General	0.000006 to 0.0011 0.00018 median value	NA	Whiteman et al., 1994
Westernmost Paleochannel	NA	0.02	18,000	GeoEngineers, 2002

While the high transmissivity and storativity values suggest that the paleochannel aquifers might be most suitable for an ASR project, additional hydrogeological information and project objectives need to be considered. The extremely high transmissivity of the paleochannel aquifers may make it difficult to create a groundwater mound around an injection well. Groundwater gradients in the westernmost paleochannel are approximately 0.004 feet per foot to the northwest and would carry injected water toward Deep Creek. ASR in the paleochannel aquifer may be feasible if groundwater flow away from the injection point is relatively slow and intended storage times are relatively brief. Alternatively, a recovery well could be positioned downgradient to capture injected water.

An ASR project within a basalt aquifer could help mitigate declining groundwater levels. Reported transmissivity and storativity characteristics for the Wanapum basalt aquifer are within the range generally considered conducive for ASR. The shallow depth of the Wanapum basalt aquifer would reduce construction costs and energy required for ASR relative to the Grande Ronde aquifer. The shallow depths and unconfined to semi-confined nature of the Wanapum basalt aquifer make it more susceptible to contamination from surface infiltration.

Very little hydrogeologic information is available for the Grande Ronde basalt aquifer. Reported Columbia Plateau-wide storativity values for the Grand Ronde basalt are comparable to those for the Wanapum basalt. No transmissivity data for the Grande Ronde aquifer was identified for this study. ASR in the Grande Ronde aquifer is probably possible, though its greater depths would increase construction and operations costs.

In summary, the limited data available suggest that ASR is possible in the basalt and paleochannel aquifers on the West Plains. General geologic and hydrogeologic data suggest that the Wanapum basalt

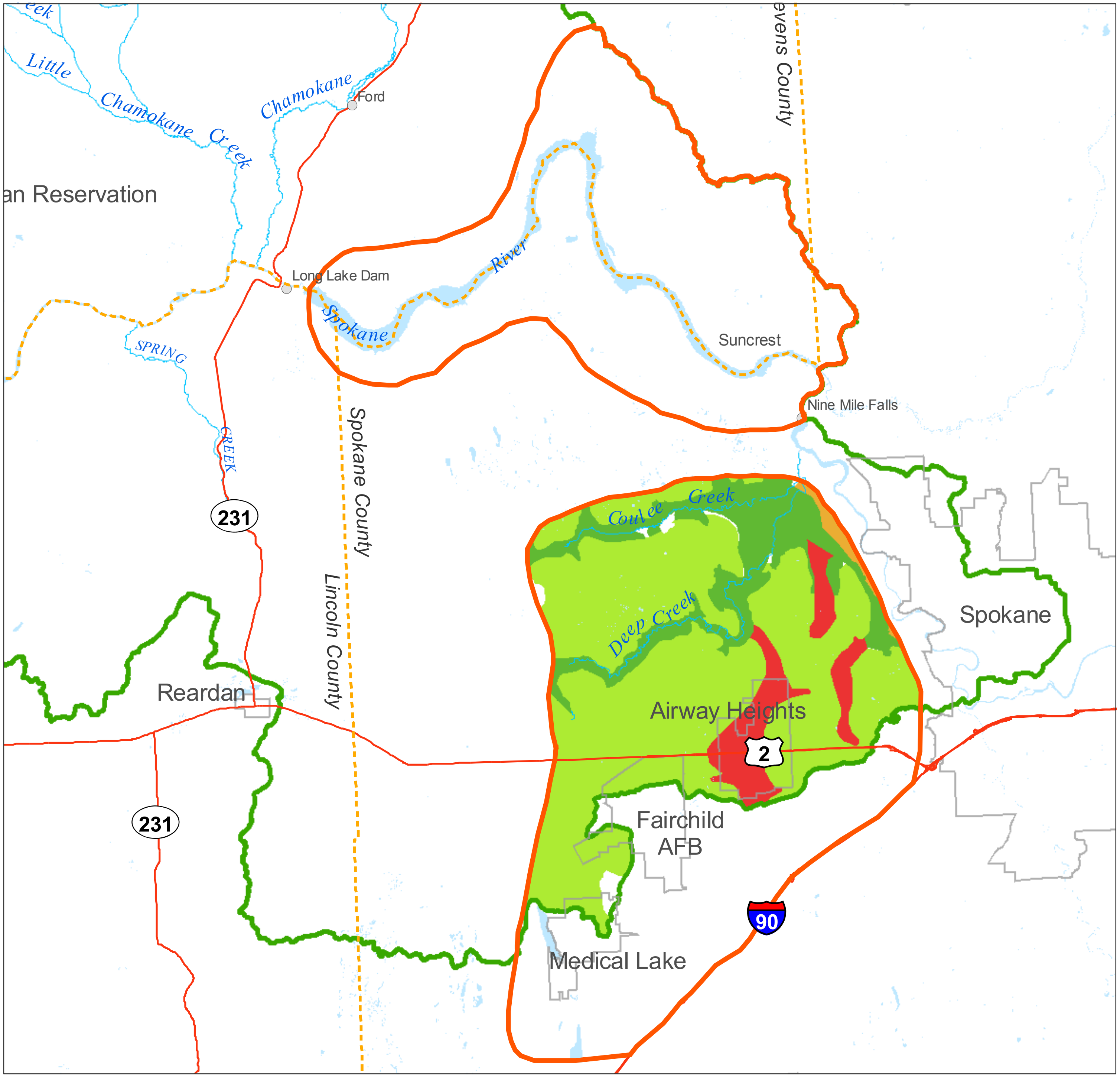

Figure 4-6

West Plains Aquifers

Legend

- Major Road
- County Boundary
- Stream
- WRIA54 Boundary
- Study Area Boundary
- Juristiction
- Waterbody

Aquifer Name

- Grande Ronde Basalt Aquifer
- Paleochannel Aquifer
- Spokane ValleyRathdrum Aquifer
- Wanapum Basalt Aquifer

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

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Map Produced 05/16/2007

aquifer may be the most favorable candidate for an ASR project. More geologic and hydrogeologic data will be needed before a target aquifer is selected.

ASR Infrastructure

Water can be stored in the target aquifer either through infiltration or direct injection through a well. Because ASR uses UIC wells ASR projects are also regulated by UIC regulations (described below), although ASR regulations are more stringent. Infiltration is usually accomplished through the use of infiltration ponds above the target aquifer. Generally, the recharge efficiency of an infiltration pond is much lower than that of an injection well. Infiltration ponds suffer substantial losses to evaporation and, depending on the permeability of the unsaturated zone, infiltration can occur slowly compared to direct injection. Furthermore, an infiltration pond can only be used for water storage and not recovery. Infiltration can also be accomplished through sub-surface trenches or galleries. Infiltration galleries and trenches are especially useful for getting below surface confining layers that impede surface infiltration. Infiltration galleries and trenches, however, are prone to clogging and are difficult to clean.

Infiltration is useful for storing water only in unconfined aquifers. In West Plains, only the paleochannel aquifers and the uppermost portion of the Wanapum Basalt are unconfined. Vertical fractures in the basalt connect the unconfined upper layers of the Wanapum Basalt to lower semi-confined layers. The Grande Ronde basalt is confined by the Wanapum-Grande Ronde interbed and/or the lower flows of the Wanapum basalt and could only be efficiently recharged through an injection well.

Evaporation losses would be negligible with an injection well, and multiple water-bearing layers in the target aquifer can be directly accessed by the well. While injection wells do not face the same contamination risks of a surface infiltration pond, water quality requirements for direct injection to the aquifer are higher. An injection well may also be used for water recovery, helping reduce construction costs. In the West Plains area, injection wells could recharge the Wanapum, Grand Ronde, or paleochannel aquifers.

ASR Water Sources

Several sources could supply water for an ASR project in the West Plains. These sources include: drinking water from the City of Spokane; surface water from the Spokane River, Deep Creek, or Coulee Creek; water supplied by the Fairchild AFB water system; or reclaimed wastewater from Spokane or Airway Heights. Each water source has its advantages and disadvantages primarily related to the quality of the source water, cost and availability.

ASR Water Quality

Water quality requirements for source water for ASR depend on the recharge method used. If water is to be added to the aquifer through infiltration through the unsaturated zone, use of lower quality water may be possible. Direct injection of water into the target aquifer requires drinking water quality injection water if drinking quality water is present in the target aquifer. Of the available water sources, City of Spokane water or Fairchild AFB water would not require treatment to meet water quality standards for injection water. Surface water taken from the Spokane River, Deep Creek, or Coulee Creek during periods of high water availability would probably require treatment to reach drinking water quality standards. Reclaimed water from wastewater treatment would require extensive treatment to be suitable for direct injection. In California, for example, treatment of water for injection into an aquifer includes microfiltration, reverse osmosis, carbon filtration, irradiation with ultraviolet light, and ozone treatment (SEWRPC, 2006). Extensive treatment of recharge water raises ASR costs significantly.

Most ASR projects proposed thus far are for public water systems and would use treated drinking water as their source waters. Using drinking water can cause problems, however, because some byproducts of disinfection exceed state groundwater quality standards (Washington Administrative Code (WAC) Chapter 173-200). Chlorine, which is the standard method of drinking water disinfection, can react with organic materials in groundwater to produce carcinogenic chemicals. Long-term health and environmental effects from the introduction of those byproducts are unlikely, but their introduction into groundwater runs contrary to the antidegradation policy of the groundwater quality standards and their removal would be costly. Public water systems are beginning to make the transition to different methods of disinfection, so the problem will gradually cease to exist.

In addition to treating water to raise water quality, treatment may be necessary to ensure geochemical compatibility of recharge water with aquifer water. Significant differences in water chemistry can result in precipitation of minerals that clog pore space around an injection well, potentially rendering the well useless for ASR. Geochemical compatibility issues are less important for infiltration recharge of an aquifer, though clogging of porous media by mineral precipitation is still a potential issue. Thorough geochemical analysis of recharge and native aquifer waters should be carried out early in the planning phase of an ASR project to reduce the likelihood of chemical compatibility issues.

Other Considerations

Other recharge water considerations include cost and availability. City of Spokane water rates might be reduced for water supplied during high water availability periods when most ASR recharge takes place. Obtaining water from the Spokane River, Deep Creek, and Coulee Creek during high flow periods would require the acquisition of new water rights. Additional costs would include infrastructure and energy to pump water to the recharge site. Reclaimed wastewater could be supplied for recharge throughout the year. Costs to purchase reclaimed wastewater have not yet been determined for the potential wastewater reclamation facilities at the City of Spokane or Airway Heights wastewater treatment plants.

Planning Level Costs

Costs for ASR projects depend on a variety of factors including project location, recharge water quality, water availability, state ASR regulations, site geology, and aquifer characteristics. Only general, order-of-magnitude estimates of project cost can be made without detailed project information. The Southeastern Wisconsin Regional Planning Commission prepared a draft report on state-of-the-art water supply practices that estimates costs for infiltration and injection ASR projects using different recharge water sources at locations throughout the United States (SEWRPC, 2006). Table 4-4 presents estimated costs for ASR projects taken from that report.

Additional treatment for infiltration or injection of wastewater adds substantially to construction and operation and maintenance costs. The Orange County Water District has estimated costs for membrane filtration, ozonation, and carbon filtration treatment technologies. The addition of membrane filtration and ozonation to a wastewater treatment regimen adds approximately $5.4 million per mgd in construction costs. Carbon filtration would cost approximately an additional $12.6 million dollars per mgd in construction costs. In total, use of these three treatment technologies would add approximately $2,260 of operation and maintenance costs per million gallons of treated water.

TABLE 4-4.
ASR COST ESTIMATE

Type	Item	Estimated Cost[a]
Surface Infiltration Basin	Construction	$1.2 million per mgd
	Operation and maintenance	$60 per acre per year
Surface Infiltration Basin for Wastewater	Construction	$1.45 million per mgd
	Operation and maintenance	$60 per acre per year
Water Treatment for Wastewater	Membrane filtration and ozonation	
	Construction	$5.4 million per mgd
	Operation and maintenance	$630 per MG
	Carbon filtration	
	Construction	$12.6 million per mgd
	Operation and maintenance	$1,630 per MG
Injection Well	Conversion of existing well with existing pump house	$330,000 to $750,000 per mgd
	Drilling new well with construction of new pump house	$830,000 to $1,750,000 per mgd
	Operation and maintenance	$15,000 per mgd per year[b]

a. Cost estimates are from the Southeastern Wisconsin Regional Planning Commission (SEWRPC) Technical Report 43 preliminary draft (2006), except injection well operation and maintenance cost.
b. Cost estimate from Pyne and et al., 1996.
MG = million gallons; mgd = million gallons per day

Direct Injection to Groundwater

An underground injection control (UIC) well is one of the following: a bored or drilled hole whose depth is greater than the largest surface dimension; an improved sinkhole; or a subsurface fluid distribution system. UIC wells used for the practices in this report are the third type. This subsurface fluid distribution system is designed to discharge fluids into the ground and consists of an assemblage of perforated pipes, drain tiles or similar mechanisms.

UIC wells must meet the non-endangerment standard, which means they must be constructed, operated, maintained and decommissioned in a manner that protects water quality. The non-endangerment standard prevents the movement of fluid containing any contaminant into the groundwater if the contaminant may cause a violation of groundwater quality standards (WAC 173-200-040), by means such as fulfilling AKART (all known, available and reasonable technology) requirements.

The most common type of UIC well in Washington is a Class V well. Class V wells are usually shallow injection wells that inject fluids above the uppermost groundwater aquifer. Classes I-IV wells include wells that inject gas, oil, or dangerous or radioactive materials or extract minerals. Class V wells are a very broad class and include, but are not limited to, draining surface fluids, stormwater, salt water intrusion barriers, multiple residence septic systems, soil remediation and ASR.

Injecting stormwater would likely be the one of the main uses of UIC wells in West Plains. Since stormwater picks up contaminants as it runs over the land surface, it can pollute groundwater once it infiltrates into the subsurface. This can be prevented by careful design of the UIC well, strategic siting and effective operations and maintenance.

UIC wells may not receive stormwater from areas used for activities that are likely to generate stormwater high in contaminant levels, including vehicle repair and service, vehicle washing, airport de-icing, storage or handling of hazardous material or waste, handling of radioactive materials, industrial or commercial activities without proper storage and spill prevention, and some recycling activities. UIC wells should not be sited near these prohibited areas or near contaminated-soil sites. As potential sources of contamination, UIC wells should be placed at least 100 feet from drinking water wells. New Class V wells for stormwater management must not discharge directly into groundwater; a separation between the bottom of the well and the top of the groundwater is required. The treatment capacity of the unsaturated zone must be considered.

Enhanced Infiltration for Rural Areas

The goal of enhanced infiltration is to infiltrate surface water such as stormwater or stream flow at a higher rate than would occur through natural process. This goal may be accomplished by diverting water from areas with low infiltration rates to areas with more permeable soils. Structures used to infiltrate water include drywells, infiltration basins and infiltration galleries. These structures increase infiltration rates by providing contact area between the structure and permeable soil.

Enhanced infiltration is only effective at recharging unconfined aquifers. In the West Plains area, suitable aquifers for enhanced infiltration are the paleochannel and Wanapum aquifers which are unconfined to semi-confined. The confined Grande Ronde basalt aquifer would not be recharged effectively through enhanced infiltration.

Infiltration Facilities

Infiltration basins consist of large pits with permeable bottoms that allow surface water to readily infiltrate into the subsurface. Infiltration basins can be constructed by excavating a depression to accept infiltration water or by using a pre-existing pit or depression such as an abandoned gravel pit. The rate at which water infiltrates in an infiltration basin depends on soil permeability at the bottom of the basin, the depth to the aquifer beneath the infiltration basin, aquifer transmissivity, the surface area of the bottom of the basin, and the depth of the basin.

The Orange County Water District in California, for example, operates multiple infiltration basins including the Deep Basin and Burris Pit/Santiago Creek Systems (Orange County Grand Jury, 2004). The Deep Basin System, with an area of 280 acres and a capacity of 8,484 acre-feet, has a maximum infiltration rate of 300 cubic feet per second (cfs). The Burris Pit/Santiago Creek System, constructed in a former gravel pit, covers an area of 373 acres and has a capacity of 17,500 acre-feet and a maximum infiltration rate of 210 cfs. The maximum infiltration rates are rarely achieved because silt, biological material and chemical precipitates clog the pore spaces in the material at the base of the infiltration basin. Clogged infiltration rates for the Deep Basin System and the Burris Pit/Santiago Creek System are approximately 89 cfs and 106 cfs, respectively. To restore infiltration rates, the infiltration basins are emptied one to two times per year and the sediments at the bottom are cleaned. The addition of settling basins to remove sediment before water enters the infiltration basin would help reduce sediment clogging of the basins. The Orange County Water District infiltration system recharges approximately 350,000 acre-feet per year to offset groundwater withdrawal.

Infiltration galleries consist of a series of horizontal, buried, gravel-filled trenches or perforated pipes used to infiltrate water into the unsaturated zone to recharge an underlying aquifer. Infiltration galleries lose less water to evaporation than infiltration basins and take up less surface space. The land above infiltration galleries can be used for other purposes. However, infiltration galleries have much less storage capacity than infiltration basins. As with infiltration basins, infiltration galleries can become clogged with sediment, reducing their capacity to infiltrate water. Cleaning is more difficult for infiltration galleries than for infiltration basins, so removal of suspended sediment from infiltration water prior to introduction into the infiltration gallery is critical.

Water Sources

Potential water sources for infiltration basins and galleries include stormwater, water drained from agricultural fields, water diverted from streams, and reclaimed wastewater. Treatment required for infiltration water will depend upon the water source. Filtration that takes place as infiltrated water percolates through the unsaturated zone above an aquifer reduces the amount of treatment necessary for infiltration water. Stormwater, diverted stream water, and water drained from agricultural fields may only require sediment removal prior to infiltration. Careful monitoring of infiltration water from these sources must be performed to prevent contamination of the aquifer from pollutants such as pesticides, fertilizers, biological organisms, petroleum compounds, or industrial chemicals. Reclaimed wastewaters requires extensive treatment prior to infiltration. Geochemical compatibility of infiltration water with sediments beneath infiltration structures is necessary to reduce problems associated with chemical precipitation that could clog the sediments, reducing infiltration rates. Care must also be taken to ensure that infiltrated water does not mobilize toxic compounds such as metals that may be present in the sediments.

Several sources of water for enhanced infiltration exist in the West Plains area. Water could be diverted from Deep Creek or Coulee Creek during high flow periods. The USGS does not monitor flow on Deep Creek and Coulee Creek, so the volume of available water for enhanced infiltration is unknown. Planning for diversions of water for enhanced infiltration should include flow measurements for several years to establish expected instream flows. New water rights would be required for diversions from Deep Creek or Coulee Creek for enhanced infiltration.

Soil conservation maps for Spokane County (SCS, 1968) show sand and gravel pits in several West Plains locations. These sand and gravel pits are potentially favorable locations for enhanced surface infiltration. Some of the sand and gravel pits are located above the paleochannels. Infiltration in these areas would likely recharge the paleochannel aquifers. For example, the gravel pit northwest of the intersection of South Craig Road and West McFarlane Road sits at the southwestern mapped edge of the westernmost paleochannel.

Planning Level Costs

Readily available information on the cost of installing and operating enhanced infiltration projects was reviewed for this report. Cost estimates for enhanced infiltration using infiltration basins are detailed in Table 4-4, and range from $1.2 million to $1.45 million per mgd of recharge capacity. Costs for infiltration galleries depend on the size and design of the system. No infiltration gallery example projects with cost estimates were identified for review for this report.

Enhanced Infiltration for Urban Areas

In an undeveloped environment, stormwater mechanisms such as floodplain storage, channel storage, infiltration and interception attenuate peak flows and distribute stormwater uniformly throughout the basin. Undeveloped land areas allow a large portion of stormwater to seep gradually into soils, removing contaminants, replenishing soil moisture and recharging groundwater aquifers. Pavement and other impervious surfaces prevent these processes. As areas become developed, a much larger percentage of rainwater hits impervious surfaces such as roofs, sidewalks, parking lots, driveways and streets. Extensive regional and national research shows a clear link between development in a watershed and degradation of aquatic resources.

Development in the West Plains area is increasing and along with it so is the area of impermeable surface and the volume of stormwater collected from these surfaces. As the West Plains population grows, the accompanying development may have negative impacts on the watershed's water resources, including reduced infiltration. This reduction can be countered by enhanced surface water recharge to groundwater, which in urban areas is called stormwater infiltration. Stormwater infiltration can easily be incorporated into public and private development projects.

Low-Impact Development

Encouraging low-impact development (LID) can help to allow water to recharge aquifers naturally. LID, which should not be confused with other stormwater management and development options, is an ecosystem-based approach. Research has shown LID to be a simple, practical approach for treating urban runoff (EPA 2000). LID is versatile and can be applied to new development and retrofits. It uses vegetation and small-scale hydrologic controls to capture, treat, store and infiltrate runoff on-site. This helps to maintain the natural hydrology of the site as development occurs. The LID approach contrasts with the traditional approach of capturing, piping and conveying stormwater away from the site. LID is a comprehensive design program that contains the following elements:

- Preservation of native vegetation, natural drainage and porous soils
- Reduction and disconnections of impervious surfaces
- The use of numerous, small-scale hydrologic controls throughout a site
- Clustering of development.

LID is about looking at water resources in a holistic, watershed-based manner, and effectively managing such resources. Such an approach involves conserving water inside and outside a house, and using decentralized stormwater management best management practices. Increasing the amount of water that can infiltrate will help raise the water table.

Despite the increased costs associated with the higher use of on-site landscaping material, experience has shown that LID saves money over conventional approaches through reduced site preparation work and reduced infrastructure, such as smaller storm pond structures and elimination of piped storm conveyance. LID practices can be cheaper to construct and maintain and have a longer life cycle than centralized stormwater strategies (EPA 2000). The need to build and maintain stormwater ponds and other conventional treatment practices will be reduced and in some cases eliminated. Developers benefit by spending less on pavement, curbs, gutters, piping, and inlet structures. These infrastructure reduction savings outweigh any cost increases due to the use of LID and enable builders to recover more developable space since there is no need to waste land for a stormwater pond. Case studies and pilot programs show at least a 25- to 30-percent reduction in costs associated with site development, stormwater fees and maintenance for residential developments that use LID techniques.

LID cost benefits are very site-specific, based on the site's soil conditions, topography, existing vegetation, land availability, etc. Many LID techniques are self-perpetuating or easily repairable, or can be left as natural areas at the end of their functional lifetime, while conventional facilities may require high costs to take out of commission and leave the area safe. The use of LID also reduces off-site costs for sewers or outfalls because it addresses stormwater at its source. Most conventional techniques require an off-site sewer to collect the stormwater from the on-site system, resulting in additional project costs for the enhancement of downstream sewers as urban areas expand.

Regional Stormwater Management

The City of Spokane currently provides water and service to much of the West Plains area but the absence of a regional stormwater facility and the poorly draining soils generally limit new developments to evaporation ponds for stormwater disposal. These facilities may require from 35 to 50 percent of the development site area (Spokane County 2006).

Spokane County is investigating the use of paleochannels for infiltration of stormwater from new residential developments south of I-90 and west of Spokane. Rather than each user having an individual system, especially in an area that does not seem well suited for infiltration, the County wants to develop a regional system. Currently most of the users in the unincorporated parts of the County have dry wells, low-flow dry wells, or evaporation ponds. Dry wells tend to lose their effectiveness due to siltation. Evaporation ponds are unpopular because they are unattractive and take up a lot of room. The regional system could entail transporting the stormwater via grass-lined ditches (which would provide some infiltration and treatment) to nearby paleochannels for infiltration.

The *Spokane County Stormwater Plan* offers a review of structural and nonstructural alternatives to address drainage problems. Structural improvements include the construction of a regional stormwater infiltration and related conveyance system, as well as small, localized stormwater improvement projects to address local concerns such as crushed culverts and road flooding. The total cost of these improvements would be approximately $15.5 million.

Reclaimed Water Use

The Revised Code of Washington (RCW) expressly encourages and provides for the use of reclaimed water to replace potable water in non-potable applications (RCW 90.46.005). Other states, including California, Florida, and Arizona have successfully used reclaimed water without threatening existing resources or public health. Several projects in Washington, including one in Medical Lake, have also been successful.

Regulations and Permits

A reclaimed water permit must be obtained before reclaimed water can be put to beneficial use. Permits may only be issued to governmental entities, private utilities or the holders of a waste discharge permit. The owner of the permit and wastewater facility has an exclusive right to the reclaimed water (RCW 90.46.120). Ecology may issue a reclaimed water permit to the generator of reclaimed water, who then may distribute the water subject to provisions in the permit governing the location, rate, water quality and purpose of use. When Ecology determines that a significant risk to public health exists, Ecology shall refer the application to the DOH. Any use of reclaimed water requires consideration in regional water supply planning efforts and incorporation into an approved sewer or water comprehensive plan when applicable.

The Reclaimed Water Act (Chapter 90.46 RCW) requires that reclaimed water be adequately and reliably treated prior to distribution and beneficial use. The treatment requirements for direct aquifer recharge for potable groundwater include the following:

- AKART shall be applied to all wastewater prior to direct recharge.
- Reclaimed water used for direct recharge to potable ground water aquifers shall be reclaimed water that, at a minimum, is at all times an oxidized, coagulated, filtered, reverse osmosis-treated, disinfected wastewater.
- Any withdrawal facilities constructed solely for the purpose of extracting reclaimed water from the underground shall comply with WAC Chapters 173-136 and 173-150. The purpose of Chapter 173-136 is the establishment of a system of authorizing the withdrawal of artificially stored ground waters embodied in an approved declaration, which are commingled with public ground waters in ground water areas, subareas, and zones. The purpose of Chapter 173-150 is to establish and set forth

the policies and procedures of the DOE in regards to the protection of the availability of ground water as it pertains to the water withdrawal facilities of holders of ground water rights.

Different laws exist for modifications to existing facilities versus new facilities. A new impairment analysis is required prior to modifying a reclaimed water permit to allow additional beneficial uses or an increase in the quantity of water reclaimed. New uses are only allowed if they result in no impairment or compensation/mitigation has been agreed to by impaired water right holders. In some cases the impairment analysis is simple. For example, if existing wastewater discharge has historically been 100 percent consumptively disposed, the analysis can be halted after the first step. For projects whose historical discharge is to a basin with one or more of the following characteristics, a more complex impairment analysis or compensation or mitigation will likely be necessary:

- Basins closed by Ecology to further appropriations
- Basins with instream flows adopted by rule
- Aquifers with declining water levels
- Aquifers designated as groundwater management areas
- Streams that go dry or are regulated each year according to priority date.

The allowable uses for reclaimed water depend first on the level of treatment. The Washington Water Reclamation and Reuse Standards (Ecology, 1997) describe four effluent classifications—Class A is the highest quality and therefore provides the broadest range of reuse options, and Class D is the lowest.

- Class A: Reclaimed water that, at a minimum, is at all times an oxidized, coagulated, filtered, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed, and the number of total coliform organisms does not exceed 23 per 100 milliliters in any sample.
- Class B: Reclaimed water that, at a minimum, is at all times an oxidized, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed, and the number of total coliform organisms does not exceed 23 per 100 milliliters in any sample.
- Class C: Reclaimed water that, at a minimum, is at all times an oxidized, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 23 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed, and the number of total coliform organisms does not exceed 240 per 100 milliliters in any sample.
- Class D: Reclaimed water that, at a minimum, is at all times an oxidized, disinfected wastewater. The wastewater shall be considered adequately disinfected if the median number of total coliform organisms in the wastewater after disinfection does not exceed 240 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed.

Water quality standards are identified for each use of reclaimed water, as shown in Table 4-5.

TABLE 4-5.
TREATMENT AND QUALITY FOR RECLAIMED WATER USE

Use	Type of Reclaimed Water			
	Class A	Class B	Class C	Class D
Irrigation of nonfood crops				
Trees, fodder, and seed crops	Yes	Yes	Yes	Yes
Sod/pasture to which milking cows or goats have access	Yes	Yes	Yes	No
Irrigation of food crops				
Spray Irrigation				
All food crops	Yes	No	Yes	Yes
Undergo physical or chemical processing	Yes	Yes	Yes	Yes
Surface Irrigation				
No contact with edible portion of crop	Yes	Yes	No	No
Root crops	Yes	No	No	No
Orchards and vineyards	Yes	Yes	Yes	Yes
Undergo physical or chemical processing	Yes	Yes	Yes	Yes
Landscape irrigation				
Restricted access areas (e.g. cemeteries)	Yes	Yes	Yes	No
Open access areas (e.g. golf courses, parks)	Yes	No	No	No
Impoundments				
Landscape	Yes	Yes	Yes	No
Restricted recreation	Yes	Yes	No	No
Nonrestricted recreation	Yes	No	No	No
Fish hatchery basins	Yes	Yes	No	No
Decorative fountains	Yes	No	No	No
Street Cleaning				
Street sweeping	Yes	Yes	Yes	No
Street washing	Yes	No	No	No
Washing of corporation yards, lots, and sidewalks	Yes	Yes	No	No
Discharge to constructed beneficial use wetlands	Yes	Yes	No	No
Discharge to natural wetlands	Yes	Yes	Yes	Yes
Human non-contact restricted access	Yes	Yes	Yes	No
Fisheries or human non-contact recreation	Yes	Yes	No	No
Human contact	Yes	No	No	No

Additional constraints apply to construction of a reclaimed water facility. The maximum attainable separation must be achieved between reclaimed water lines and potable water lines. A minimum horizontal separation of 10 feet shall be maintained between reclaimed water lines and potable water lines. When crossing, a minimum vertical separation of 18 inches shall be maintained between reclaimed water lines and potable water lines. The minimum horizontal separation distance between the point of direct recharge and withdrawal as a source of drinking water supply shall be 2,000 feet.

Currently Operating or Proposed Reclaimed Water Projects In West Plains

The only existing reclaimed water facility in WRIA 54 is in Medical Lake. Medical Lake and the state Department of Social and Health Services replaced the City's wastewater treatment facultative lagoon plant with a water reclamation facility in 2001. The plant has a design capacity of 1 mgd. The Class A reclaimed water is discharged to West Medical Lake to maintain water levels for recreation and to the Deep Creek tributary. State facilities located on the lake have water rights to withdraw water from West Medical Lake for on-site irrigation. As flows increase, the City of Medical Lake anticipates expanding reclaimed water use for irrigation of city parks and urban landscape areas. This project has public support and was more cost-effective than retrofitting the old treatment facility.

Fairchild AFB has examined in limited detail several water reclamation options for the base:

- The first option is to collect water from aircraft washings and recycle it for reuse in other aircraft washings. A reclamation system of this variety would likely cost around $225,000 and be able to recycle about 15,000 gallons per day, or 5.5 million gallons per year.
- The second option is to collect stormwater runoff from impervious sources and direct it to a storage lagoon. This water could be used to supplement irrigation water supplies. Since most precipitation at Fairchild AFB falls during the non-summer months, large storage tanks or lagoons would be necessary. Fairchild AFB estimated that 50 to 90 million gallons per year could be captured for reuse.
- The third option is reclamation of domestic wastewater. Considering that domestic water use is one of the largest water uses besides irrigation, this option provides high reclamation and reuse potential. Building a treatment facility would likely cost $12 million to $15 million and could treat 1.2 mgd during the summer months.

The City of Spokane hopes to find a beneficial use for the 15 billion gallons of treated wastewater that it discharges to the Spokane River annually. The City's discharge, averaged over one year, is about 1 percent of the average river flow. The City has undertaken a study to determine the feasibility of establishing a large-scale agriculture irrigation district using reclaimed water from the City of Spokane in WRIAs 43, 54, 55, 56, and 57. This project is unusual because very few reclaimed water utilities are located in sufficiently rural locations to supply large-scale irrigation for agricultural use. One issue that arises from this study is the transportation method, because the wastewater facility will not be able to release the reclaimed water to the Spokane River. Although the generator of reclaimed water has a right to that reclaimed water with a permit, there are no laws stating that the permit holder has a right to the water once it has been discharged to waters of the state. This problem could be overcome by building storage and/or piping to the water user. As designed, the plant would provide 50 mgd of Class D water; however, treating the water to Class A standards may make developing an irrigation district more viable. The success of this project is also dependent on finding users and sufficient areas of soils that will be suitable for agriculture to create sufficient economic demand for water. Of the six potential sites for a suitable irrigation district in the 20-mile radius from the treatment plant, one falls in the West Plains study area.

Airway Heights is currently designing a $34 million water reclamation facility to produce Class A reclaimed water. Phase 1 construction will be for 1 mgd and Phase 2 will add another 0.5 mgd. The City expects the reclaimed water to be used for irrigation and for manufacturing by large commercial and industrial users.

Use of Reclaimed Water for Groundwater Recharge

Reclaimed water could be used as a water source for groundwater recharge, ASR, or wetland restoration. Using reclaimed water for these types of projects could serve as mitigation of declining groundwater levels within the basalt aquifers on the West Plains, depending on the project design. They would provide substantially more groundwater recharge than would result from agricultural irrigation projects which would have high losses due to application and evapotranspiration. These uses would likely require water treatment to a Class A standard.

Potential water sources other than reclaimed water for groundwater recharge projects in the West Plains area include surface water or City of Spokane water taken during periods of high water availability. During the summer, however, surface water or City of Spokane water may not be a feasible water source for groundwater recharge projects for environmental or economic reasons. A supply of reclaimed water from a sewage treatment facility would be more stable throughout the year, including the summer months (see Figure 4-7). Year-round operation of the groundwater recharge project could increase annual recharge and the cost effectiveness of the groundwater recharge project.

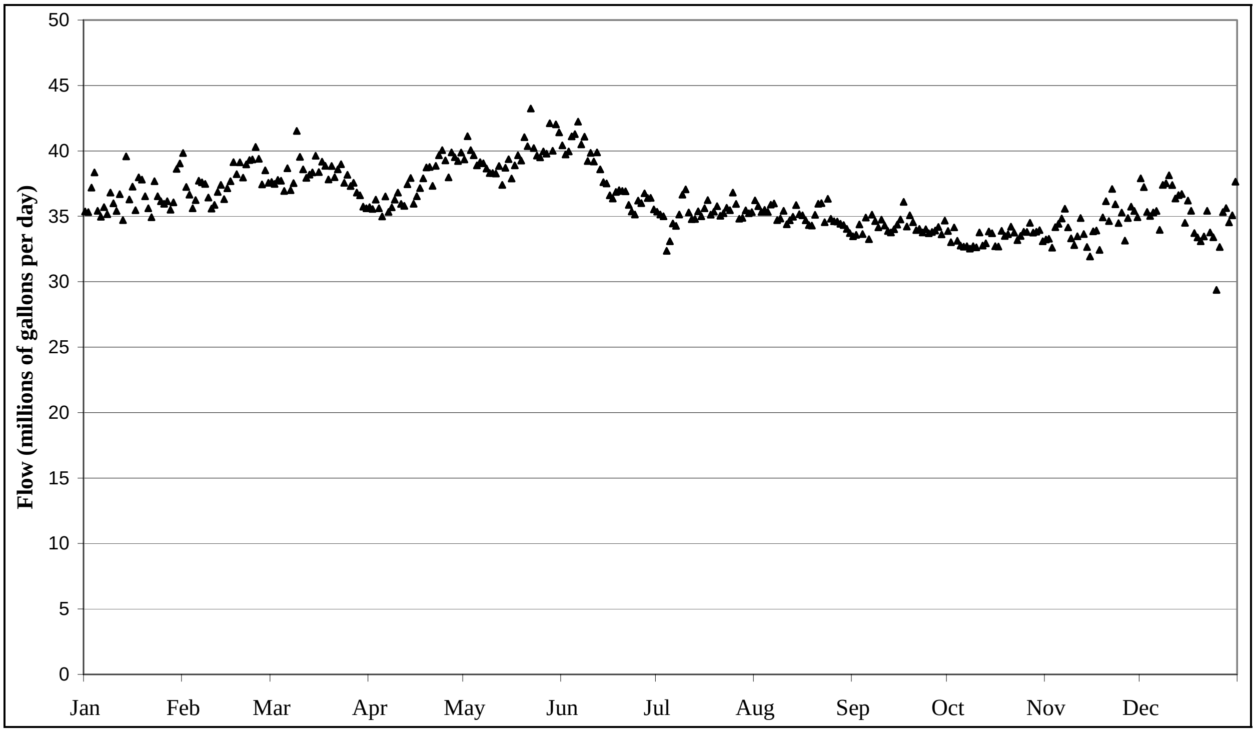

Figure 4-7. Daily Average Primary Influent Flow to Spokane Wastewater Treatment Plant

Use of reclaimed water for groundwater recharge could simplify the process of finding end users for reclaimed water compared to making the water available for irrigation. Instead of relying on farmers to form an irrigation district that could negotiate to obtain reclaimed water, the cities would coordinate the project internally. Distribution of reclaimed water would be greatly simplified. Instead of building a new, complex delivery network to multiple end users in an irrigation district, reclaimed water would be delivered to a few centralized groundwater recharge sites. Reduction in the complexity of delivery could reduce costs and project implementation time.

Comparison of Methods for Enhanced Surface Water Recharge to Groundwater

The methods of water infiltration and injection discussed above—ASR, UIC, reclaimed water, and enhanced urban or rural infiltration—have different regulations that control them:

- ASR projects must comply with regulations for UIC wells or infiltration, depending on which type of facility is used.

- Collecting stored water requires a reservoir permit.
- Washington State requires the water source for ASR wells to be treated to drinking water standards.
- Direct injection of water into the target aquifer requires drinking water quality injection water if drinking quality water is present in the target aquifer.
- UIC wells must be registered with the state and have a discharge permit. The water may be untreated, such as stormwater, when pollutant concentrations that are expected to reach the groundwater do not exceed Washington State groundwater quality standards (non-endangerment standards).
- UIC wells must be sited to avoid areas of high contaminant runoff and drinking water wells.
- Stormwater UIC wells must have some separation and may not discharge directly to the groundwater.
- Treatment requirements for an infiltration facility are based on the type of water being discharged to, and whether oil, pollutant, phosphorus or metals treatment is required. Water to be added to the aquifer by infiltration through the unsaturated zone may be allowed to meet lower quality water standards than water injected directly to the aquifer.
- Infiltration may be handled on site or regionally. Regional methods may need to be used if no adequate infiltration sites exist on site.
- An infiltration facility must meet setback criteria and not be in wellhead protection zones, aquifer sensitive areas, etc. A site is considered unsuitable if the infiltration facility will cause a violation of groundwater quality standards.
- The regulations regarding reclaimed water are mostly dependent on the end use of the reclaimed water. Reclaimed water may not be used for any potable applications. Higher quality reclaimed water may be used for food crops, open access areas, fish hatchery basins, etc.
- Reclaimed water may be used as the water source for ASR but there are stricter regulations on the treatment, such as mandatory reverse osmosis.

Off-Channel Reservoirs

Off-channel reservoirs store water away from the main channel of a surface water body such as a stream or lake. Off-channel reservoirs may be above ground or in-ground. Above-ground reservoirs usually are steel or concrete tanks with relatively low storage volumes. In-ground reservoirs are built in natural or excavated depressions and should be lined and covered. Existing above-ground and in-ground reservoirs in the West Plains area have capacities that range from a 75,000-gallon steel tank at Fairchild AFB to a 1.5 million gallon reservoir at Medical Lake.

Potential water sources to fill new reservoirs in the West Plains area include Deep Creek, Coulee Creek, the Spokane River, groundwater, and City of Spokane municipal water. Water from these sources would be stored in the reservoir during periods of high water availability. Water taken from Deep Creek, Coulee Creek or the Spokane River would need treatment before storage in a reservoir. Multiple sources of water could be used to fill the reservoir depending on water availability and cost. The most favorable area in West Plains for additional reservoir construction would be northeast of Airway Heights; this area is relatively close to the Spokane River, Deep Creek, Coulee Creek, and Spokane City water pipelines.

Above-ground tank reservoirs have the greatest flexibility in placement. Siting considerations consist of proximity to water sources, proximity to water delivery infrastructure, and site geotechnical characteristics. From a geotechnical perspective, above-ground tank reservoirs could be placed at many West Plains locations.

In-ground reservoirs face the same location requirements as above-ground reservoirs with respect to proximity to water sources and distribution infrastructure. Geotechnical site requirements are more demanding for an in-ground reservoir. Extensive site excavation generally is required. Large excavations in West Plains may be difficult and expensive due to the underlying basalt's proximity to the surface. Siting in-ground reservoirs in areas with known sand and gravel deposits would make excavation easier and less costly. Possible sites for in-ground reservoirs include former borrow pits where there are known deposits of sand and gravel. One such site exists northwest of downtown Airway Heights. The site is approximately 80 acres in area. The area of the gravel pit is approximately 30 acres. A 10-acre, in-ground reservoir on the site 5 feet deep could store approximately 16 million gallons of water.

Total project costs for reservoirs are difficult to estimate and depend on a variety of factors, including site characteristics, reservoir type, and economic conditions. Without specific project information, cost estimates can only be very general in nature. The City of Medical Lake has four reservoirs, including steel tanks and in-ground, neoprene-lined concrete tanks. The 1.5 million-gallon ground-level steel tank was constructed in 1997 for an approximate cost of $1.5 million (Dorshorst, personal communication, 2007). The City of Belle Plaine, Minnesota built a concrete, 500,000-gallon ground storage reservoir in 2003 for a total cost of approximately $540,000 (Bolton-Menk, 2007). The City of Belle Plaine also constructed a 400,000-gallon steel elevated storage tank and associated pump station in 2006. The elevated storage tank and pump station cost approximately $563,000 and $746,000, respectively (Bolton-Menk, 2007). Costs for a lined and covered in-ground reservoir depend on the size of the excavation, the lining and cover used, and associated water conveyances to fill the reservoir.

Wetlands Storage

Under the Clean Water Act, wetlands are defined as "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."

Functions of Wetlands

Wetlands play an important role in groundwater hydrogeology. They can act as both discharge and recharge areas for groundwater. A wetland in depressions that collect surface runoff that then infiltrates through the bottom of the wetland will help recharge an aquifer. Wetlands may also be fed by groundwater. The wetlands may in turn drain to surface water bodies such as streams or lakes. In this case, the wetland acts as an area of groundwater discharge.

Wetlands are also important from ecological and hydrological standpoints. They serve as important habitat for a variety of species, such as frogs, fish, insects, migratory birds, beavers and other mammals. The vegetation and micro-organisms that inhabit wetlands help remove nutrients and other potential pollutants from water, thus improving surface and groundwater quality. The slow movement of water through wetlands also helps remove suspended sediment, reducing turbidity and further improving water quality. The ability of wetlands to absorb large volumes of water and then release them slowly helps moderate stream flows and reduce flooding.

Wetlands in West Plains

Figure 4-8 shows the locations of wetlands in the West Plains study area, based on data from the 2007 National Wetlands Inventory. West Plains wetlands are broken down into the following types: freshwater emergent wetland, freshwater forested/shrub wetland, freshwater pond, lakes, and riverine. Lakes and freshwater emergent wetlands cover the largest amount of wetland area, at approximately 18,000 acres and 2,400 acres, respectively. Forested/shrub wetlands and freshwater ponds cover 220 acres and 230 acres, respectively. Riverine wetlands cover 134 acres. Of the emergent wetlands, approximately 95 percent are less than 10 acres in size. The largest emergent wetland is 114 acres, and two wetlands are between 60 and 70 acres. The largest forested/shrub wetland covers approximately 10 acres, and the largest pond covers approximately 20 acres.

Management of wetlands on the West Plains area can play a role in increasing water storage. Enlargement of wetlands could have a beneficial effect on water storage both in wetlands that recharge groundwater and in wetlands that are fed by groundwater discharge. In wetlands that are fed by groundwater discharge, impounding exit points that release wetland water to streams would increase water storage in the wetlands. This water could then be released later to augment stream flow during low-flow periods. Diversion of surface water or runoff into wetlands where groundwater recharge is occurring could help increase groundwater recharge. Because of the relatively small size of most of the emergent, forested/shrub, and pond wetlands, relatively small volumes of water would be stored on a per wetland basis. Over the entire West Plains area, the additional amount of water that could be stored in wetlands is substantial.

Wetland Reservoir Sub-Irrigation Systems

A new and innovative approach to irrigation that would involve temporary storage of water in wetlands is the Wetland Reservoir Sub-Irrigation System (WRSIS). In a WRSIS, water is removed from fields where the water table is too high using a sub-surface drainage system consisting of a network of perforated pipe. Drained water is fed into a wetland where sediments are allowed to settle. Plants and microorganisms in the wetland remove nutrients, pesticides, and herbicides from the water, improving water quality. After spending time in the wetland, water is moved to a reservoir where it is stored for irrigation during the summer. When irrigation water is needed, water from the reservoir is fed back through the drainage pipes to irrigate the field from beneath. Using this method of irrigation, little water is lost to evaporation.

Three WRSIS demonstration projects are in operation Defiance, Fulton and Van Wert counties in northwest Ohio. At all of the demonstration sites, the sub-irrigated fields are used for raising corn and soybeans. The following information on the sites was provided by the USDA (2007):

- The Defiance County site has two 3.5-acre sub-irrigated fields. Drainage from the sub-irrigated field and 20 acres of conventionally irrigated cropland feeds a 0.3-acre wetland capable of storing 185,000 gallons of water. Water in the wetland is then pumped to a 780,000-gallon reservoir. Capital construction costs of the Defiance site total $44,700.
- At the Fulton County site, the sub-irrigated field area is 20 acres. The wetland and reservoir store approximately 1.0 million gallons of water and 2.3 million gallons of water, respectively. The Fulton County site's capital costs were approximately $80,600.
- A 1.0 million gallon wetland and a 7.5 million gallon reservoir receive drainage water and surface runoff from 45 acres of cropland at the Van Wert demonstration site. The stored water is used to sub-irrigate 30 acres of cropland. Total capital costs were $86,000.

Use of WRSIS technology could bring many benefits to agriculture in West Plains. The sub-surface drainage networks would help remove water from fields more quickly during the spring. Instead of having

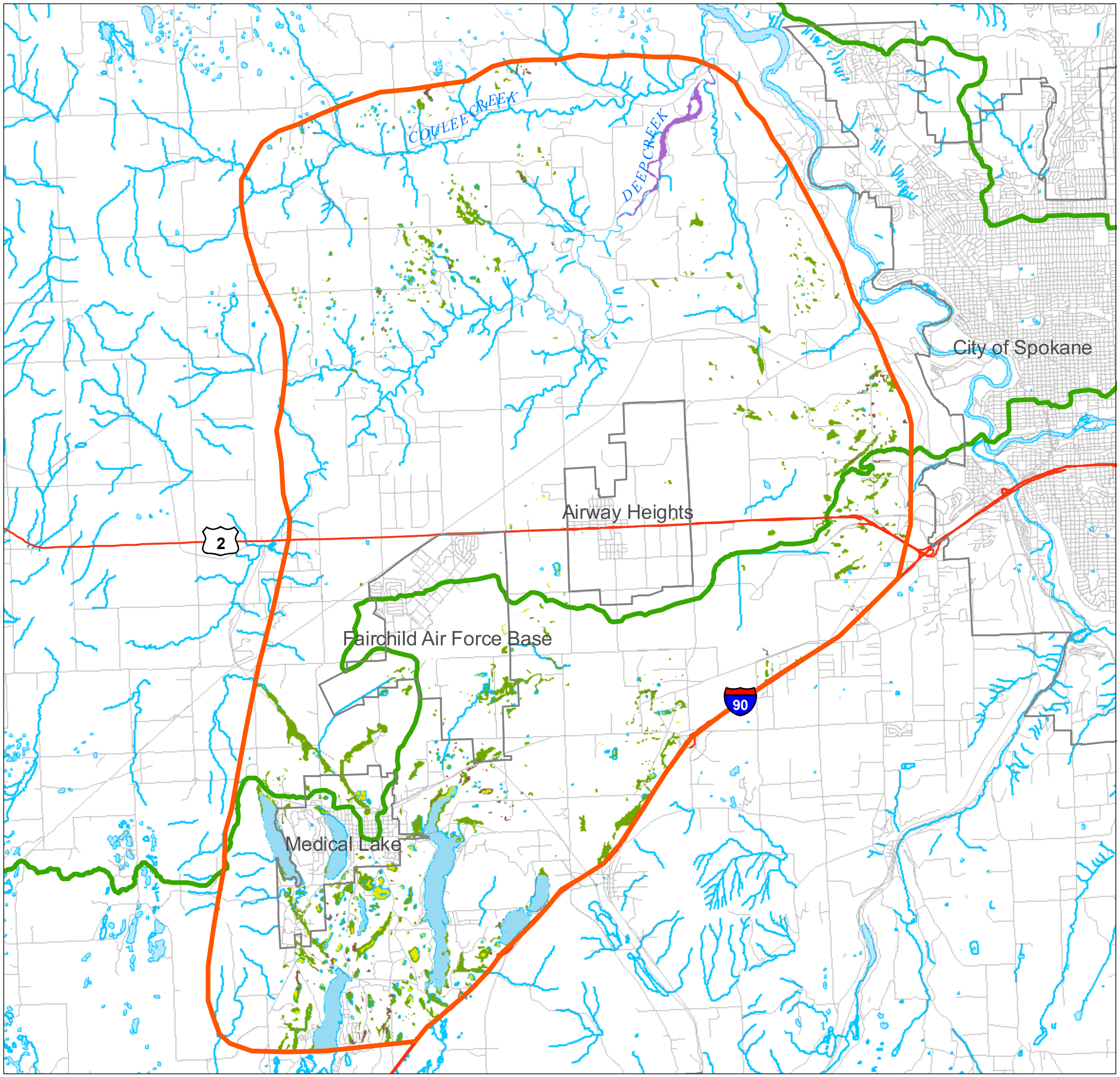

Figure 4-8

West Plains Wetlands

Legend

- Major Road
- Street
- County Boundary
- Stream
- WRIA54 Boundary
- Study Area Boundary
- Juristiction

Wetland Type

- Freshwater Emergent Wetland
- Freshwater Forested Shrub Wetland
- Freshwater Pond
- Lake
- Riverine

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

0 0.5 1 2 3
Miles

N

TETRA TECH/KCM
1420 Fifth Avenue, Suite 600
Seattle, Washington 98101-4085
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Map Produced 05/16/2007

the water drain to streams where it could no longer be withdrawn for agricultural use, the water would be stored in small wetlands and reservoirs. The water storage in wetlands would bring the hydrologic and ecological benefits described above. Water stored in the reservoirs would be used for irrigation, reducing the need for pumping groundwater for irrigation. Current farming in West Plains consists largely of dry-land wheat farming. The availability of water from a WRSIS could allow more water-intensive crops to be grown. Additional study would be needed to determine how much water would be available for storage in a WRSIS from precipitation, runoff, and field drainage and whether sub-irrigation would be appropriate for the soil types and unsaturated zone conditions found in the West Plains area.

NONSTRUCTURAL OPPORTUNITIES

The nonstructural alternatives that offer storage opportunities in the West Plains study area are conservation and transfer of water rights.

Water Conservation

The number of water utilities in the U.S. that have a water conservation and reuse program has increased dramatically over the last 10 years (EPA, 2002). These programs include residential, commercial, and industrial customers. An important finding of the Phase 2, Level 1 Technical Assessment for WRIA 54 is that the use of water for irrigation, including commercial and residential landscaping, far exceeds water used for other purposes (Tetra Tech, 2006). Therefore, conservation measures targeted to reducing water for landscaping and irrigation are likely to produce significant water savings. Reducing water can save money for both the purveyors and the customers. The purveyors do not need to build additional and unnecessary infrastructure and the customers pay lower water and sewer bills.

Water conservation is a critical component of meeting existing and future water needs, including in-stream and out-of-stream uses. Increased conservation reduces the amount of water being withdrawn from surface water and groundwater sources, leading to less impact on water supply sources. Using water efficiently is particularly important during summer months, when rainfall is scarce and customer demand is high. Water rate structures can be adjusted to promote conservation by charging for water usage above a specified volume. Addressing water losses within a water purveyor’s supply system would also lead to less demand on supply sources.

In 2003 the DOH enacted the Municipal Water Supply-Efficiency Requirements Act (commonly called the Municipal Water Law) as part of a multi-year effort to reform the state’s water laws. The law provides utilities the opportunities to exercise their water rights while establishing achievable water use efficiency requirements. This law is expected to provide more certainty and flexibility for water rights held by water systems, more closely tie water system planning and engineering approvals by the DOH to water rights administered by Ecology, improve the ability to plan for future growth, and advance water use efficiency. The law requires municipal water suppliers to develop a conservation plan, reduce distribution systems leaks to 10 percent or less, and report annually on their progress. Municipal providers in West Plains that include unaccounted-for water in their water system plans are as follows:

- Airway Heights (Group A Municipal System): Unaccounted-for water = 21 percent
- Fairchild AFB (Group A Municipal System): Unaccounted-for water = 3 percent
- Medical Lake (Group A Municipal System): Unaccounted-for water = 8 percent

Existing Conservation Plans

Several West Plains municipalities, including Airway Heights, Fairchild AFB, Medical Lake, and the City of Spokane, currently have conservation plans. Key elements of their conservation plans documented in their water systems plans are as follows:

- Airway Heights set a goal to reduce water consumption by 5 percent, although a detailed schedule was not provided in the water system plan. Currently Airway Heights is meeting requirements to meter wells and to check for inconsistencies in data. The City is providing public education on water conservation methods and providing customer assistance. Airway Heights is not currently providing incentives to encourage water conservation.
- 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. Fairchild AFB has source meters installed at all groundwater sources and has reduced unaccounted-for water from 15 percent to 3 percent. A program to convert manual above-ground irrigation systems to an automatic and underground setup is improving water efficiency. This program may be expanded by adding a precipitation-based irrigation system instead of a timer-based system.
- Medical Lake is metering all facilities and reviewing the meters to identify system problems. Medical Lake estimates that this has resulted in a 2-percent reduction 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.
- The City of Spokane's objective is to limit the growth of peak-day demand so that existing resources can 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 and other system problems. The City has had a leak detection system in place since the 1970s. To encourage conservation, the City has implemented a new inclining block rate structure. The City's education program is fairly extensive, especially for youth. The City is actively pursuing water reclamation projects to save on the demand for potable water, with the first phase to commence in 2007.

Potential New Conservation Measures

Public Education on Water Use and Waste

Most municipalities that have a conservation program provide some sort of public education. Public education includes a variety of methods including public relations campaigns, water use information provided with water bills, water audits, and cooperative programs with schools and other organizations. Some providers, such as Phoenix Water Services Department, have implemented a water conservation plan that focuses less on structural fixes and more on changing behaviors and educating the next generation of water users (EPA, 2002). The town of Cary, North Carolina estimated that its public education program will save 0.3 mgd in 2009 and have a benefit-cost ratio of 1.53 (EPA, 2002).

Ensure That Utility Rate Structures Encourage Water Efficiency

Water rate structures can be adjusted to promote conservation by charging for water usage above a specified volume. The City of Spokane has instituted a rate structure that increases costs of water proportional to the consumption (increasing block). For residences within the city limits, the water rates are $0.23 to $0.66 per 100 cubic feet. Those costs double for residences outside the City. The standard rates for purveyors outside the City's service area are $.90 per 100 cubic feet. Previous conservation pricing at the City of Spokane showed some reduction in average per capita usage. Rates could even be made seasonal to have a greater effect on peak daily demand. Increasing the frequency of billing cycles can also allow users to see how their water use is changing and allow them to alter their water consumption in a more timely manner. Some other cities with low precipitation, such as Albuquerque, have added summer surcharges of 21 cents per 100 cubic feet when customers' use exceeds 200 percent of their winter average (EPA, 2002). Much of this surcharge is allocated for conservation programs and a large portion is returned to customers through rebates and other incentives. The Irvine California Water District implemented a new rate structure and water use declined by 19 percent the following year (EPA, 2002).

Equip Homes with High-Efficiency Plumbing Fixtures and Appliances

High-efficiency toilets, washing machines, aerators and other plumbing fixtures can save significant amounts of water, and many of these fixtures have proved popular with customers. The EPA set up two pilot studies to help calculate actual water savings associated with these fixtures. Houses in the pilot study were retrofitted with high-efficiency toilets, showerheads, clothes washers, and faucets. The study found that that daily indoor use dropped 35 percent from 191.0 gallons per day per household to 123.3 gallons per day per household, or 24,700 gallons per year per household. This equates to $22 per year in savings. An analysis of benefits and costs showed that these products pay for themselves in water and sewer costs savings within the expected life of the products (Aquacraft 2003). The largest water savings resulted from high-efficiency toilets (10.1 gallons per day), high-efficiency clothes washers (5.1 gallons per day), and leak repairs (16.8 gallons per day). Many water purveyors provide high-efficiency devices free of charge or at a reduced rate to their users. Albuquerque, New Mexico and Ashland, Oregon provided up to $100 rebates for toilets, while New York offered up to $250 per toilet (EPA, 2002).

Leak Management and Repair

Repairing water leaks can be a simple and effective conservation method. Audits and metering can help identify the locations and magnitudes of leaks. The amount of water dribbling out of a leaky faucet, spray valve, or hose valve may seem insignificant, but that water is leaking all day, every day and the gallons start to add up.

Increase Irrigation Efficiency with Application Nozzles, Timers and Distribution Systems

Improving outdoor water efficiency can be a fundamental part of any conservation program, especially in West Plains. Of the tremendous amounts of water applied to lawns and gardens, much of it is never absorbed by the plants and put to use. Some water is lost to runoff by being applied too rapidly, and some water evaporates from exposed, unmulched soil; but, the greatest waste of water is applying too much too often. Watering techniques and irrigation systems differ for lawns and gardens. Automatic timers can be used to avoid over-watering lawns and gardens. Timers should be set for early morning or later in the evening to help reduce evaporation.

Encourage Low-Impact Development and Xeriscape Landscaping

Xeriscape landscaping is a comprehensive approach to landscaping for water conservation. It can be an integral part of a LID approach. Xeriscape landscaping incorporates basic principles which lead to saving water:

- Planning and design
- Practical turf areas
- Appropriate plant selection

- Efficient irrigation
- Use of mulches
- Appropriate maintenance.

An example of a Xeriscape is given in Figure 4-9. Many Xeriscape incentive programs are being offered through water purveyors and they offer rebates such as $0.20 to $1.20 per square foot of converted landscape areas up to a certain dollar amount such as $500.

Figure 4-9. Before and after picture for a Xeriscape house (http://www.ose.state.nm.us/water-info/conservation/xeriscape-101.html)

Creating a water-efficient landscape begins with a well thought-out landscape design. According to the City of Spokane Municipal Code "Landscape areas that are irrigated should be designed so that plants are grouped according to distinct hydrozones for irrigation of plants with similar water needs".

Trees, shrubs and groundcovers should be selected based on their adaptability to the region's soil and climate. Native plants are those that have naturally adapted to a region. Ponderosa pine, Quaking aspen, Woods rose and Douglas spirea are some of the native species in the Spokane region. Native plants are hardy and adaptable in the regional climate, can tolerate less fertility in the soil, are less susceptible to pests and diseases, and are generally easier to maintain. Grass should be selected according to its intended use, planting location and maintenance requirements. The choice of grass is most important in parks and golf courses. Achieving a significant reduction in water consumption and landscape maintenance may also involve reducing the size of water-sensitive lawns through the use of patios, decks, shrub beds and groundcovers.

Municipalities can also adopt strict requirements that landscaping for new developments may only have a low percentage of high-water-use grasses or that commercial landscaping may only use drought-tolerant plants and other water-efficient landscaping methods.

An added benefit of Xeriscape landscapes is reduced maintenance. A well-designed landscape can decrease maintenance by as much as 50 percent through reduced mowing; once-a-year mulching; elimination of weak, unadapted plants; and more efficient watering techniques.

Water Rights Transfers

When one user in an area has a significant amount of inchoate water rights while another user is in need of water, water rights transfers or leases can be used in place of creating new structural storage projects. Opportunities for water rights transfers are likely to be from some of the largest water rights holders. Table 4-6 summarizes the largest water rights holders in West Plains, all of which belong to the large water purveyors.

**TABLE 4-6.
LARGEST WATER RIGHT HOLDERS**

Name Listed on Claim	Purpose	Type	File Number	Maximum Annual Withdrawal (Acre-feet)
Fairchild AFB	DM	Claim	G3-112893	3130
Medical Lake and CSS	DM	Permit	G3-28914	2400
Fairchild AFB	—	Claim	112894	2164
Medical Lake and CSS	—	Certificate	3300-A	1600
Medical Lake and CSS	—	Certificate	G3-05268	1600
Fairchild AFB	IR, DM	Claim	G3-112895	1545
Fairchild AFB	—	Claim/change	112892	1545
Airway Heights	—	Permit	G3-29249	1200
Airway Heights	MU	Certificate	G3-26657	800
Medical Lake and CSS	—	Certificate	G3-25319	800
Airway Heights	—	Certificate	G3-09535	224
Airway Heights	—	Certificate	G3-27427	102

DM= domestic, MU= municipal, IR= irrigation

A water rights transfer may be permanent or temporary. A permanent transfer of water involves the acquisition of water rights and a change in ownership of the right. Permanent transfers are a form of supply augmentation and serve many of the same needs as capacity expansion projects. In other cases, potential buyers of water are less interested in acquiring permanent supplies than in increasing the reliability of their water supply system during drought, supply interruptions due to earthquake, flooding, contamination, mechanical failure, or periods of unusually great demand. For these cases temporary transfers contingent on water shortages may be desirable.

The purchase of a water right is usually insufficient to effect an actual water transfer. Transferred water must typically be conveyed and pumped to a new location and often stored. Since both emergency and short-term and long-term transfers may require modifying the operation of existing water infrastructure, considerable work may be required to coordinate the use of conveyance, storage and treatment systems.

Researching prices of water transfers in order to estimate the current market value can be difficult because the prices vary by region and by type (e.g. agricultural to municipal, industrial to agricultural, etc). Ecology does not keep records of prices for water rights transfers. Although water rights transfers are often desirable, the economic efficiency of water markets is subject to problems such as the following:

- Water rights are often poorly defined.
- Water transfers can have high transaction costs.
- Water markets often consist of relatively few buyers or sellers.
- Water is often costly to convey between willing buyers and sellers.
- Communication between buyers and sellers may be difficult.

Policy makers must consider these problems when they are making appraisals of water transfers. After researching the technical, political and economic factors associated with many of the water transfer possibilities in West Plains, only a few were identified as potentially feasible.

One option would be for Fairchild AFB to sell its water rights. Fairchild AFB has claims on a high volume of quality water; but base officials do not feel that the Air Force base should be in the business of selling and distributing this water. Fairchild AFB analyzed the potential value of selling its water rights to the City of Spokane. Including its claims, the base has 6,480 acre-feet of water rights at the Fort Wright wells. Because the City of Spokane is one likely purchaser of the water rights, the City's water rates and inflation rates were used in the analysis. In 2004, the City's in-city water rate was $0.64 per 100 cubic feet, or $278.78 per acre-foot. Over life cycles of 20 and 40 years, the net present value for this sale is $36.7 million and $72.2 million, respectively.

From the Phase 2 Level 1 Report, Spokane has 8,519 acre-feet per year of inchoate water rights so they might not be interested in this purchase. However, since Airway Heights already purchases a portion of water from the City of Spokane, another option would be to remove the middle man and have Fairchild AFB sell its water rights directly to Airway Heights.

CHAPTER 5.
SUNCREST STUDY AREA

The Suncrest area lies along both sides of Long Lake just west of the City of Spokane. There are no cities in this study area. The population in the eastern portion of the study area is growing fast however, because of the real estate along Long Lake and its proximity to the City of Spokane. Suncrest is estimated to have a population of 7,232. One fourth of the population does not have water service.

The Suncrest area is in a better water situation than West Plains because it receives more precipitation (15 to 24 inches annually) and has access to the Spokane River and a small piece of the SVRP aquifer. Suncrest also has better water resources due to higher forest cover and lower population density. The water storage opportunity studies were severely scaled back in Suncrest by direction of the MSG and due to the lower requirements for water in the future compared to West Plains .

The Stevens County Public Utility District (PUD) manages 22 water purveyors, five of which are located in the Suncrest study area. They pump almost all of their water from wells located on both sides of the Spokane River. Stevens County likely has enough water into the foreseeable future; however, storage capabilities in the Suncrest region are often inadequate for summer demand.

The Stevens County Comprehensive Plan states that its goal is to "designate UGAs of adequate size and appropriate permissible densities to accommodate the urban growth that is projected by the State Office of Financial Management for the coming 20-year planning period." To help accommodate the future growth in the County, five unincorporated areas are being designated to encompass existing communities. The Long Lake UGA is the only UGA designated by Stevens County in the Suncrest area. The Long Lake UGA lies along the northern shoreline of Long Lake just east of Nine Mile Falls and is about 6 miles long and 1 mile wide (an additional 430 acres). Designation of a UGA at Long Lake recognizes its current population levels, its presence of commercial services, and its strategic proximity to the City of Spokane. However, in the near term, the growth potential may be constrained by lack of public sewer service.

CURRENT WATER USE

Water rights data for the Suncrest study area were collected from the WRATS and the Stevens County PUD water system plan. Water use data was gathered from the Stevens County PUD water system plan. The Suncrest and Long Lake systems, serving the Lake Spokane UGA, are the largest purveyors in the area. Table 5-1 shows the maximum annual withdrawals, water rights, and inchoate rights for the largest purveyors in Suncrest. About 45 percent of the water rights in the Suncrest area are not being used, based on the assumptions used in this analysis. The domestic exempt water demand in Suncrest is 971 acre-feet.

TABLE 5-1.
MAXIMUM ANNUAL WITHDRAWALS, WATER RIGHTS, AND INCHOATE RIGHTS

Water User	Maximum Annual Withdrawal (acre-feet)	Water Rights (acre-feet)	Inchoate Rights (acre-feet)
SPUD River Park Estates	10	31	21
SPUD Spokane Lake Park	339	1,000	661
SPUD Suncrest and Long Lake	1,690	3,010	1,320
SPUD Westshore	402	285	-117
Total	**2,441**	**4,326**	**1,885**

FUTURE WATER USE

Future consumptive water needs, which are anticipated to be primarily for domestic supply, are expected to increase in the future. The Suncrest area falls in both Spokane and Stevens Counties. Population estimates for the Spokane County portion used the TAZ forecast but interpolated between the TAZ 2015 and 2030 projections. The only available population projection for the Stevens County section was the 2020 target population set for the Long Lake UGA in the Stevens County Comprehensive Plan. Since this is the most populated area in the study area it should be a good estimate. Figure 5-1 shows the resulting population projection for the Suncrest study area. This estimate yields a future water use projection for 2020 of 3,100 acre-feet, a 26 percent increase from 2005.

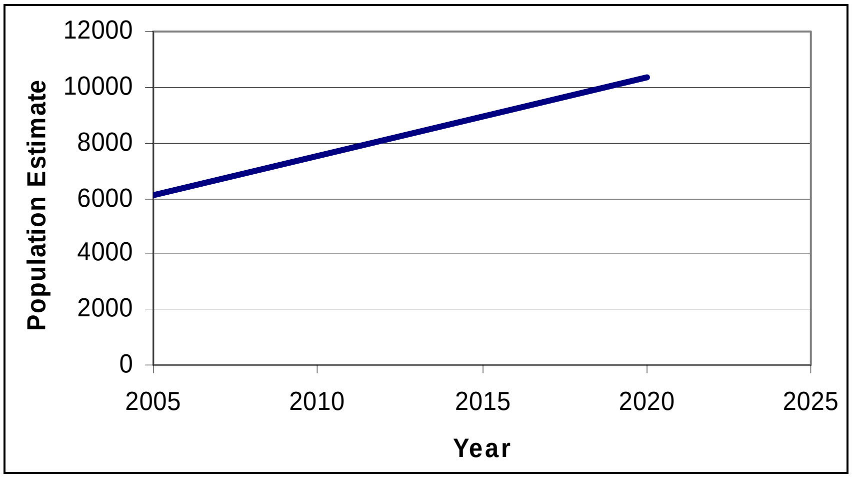


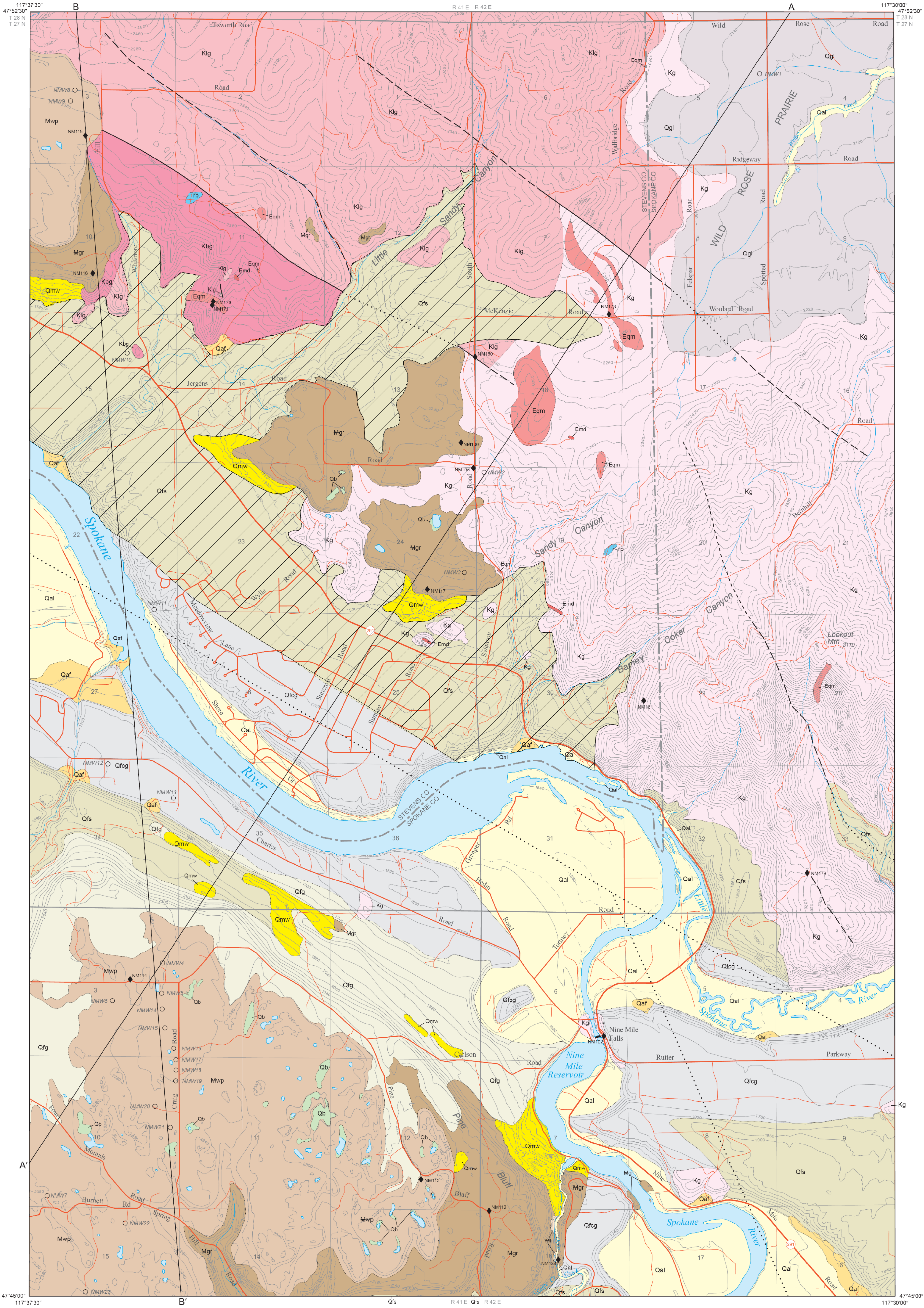
Figure 5-1. Suncrest Population Growth Estimates

The Suncrest region will have significant population growth, but an in-depth study of the available water and water rights indicated that Suncrest has sufficient water resources for the future. Given its resources for accommodating future water needs, Suncrest was de-emphasized as a special study area, except for the ASR opportunity described below.

WATER STORAGE OPPORTUNITY—ASR IN CATARACT DEPOSITS

Recent geologic mapping by the Washington Department of Natural Resources documented sediments possibly deposited in a cataract environment during one or more flood events associated with catastrophic draining of glacial Lake Missoula. The sediments consist of flood sands and gravels deposited in an apparent plunge pool scoured into granite basement rocks in the vicinity of Whitemore Road as shown in Figure 5-2 (Derkey et al., 2003). Hatching in Figure 5-2 marks the approximate mapped area of the cataract deposits; the mapped geologic units are described in Figure 5-3. Cross-section B-B' shows a maximum thickness of flood sands of a little over 500 feet in the deepest portion of the plunge pool (Figure 5-4). The flood sands grade into flood gravels in and adjacent to the Spokane River, with the flood gravels attaining a maximum thickness of approximately 400 feet. As shown in cross-section A-A' (Figure 5-4), the flood sands appear to thin to approximately 300 feet to the southeast while the flood gravels probably thicken. There is moderate uncertainty in the thickness of the flood sands and gravels due to the limited amount of existing subsurface data from water wells that penetrate the full thickness of the sedimentary deposit.

The flood sands and gravels constitute a potential location for water storage projects. One possible project would be to infiltrate surface water or stormwater into the cataract deposits during periods of water surplus and then allow the water to drain into the Spokane River to augment flow during low flow



SCALE 1:24 000

contour interval 40 feet
supplementary contour interval 20 feet

Lambert conformal conic projection
North American Datum of 1927
Base map information from the Washington Department of Natural Resources, Geographic Information System
Digital cartography by Robert E. Derkey, Chuck Caruthers, and J. Eric Schuster
Edited by Karen D. Meyers and Jaretta M. Roloff

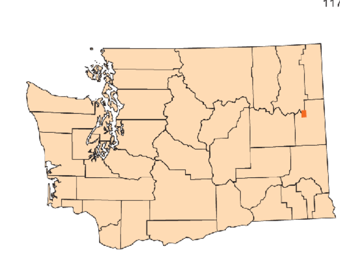


Figure 5-2. Cataract Deposits

Geologic Map of the Nine Mile Falls 7.5-minute Quadrangle, Spokane and Stevens Counties, Washington

by Robert E. Derkey, Michael M. Hamilton, and Dale F. Stradling

2003

INTRODUCTION

The earliest geologic mapping in the Spokane area (including the Nine Mile Falls quadrangle) was by Pardee and Bryan (1926). Griggs (1966) completed a 1:125,000-scale geologic map of the western half of the Spokane 1- by 2-degree quadrangle. He later extended his mapping eastward to encompass the entire Spokane 1- by 2-degree quadrangle (Griggs, 1973). Joseph (1990) compiled a 1:100,000-scale map of the Spokane quadrangle that incorporated more detailed interpretations of Pleistocene glacial features based on Kiver and others (1979) and basalt stratigraphy based on Swanson and others (1979). In 1993 to 1994, Wendy Gerstel, Chuck Gulick, and Bob Derkey of the Washington Department of Natural Resources mapped the Quaternary deposits related to the Spokane aquifer recharge and aquifer-sensitive areas at a 1:24,000 scale. This unpublished mapping was entered into the Spokane County geographic information system (GIS), which has been available to county officials since 1996. We initiated detailed mapping of the quadrangle in July of 2002.

GEOLOGIC SYMBOLS

Contact—long-dashed where approximately located; short-dashed where inferred

Fault, unknown offset—long-dashed where approximately located; short-dashed where inferred; dotted where concealed

○ Well location

♦ Geochemistry sample location

DESCRIPTION OF MAP UNITS

Holocene and Pleistocene Sedimentary Deposits

Qal — **Alluvium (Holocene)**—Silt, sand, and gravel deposits in present-day stream channels, on flood plains, and on lower terraces; consists of reworked glacial flood deposits (units Qfcg, Qfg, and Qfs) and reworked loess; may include small alluvial fans and minor mass-wasting deposits that extend onto the flood plain from tributaries.

Qaf — **Alluvial fan deposits (Holocene)**—Gravel, sand, and silt deposited in fans at the base of steep drainages; very poorly sorted; most lack a large drainage source; minimal soil development.

Qb — **Bog deposits (Holocene and Pleistocene)**—Peat with lesser amounts of silt, ash, marl (bog lime), and gyttja (freshwater mud with abundant organic matter); located predominantly in Channeled Scabland depressions on basalt bedrock (Milne and others, 1975).

Qmw — **Mass-wasting deposits (Holocene and late Pleistocene)**—Landslide debris with lesser amounts of debris-flow and rock-fall deposits; consists mostly of a mixture of basalt blocks and Latah Formation sediments; basalt blocks range in size from several feet to hundreds of feet in diameter. Most mass-wasting events occurred during or shortly after Pleistocene catastrophic flood events, but some mass wasting continued to the present; mass-wasting events that occurred during glacial flooding incorporated flood materials as scattered sand and pebble lenses interspersed with the mass-wasting deposits.

Qgl — **Glaciolacustrine deposits of glacial Lake Columbia (Pleistocene)**—Silt and sand interbedded with clay and silt lakebeds; consists predominantly of quartz, feldspar, and mica grains; very light gray to pinkish or yellowish gray; contain scattered boulders and some sand and gravel lenses; occurs in the northeast corner of the quadrangle; coarser-grained materials may have been ice rafted or may be debris-flow deposits from the surrounding highlands. Includes abundant flood sand (unit Qfs), which capped the lake beds during a late stand of glacial Lake Columbia and occurs primarily as erosional remnants at higher elevations.

The following units are deposits from outburst floods of glacial Lake Missoula. They are a composite of numerous flood events and do not represent deposits from any single flood event.

Qfs — **Glacial flood deposits, predominantly sand (Pleistocene)**—Medium- fine- to coarse-grained sand and granules with sparse pebbles, cobbles, and boulders; may contain beds and lenses of gravel; composed mainly of granitic and metamorphic detritus from sources to the east; gray, yellowish gray, or light brown; subangular to subrounded; poorly to moderately well sorted; thin bedded to massive; appears speckled in some exposures because of the mixture of light and dark fragments; distribution uneven and thickness variable due to irregular underlying topography and varying degrees of preservation from erosion. Includes some occurrences of glacial-lake and glacial-flood deposits that are too small to map separately; includes rhythmically bedded lake-bed sediments and sand and granule flood deposits similar to exposures along Hangman Creek about 10 mi southeast of the quadrangle; appears to have been deposited when Lake Missoula outburst floods flowed into a high stand of glacial Lake Columbia.

Qfg — **Glacial flood deposits, predominantly gravel (Pleistocene)**—Thick-bedded to massive mixtures of boulders, cobbles, pebbles, granules, and sand; contains beds and lenses of sand and silt; gray, yellowish gray, or light brown; poorly to moderately sorted; both matrix and clast supported; locally composed of cobbles and some boulders in a matrix of mostly pebbles and coarse sand; derived from granitic and metamorphic rocks similar to those exposed both locally and to the northeast and east in Idaho; found outside the main flood channel, which approximates the present course of the Spokane River.

Qfcg — **Glacial flood channel deposits, predominantly gravel (Pleistocene)**—Thick-bedded to massive mixtures of boulders, cobbles, pebbles, granules, and sand; may contain beds and lenses of sand and silt; gray, yellowish gray, or light brown; poorly to moderately sorted; both matrix and clast supported; locally composed of boulders and cobbles in a matrix of mostly pebbles and coarse sand; derived from granitic and metamorphic rocks similar to those exposed both locally and to the northeast and east in Idaho. Differs from flood gravel (unit Qfg) in that it occurs only in the main flood channel, which is known to be several hundred feet deep and appears to be entirely filled with flood deposits; boundaries between this unit and unit Qfg are based primarily on location rather than clast differences; forms the channel of the Spokane River.

Pre-Quaternary Igneous and Sedimentary Rocks

Mwp — **Priest Rapids Member of the Wanapum Basalt, Columbia River Basalt Group (middle Miocene)**—Dark gray to black, fine-grained, dense basalt consisting of plagioclase (20–30%), pyroxene (10–20%), and olivine (1–2%) in a mostly glass matrix (40–60%); variable thickness; very thin where it laps upon pre-Miocene highlands; lies directly on pre-Miocene rocks, Latah Formation, or Grande Ronde Basalt; contact with the underlying Grande Ronde Basalt occurs between 2200 and 2300 ft elevation in this quadrangle. Basalt is of the Rosalia chemical type, which has higher titanium and lower magnesium and chromium content than other flows of the Wanapum Basalt (Steve Reidel, Pacific Northwest National Laboratory, oral commun., 1998); between 14.5 and 15.3 m.y. old and has reversed magnetic polarity (Reidel and others, 1989).

Mgr — **Grande Ronde Basalt, magnetostratigraphic units R_2 and N_2, Columbia River Basalt Group (middle Miocene)**—Dark gray to dark greenish gray, fine-grained basalt consisting of pale green augite and pigeonite grains (10–40%) and plagioclase laths and sparse phenocrysts (10–30%) in a matrix of black to dark brown glass (30–70%) and opaque minerals; locally vesicular with plagioclase laths tangential to vesicle boundaries; some vesicles contain botryoidal carbonate and red amorphous secondary minerals; thickness is quite variable due to irregular underlying topography. Identified in the map area on the basis of chemical analyses; between 15.6 and 16.5 m.y. old (Reidel and others, 1989).

Ml — **Latah Formation (middle Miocene)**—Lacustrine and fluvial deposits of finely laminated siltstone, claystone, and minor sandstone; light gray to yellowish gray and light tan; commonly weathers brownish yellow with stains, spots, and seams of limonite; poorly indurated; exposures are limited in the map area; unconformably overlies pre-Miocene rocks or is interbedded with Grande Ronde Basalt (unit Mgr); easily eroded and commonly blanketed by colluvium, talus, and residual soils; floral assemblages indicate a Miocene age (Knowlton, 1926; Griggs, 1976).

Emd — **Mafic dikes (Eocene)**—Fine-grained mafic dikes that intrude all of the Cretaceous granitic units; contains phenocrysts of hornblende and biotite in a fine-grained matrix of feldspar, quartz, hornblende, and biotite; mostly altered; alteration minerals include chlorite and epidote; light to dark gray; only the largest dikes are shown at this map scale. Similar mafic dikes in the Fan Lake area about 15 mi northeast of the Nine Mile Falls quadrangle are "spatially, mineralogically, and compositionally related to the Silver Point Quartz Monzonite" (Miller, 1974). The Fan Lake area yielded a K-Ar age of 47.3 ±1.6 Ma on hornblende and 46.8 ±1.4 Ma on biotite (Miller, 1974).

Eqm — **Silver Point Quartz Monzonite (Eocene)**—Quartz monzonite consisting of distinct microperthitic orthoclase phenocrysts up to 1 in. long accompanied by smaller, zoned-plagioclase, hornblende, biotite, and quartz crystals in a fine- to very fine-grained groundmass; generally light gray with a greenish tinge at contact with host rocks; hornblende has a long dimension of as much as 0.4 in. and is associated with biotite; orthoclase phenocrysts are euhedral; other phenocrysts range from euhedral to anhedral, most are subhedral; titanite is the most common accessory mineral, followed by magnetite, apatite, zircon, and rare allanite (Miller and Clark, 1975); as much as 50 percent of the rock is groundmass; consists of dikes and irregularly shaped intrusive bodies. Two samples from the Chewelah 1:100,000-scale quadrangle to the north gave whole-rock Rb-Sr ages of 39.4 Ma and 46.2 Ma (Armstrong and others, 1987); recalculated K-Ar ages on rocks from the Chewelah 1:100,000-scale quadrangle were 51 Ma on biotite and 62 Ma on hornblende (Miller and Clark, 1975).

Klg — **Leucocratic intrusive rocks (Cretaceous)**—Medium-grained muscovite quartz monzonite; consists of microcline and albite in microperthitic combination, quartz, and muscovite; microcline and albite content are nearly equal; muscovite can range up to 10 percent but is generally less than 5 percent; rarely contains a trace to 2 percent biotite; pink to cream colored; leucocratic dikes cut biotite granite (unit Kbg). Miller and Clark (1975) reported that exposures of leucocratic granitic rocks noted by Griggs (*in* Miller and Clark, 1975) south of Clayton (~6 mi north of the map area) were the same unit as their leucocratic muscovite quartz monzonite and that because the plagioclase is albite the rock could be classified chemically as granite.

Kbg — **Biotite granite (Cretaceous)**—Massive, medium- to coarse-grained, equigranular biotite granite to quartz monzonite; quartz forms clots or aggregates of crystals and is intergrown with potassium feldspar; potassium feldspar also forms some phenocrysts and clots of phenocrysts; anhedral to subhedral black biotite comprises 2 to 7 percent of the rock and generally is interstitial to other minerals; leucocratic dikes (unit Klg) cut the biotite granite; considered the same as biotite-bearing intrusive rock near Four Mound Prairie and in Corkscrew Canyon in the adjacent Four Mound Prairie quadrangle to the west (Joseph, 1990).

Kg — **Biotite muscovite granite (Cretaceous)**—Medium- to coarse-grained, massive, muscovite-biotite granite to quartz monzonite; contains medium-gray anhedral quartz (20–40%) that commonly forms graphic intergrowths with feldspar; potassium feldspar and plagioclase (50–70%) are present in a ratio of about 2:3; large crystals of potassium feldspar in some exposures enclose small biotite grains; plagioclase is commonly altered; subhedral biotite comprises as much as 10 percent of the rock and forms clots; muscovite ranges from 0 to 10 percent of the rock and is present as single euhedral crystals, in clots, or with biotite; undisturbed outcrops are medium gray due to lichen cover; light gray in roadcuts and fresh exposures; weathers yellow with limonitic staining. Yielded discordant K-Ar ages of 48 Ma on biotite and 53 Ma on muscovite (Miller and Engels, 1975), which are probably reset; similar to and most likely of the same age as the Mount Spokane granite.

rp — **Roof pendants**—Small bodies of predominantly quartzite and minor argillite; one sample of quartzite contains diopside; only the larger bodies are shown on the map at this scale; probably related to Precambrian Belt Supergroup rocks exposed north of the map area (Miller, 2000).

ACKNOWLEDGMENTS

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Figure 5-3. Geologic Units

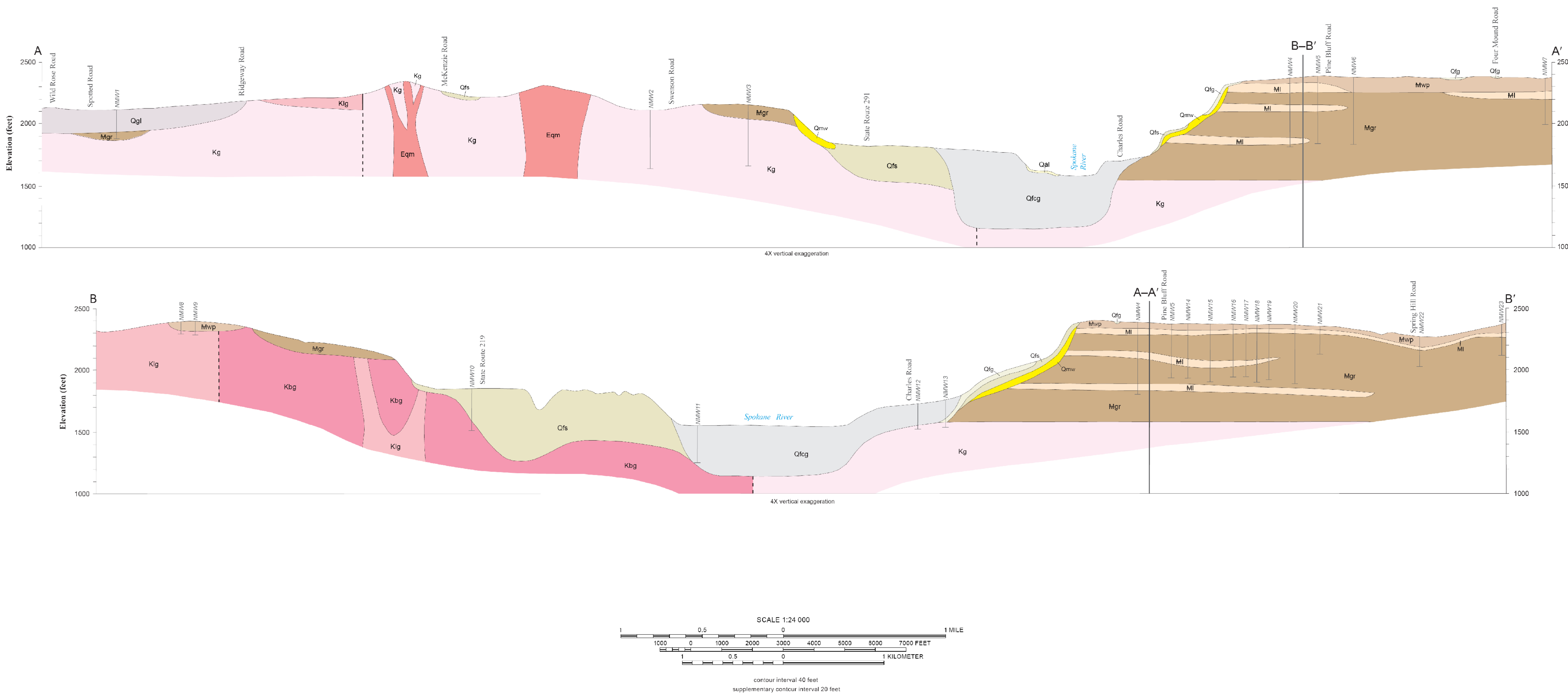

Figure 5-4. Cross Sections

periods. The feasibility of this project depends heavily on the hydraulic connection between the subject aquifers and the Spokane River, as well as the timing and direction of flow of water between the aquifers and the river. This information has not yet been documented by field hydrogeologic studies.

The cataract deposits could also be used for an ASR project. Water from the Spokane River or City of Spokane water could be injected or infiltrated into the cataract deposits during periods of high water availability and then withdrawn during periods of low water availability. Cross-section B-B' suggests that there may be plunge pool-like features in the granite basement that could be hydraulically disconnected from the Spokane River. If the plunge-pools are disconnected from the Spokane River and the granite basement is relatively impermeable to groundwater, water could be stored in the sand and gravel deposits could be stored with high efficiency for long periods of time, making the deposits ideal for ASR.

Extensive geologic and hydrogeologic study would be required before a water storage project could be undertaken using the cataract deposits. A large amount of uncertainty exists in the lateral and vertical extent of sand and gravel deposits because of the small number of wells that reach granite basement rocks beneath the sedimentary deposits. This uncertainty could be reduced through subsurface investigation, which could include drilling or geophysical surveys. A particularly important question to address is the lateral extent of the plunge pool-like feature and whether this feature forms a closed structural basin capable of retaining groundwater. The hydrologic relationship between aquifers in the deposits and the Spokane River would also need to be investigated. Once the basic geology and hydrogeology of the cataract deposits are adequately understood, other issues associated with ASR and artificial recharge projects would need to be addressed including water sources, treatment of injection/recharge water, and water withdrawal costs.

CHAPTER 6.
CHAMOKANE CREEK AREA

Chamokane Creek is a major Spokane River tributary in WRIA 54, entering from the north downstream from Long Lake Dam and upstream from Little Falls Dam. Originating in the highlands north the Spokane Indian Reservation, Chamokane Creek flows eastward for nearly 20 miles before turning south toward the Spokane River south of the community of Springdale. The Spokane Indian Reservation borders Chamokane Creek to the west, with tribal treaty documents specifying tribal ownership to the east bank of the creek. Land use on both tribal and non-tribal lands is primarily sparse residential and agricultural. The entire drainage lies within Stevens County.

In 1979, a federal adjudication quantified water rights for the Spokane Tribe to Chamokane Creek for two purposes:

- Irrigation water of 25,380 acre-feet annually.
- Instream flow in Chamokane Creek at Chamokane Falls (initially set at 20 cfs, and later raised to 24 or 27 cfs, depending on priority date of water rights).

These adjudicated rights, which include shallow groundwater, essentially consume any available water in the Chamokane Creek drainage, and Ecology has unofficially closed the drainage to new water rights. The only exception is water uses considered “de minimus”, small uses such as single domestic and stock water.

Six possible storage opportunities were identified for the Chamokane Creek drainage:

- Leasing or purchasing water rights from the Spokane Tribe – Since the federal adjudication granted irrigation water rights to the Spokane Tribe, these could be available for lease or purchase. These rights could be used for irrigation and potentially other consumptive uses. The Spokane Tribe currently does not fully utilize their irrigation water rights.
- Conservation and water reuse – As described in Chapter 4, conservation and water reuse could play a role in meeting water needs. While water law and policies have historically made it difficult for water users to reap the benefit of their conservation/reclamation efforts, these laws and policies are becoming much more flexible.
- Side canyon reservoirs – Sorenson Canyon, in the upper Chamokane Creek drainage, is a potential site for in-channel reservoir. As with all in-channel reservoirs, these projects would be expensive to build, difficult to permit, and environmentally impactive.
- Promote natural water storage through beaver habitat – The headwater region of Chamokane Creek could be an appropriate location to encourage beaver activity, including dam building and maintenance of beaver ponds. This water storage project would enhance the natural storage capacity of the stream system, helping to augment and maintain instream flow in Chamokane Creek. Because beavers can be very impactive to their surrounding land and considered a nuisance, this project is not recommended for populated portions of the watershed.

Any of these projects could be eligible for funding through the Columbia River Initiative, particularly if it can be demonstrated that the project will aid in restoring/preserving instream flows contributing to the Columbia River.

CHAPTER 7.
CONCLUSIONS/RECOMMENDATIONS

In general, WRIA 54 is not suffering from inadequate water supply relative to the current and projected future demand. The focus of this report is the West Plains area because that region's population is growing rapidly, water purveyors are already having difficulty providing water to existing customers, and aquifers are showing signs of strain from existing water withdrawals.

An ASR project in the Wanapum basalt aquifer shows promise in the West Plains Study Area. Such a project would require extensive analysis to evaluate feasibility, pilot testing, and construction of new infrastructure. Appropriate source water would also have to be identified.

While increasing the volume of water stored is one option, another opportunity for the region would be to simply increase the connectivity of the area so that water can be efficiently distributed where it is needed. Increased connectivity could consist of building more infrastructure for intermittent buying and selling of water or for permanent water rights transfers. Alternatively, if water use declines through the use of conservation and water reuse methods, then the requirement for new storage measures may be delayed many years into the future.

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