Level I Technical Assessment
Water Resource Inventory Area 60
Kettle River Watershed

March 16, 2004

Prepared by
Keith K. Holliday
Project Scientist:

Reviewed by
Eugene N.J. St.Godard, LG, LHG
Principal Hydrogeologist:

GeoEngineers

523 E. Second Avenue
Spokane, Washinton 99202

CONTENTS

Page No.

INTRODUCTION 1
PROJECT OVERVIEW 1
PROJECT OBJECTIVES 1

WRIA 60 OVERVIEW 1
PHYSICAL DESCRIPTION 1
SUBBASIN DELINEATION 2
Ferry Subbasin 2
Laurier Subbasin 2
Chesaw Subbasin 2
CLIMATE 3
Climate Stations 3
Chesaw 4 NNW 3
Irene Mountain Wauconda 3
Laurier 3
Basin-Scale Precipitation and Temperature Distribution 4
GEOLOGIC SETTING 5
HYDROLOGIC SETTING 6

PLANNING 6
INTRODUCTION 6
POPULATION 7
LAND USE 8
LAND OWNERSHIP 8

SURFACE WATER RESOURCES 9
INTRODUCTION 9
EXISTING STREAMFLOW STUDIES 9
Ferry Subbasin 10
Laurier Subbasin 10
Chesaw Subbasin 10
EVALUATION OF STREAM GAGE DATA 11
Ferry Stream Gage Station 12
Laurier Stream Gage Station 13
Boyds Stream Gage Station 13
Chesaw Stream Gage Station 13

GROUNDWATER RESOURCES 14
INTRODUCTION 14
PRINCIPAL HYDROGEOLOGIC UNITS 14
Basement Rock Aquifer 14
Sedimentary Aquifer 15
HYDROGEOLOGIC SECTIONS 16

WATER RIGHTS 17
INTRODUCTION 17
NUMBER OF WATER RIGHTS AND APPLICATIONS 17
QUANTITY OF WATER ALLOCATED 18

CONTENTS (Cont.)

Page No.

PRIMARY PURPOSE 19

CONCLUSIONS 20

WATER BALANCE 21
INTRODUCTION 21
WATER BALANCE COMPONENTS AND METHODOLOGY 21
HYDROLOGIC COMPONENTS 22
Precipitation 22
Evapotranspiration 22
Surface Water Inflow 24
Surface Water Outflow 25
Groundwater Inflow and Outflow 25
Net Demand 26
General 26
Domestic 27
Non-Domestic 27
SIMPLIFYING ASSUMPTIONS 28
WATER BALANCE SUMMARY 29

LIMITATIONS 30

RECOMMENDATIONS 30
INTRODUCTION 30
ADEQUACY OF EXISTING DATA 31
Climate Data 31
Planning Data 31
Surface Water Data 31
Groundwater Data 32
Groundwater/ Surface Water Interaction 32
Water Rights Data 32

REFERENCES 33

TABLES **Table No.**

Average Precipitation – WRIA 60 1
Average Temperature – WRIA 60 2
2000 Census Population Information 3
Population Forecast 4
Land Cover in Watershed 5
Land Ownership and Management of the Major Public Lands 6
Monthly and Annual Streamflow Estimates – WRIA 60 7
Number of Water Rights and Applications 8
Annual Total Quantity of Water Allocated in Acre-Feet 9
Potential Evapotranspiration Calculation Thornthwaite Method – WRIA 60 10
Groundwater Inflow and Outflow Analysis – WRIA 60 11
Domestic Annual Net Demand Estimate – WRIA 60 12

CONTENTS (Cont.)

TABLES	Table No.
Non-Domestic Annual Net Demand Estimate – WRIA 60	13
Annual Water Balance Summary – WRIA 60	14

FIGURES	Figure No.
Watershed Plan	1
Average Annual Precipitation Map	2
Average Annual Air Temperature Map	3
Chesaw 4 NNW Climate Data	4
Irene Mountain Wauconda Climate Data	5
Laurier Climate Data	6
Stream Gage Station Locations	7
Kettle River Near Ferry Summary Hydrograph	8
Kettle River Near Ferry Exceedance Values	9
Kettle River Near Laurier Summary Hydrograph	10
Kettle River Near Laurier Monthly Exceedance Chart	11
Kettle River at Boyds Summary Hydrograph	12
Myers Creek Near Chesaw Summary Hydrograph	13
Hydrogeologic Section Location Map	14
Hydrogeologic Section A-A’ (Ferry)	15
Hydrogeologic Section B-B’ (Danville)	16
Hydrogeologic Section C-C’ (Laurier)	17
Hydrogeologic Section D-D’ (Boyds)	18
Hydrogeologic Section E-E’ (Chesaw)	19
Percentage of Water Rights by Basin	20
Number of each Document Type in each Basin	21
Number of Active Applications by Water Rights Type in each Basin	22
Percentage of Water Rights Type for Annual Quantity Allocated in WRIA 60	23
Percentage of Annual Quantity Allocated by Document Type	24
Annual Quantity Allocated by Water Right Type	25
Percentage by Allocated Groundwater by Purpose in Chesaw Basin	26
Percentage of Surface Water Allocated by Purpose in Chesaw Basin	27
Percentage of Groundwater Allocated by Purpose in Ferry Basin	28
Percentage of Surface Water Allocated by Purpose in Ferry Basin	29
Percentage of Groundwater Allocated by Purpose in Laurier Basin	30
Percentage of Surface Water Allocated by Purpose in Laurier Basin	31
Annual Quantity of Surface Water Rights with Domestic Purpose in Laurier Basin	32
Surface Water Right Allocations	33
Groundwater Right Allocations	34
Land Cover Map	35

APPENDICES

Appendix A – Comment Response Table for Draft Level I Technical Assessment

LEVEL I TECHNICAL ASSESSMENT
WATER RESOURCE INVENTORY AREA 60
KETTLE RIVER WATERSHED

INTRODUCTION

PROJECT OVERVIEW

This Level I Technical Assessment has been prepared for Water Resource Inventory Area (WRIA) 60 in accordance with the requirements of Revised Code of Washington (RCW) 90.82. The study area includes the portion of the Kettle River Watershed that is located within Ferry County, eastern Okanogan County and western Stevens County in northeast Washington State. The remainder of the Kettle River Watershed is located in British Columbia, Canada.

The Level I Technical Assessment was completed under the provisions of the 1998 Watershed Planning Act (RCW 90.82). The assessment was completed for Ferry County as the lead agency and the members of the WRIA 60 Planning Unit.

Based on guidance provided for RCW 90.82, a Level 1 Technical Assessment should consist of a comprehensive compilation and review of readily available information relevant to defined watershed planning objectives. Readily available information could include watershed scale plans, relevant technical studies and reports, aerial photographs, Geographic Information System (GIS) coverages, and the identification of environmental issues and economic projects important to the watershed (Economic and Engineering Services, 1999).

PROJECT OBJECTIVES

Members of the WRIA 60 Planning Unit have expressed diverse objectives for this technical assessment. Based on a consensus of expressed views and the requirements of RCW 90.82, the objectives of this study were to (1) develop a Level 1 Technical Assessment that is comprehensive in its compilation and review of readily available data of the water quantity element for the WRIA, within relevant budgetary and time constraints, (2) develop a water balance for the WRIA, (3) evaluate the adequacy of compiled data with respect to approximating groundwater and surface water quantity, water use, and water budget for the WRIA, and (4) identify data gaps that could be addressed in subsequent levels of Phase 2 or the remaining phases of watershed planning.

WRIA 60 OVERVIEW

PHYSICAL DESCRIPTION

WRIA 60 includes the portion of the Kettle River Watershed located within Ferry County, eastern Okanogan County and western Stevens County in northeast Washington State, as shown on Figure 1. It occupies an area of about 1,022 square miles. The communities of Chesaw, Danville, Curlew, Laurier, Malo, Orient, and Boyds are located within the WRIA. The study area's landscape consists of rugged upland regions with both forested and logged areas incised by frequent drainageways. The Kettle River Valley is the primary drainage within the WRIA and consists of an alluvial valley generally less than two miles in width.

The limits of WRIA 60 are, in part, based on political rather than hydrologic boundaries. A significant portion of the Kettle River Watershed, including the headwaters, is located north of the boundaries of the WRIA in British Columbia, Canada. There are two reaches of the Kettle River within the WRIA. The Kettle River enters WRIA 60 from British Columbia in two locations, in the vicinity of an area referred to as Ferry and near the community of Laurier, Washington. The Kettle River exits WRIA 60 into British Columbia in the vicinity of Danville, Washington and into Lake Roosevelt near Boyds, Washington in the southeast corner of the WRIA.

There are a number of tributaries to the Kettle River located within the WRIA. Some of the larger tributaries are Myers Creek, Toroda Creek, Curlew Creek, Boulder Creek, and Deadman Creek. Myers Creek drains a significant portion of the watershed in the northwest portion of the WRIA and flows outside of the boundaries of the WRIA into British Columbia before discharging to the Kettle River.

SUBBASIN DELINEATION

This technical assessment subdivided WRIA 60 into three Subbasins. These Subbasins have been named Ferry, Laurier, and Chesaw for future reference and are displayed in Figure 1. The delineation of Subbasins was largely performed to facilitate the water balance portion of the technical assessment and account for the inflow and outflow of surface water and groundwater from portions of the watershed located outside of the boundaries of the WRIA in Canada.

Ferry Subbasin

The Ferry Subbasin generally refers to the portion of WRIA 60 that drains to the segment of the Kettle River located between the area referred to as Ferry and the community of Danville, Washington. It occupies an area of about 546 square miles. The Kettle River tributaries located within this Subbasin include Catherine Creek, Tenas Mary Creek, Toroda Creek, Tonata Creek, Emmanuel Creek, Cottonwood Creek, Curlew Creek, La Fleur Creek, Long Alec Creek, West Deer Creek, Little and Big Goosmus Creeks, and Lone Ranch Creek. Curlew Lake is located in the southern portion of the Subbasin and discharges to Curlew Creek.

Laurier Subbasin

The Laurier Subbasin generally refers to the portion of WRIA 60 that drains to the segment of the Kettle River located between Laurier, Washington and Lake Roosevelt. It occupies an area of about 388 square miles. The primary Kettle River tributaries located within this Subbasin include Deep Creek, Little Boulder Creek, Boulder Creek, Toulou Creek, and Deadman Creek. This Subbasin contains numerous small ponds and lakes, including Pierre Lake, Pittman Lake, Lamar Lake, Summit Lake, and others.

Chesaw Subbasin

The Chesaw Subbasin generally refers to the portion of the WRIA that drains to Myers Creek and exits WRIA 60 before discharging to the Kettle River in British Columbia. It occupies an area of about 88 square miles. A number of tributaries originate and flow into Myers Creek within this Subbasin, including Ethel Creek, Mary Ann Creek, Bolster Creek, Gafvery Creek, and Gold Creek. This Subbasin contains several small ponds and lakes, including Muskrat Lake, Fields Lake, Strawberry Lake, and others.

CLIMATE

The purpose of the climate analysis is to compile information on seasonal changes in precipitation and temperature and to evaluate the distribution of precipitation and temperature across the study area. Variations in precipitation and climate are a dominating influence on groundwater recharge and streamflow and largely determine the availability of groundwater and surface water resources (Smith, 1993). Climatic patterns within WRIA 60 are significantly impacted by elevation, with temperature generally decreasing with increasing elevation.

Climate Stations

Climatic data were collected from the Western Regional Climatic Center (WRCC). The WRCC compiles and maintains climatic data from National Oceanographic and Atmospheric Administration (NOAA), the Natural Resource Conservation Service Snowpack Telemetry System (SNOTEL) and regional cooperators that operate individual recording stations (WRCC, 2003). Climatic data was collected for three recording stations within the study area, designated by WRCC as Chesaw 4 NNW, Irene Mountain Wauconda, and Laurier. Climate station locations are presented in the Average Annual Precipitation Map, Figure 2, and the Average Annual Air Temperature Map, Figure 3.

Chesaw 4 NNW

The climate station designated Chesaw 4 NNW, Station No. 451385, is located at 49°00' N latitude and 119°04' W longitude. Its elevation is 3,961.9 feet above mean sea level. The period of record for this station is May 28, 1959 to April 30, 1984. Over the period of record, average daily maximum temperature varied from 28.8 °Fahrenheit (F) (-1.8 °Celsius (C)) in January to 75.7 °F (24.3 °C) in July (WRCC, 2003). Average daily minimum temperature varied from 11.0 °F (-11.7 °C) in January to 44.6 °F (7.0 °C) in July. Average monthly precipitation over the period of record varied from 0.71 inches in October to 1.60 inches in June, yielding an average annual precipitation of 14.04 inches (WRCC, 2003). Average annual snowfall is 50.2 inches (WRCC, 2003). WRCC (2003) prepared a graph of average daily maximum temperature, minimum temperature, and precipitation for available data from the period from 1961 to 1990. This graph is presented in Chesaw 4 NNW Climate Data, Figure 4.

Irene Mountain Wauconda

The climate station designated Irene Mountain Wauconda, Station No. 453975, is located at 48°49' N latitude and 118°54' W longitude. Its elevation is 2,702.4 feet above mean sea level. The period of record for this station is June 2, 1948 to August 31, 1988. Temperature data were not available. Average monthly precipitation over the period of record varied from 0.84 inches in February to 1.98 inches in June, yielding an average annual precipitation of 14.45 inches (WRCC, 2003). Average annual snowfall is 46.5 inches. WRCC (2003) prepared a graph of average daily precipitation for available data from the period from 1961 to 1990. This graph is presented in Irene Mountain Wauconda Climate Data, Figure 5.

Laurier

The climate station designated Laurier, Station No. 454549, is located at 49°00' N latitude and 118°14' W longitude. Its elevation is 1,643.6 feet above mean sea level. The period of record for this station is June 2, 1948 to October 31, 1986. Over the period of record, average daily maximum temperature varied from 29.8 °F (-1.2 °C) in January to 86.2 °F (30.1 °C) in July (WRCC, 2003). Average daily minimum temperature varied from 15.3 °F (-9.3 °C) in January to 49.2 °F (9.6 °C) in July (WRCC, 2003). Average monthly precipitation over the period of record varied from 1.09 inches in September to 2.39 inches in December, yielding an average annual precipitation of 19.97 inches (WRCC, 2003). Average annual snowfall is 51.9 inches (WRCC, 2003). WRCC (2003) prepared a graph of average daily maximum temperature, minimum temperature, and precipitation for available data from the period from 1961 to 1990; this graph is presented in Laurier Climate Data, Figure 6.

Basin-Scale Precipitation and Temperature Distribution

An isohyetal precipitation distribution was developed for each of the three Subbasins within WRIA 60 and was based on PRISM (Daly and Taylor, 1998), a statistical topographic model developed by Daly and others (1994) for mapping precipitation within mountainous terrain. The isohyetal precipitation distribution was imported into a Geographic Information System (GIS), as presented in Figure 2, to derive the area-weighted average monthly and annual precipitation (volumetric) for each Subbasin (Oregon Climate Service, 2001). The results of this analysis are presented in Table 1. Average annual precipitation volumes for the Ferry, Laurier, and Chesaw Subbasins total 509,231 acre-feet, 507,424 acre-feet, and 79,679 acre-feet, respectively.

TABLE 1
AVERAGE PRECIPITATION - WRIA 60

MONTH	FERRY SUBBASIN PRECIPITATION[1] (acre-feet)	LAURIER SUBBASIN PRECIPITATION[1] (acre-feet)	CHESAW SUBBASIN PRECIPITATION[1] (acre-feet)
October	30,455	34,390	4,224
November	48,222	55,356	7,875
December	55,733	62,584	9,042
January	44,976	53,020	7,473
February	35,207	40,921	5,753
March	35,944	40,405	5,289
April	39,225	35,201	6,198
May	55,306	48,008	8,826
June	57,888	47,762	8,683
July	36,242	28,614	5,518
August	41,805	33,288	6,473
September	28,228	27,875	4,325
Annual[2]	**509,231**	**507,424**	**79,679**

Notes:

1. Average monthly precipitation was calculated from the isohyetal precipitation distribution using GIS to derive area-weighted averages for each Subbasin.
2. Average annual precipitation calculated by summing the monthly averages.

The average monthly and annual air temperatures within WRIA 60 were obtained from PRISM (Daly and Taylor, 1998). The temperature distribution was imported into a GIS, as presented in Figure 3, to derive area-weighted average monthly and annual air temperatures for each Subbasin. The results of this analysis are presented in Table 2. Average annual air temperature for the Ferry, Laurier, and Chesaw Subbasins is 41.0 °F (5.0 °C), 40.8 °F (4.9 °C), and 41.0 °F (5.0 °C), respectively.

TABLE 2
AVERAGE TEMPERATURE - WRIA 60

MONTH	FERRY SUBBASIN TEMPERATURE[1] (Degrees Celsius)	LAURIER SUBBASIN TEMPERATURE [1] (Degrees Celsius)	CHESAW SUBBASIN TEMPERATURE [1] (Degrees Celsius)
October	41.4 °F (5.2 °C)	41.4 °F (5.2 °C)	41.2 °F (5.1 °C)
November	29.3 °F (-1.5 °C)	29.3 °F (-1.5 °C)	29.1 °F (-1.6 °C)
December	21.9 °F (-5.6 °C)	21.9 °F (-5.6 °C)	21.2 °F (-6.0 °C)
January	20.5 °F (-6.4 °C)	19.9 °F (-6.7 °C)	20.8 °F (-6.2 °C)
February	27.9 °F (-2.3 °C)	25.7 °F (-3.5 °C)	26.1 °F (-3.3 °C)
March	32.5 °F (0.3 °C)	31.1 °F (-0.5 °C)	31.3 °F (-0.4 °C)
April	41.0 °F (5.0 °C)	40.6 °F (4.8 °C)	39.6 °F (4.2 °C)
May	49.1 °F (9.5 °C)	48.4 °F (9.1 °C)	48.2 °F (9.0 °C)
June	56.1 °F (13.4 °C)	55.8 °F (13.2 °C)	54.5 °F (12.5 °C)
July	61.5 °F (16.4 °C)	61.7 °F (16.5 °C)	60.1 °F (15.6 °C)
August	60.9 °F (16.1 °C)	60.9 °F (16.1 °C)	60.1 °F (15.6 °C)
September	51.9 °F (11.1 °C)	51.9 °F (11.1 °C)	52.5 °F (11.4 °C)
Annual[1]	**41.0 °F (5.0 °C)**	**40.8 °F (4.9 °C)**	**41.0 °F (5.0 °C)**

Notes:

1. Average monthly and annual temperature was calculated from the PRISM-based temperature distribution using GIS to derive area-weighted averages for each Subbasin.

GEOLOGIC SETTING

The surficial geology of WRIA 60 has been described in Stoffel et al. (1991) for the entire watershed and in U.S. Geological Survey (1964, 1966, and 1967) and Stoffel (1990) for portions of the watershed. Aspects of the subsurface geology of portions of the watershed have been presented in a number of documents, including Busch (1991), Campbell and Thorsen (1975), Cheney and Rasmussen (1996), Dobell (1955), Donnelly (1978), Golder & Associates (1994c, 1994d, 1993a, 1992), Holder (1990, 1985), Hunt (1989), Knaack (1991), Lyons (1967), Phetteplace (1954), Price (1991), Rhodes (1980), U.S. Geological Survey (1964), and others.

WRIA 60 is located within a zone of exotic terranes that accreted to the North American margin during a period of convergence during the Jurassic, Triassic and Permian periods (Cheney and Rasmussen, 1996; Stoffel et al. 1991). This period of compression (and associated thrust faulting) was followed by a period of regional east-west extension during the late Cretaceous and early Tertiary periods. This period of extension was accompanied by low-angle detachment faulting that resulted in the formation of the Okanogan and Kettle Metamorphic Core Complexes. The upthrown blocks of the core complexes largely consist of Proterozoic and Palezoic metasedimentary and metavolcanic rocks locally intruded by Tertiary plutonic rocks. The downthrown blocks largely consist of Tertiary volcanic and plutonic rocks.

The current geomorphology and sediments of the Kettle River valley and its tributaries are primarily the result of successive periods of glaciation during the Pleistocene, which resulted in the deposition of abundant glacial drift, consisting of heterogeneous till, outwash, and glaciolacustrine soils. Till deposits generally consist of unsorted, unstratified mixtures of clay, silt, sand and gravel deposited at the glacier base. Glaciolacustrine soils generally consist of clay and silt deposited within glacial lake environments. Outwash deposits consist of stratified sand and gravel deposited by glacial meltwater.

Recent alluvial deposits associated with the Kettle River and its tributaries consist of stratified silt, sand and gravel. Alluvial deposits include channel and overbank deposits of the Kettle River and tributaries as well as alluvial fan deposits at the tributary mouths.

HYDROLOGIC SETTING

The primary surface water features within WRIA 60 are the Kettle River and Curlew Lake. Numerous tributaries of the Kettle River are located within the WRIA; these are presented in the Subbasin Delineation portion of this assessment. The headwaters of the Kettle River are located north of the WRIA within British Columbia. The Kettle River enters WRIA 60 near the area referred to as Ferry with an approximate elevation of 1,860 feet. It drains the western and central portion of the WRIA before flowing into British Columbia near Danville, Washington. River elevation at the border is approximately 1,700 feet.

The Kettle River re-enters WRIA 60 near Laurier, Washington at an approximate elevation of 1,460 feet. It flows south, draining the eastern portion of the WRIA before discharging to Lake Roosevelt south of Boyds, Washington. The normal pool elevation of Lake Roosevelt is 1,289 feet.

Groundwater within the Kettle River watershed primarily occurs in two hydrogeologic settings: (1) within fractures in basement rocks, and (2) within alluvial sediments. Basement rocks occur throughout the basin and generally contain confined to semi-confined aquifers of relatively low permeability. Alluvial sediments occur within the Kettle River valley and the drainages associated with the various tributaries of the Kettle River. Sedimentary aquifers are generally unconfined except where overlain by low permeability confining layers. Permeability of the sedimentary aquifers varies with depositional environment, and is generally highest in glaciofluvial sediments and lowest in glaciolacustrine sediments.

PLANNING

INTRODUCTION

Many factors may influence future demand and water availability in WRIA 60. Land use and population are two that can have significant impacts to future demand and water availability. This section presents a summary of the existing information estimating the recent population and the future growth trend, as well as describing land use and ownership in the watershed.

POPULATION

Obviously, increasing population and changes in the economy may have direct impacts on the future demand for water. As water demands increase with population and economic growth, the type of water demand can have a great influence on the actual amount needed. This section is designed to identify information as it relates to population. This section begins with a review of the current population, followed by a description of the forecasted future population.

Regionally, the populations of Ferry, Okanogan, and Stevens County have increased 15.3 percent, 18.6 percent, and 29.5 percent, respectively, from 1990 to 2000 (U.S. Census Bureau, 2000). For the purposes of watershed planning in WRIA 60, it is important to understand growth rates in the rural areas of these counties. There are no incorporated areas within WRIA 60.

The GIS was used to create a layer from the 2000 Census Blocks that are located inside or intersected with the watershed's border to determine the population within WRIA 60. From this layer, the GIS was used to identify the Census Blocks within WRIA 60 by county. Table 3 below summarizes the GIS analyses to determine the population in WRIA 60 and for that portion of WRIA 60 in each county.

Utilizing the intermediate population projections from the Washington State Office of Financial Management (2002), forecasts have been calculated for that portion of the WRIA in each county by assuming the current percentage of the rural population of each county within the WRIA will remain consistent in the future. Table 4 below displays the resulting population forecasts for the WRIA and for that portion of the WRIA in each county.

TABLE 3
2000 CENSUS POPULATION INFORMATION

Area	Population[1]
WRIA 60	4026
Ferry County Portion	3063
Okanogan County Portion	513
Stevens County Portion	450

1 Source: 2000 Census Data

TABLE 4[1]
POPULATION FORECAST

Area	2000	2005	2010	2015	2020	2025
WRIA 60	4026	4336	4623	4900	5242	5570
Ferry County Portion	3063	3334	3538	3725	3979	4223
Okanogan County Portion	513	539	573	602	623	642
Stevens County Portion	450	463	512	573	640	705

1 Source: Washington State Office of Financial Management Growth Management Population Projections, Intermediate Series, January 2002.

LAND USE

Land use directly influences water quantity. Changes in land cover can have an influence on a watershed's response to precipitation both in terms of timing and volume. In particular, such changes can alter the hydrologic cycle, most notably changing the evapotranspiration, the volume of water entering as infiltration, and the quantity and timing of runoff.

Land use affects water availability by modifying recharge and runoff and by redirecting water from its natural flow path. Land uses also differ significantly in the amount of water required to support native vegetation or crops. Thus, understanding existing land uses and the geographic extent in the WRIA is an essential component in discussing and developing management strategies.

Table 5 displays that land cover in the watershed ranges from evergreen forest in the higher elevations to grasslands in the lower elevations. Although specific estimates vary, the primary land cover is evergreen forest, which covers approximately 71 percent of land area in the WRIA. The second largest land cover type is grassland at about 10 percent of the WRIA.

TABLE 5
LAND COVER IN WATERSHED

Land Cover	WRIA 60		Laurier		Ferry		Chesaw	
	Acres	%	Acres	%	Acres	%	Acres	%
Open Water	3599	0.55%	1774	0.71%	1667	0.48%	158	0.28%
Residential	463	0.07%	189	0.08%	233	0.07%	41	0.07%
Commercial	653	0.10%	484	0.20%	164	0.05%	5	0.01%
Bare Rock	310	0.05%	48	0.02%	259	0.07%	3	0.01%
Transitional	29706	4.54%	15341	6.18%	13302	3.81%	1063	1.88%
Deciduous Forest	5240	0.8%	945	0.38%	3643	1.04%	652	1.15%
Evergreen Forest	466367	71.31%	204957	82.60%	235259	67.36%	26151	46.17%
Mixed Forest	5574	0.85%	2856	1.15%	2407	0.69%	311	0.55%
Shrubland	46109	7.05%	7690	3.10%	26515	7.59%	11904	21.02%
Orchards/Vineyards	9	0.00%	0	0.00%	9	0.00%	0	0.00%
Grasslands	67553	10.33%	5847	2.36%	52997	15.18%	8709	15.38%
Pasture/Hay	14707	2.25%	2521	1.02%	6439	1.84%	5747	10.15%
Row Crops	722	0.11%	586	0.24%	136	0.04%	0	0.00%
Small Grains	1522	0.23%	663	0.27%	859	0.25%	0	0.00%
Fallow	826	0.13%	476	0.19%	350	0.10%	0	0.00%
Woody Wetlands	60	0.01%	1	0.00%	12	0.00%	47	0.08%
Emergent Wetlands	10	0.00%	4	0.00%	4	0.00%	2	0.00%
Total	643430	98.39%	244382	98.50%	344254	98.57%	54794	96.75%
Note: Land Use Land Cover from USGS 1993, scale 1:100,00								

LAND OWNERSHIP

Land cover and use is controlled through land ownership and management. Table 6 summarizes the land ownership and management in WRIA 60. The largest land manager is the federal government, which owns approximately 56 percent of the WRIA. Understanding the mission and goals of the major land managers provides an indication if, and how, land cover and use might change in the next 20 years. This information needs to be recognized and included in the discussion and recommendations about how to manage the WRIA 60 water resources.

TABLE 6
LAND OWNERSHIP AND MANAGEMENT OF THE MAJOR PUBLIC LANDS

Major Public Lands Manager	WRIA 60		Laurier Subbasin		Ferry Subbasin		Chesaw Subbasin	
	Acres	%	Acres	%	Acres	%	Acres	%
Private	9446	1.44%	6298	2.54%	2991	0.86%	157	0.28%
U. S. Forest Service	364085	55.67%	185985	74.95%	163681	46.87%	14418	25.46%
Bureau of Land Management	10631	1.63%	1334	0.54%	8318	2.38%	980	1.73%
Bureau of Reclamation	2506	0.38%	2506	1.01%	0	0.00%	0	0.00%
Washington State Department of Fish and Wildlife	4322	0.66%	4	0.00%	0	0.00%	4318	7.62%
Washington State Parks and Recreation Commission	134	0.02%	0	0.00%	134	0.04%	0	0.00%
Washington Department of Natural Resources	262853	40.20%	52014	20.96%	174113	49.86%	36762	64.91%
Total	653977	100.00%	248141	100.00%	349237	100.00%	56635	100.00%

Note: Data from Washington State Department of Natural Resources, 2000, Scale 1:100,000

SURFACE WATER RESOURCES

INTRODUCTION

This section contains a summary of existing information for WRIA 60 regarding surface water resources and an analysis of available stream gage data for the WRIA. The goal of the evaluation was to qualitatively describe the surface water resources of each watershed, and to quantitatively describe the nature and rate of streamflow for the major surface water features to the extent allowed by the readily available data.

EXISTING STREAMFLOW STUDIES

The interpretation of the surface water resources within WRIA 60 is based on a review of information in the available literature and an analysis of the readily available streamflow data. A relatively limited number of documents were encountered relative to streamflow conditions within the WRIA. These documents were largely related to a prospective mineral property located on Buckhorn Mountain near Chesaw, Washington, locally known as the Crown Jewel Project. These documents included Battle Mountain Gold Company (1993), Cascade Environmental Services, Inc. (1995), Cascade Environmental Services, Inc. and Caldwell Associates (1996), David Snow and Associates (1996), Golder Associates (1998, 1996a, 1996b, 1995a, 1995b, 1994a, 1994b, 1994d, and 1993b), Hydro-Geo Consultants (1996), and U.S. Department of Agriculture (1996).

In addition, streamflow data collected in conjunction with water quality monitoring efforts was obtained from the U.S. Forest Service and the Ferry Conservation District. This information was found to be of limited usefulness related to assessing water quantity in the WRIA due to sporadic collection of data. For the most part, flow measurements on tributaries had not been systematically located and had a period of record of less than two years.

Ferry Subbasin

The Ferry Subbasin generally refers to the portion of WRIA 60, about 546 square miles, which drains to the segment of the Kettle River located between the area referred to as Ferry and the community of Danville, Washington. The Kettle River tributaries located within this Subbasin include Catherine Creek, Tenas Mary Creek, Toroda Creek, Tonata Creek, Emanuel Creek, Cottonwood Creek, Curlew Creek, La Fleur Creek, Long Alec Creek, Little and Big Goosmus Creek, West Deer Creek, and Lone Ranch Creek. Curlew Lake is located in the southern portion of the Subbasin and discharges to Curlew Creek.

Limited streamflow studies exist within the Ferry Subbasin. Golder Associates (1996b) measured streamflow at a variable interval during water year (WY) 1995 at 12 locations within the Toroda Creek catchment basin. A wide range in discharge was observed at each location. Golder and Associates (1995b) and Hydro-Geo Consultants (1996) evaluated potential streamflow impacts within the Toroda Creek catchment basin based on the proposed Crown Jewel Project. Golder Associates (1998) also prepared a streamflow mitigation plan in response to the anticipated streamflow impacts of the proposed Crown Jewel Project.

Laurier Subbasin

The Laurier Subbasin generally refers to the portion of WRIA 60, about 388 square miles, which drains to the segment of the Kettle River located between Laurier and Lake Roosevelt. The primary Kettle River tributaries located within this Subbasin include Deep Creek, Little Boulder Creek, Boulder Creek, Toulou Creek, and Deadman Creek. This Subbasin contains numerous small ponds and lakes, including Pierre Lake, Pittman Lake, Lamar Lake, Summit Lake, and others.

No documents were encountered specific to streamflow conditions within the Laurier Subbasin.

Chesaw Subbasin

The Chesaw Subbasin generally refers to the portion of WRIA 60, about 88 square miles, which drains to Myers Creek and exits the WRIA before discharging to the Kettle River in British Columbia. A number of tributaries originate and flow into Myers Creek within this Subbasin, including Ethel Creek, Mary Ann Creek, Bolster Creek, Gafvery Creek, and Gold Creek. This Subbasin contains several small ponds and lakes, including Muskrat Lake, Fields Lake, Strawberry Lake, and others.

The majority of documents specific to streamflow conditions within WRIA 60 that were encountered were related to the Crown Jewel Project, located near Chesaw, Washington. These were largely specific to Myers Creek and/or its tributaries. Golder and Associates (1994b and 1994c) conducted a hydrologic investigation along Myers Creek near Myncaster, British Columbia to assess hydraulic continuity between Myers Creek and shallow groundwater in this area. This study concluded that approximately a 2.2-mile reach of Myers Creek was losing an average of 1.6 cubic feet per second (cfs) to shallow groundwater, and that surface water-groundwater interaction was somewhat limited by low permeability streambed sediments. Golder and Associates (1995b) and Hydro-Geo Consultants (1996) evaluated potential streamflow impacts within the Myers Creek catchment basin based on the proposed Crown Jewel Project. Golder Associates (1998) also prepared a streamflow mitigation plan in response to the anticipated streamflow impacts from the Crown Jewel Project. Golder Associates (1996b) measured streamflow at a variable interval during water year (WY) 1995 at 11 locations within the Myers Creek catchment basin. A wide range in flows were observed at each location, particularly in tributaries such as Gold Creek, Ethel Creek and Bolster Creek. Cascade Environmental Services, Inc. and Caldwell Associates (1996) used the Instream Flow Incremental Methodology (IFIM) to quantify potential physical habitat available to fish species within Myers Creek.

EVALUATION OF STREAM GAGE DATA

An analysis of stream gage data was performed for four stream gaging stations located within the WRIA, including the Kettle River gaging stations near the area referred to as Ferry and the communities of Laurier, and Boyds, Washington, and the Myers Creek gaging station located near Chesaw, Washington. The locations of the four stations are presented in Figure 7. Stream gage data from these gage stations were obtained from the U.S. Geological Survey National Water Information System.

Descriptive statistics were calculated for each of the four stream gage stations. The descriptive statistics include the average annual and monthly discharges, and summary statistics for the entire data set. The summary statistics include the maximum, mean, and minimum daily streamflow values.

The analysis completed for the Ferry and Laurier gage stations included calculation of monthly and annual recurrence intervals and descriptive statistics of streamflow. Recurrence statistics were calculated on a monthly and annual frequency for the Kettle River gage records from the Ferry and Laurier Stations. The daily discharge data was grouped monthly and annually. The daily discharges for the streamflow gage record were ranked from largest to smallest. Each ranked discharge was then plotted against its calculated exceedance probability using Equation 1:

$$P = m/n \qquad \text{Eq. 1}$$

Where:

P is the exceedance probability
m is the streamflow value rank
n is the total number of discharge measurements for the period of record

These statistical evaluations are used to describe the statistical probability of high, median and low streamflow for a given month of the year, based on the available gage records. Low streamflow is estimated by determining the 90 percent exceedance probability and is defined as the flow rate for a particular time period that is exceeded nine out of ten years. Median streamflow is estimated by determining the 50 percent exceedance probability and is defined as the flow rate for a particular time period that is exceeded five out of ten years. High streamflow is estimated by determining the 10 percent exceedance probability and is defined as the flow rate for a particular time period that is exceeded one out of ten years.

Exceedance probabilities were not calculated for the Boyds and Chesaw gage stations because the period of record was not sufficient to develop reliable exceedance estimates.

Ferry Stream Gage Station

The stream gage located near the area referred to as Ferry (USGS Station 12401500; 1929 to 2001 water years) is situated downstream of the location where the Kettle River first enters WRIA 60 from the Canada Subbasin. A summary hydrograph showing maximum, minimum and average daily streamflow rate for the gage record is presented in the Kettle River near Ferry Summary Hydrograph, Figure 8. The maximum-recorded flow was 20,300 cfs, measured on May 29, 1948. The minimum recorded flow was 15 cfs, measured from January 16 through 30, 1930.

Exceedance probability flows are presented in the Kettle River near Ferry Exceedance Flows, Figure 9. Ten percent exceedance flows range from 394 cfs in the month of January to 10,700 cfs in the month of May. Fifty percent exceedance flows range from 190 cfs in the month of January to 6,280 cfs in the month of May. Ninety percent exceedance flows range from 95 cfs in the month of January to 3,320 cfs in the month of May.

Average monthly streamflow rate for the Ferry Gage Station is presented in Table 7 and varies from 220 cfs in the month of January to 6,722 cfs in the month of May. The sum of the average monthly streamflow rates yield an average annual streamflow volume of about 1,120,871 acre-feet that passes the Ferry Stream Gage.

TABLE 7
MONTHLY AND ANNUAL STREAMFLOW ESTIMATES - WRIA 60

MONTH	AVG. FERRY STREAM FLOW RATE[1] (cfs)	AVG. FERRY STREAM FLOW VOLUME[2] (acre-feet)	AVG. LAURIER STREAM FLOW RATE[3] (cfs)	AVG. LAURIER STREAM FLOW VOLUME[2] (acre-feet)	AVG. BOYDS STREAM FLOW RATE[4] (cfs)	AVG. BOYDS STREAM FLOW VOLUME[2] (acre-feet)	AVG. CHESAW STREAM FLOW RATE[5] (cfs)	AVG. CHESAW STREAM FLOW VOLUME[2] (acre-feet)
October	382	23,488	684	42,058	970	59,643	11	695
November	381	22,671	760	45,223	1,171	69,679	12	690
December	271	16,663	611	37,569	770	47,345	10	598
January	220	13,527	516	31,728	802	49,313	8	503
February	230	12,774	562	31,212	786	43,652	9	502
March	424	26,071	1,086	66,776	927	56,999	13	799
April	2,493	148,344	5,202	309,540	6,709	399,213	37	2,124
May	6,722	413,320	12,185	749,226	11,361	698,561	57	3,511
June	5,099	303,412	9,228	549,104	7,478	444,972	41	2,457
July	1,507	92,662	2,829	173,948	3,223	198,175	19	1,162
August	440	27,055	842	51,773	1,145	70,403	10	627
September	351	20,886	636	37,845	580	34,512	9	561
Annual[6]		**1,120,871**		**2,126,001**		**2,172,468**		**14,229**

Notes:

1. Average monthly streamflow rate at the Kettle River gage near the area referred to as Ferry for the water years from 1929 to 2001.
2. Average monthly streamflow volumes calculated using average streamflow rates.
3. Average monthly streamflow at the Kettle River gage near Laurier, Washington for the water years from 1930 to 2001.
4. Average monthly streamflow at the Kettle River gage near Boyd, Washington for the period of record from 1914 to 1915.
5. Average monthly streamflow at the Myers Creek gage near Chesaw, Washington for the period of record from 1996 to 2001.
6. Average annual streamflow volume was calculated by summing the monthly averages.

Laurier Stream Gage Station

The stream gage located near Laurier, Washington (USGS Station 12404500; 1930 to 2001 water years) is situated downstream of the location where the Kettle River enters the Laurier Subbasin and WRIA 60 for the second time. A summary hydrograph showing maximum, minimum and average daily streamflow rate for the gage record is presented in the Kettle River Near Laurier Summary Hydrograph, Figure 10. The maximum-recorded flow was 34,200 cfs, measured on May 29, 1948. The minimum recorded flow was 70 cfs, measured from January 11 through 31, 1930.

Exceedance probability flows are presented in the Kettle River Near Laurier Exceedance Flows, Figure 11. Ten percent exceedance flows range from 890 cfs in the month of January to 19,100 cfs in the month of May. Fifty percent exceedance flows range from 450 cfs in the month of January to 11,800 cfs in the month of May. Ninety percent exceedance flows range from 250 cfs in the month of January to 6,770 cfs in the month of May.

Average monthly streamflow rate for the Laurier Gage Station is presented in Table 7 and varies from 516 cfs in the month of January to 12,185 cfs in the month of May. The sum of the average monthly streamflow rates yield an average annual streamflow volume of about 2,126,001 acre-feet that passes the Laurier Stream Gage.

Boyds Stream Gage Station

The stream gage located at Boyds, Washington (USGS Station 12405000; period of record 1914 to 1915 water years) is situated upstream of the location where the Kettle River enters Lake Roosevelt. A summary hydrograph showing maximum, minimum and average daily streamflow rate for the gage record is presented in the Kettle River at Boyds Summary Hydrograph, Figure 12. The maximum recorded flow was 18,000 cfs, measured on May 17, 1914. The minimum recorded flow was 288 cfs, measured on August 30, 1914.

Average monthly streamflow rate for the Boyds gage station is presented in Table 7 and varies from 580 cfs in the month of September to 11,361 cfs in the month of May. The sum of the average monthly streamflow rates yield an average annual streamflow volume of about 2,172,468 acre-feet that passes the Boyds Stream Gage.

Chesaw Stream Gage Station

The stream gage located near Chesaw, Washington (USGS Station 12400900; 1996 to 2001 water years) is situated upstream of the location where the Myers Creek exits WRIA 60 into British Columbia, Canada Subbasin. A summary hydrograph showing maximum, minimum and average daily streamflow rate for the gage record is presented in the Myers Creek Near Chesaw Summary Hydrograph, Figure 13. The maximum-recorded flow was 250 cfs, measured on May 27, 1997. The minimum recorded flow was 2.1 cfs, measured from August 17 through 18, 2001.

Average monthly streamflow rate for the Chesaw Gage Station is presented in Table 7 and varies from 8 cfs in the month of September to 57 cfs in the month of May. The sum of the average monthly streamflow rates yield an average annual streamflow volume of about 14,229 acre-feet that passes the Chesaw Stream Gage.

GROUNDWATER RESOURCES

INTRODUCTION

This section contains a summary of existing information for WRIA 60 regarding groundwater quantity. The interpretation of surface and subsurface hydrogeologic conditions within WRIA 60 is based on a review of information in the available literature, including water well reports obtained from the Washington State Department of Ecology (Ecology) for wells within the watershed. A very limited readily available data set was encountered in regard to watershed hydrogeology. Aquifer testing information is largely limited to a small number of mineral property investigations and performance tests associated with domestic supply wells. Comprehensive watershed-scale groundwater flow modeling has not been performed within the WRIA 60 watershed. Estimates regarding aquifer extent, as well as estimates of aquifer characteristics within the watershed, such as hydraulic conductivity, transmissivity and storativity, are scarce. Approximate aquifer characteristics were generalized for portions of the WRIA as a component of a groundwater pollution susceptibility study performed by Graham et al. (1992).

PRINCIPAL HYDROGEOLOGIC UNITS

During the review of watershed hydrogeology, two principal hydrogeologic units were identified. Principal aquifers within WRIA 60 occur within (1) basement rocks, and (2) Quaternary sediments in the valleys. Each of these units likely could be divided into a number of separate aquifers. However, the absence of existing information regarding watershed hydrogeology makes more detailed aquifer delineation and characterization difficult with the existing data set.

Basement Rock Aquifer

The lithology of the basement rock aquifer varies considerably across the watershed. Within the upthrown blocks of metamorphic core complexes, basement rocks largely consist of Proterozoic and Palezoic metasedimentary and metavolcanic rocks locally intruded by Tertiary plutonic rocks. The downthrown blocks of metamorphic core complexes largely consist of Tertiary volcanic and plutonic rocks. Basement rocks occur in close proximity to the ground surface within upland areas but are up to several hundred feet below ground surface within the Kettle River Valley.

The aquifer characteristics of the basement rock aquifer(s) have not been studied in detail, except in close proximity to various mineral properties such as the proposed Crown Jewel Project in Okanogan County. Golder and Associates (1992) conducted a hydrogeologic study of the Crown Jewel Project that included pump testing and permeability testing. Results indicated bedrock at the site has a generally low hydraulic conductivity (about 0.3 feet per day [ft/d]) and range in storage coefficient from 3.5×10^{-3} to 1.2×10^{-2}. Golder and Associates (1993a) performed a pumping test within the North Lookout Fault Zone to assist with an analysis of groundwater inflows to the proposed Crown Jewel Project's mine pit. Analysis of pumping test data associated with this project yielded a range of 0.05 to 1.48 ft/d for basement rock hydraulic conductivity and a range of 1.0×10^{-4} to 2.7×10^{-3} for storage coefficient. Knight Piesold and Co. (1993) characterized local hydrogeology in the vicinity of the Crown Jewel Project's proposed tailing disposal facility through a program of test well installations and packer permeability testing. Hydraulic conductivity of basement rock was estimated at 10^{-3} to 10^{-7} centimeters per second (cm/s) during this investigation. Golder and Associates (1994a) used existing hydraulic data for the bedrock aquifer in the vicinity of the Crown Jewel Project to estimate groundwater inflows to the proposed mine pit.

Basement rock aquifers within the watershed generally are confined. The primary porosity of basement rocks generally is low, resulting in low aquifer permeability, transmissivity, and storage properties. Well yields within basement rocks, therefore, will typically be low. Secondary porosity, in the form of joints, fractures, and faults, accounts for the majority of aquifer storage and groundwater transport within basement rocks. Well yields can be significantly increased in proximity to zones of significant jointing, fracturing, or faulting. Basement rock aquifer transmissivity and storativity are also assumed to be low.

Groundwater flow within bedrock aquifers generally is directed toward the drainages within and adjacent to the watershed. At relatively shallow depths, basement rock groundwater flow direction could be controlled by the geometry of drainages within the WRIA, such as the Kettle River and its tributaries. At greater depth, groundwater flow direction is likely controlled by regional features such as the Columbia River.

The basement rock aquifer(s) receive recharge from infiltration of precipitation in the highland areas. The bedrock aquifers primarily discharge groundwater to surface water and/or sedimentary aquifers within adjacent drainages. A minor component of discharge occurs through groundwater supply wells.

Sedimentary Aquifer

The sedimentary aquifers within WRIA 60 generally occur within drainages, such as the Kettle River and its tributaries. The lithology of the sedimentary aquifer varies considerably across the watershed. Successive periods of glaciation during the Pleistocene deposited abundant glacial drift, consisting of heterogeneous till, outwash, and glaciolacustrine soils. Till deposits generally consist of unsorted, unstratified mixtures of clay, silt, sand and gravel. Glaciolacustrine soils generally consist of clay and silt. Outwash deposits consist of stratified sand and gravel. In places, glacial drift is overlain by recent alluvial deposits associated with the Kettle River and its tributaries. These deposits largely consist of stratified silt, sand and gravel.

Sedimentary aquifers are generally unconfined except where overlain by low permeability confining layers. Aquifer material varies depending on location and geologic conditions. Soils with relatively high hydraulic conductivity are generally encountered within the glacial outwash deposits. Low permeability confining layers are generally encountered within glacial till and glaciolacustrine deposits. Aquifer transmissivity varies locally as a function of permeability and sediment thickness. Aquifer storativity varies locally as a function of sediment composition, porosity, and hydrogeologic conditions.

Sedimentary aquifers are recharged by precipitation, infiltration of irrigation water, the losing reaches of streams, and leakage from adjacent basement rock aquifers. Sedimentary aquifer discharge occurs within gaining reaches of streams, as downward leakage to basement rock aquifers, as transpiration to plants, and as discharge to groundwater supply wells. Groundwater flow within sedimentary aquifers generally follows the topography of the respective drainages. Groundwater inflow and outflow occurs at locations where the valleys of the Kettle River and various tributaries enter and exit the WRIA.

Golder and Associates (1994b and 1994c) conducted a hydrologic investigation along Myers Creek near Myncaster, British Columbia to assess hydraulic continuity between Myers Creek and shallow groundwater in this area. This study concluded that approximately a 2.2-mile reach of Myers Creek was losing an average of 1.6 cfs to shallow groundwater, and that surface water-groundwater interaction was somewhat limited by low permeability streambed sediments. Elsewhere within WRIA 60, the nature and extent of the exchange between groundwater and surface water is not well understood. Groundwater/surface water interaction is dependent on piezometric conditions, surface water elevations, aquifer vertical and horizontal hydraulic conductivity, and confining unit properties, each of which has not been widely examined within the WRIA.

HYDROGEOLOGIC SECTIONS

Geologic/hydrogeologic data from water well reports obtained from Ecology were used to construct hydrogeologic sections across the sedimentary aquifer at an approximate right angle to the interpreted direction of the hydraulic gradient (Ecology, 2003b). Hydrogeologic sections were prepared within each of the three Subbasins at locations where significant groundwater inflow and outflow from the basin is suspected to occur (the precise section locations depended on area water well information and location obtained from the Ecology water well database). Hydrogeologic section locations are presented in the Hydrogeologic Section Location Map, Figure 14.

Within the Ferry Subbasin, hydrogeologic sections were prepared across the Kettle River valley near the area referred to as Ferry and the community of Danville. Groundwater inflow from the sedimentary aquifer into the Ferry Subbasin generally occurs perpendicular to Hydrogeologic Section A-A', Figure 15. At this location, the sedimentary aquifer largely consists of glaciofluvial sand and gravel. The cross-sectional area of the aquifer along hydrogeologic section A-A' is poorly constrained, but was estimated to be about 234,000 square feet. Groundwater outflow from the sedimentary aquifer out of the Ferry Subbasin generally occurs perpendicular to Hydrogeologic Section B-B', Figure 16. At this location, the sedimentary aquifer also largely consists of glaciofluvial sand and gravel. Aquifer area along hydrogeologic section B-B' was estimated to be about 16,000 square feet.

Within the Laurier Subbasin, hydrogeologic sections were prepared across the Kettle River Valley near Laurier and Boyds, Washington. Groundwater inflow from the sedimentary aquifer into the Laurier Subbasin generally occurs perpendicular to Hydrogeologic Section C-C', Figure 17. At this location, the sedimentary aquifer largely consists of glaciofluvial sand and gravel underlain by glaciolacustrine clay. The cross-sectional area of the aquifer along hydrogeologic section C-C' was estimated to be about 124,000 square feet. Groundwater outflow from the sedimentary aquifer out of the Laurier Subbasin generally occurs perpendicular to Hydrogeologic Section D-D, Figure 18. At this location, the sedimentary aquifers largely consist of glaciofluvial sand and gravel interbedded with glaciolacustrine clay. Aquifer area along hydrogeologic section D-D' was estimated to be about 338,000 square feet.

The headwaters of Myers Creek are located within the Chesaw Subbasin. Therefore, inflow of groundwater from the sedimentary aquifer into the Chesaw Subbasin was assumed to be insignificant. Groundwater outflow from the sedimentary aquifer out of the Chesaw Subbasin generally occurs perpendicular to Hydrogeologic Section E-E', Figure 19. At this location, the sedimentary aquifer largely consists of glaciofluvial sand and gravel interbedded with glaciolacustrine clay. The cross-sectional area of the aquifer along hydrogeologic section E-E' was estimated to be about 164,000 square feet.

The hydrogeologic sections were used to estimate groundwater inflow and outflow rates. These are presented in the Water Balance section of this Technical Assessment.

WATER RIGHTS

INTRODUCTION

The water rights analysis for WRIA 60 has been conducted with the information stored in Ecology's Water Rights Application Tracking System (WRATS) database. Although the State of Washington has retained files for nearly every water right recorded, the scope and schedule of this analysis did not allow for review of the hardcopy information.

A Public Records request was made of Ecology to provide the water rights and application information contained in the WRATS database for WRIA 60 in an electronic file. Washington State Department of Ecology delivered the electronic data requested on October 27, 2003 (Ecology, 2003a). The resulting electronic data was linked to a GIS such that the water right information could be organized and analyzed for each of the three basins (see Figure 1) in WRIA 60.

The use of GIS allowed an analysis to be performed to determine the number of water rights and applications, and the quantity of water represented by these rights on an annual basis. In recognition that the analysis is only as representative as the data contained in the WRATS database, efforts were made to attempt to ensure the quality of the information assessed. Efforts were made to eliminate multiple copies of a right and to identify the primary purpose of the right. Additional efforts to ensure data quality would have required comparing the hardcopy files associated with each individual water right with the information entered into the WRATS database. Such a level of effort was beyond the scope and schedule of this assessment.

The water rights analysis estimates the number of water rights and applications for WRIA 60, each Subbasin, and each water right (e.g., surface, groundwater, and reservoir) and document (e.g., certificate, permit, and claim) type. Although water resources are commonly measured and allocated on an annual total or an instantaneous rate basis, this analysis describes the annual total quantity allocated by water right and document type for WRIA 60 and each of its Subbasins. Since instantaneous rates (e.g., cubic feet per second or gallons per minute) are often short-term or seasonal, the instantaneous quantities are assumed to be represented in the annual totals. Finally, the analysis identifies the primary purpose by percentage in WRIA 60 and each of its Subbasins for each water right type and the annual total quantities associated with that primary purpose by document type. The key for the two character use codes can be found in Appendix A.

NUMBER OF WATER RIGHTS AND APPLICATIONS

As of October 2003, approximately 1,824 certificate, permit, and claim documents have been recorded for water rights in WRIA 60 (Ecology, 2003a). Roughly 1,284 of these are surface water rights. About 535 of these are groundwater rights, and approximately five of these are reservoir rights. There are about 633 certificates, 183 permits, and 1,008 claims located in WRIA 60. Approximately 60 percent of the water rights in WRIA 60 are located in the Ferry Subbasin, as displayed in Figure 20. There are approximately 143 applications in the WRATS database for WRIA 60. Ten of these applications are classified as active applications. About four of these are applications for groundwater rights and six are applications for surface water rights. Table 8 below displays a summary of the analysis results from estimating the number of water rights and applications within WRIA 60 and each of its Subbasins.

There are an estimated 345 water rights in the Chesaw Basin of WRIA 60. Ninety of these are groundwater rights, 253 are surface water rights, and two are reservoir rights. Approximately 106 are certificates, 18 are permits, and 221 are claims, as displayed in Figure 21. Figure 22 displays that there are three applications classified as active in this Subbasin, two for groundwater rights and one for a surface water right.

The Ferry Subbasin has approximately 1,095 or 60 percent of WRIA 60's water rights within its boundaries. There are 352 rights for groundwater, 741 rights for surface water, and 2 reservoir rights in the Subbasin. Roughly 373 are certificates, 108 are permits, and 614 are claims. There are seven active applications in the Ferry Subbasin, two for groundwater rights and five for surface water rights.

Approximately 384 water rights have been recorded that are located in the Laurier Subbasin of WRIA 60. The water rights for groundwater, surface water, and reservoirs total 93, 290, and 1, respectively. The water rights documents include 154 certificates, 57 permits, and 173 claims. The WRATS database does not contain any applications classified as active in the Laurier Subbasin.

TABLE 8
NUMBER OF WATER RIGHTS AND APPLICATIONS

	Chesaw Subbasin	Ferry Subbasin	Laurier Subbasin	WRIA 60
Water Right Types	345	1095	384	1824
Groundwater	90	352	93	535
Surface Water	253	741	290	1284
Reservoir	2	2	1	5
Document Types	345	1095	384	1824
Certificate	106	373	154	633
Permit	18	108	57	183
Claim	221	614	173	1008
Applications	20	99	24	143
Active	3	7	0	10

QUANTITY OF WATER ALLOCATED

The annual total quantity estimated from water rights should be viewed more as a minimum, than a maximum. The reason this assumption needs to be made is because a relatively small percentage of the claim documents identify the amount of water to be used.

As a result of this absence of information, there is possibly a significant amount of water being legally used that has not been accounted for in WRIA 60. To some degree, the opposite may be true for the certificated water rights. Certificates usually identify the amount of water allocated for use. However, the WRATS database does not identify those certified rights not in use or known candidates for relinquishment. Addressing claims and out of compliance rights makes estimating actual water use through water rights difficult. Therefore, taking a conservative approach, such as assuming the allocated quantity represents a minimum amount of water used, may help reduce the potential errors in managing water resources.

Approximately 39,323 acre-feet of water per year have been allocated through the water rights stored in the WRATS database for WRIA 60. As displayed in Figure 23, approximately 9,196 acre-feet or 23 percent of the total annual amount has been allocated through groundwater rights. Surface water rights have allocated 26,439 acre-feet or 68 percent of the total annual amount estimated for WRIA 60. Reservoir rights have allocated 3,688 acre-feet or 9 percent of the annual total quantity. Roughly 18,323, 10,178, and 10,823 acre-feet have been allocated in WRIA 60 through certificate, permit, and claim documents, respectively. Figure 24 displays that 46, 26, and 28 percent of the total annual quantity have been allocated through certificate, permit, and claim documents, respectively, in WRIA 60. Table 9 below displays a summary of the results of the analysis related to estimating the total annual quantity allocated in WRIA 60 and each of its Subbasins.

In the Chesaw Subbasin of WRIA 60, approximately 2,579 acre-feet of water have been allocated. Figure 25 displays that groundwater rights account for 631 acre-feet, surface water rights account for 1,280 acre-feet, and reservoir rights account for 668 acre-feet of the estimated annual total. Certificate, permit, and claim documents have allocated approximately 252, 2,189, and 138 acre-feet, respectively.

Roughly 26,696 acre-feet of water have been allocated annually in the Ferry Subbasin of WRIA 60. Approximately 8,418 acre-feet of this total are allocated through groundwater rights. Surface water rights account for approximately 15,559 acre-feet of the total amount allocated, and 2,720 acre-feet has been allocated through reservoir rights. Certificate, permit, and claim documents have allocated approximately 13,372-, 5,756-, and 7,569-acre-feet, respectively, in this Subbasin.

The water allocated annually in the Laurier Subbasin of WRIA 60 totals about 10,049 acre-feet. Groundwater rights account for approximately 148 acre-feet. Surface water and reservoir rights account for roughly 9,601 and 300 acre-feet, respectively. Approximately 4,699-, 2,233-, and 3,117-acre-feet have been allocated through the Laurier Subbasin's respective certificate, permit, and claim documents.

TABLE 9
ANNUAL TOTAL QUANTITY OF WATER ALLOCATED IN ACRE-FEET

	Chesaw Subbasin	Ferry Subbasin	Laurier Subbasin	WRIA 60
Water Right Types	2579	26696	10049	39323
Groundwater	631	8418	148	9196
Surface Water	1280	15559	9601	26439
Reservoir	668	2720	300	3688
Document Types	2579	26696	10049	39323
Certificate	252	13372	4699	18323
Permit	2189	5756	2233	10178
Claim	138	7569	3117	10823

PRIMARY PURPOSE

The WRATS database identifies the purpose(s) of the water right in most cases. The types of purposes most often identified are commercial and industrial manufacturing, domestic general, domestic multiple users, domestic single user, environmental quality, fire protection, fish propagation, heat exchange, highway (roads), irrigation, mining, railway, stock watering, and wildlife propagation. An attempt has been made to identify the primary purpose of surface, groundwater, and reservoir rights by percentage.

Multiple purposes may be identified on a water right. For this analysis, the purpose listed having the largest potential for water use was designated the primary purpose. This method of designating a primary purpose to each water right may create errors if an attempt is made to sum the total number of rights or quantity of water allocated by purpose. The discussion related to purpose should be viewed as a rough indicator of what water may be allocated for based on the information within the WRATS database.

Figure 26 displays that in the Chesaw Subbasin, approximately 158 and 442 acre-feet or roughly 96 percent of the groundwater allocated through the respective certificate and permit documents is for the purpose of irrigation. The surface water rights appear to be allocated primarily for the purpose of mining. Permit documents have allocated roughly 980 acre-feet or 77 percent of surface water rights to the purpose of mining in this Subbasin, as displayed in Figure 27. The reservoir type rights include allocations to irrigation and state reserve purposes for 240 and 428 acre-feet, respectively, through permit documents.

In the Ferry Subbasin, approximately 3,394-, 3,214-, and 18-acre-feet or roughly 79 percent of the groundwater rights, as displayed in Figure 28, are allocated through the respective certificate, permit, and claim documents for the purpose of irrigation. The surface water and reservoir rights in this Subbasin appear to be allocated primarily for the purpose of irrigation, similar to the Chesaw Subbasin. Certificate, permit, and claim documents have allocated roughly 6,970-, 624-, and 2,883-acre-feet, respectively, or 67 percent of the surface water rights, as displayed in Figure 29, to the purpose of irrigation in this Subbasin. The reservoir rights include allocations for irrigation purposes of 2000 acre-feet or 74 percent of these types of rights through certificate documents.

In the Laurier Subbasin, approximately 47, 55, and 2 acre-feet or roughly 71 percent of the groundwater rights, as displayed in Figure 30, are allocated through the respective certificate, permit, and claim documents for domestic purposes. While the surface water and reservoir type rights appear to be allocated primarily for the purpose of irrigation. Certificate, permit, and claim documents have allocated roughly 4,184-, 1,831-, and 803-acre-feet, respectively, or 71 percent of surface water, as displayed in Figure 31, to the purpose of irrigation in this Subbasin. Figure 32 displays that approximately 806 acre-feet of surface water rights have been allocated through claim documents in this Subbasin. The reservoir rights include allocations for irrigation purposes of 300 acre-feet through permit documents.

CONCLUSIONS

As of October 2003, approximately 1,824 certificate, permit, and claim documents have been recorded in WRIA 60 allocating approximately 39,323 acre-feet of water per year. The annual quantity of water calculated to have been allocated should be viewed more as a minimum, than a maximum. A significant percentage of water rights in WRIA 60 have been recorded through claim documents. Water right claim documents seldom identify the amount of water to be used. As a result, there could possibly be a significant amount of water being used under a recorded claim that is not accounted for in the

WRATS database. In fact, the Draft Initial Watershed Assessment made several assumptions about claims that resulted in calculating the water allocated in WRIA 60 to be 46,497 acre-feet per year (Dames & Moore, 1995). The annual quantity of water calculated to have been allocated in the Draft Initial Watershed Assessment should be viewed more as a maximum (Dames & Moore, 1995). Addressing claims and out of compliance rights makes estimating actual water use through water rights difficult.

WATER BALANCE

INTRODUCTION

The purpose of the water balance component of this assessment is to characterize the climatic, surface water, and groundwater components of the watershed. The water balance is intended for use as a screening tool to further evaluate water resource allocations within the watershed and to identify water balance components that may require further analysis during the next levels of watershed planning.

WATER BALANCE COMPONENTS AND METHODOLOGY

The water balance presented in this section estimates the quantity of water entering and exiting the WRIA 60 basin through a set of hydrologic pathways. It does not evaluate the exchange of water between hydrologic pathways within the basin. The water balance is based on the readily available data for the basin. When the existing data allowed, components of this water balance assessment were evaluated using monthly averages, which were summed to determine annual averages. The overall water balance is presented on an annual basis.

The limits of WRIA 60 are, in part, based on political rather than hydrologic boundaries. The Kettle River enters WRIA 60 in two locations; in the vicinity of the area referred to as Ferry and again at Laurier, Washington. The Kettle River exits WRIA 60 in two locations as well; in the vicinity of Danville, Washington and into Lake Roosevelt in the southeast corner of the WRIA. Myers Creek drains a significant portion of the watershed located in the northwest portion of the WRIA and flows outside of the boundaries of the WRIA into British Columbia before discharging to the Kettle River. Because of these considerations, a separate water balance was performed for each of the three Subbasins within WRIA 60.

Portions of the Kettle River watershed are located outside of the WRIA 60 boundaries. Therefore, inflow to the system is not limited to precipitation. Inflows include groundwater and surface water contributions from upgradient portions of the watershed that are not located within the WRIA 60 boundaries. The quantity of water entering each Subbasin, therefore, was assumed to consist of the following components:

$$\text{Total Basin Inputs} = PPT + GWI + SWI \qquad \text{(Eq. 1)}$$

where:

PPT = Precipitation
GWI= Groundwater Inflow
SWI = Surface Water Inflow

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

Total Basin Outputs = ET + ND+GWO + SWO (Eq. 2)

where:

ET = Evapotranspiration
ND = Net Demand
GWO = Groundwater Outflow
SWO = Surface Water Outflow

This water balance assumes that on an annual basis, there is no change in water storage within the basin. Given this assumption, total annual basin inputs equal total annual basin outputs.

HYDROLOGIC COMPONENTS

The methods used to evaluate each of the water balance components are presented below.

Precipitation

Annual precipitation rates for each of the three Subbasins were calculated from the isohyetal precipitation distribution presented in the Average Annual Precipitation Map, Figure 2. The isohyetal precipitation distribution was imported into a GIS to derive the area-weighted average monthly and annual precipitation (volumetric) for each Subbasin. The results of this analysis are presented in Table 1.

Evapotranspiration

Potential evapotranspiration, the amount of water returned to the atmosphere from surface water and groundwater evaporation and vegetation transpiration, was calculated for each of the three Subbasins using the Thornthwaite method (Dunne and Leopold, 1978). The Thornthwaite method is an empirical equation that incorporates average monthly air temperatures to calculate potential evapotranspiration. The average monthly and annual air temperatures within the WRIA 60 Subbasins were obtained from PRISM (Daly and Taylor, 1998). The temperature distribution was imported into a GIS to derive area-weighted average monthly and annual air temperatures for each Subbasin, as presented in Table 2.

The Thornthwaite method is not suited for estimating potential evapotranspiration during months when the average temperature is less than zero degrees Celsius. Potential evapotranspiration was assumed to be negligible during these conditions. The evapotranspiration was estimated to equal potential evapotranspiration during months when average precipitation exceeds average potential evapotranspiration. During months when average potential evapotranspiration exceeds average precipitation, total evapotranspiration was assumed to be equal to precipitation. This assumption neglects groundwater recharge and surface water runoff. The results of this analysis are presented in Table 10.

TABLE 10
POTENTIAL EVAPOTRANSPIRATION CALCULATION
THORNTHWAITE METHOD[1] – WRIA 60
FERRY SUBBASIN

MONTH	AVERAGE MONTHLY TEMP.[2] (degrees Celsius)	ANNUAL HEAT INDEX[3]	THORNTHWAITE POTENTIAL EVAPOTRANS-PIRATION[4] (Feet)	MONTHLY CORRECTION FACTOR[5]	CORRECTED POTENTIAL EVAPOTRANS-PIRATION (feet)	VOLUMETRIC POTENTIAL EVAPOTRANS-PIRATION[6] (acre-feet)	AVERAGE MONTHLY PRECIPITATION (acre-feet)	EST. EVAPO-TRANS-PIRATION[7] (acre-feet)
October	5.2	37.5	0.07	1.32	0.10	34,540	30,455	30,455
November	-1.5	37.5	Negligible	1.20	0	0	48,222	0
December	-5.6	37.5	Negligible	1.06	0	0	55,733	0
January	-6.4	37.5	Negligible	0.90	0	0	44,976	0
February	-2.3	37.5	Negligible	0.77	0	0	35,207	0
March	0.3	37.5	0.003	0.69	0.002	809	35,944	809
April	5.0	37.5	0.07	0.72	0.05	18,053	39,225	18,053
May	9.5	37.5	0.14	0.85	0.12	42,858	55,306	42,858
June	13.4	37.5	0.21	0.98	0.21	71,851	57,888	57,888
July	16.4	37.5	0.26	1.14	0.30	104,138	36,242	36,242
August	16.1	37.5	0.26	1.27	0.33	113,705	41,805	41,805
September	11.1	37.5	0.17	1.35	0.23	80,636	28,228	28,228
Annual[8]	**5.0**				**1.34**			**256,339**

LAURIER SUBBASIN

MONTH	AVERAGE MONTHLY TEMP.[2] (degrees Celsius)	ANNUAL HEAT INDEX[3]	THORNTHWAITE POTENTIAL EVAPOTRANS-PIRATION[4] (Feet)	MONTHLY CORRECTION FACTOR[5]	CORRECTED POTENTIAL EVAPOTRANS-PIRATION (feet)	VOLUMETRIC POTENTIAL EVAPOTRANS-PIRATION[6] (acre-feet)	AVERAGE MONTHLY PRECIPITATION (acre-feet)	EST. EVAPO-TRANS-PIRATION[7] (acre-feet)
October	5.2	37.5	0.07	1.32	0.10	24,542	34,390	24,542
November	-1.5	37.5	Negligible	1.20	0	0	55,356	0
December	-5.6	37.5	Negligible	1.06	0	0	62,584	0
January	-6.7	37.5	Negligible	0.90	0	0	53,020	0
February	-3.5	37.5	Negligible	0.77	0	0	40,921	0
March	-0.5	37.5	Negligible	0.69	0	0	40,405	0
April	4.8	37.5	0.07	0.72	0.05	12,270	35,201	12,270
May	9.1	37.5	0.14	0.85	0.12	29,059	48,008	29,059
June	13.2	37.5	0.21	0.98	0.20	50,223	47,762	47,762
July	16.5	37.5	0.26	1.14	0.30	74,484	28,614	28,614
August	16.1	37.5	0.26	1.27	0.33	80,790	33,288	33,288
September	11.1	37.5	0.17	1.35	0.23	57,293	27,875	27,875
Annual[8]	**4.9**				**1.32**			**203,409**

CHESAW SUBBASIN

MONTH	AVERAGE MONTHLY TEMP.[2] (degrees Celsius)	ANNUAL HEAT INDEX[3]	THORNTHWAITE POTENTIAL EVAPOTRANS-PIRATION[4] (Feet)	MONTHLY CORRECTION FACTOR[5]	CORRECTED POTENTIAL EVAPOTRANS-PIRATION (feet)	VOLUMETRIC POTENTIAL EVAPOTRANS-PIRATION[6] (acre-feet)	AVERAGE MONTHLY PRECIPITATION (acre-feet)	EST. EVAPO-TRANS-PIRATION[7] (acre-feet)
October	5.1	37.5	0.07	1.32	0.10	5,481	4,224	4,224
November	-1.6	37.5	Negligible	1.20	0	0	7,875	0
December	-6.0	37.5	Negligible	1.06	0	0	9,042	0
January	-6.2	37.5	Negligible	0.90	0	0	7,473	0
February	-3.3	37.5	Negligible	0.77	0	0	5,753	0
March	-0.4	37.5	Negligible	0.69	0	0	5,289	0
April	4.2	37.5	0.06	0.72	0.04	2,420	6,198	2,420
May	9.0	37.5	0.14	0.85	0.12	6,549	8,826	6,549
June	12.5	37.5	0.19	0.98	0.19	10,796	8,683	8,683
July	15.6	37.5	0.25	1.14	0.28	15,983	5,518	5,518
August	15.6	37.5	0.25	1.27	0.31	17,806	6,473	6,473
September	11.4	37.5	0.18	1.35	0.24	13,453	4,325	4,325
Annual[8]	**5.0**				**1.28**			**38,192**

Notes:
1. Thornthwaite Method adapted from Dunne and Leopold (1978) for the calculation of potential evapotranspiration.
2. Average monthly temperature was calculated from the PRISM temperature distribution using GIS to derive area-weighted averages for each Subbasin.
3. Annual heat index derived from average annual temperatures.
4. Potential evapotranspiration for months with an average temperature less than 0 degrees Celsius could not be evaluated with this method and was assumed negligible.
5. Monthly correction factor is based on the monthly sunshine duration at 49 degrees latitude.
6. Volumetric potential evapotranspiration based on a surface area of 1.768 x 10^{10} square feet for the Ferry Subbasin and 1.081 X 1010 square feet for the Laurier Subbasin.
7. The evapotranspiration was estimated to equal potential evapotranspiration during months when average precipitation exceeds average Potential evapotranspiration.
   During months when average potential evapotranspiration exceeds average precipitation, estimated evapotranspiration was assumed to be Equal to precipitation.
8. Annual quantity calculated by averaging monthly temperatures and summing monthly evapotranspiration.

Surface Water Inflow

Streamflow entering WRIA 60 was evaluated at two stream gages on the Kettle River. A stream gage located near the area referred to as Ferry (USGS Station 12401500; 1929 to 2001 water years) was used to evaluate surface water inflow to the Ferry Subbasin. A stream gage located near Laurier, Washington (USGS Station 120404500; 1930 to 2001 water years) was used to evaluate surface water inflow to the Laurier Subbasin.

Average monthly streamflow data for each of the two stream gages is presented in Table 7. The average monthly data for the Ferry and Laurier stations were summed to derive the average annual streamflow estimates incorporated into this water balance for the Ferry and Laurier Subbasins, respectively.

The headwaters of Myers Creek are located within the Chesaw Subbasin. Therefore, surface water inflow to the Chesaw Subbasin was assumed to be insignificant.

Surface Water Outflow

Streamflow exiting WRIA 60 was evaluated at one stream gage on the Kettle River and one stream gage on Myers Creek. A stream gage located near Boyds, Washington (USGS Station 12405000; 1914 to 1915 water years) was used to evaluate surface water flow out of the Laurier Subbasin via the Kettle River. A stream gage located near Chesaw, Washington (USGS Station 12400900; 1996 to 2001 water years) was used to evaluate surface water flow out of the Chesaw Subbasin via Myers Creek. Streamflow estimates derived from these stations should be viewed as approximate due to the short period of record.

Average monthly streamflow data for each of the two stream gages is presented in Table 7. The average monthly data for the Boyds and Chesaw stations were summed to derive the average annual streamflow estimates incorporated into this water balance for the Laurier and Chesaw Subbasins, respectively.

Surface water outflow data was not encountered for the Ferry Subbasin. Surface water outflow in this Subbasin was calculated as the residual of the water balance.

Groundwater Inflow and Outflow

The watershed groundwater inflow and outflow analysis was based on an understanding of watershed geology and hydrogeology, which was limited by the existing geologic and hydrogeologic data set. For the purposes of this water balance, groundwater inflow and outflow to the WRIA is assumed to occur within the sedimentary aquifers located within alluvial and glacial sediments within the Kettle River Valley and Myers Creek drainage.

Geologic/hydrogeologic data from water well reports obtained from Ecology were used to construct hydrogeologic cross sections of the sedimentary aquifer at an approximate right angle to the interpreted direction of the hydraulic gradient (Ecology, 2003b). Hydrogeologic sections were prepared within each of the three Subbasins at locations where significant groundwater inflow and outflow from the basin is suspected to occur. Hydrogeologic section locations are presented in the Hydrogeologic Section Location Map, Figure 14.

Groundwater inflow from the sedimentary aquifer into the Ferry Subbasin was estimated perpendicular to Hydrogeologic Section A-A', Figure 15 and groundwater outflow from the sedimentary aquifer out of the Ferry Subbasin was estimated perpendicular to Hydrogeologic Section B-B', Figure 16. Groundwater inflow from the sedimentary aquifer into the Laurier Subbasin was estimated perpendicular to Hydrogeologic Section C-C', Figure 17 and groundwater outflow from the sedimentary aquifer out of the Ferry Subbasin was estimated perpendicular to Hydrogeologic Section D-D', Figure 18. The headwaters of Myers Creek are located within the Chesaw Subbasin, therefore groundwater inflow to the Chesaw Subbasin was assumed to be insignificant. Groundwater outflow from the sedimentary aquifer out of the Chesaw Subbasin was estimated perpendicular to Hydrogeologic Section E-E', Figure 19.

Groundwater inflow and outflow to the WRIA were calculated using the Darcy Equation:

$$Q = KA(dh/dl) \qquad \text{(Eq. 3)}$$

where:

Q = Groundwater Flux
K = Hydraulic Conductivity
A = Area of Alluvial/Glacial Aquifer
dh/dl = Hydraulic Gradient

Hydraulic conductivity estimates were adapted from estimates provided in Graham et al. (1992) for the alluvial/glacial aquifers in the vicinity of the hydrogeologic sections. Aquifer area was estimated from hydrostratigraphic unit geometry presented in the hydrogeologic sections. Hydraulic gradient was estimated from the Kettle River and/or Myers Creek gradient in the vicinity of the hydrogeologic sections. A summary of the groundwater inflow and outflow analysis is presented in Table 11.

TABLE 11
GROUNDWATER INFLOW AND OUTFLOW ANALYSIS - WRIA 60

HYDROGEOLOGIC SECTION[1]	HYDRAULIC CONDUCTIVITY[2] (feet per day)	AREA[3] (square feet)	HYDRAULIC GRADIENT[4] (feet per foot)	GROUNDWATER FLOW[5] (acre feet per year)
A-A' (Ferry)	110	234,000	1.5×10^{-3}	3,234
B-B' (Danville)	65	16,000	1.2×10^{-3}	11
C-C' (Laurier)	65	124,000	1.4×10^{-3}	95
D-D' (Boyds)	65	338,000	1.4×10^{-3}	258
E-E' (Chesaw)	65	164,000	1.2×10^{-2}	1,072

Notes:

1. Groundwater flow was calculated through the alluvial/glacial aquifers delineated in the hydrogeologic sections. It was assumed that the sections trend at a right angle to groundwater flow.
2. Hydraulic conductivities were derived from the midpoint of the range provided in Graham et. al. (1992) for the locations of the hydrogeologic sections. Hydraulic conductivity at hydrogeologic section E-E' was estimated based on hydrogeologic setting and representative values in Graham et. al. (1992).
3. The area of the aquifers were estimated from the hydrogeologic sections.
4. Hydraulic gradient was estimated from the Kettle River and/or Myers Creek gradient in the vicinity of the hydrogeologic sections.
5. Groundwater flow was calculated using the Darcy Equation.

Net Demand

General

The annual net water demand is the difference between water supplied from WRIA 60 for consumptive use (domestic, municipal, industrial, commercial, irrigation, etc.) and the water returned after use to the hydrologic system. The following analysis examined annual net domestic and non-domestic water demand separately, the sum of which forms the estimated total annual net demand. Summaries of surface water and groundwater right distribution within the WRIA are presented in Surface Water and Groundwater Allocations, Figures 33 and 34.

Domestic

Gross domestic use estimates for each Subbasin are presented in Table 12. To estimate gross domestic use, 2000 census data for WRIA 60 was incorporated into a GIS to estimate the population and number of households in each Subbasin. The estimated water demand per household (3.41 acre-feet per year) was adapted from data reported by the U.S. Geological Survey (2003) for the Colville River Watershed (WRIA 59). The product of the number of households and estimated annual water demand per household represents the estimated gross annual water demand for domestic use within WRIA 60. To estimate the amount of the domestic water returned to the system, the Washington State Department of Health's recommendation of assuming 200 gallons per day (about 0.22 acre-feet per year) per household was used (USGS 2003). Net annual water demand for domestic use was then calculated by subtracting the estimated annual return flow from the estimated gross annual water demand. This yielded estimates of 3,279-, 1,240-, and 430-acre-feet per year for the Ferry, Laurier, and Chesaw Subbasins, respectively.

TABLE 12
DOMESTIC ANNUAL NET DEMAND ESTIMATE - WRIA 60

SUBBASIN	POPULATION[1]	NUMBER OF HOUSEHOLDS[1]	ANNUAL DOMESTIC WATER DEMAND[2] (acre-feet)	ESTIMATED RETURN FLOW[3] (acre-feet)	ANNUAL NET DOMESTIC DEMAND (acre-feet)
Ferry	2,724	1,028	3,505	226	3,279
Laurier	995	389	1,326	86	1,240
Chesaw	307	135	460	30	430

Notes:

1. Population and number of household estimates derived from 2000 census data from the U.S. Census Bureau.
2. Annual domestic water demand is the product of the number of households and the average estimated annual water demand per household, 3.41 acre-feet.
3. Estimated return flows are the product of the number of households and the average annual return flow per household, 0.22 acre-feet.

Non-Domestic

Gross, non-domestic water use within WRIA 60 was calculated by totaling the non-domestic water right allocations compiled in Ecology's Water Right Application Tracking System (WRATS) database. The annual non-domestic net demand estimate is summarized in Table 13. There are 1,095-, 384-, and 345-water right documents on file with Ecology for the Ferry, Laurier, and Chesaw Subbasins, respectively. These were separated into surface water, groundwater, and reservoir allocations, as shown in Table 8. Water right permit, certificate and claim documents that have annual quantities associated with them were included in this analysis. Claims without annual quantities were not included. The annual gross water demand for each purpose except domestic use was calculated by assuming the annual total of the associated water rights has been supplied and used.

The annual net water demand for non-domestic use was calculated by subtracting estimated return flow from the gross demand. The majority of non-domestic allocated water within both WRIA 60 Subbasins is designated for irrigation, with minor quantities designated for mining, fish propagation, stock-watering, fire protection, and unknown purposes. For the purposes of this water balance, non-domestic return flows were estimated to be 30 percent, based on typical estimates for irrigated use

(Hargreaves and Merkley 1998). The analysis yielded totals of 16,512, 6,318 and 1,767 acre-feet for annual net demand in the Ferry, Laurier, and Chesaw Subbasins, respectively.

TABLE 13
NON-DOMESTIC ANNUAL NET DEMAND ESTIMATE[1, 2] - WRIA 60

SUB-BASIN	SURFACE WATER ALLOCATIONS (acre-feet)	GROUNDWATER ALLOCATIONS (acre-feet)	RESERVOIR ALLOCATIONS (acre-feet)	TOTAL ALLOCATIONS (acre-feet)	ESTIMATED RETURN FLOWS[3] (acre-feet)	ANNUAL NON-DOMESTIC NET DEMAND (acre-feet)
Ferry	13,577	7,291	2,720	23,588	7,076	16,512
Laurier	8,683	43	300	9,026	2,708	6,318
Chesaw	1,250	607	668	2,525	758	1,767

Notes:

1. Non-domestic annual net demand based on information provided by Ecology's WRATS databases for uses other than domestic general, domestic multiple, and domestic single.
2. Water right certificates, permits, and claims with quantities associated with them were included in this estimate. Claims without quantities were not included.
3. Return flows were estimated to be 30 percent of the allocations.

SIMPLIFYING ASSUMPTIONS

Water balances are used to evaluate the distribution of the various components of watershed hydrology between the overall watershed hydrologic systems. The purpose of a water balance is to complete a simple evaluation of the relative influence of an existing or proposed water use on the overall water resources of a watershed. It is important to recognize the limitations of water balances in evaluating the water resources, as described below.

- The watershed hydrology components were based on previous data compilation and analyses, which are relatively sparse within WRIA 60. The simplifying assumptions used to develop estimates for each of the watershed components apply to the water balance assessment.
- Water balances are not adequate to evaluate the potential influence of an increase in groundwater use for watersheds with complex hydrology or large groundwater use. This is because groundwater use is dependent upon aquifer hydraulics, spatial and temporal characteristics and the capture of natural discharge and water balances cannot be used to accurately evaluate any of these factors (Bredehoeft 1997, Sophocleous, 1997; Bredehoeft et al., 1982).
- Steady-state (static) conditions are assumed to be an accurate representation of the hydrologic system within each watershed. In reality, watersheds are actually transient systems that are dynamically balanced between water inputs and output. Watersheds with significant consumptive use and complex watershed hydrology should be evaluated as transient systems.
- The watershed boundaries were assumed to be identical for the surface water and groundwater hydrologic systems. In reality, the groundwater flow system boundary conditions are complex, and the groundwater boundaries may not be identical to the surface water boundaries for many of the watersheds.
- Groundwater inflow and outflow from the bedrock aquifers was assumed to be negligible.

- Water balances are only valid to describe existing conditions where sufficient empirical data is available. Water balances are widely recognized as inappropriate for predictive analysis due to the simplifying assumptions and the inability of the method to predict changes in hydrologic systems (Bredehoeft et al., 1982; Sokolov and Chapman, 1984). For this Level I Technical Assessment, this water balance should be used as a screening tool to identify hydrologic and/or hydrogeologic data gaps.

WATER BALANCE SUMMARY

The annual water balance for WRIA 60 is summarized in Table 14. Inputs to the Ferry Subbasin total 1,633,336 acre-feet per year, of which roughly 509,231 acre-feet, 3,234 acre-feet, and 1,120,871 acre-feet per year are attributed to precipitation, groundwater inflow, and surface water inflow, respectively. Because surface water outflow in this subbasin was calculated as the residual of the water balance, outputs from the Ferry Subbasin also total 1,633,336 acre-feet per year, of which roughly 256,339 acre-feet, 19,791 acre-feet, 11 acre-feet, and 1,357,195 acre-feet per year are attributed to evapotranspiration, net demand, groundwater outflow, and surface water outflow, respectively.

TABLE 14
ANNUAL WATER BALANCE SUMMARY[1,2] - WRIA 60

INPUTS

WRIA 60 SUBBASIN	PRECIPITATION (acre-feet)	GROUNDWATER INFLOW (acre-feet)	SURFACE WATER INFLOW[5] (acre-feet)	TOTAL INPUTS (acre-feet)
Ferry	509,231	3,234	1,120,871	1,633,336
Laurier	507,424	95	2,126,001	2,633,520
Chesaw[3]	79,679	0	0	79,679

OUTPUTS

WRIA 60 SUBBASIN	EVAPOTRANS-PIRATION (acre-feet)	NET DEMAND (acre-feet)	GROUNDWATER OUTFLOW (acre-feet)	SURFACE WATER OUTFLOW[5] (acre-feet)	TOTAL OUTPUTS (acre-feet)
Ferry[4]	256,339	19,791	11	1,357,195	1,633,336
Laurier	203,409	7,558	258	2,172,468	2,383,693
Chesaw	38,192	2,197	1,072	14,229	55,690

Notes:

1. This water balance assumes that steady state conditions exist within WRIA 60 on an annual basis- that is no change in storage occurs.
2. This water balance presents results to the nearest acre-foot. In reality, the precision of our calculations is subject to greater uncertainty.
3. The headwaters of Myers Creek are within the Chesaw Subbasin, therefore surface water and groundwater inflow were assumed to be negligible.
4. Outflow stream flow data was not available for the Ferry Subbasin. Surface water outflow was calculated as the residual of the water balance.
5. USGS gage station data was used except for the Ferry Subbasin.

Inputs to the Laurier Subbasin total 2,633,520 acre-feet per year, of which roughly 507,424 acre-feet, 95 acre-feet, and 2,126,001 acre-feet per year are attributed to precipitation, groundwater inflow, and surface water inflow, respectively. Outputs from the Laurier Subbasin total 2,383,693 acre-feet per year, of which roughly 203,409 acre-feet, 7,558 acre-feet, 258 acre-feet, and 2,172,468 acre-feet per year are attributed to evapotranspiration, net demand, groundwater outflow, and surface water outflow, respectively.

Precipitation was assumed to be the only input to the Chesaw Subbasin, and was estimated to provide about 79,679 acre-feet of water per year. Outputs from the Chesaw Subbasin total 55,690 acre-feet per year, of which roughly 38,192 acre-feet, 2,197 acre-feet, 1,072 acre-feet, and 14,229 acre-feet per year are attributed to evapotranspiration, net demand, groundwater outflow, and surface water outflow, respectively.

The discrepancy in total input and output in the Laurier and Chesaw Subbasins and the increase in surface water outflow calculated in the Ferry Subbasin may be a reflection of the uncertainty in many of the water balance components. If this water balance is to be used as a planning tool, additional studies may need to be performed to more precisely define WRIA hydrology and hydrogeology.

LIMITATIONS

The Level I Technical Assessment was based solely on readily available data, and was subject to limitations of both financial resources and time. Relative to other watersheds within the State of Washington, a limited data set exists for the Kettle River Watershed. This technical assessment could be augmented with targeted data collection during watershed planning before using it in development of the watershed plan.

Existing hydrologic and hydrogeologic data for WRIA 60 are relatively limited. Data limitations negatively impacted the precision of this water balance and are summarized below:

- Streamflow records are limited to the period from 1914 to 1915 for Boyds, Washington and surface water outflow data is not available for the Ferry Subbasin.
- The hydrogeology of the watershed is largely unknown. Estimates of aquifer thickness and extent, hydraulic conductivity, and hydraulic gradient for the various aquifers are generally unavailable. Water level information is very limited and relatively imprecise.
- Groundwater/surface water interaction, as well as the relationship between groundwater use and streamflow is generally unknown.
- The effect of land use on evapotranspiration rates within WRIA 60 has not been evaluated. Land cover distribution throughout the WRIA is presented in the Land Cover Map, Figure 35.
- The water balances were completed at a relatively coarse spatial scale. Evaluation of the impact of a concentration of high consumptive water use rates in a localized area would require more detailed evaluation.
- The water balances were completed under steady state conditions and did not evaluate potential impacts to regional aquifers and aquifer storage. Supplemental analyses that incorporate spatial and temporal variations within the watershed and affected regional aquifers may be required.

RECOMMENDATIONS

INTRODUCTION

This Level 1 Technical Assessment represents a compilation and review of readily available data for WRIA 60 that was subject to funding and time constraints. A component of the evaluation of existing data included the development of a water balance for each of the three Subbasins identified for the WRIA.

During the review and evaluation, a widespread lack of hydrologic and hydrogeologic data was identified for the watershed. Depending on Planning Unit objectives, a number of these data gaps could be addressed during the Level 2 portion of Phase 2 in the watershed planning process.

ADEQUACY OF EXISTING DATA

This section includes a discussion of the adequacy of existing data for WRIA 60, organized by data type. Primary data gaps are identified and general recommendations are provided for filling the respective data gaps.

Climate Data

Climate data was collected for three recording stations within the study area, designated by WRCC as Chesaw 4 NNW, Irene Mountain Wauconda, and Laurier. Station data was augmented by a basin-wide precipitation and temperature distributions developed using PRISM. Existing data could be strengthened by the addition of additional climate stations to achieve a more complete distribution of data. However, the period of record required to adequately characterize climatic conditions could make this option unfeasible.

Data regarding snowpack thickness from within the WRIA is generally absent. This data could be useful in defining water storage and runoff throughout an annual cycle. It is understood that a SNOTEL (SNOwpack TELemetry) station began operation this fall near Boulder Pass in the east portion of the WRIA and could be utilized in future phases of watershed planning.

Limited evapotranspiration data specific to WRIA 60 was encountered during the review. To estimate evapotranspiration, an empirical equation was used that incorporates average monthly air temperatures to calculate potential evapotranspiration.

This method was not suited for estimating potential evapotranspiration during months when the average temperature is less than zero degrees Celsius. Evapotranspiration estimates could be improved by using an approach that accounts for aspect, elevation, land use and cover distribution. Developing characteristic evapotranspiration rates coincident for the primary land uses common to the WRIA could result in more accurate estimates.

Planning Data

Since development is not linked to an urban settings, the WRIA 60 Planning Unit needs to identify and prioritize the non-federal lands for development purposes based on their local knowledge and understanding of this area. In order to assess these prioritized areas for how changes in land cover and/or increases in populations would affect water resources, baseline information will need to be organized, if it exists, or collected, if currently absent, for these areas. The collection of information specific to these areas would facilitate assessing development scenarios during preparation of the WRIA 60 Watershed Plan.

Surface Water Data

An analysis of stream gage data was performed for four stream gaging stations located within the WRIA, including Kettle River gaging stations near the area referred to as Ferry and the communities of

Laurier and Boyds, Washington, and the Myers Creek gaging station located near Chesaw, Washington. The periods of record for the Boyds and Chesaw stations are two and five years, respectively. The understanding of the quantity of surface water outflow from the Laurier and Chesaw Subbasins would be improved by lengthening the period of record associated with both of these stations.

In addition, surface water outflow data for the Kettle River within the Ferry Subbasin is generally not available. Surface water outflow is a significant component of the water balance. Establishing a stream gage on the Kettle River near Danville, Washington would increase the understanding of surface water quantity within the Ferry Subbasin.

Limited streamflow data was encountered that was associated with tributaries of the Kettle River during the review. Stream gage installation and data collection along key tributaries within the WRIA would increase the understanding of watershed surface water hydrology.

Groundwater Data

Existing data regarding the hydrogeology of principal aquifers within WRIA 60 is limited. Identification, delineation, and characterization of principal aquifers would be required to adequately estimate the groundwater resources available within the WRIA. This could be accomplished by detailed review of available well logs for each Subbasin, augmentation of existing wells with strategically placed test wells, long-term groundwater elevation monitoring in key wells, and hydraulic testing in key wells. This data could be used to develop a groundwater flow model for the watershed or for local areas of concern within the watershed. The groundwater flow model could be used as a tool to assist with developing recommendations for the watershed plan.

Groundwater/Surface Water Interaction

Existing data regarding groundwater/surface water interaction is generally limited to a study performed along Myers Creek in the vicinity of Myncaster, British Columbia (Golder and Associates, 1994d). Characterization of the extent and location of losing and gaining reaches of streams are generally not available within WRIA 60. Quantification of groundwater/surface water interaction would assist the Planning Unit in assessing the impact of groundwater pumping on streamflow and the impact of streamflow on groundwater recharge. Groundwater/surface water interaction could be evaluated by groundwater/surface water elevation monitoring and the characterization of the permeability of streambed sediments and the underlying aquifer.

Water Rights Data

The water rights analysis indicates that a more detailed review of the hardcopy files of the surface water rights in the Ferry Subbasin might be warranted. The surface water rights of the Ferry Subbasin allocate the largest quantity of water in WRIA 60. A more detailed analysis would provide a better level of understanding about the validity of these documents and the level of error in the estimated total annual quantity for surface water in the Ferry Subbasin. This information would facilitate discussion and recommendations related to instream flow on this reach of the Kettle River and its tributaries in the Ferry Subbasin.

REFERENCES

Battle Mountain Gold Company. 1993. Water Resources Plan. Submitted to WDOE. Battle Mountain Gold Company, Oroville, WA.

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

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

Busch, J.P. (1991). Structural Geology and Development of the Lincoln Metamorphic Core Complex, northeast Washington. Pullman: Washington State University, Department of Geology.

Cascade Environmental Services, Inc. 1995. Draft Fisheries Studies Report Myers Creek Project. Prepared for Terramatrix, Inc. and Myers Creek Instream Flow Committee.

Cascade Environmental Services, Inc. and Caldwell Associates. 1996. Final Fisheries Studies Report, Myers Creek Project. Prepared for Terramatrix, Inc. and Myers Creek Instream Flow Committee, March.

Campbell, C.D., & Thorsen, G.W., 1975. Geology of the Sherman Peak and west half of the Kettle Falls Quadrangle, Ferry County, Washington. Seattle: University of Washington.

Cheney, E.S., & Rasmussen, M.G., 1996. Regional Geology of the Republic Area. Washington Geology, 24(2), 3-7.

Daly, C, Neilson, R.P., and Phillips, D.L., 1994, A Statistical-Topographic Model for Mapping Climatological Precipitation Over Mountainous Terrain: Journal of Applied Meteorology, v. 33, p. 140-158.

Daly, C, and Taylor, G.H., 1998, 1961-90 Mean Annual and Monthly Precipitation Maps For the Conterminous United States, Oregon Climate Center: March 2002.

Dames & Moore, 1995. Draft Initial Watershed Assessment Water Resource Inventory Area 60 Kettle River Watershed. Open-File Technical Report 95-16. Department of Ecology.

David Snow and Associates. 1996. A Review of Hydrological Issues. Crown Jewel Project, Okanogan County, Washington. Prepared for Terramatrix, Inc.

Dobell, J.P., 1955. The Petrology and General Geology of the Kettle River: Toroda Creek District of northeastern Washington. Ann Arbor: University Microfilms.

Donnelly, B.J., 1978. Structural Geology of the Nancy Creek Area, east Flank of the Kettle Dome, Ferry County, Washington. Pullman: Washington State University, Department of Geology.

Dunne, T. and L.B. Leopold, 1978. Water in Environmental Planning. W.H. Freeman and Company, New York.

Ecology, 2003a. Water Rights Application Tracking System Database Information for WRIA 60. October 2003.

Ecology, 2003b. Washington State Well Log Viewer. October 2003.

Economic and Engineering Services, Inc., 1999. Draft Guide to Watershed Planning and Management. Washington State Department of Ecology Grant. Prepared for Local Governments and Tribes.

Golder and Associates, 1998. Report to Battle Mountain Gold Company Crown Jewel Mine Streamflow Mitigation Plan. Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Golder and Associates, 1996a. Battle Mountain Gold Crown Jewel Project Diversion Channels and Sediment Traps Conceptual Design Report. Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Golder and Associates, 1996b. Summary of Surface Water Discharge Data Collected by the Battle Mountain Gold Company for the Crown Jewel Project Chesaw, Washington, Water Year 1995. Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Golder and Associates, 1995a. Technical Report on the Draft EIS for the proposed Crown Jewel Mine Topic: DEIS Background Report: Impacts of Mining on Buckhorn Mountain Drainages Crown Jewel Project. Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Golder and Associates, 1995b. Potential Effects of the Proposed Crown Jewel Pit on the Streamflows at Buckhorn Mountain Okanogan County, WA. Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Golder and Associates, 1994a. Report on Inflows to the Crown Jewel Pit, Okanogan County, Washington, Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Golder and Associates, 1994b. Memorandum: Estimated Mean Monthly Flow in Myers Creek and Effects of Proposed Diversion on Streamflow Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Golder and Associates, 1994c. Memorandum: Groundwater Supply Investigation: Johnny Thorpe Property, Chesaw, Washington. Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Golder and Associates, 1994d. Streamflow Investigations Conducted Along Myers Creek Near Myncaster, British Columbia. Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Golder and Associates, 1993a. Final Report on Pumping Test of the North Lookout Fault Zone, Crown Jewel Mine Site, Okanogan County, Washington, Volume 1. Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Golder and Associates, 1993b. Design Report Starrem Creek Dam and Reservoir. Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Golder and Associates, 1992. Geohydrology Study, Crown Jewel Project, Okanogan County, Washington. Prepared for Battle Mountain Gold Company by Golder and Associates, Redmond WA.

Graham, B, Hattenburg, T, and J.P. Buchanan, 1992. Evaluation of Groundwater Pollution Susceptibility In Northern Ferry County, Washington Using the Drastic Method. Prepared for the Ferry County Planning Department, December.

Hargreaves, G.H. and G.P. Merkley, 1998. Irrigation Fundamentals. Water Resources Publications, LLC, Highlands Ranch, Colorado.

Holder, G.A.M., 1990. Geochemical Character and Correlation of Contemporaneous Volcanic, Plutonic and Hypabyssal Igneous Activity Associated with Eocene Regional Extension, northeast Washington. Pullman: Washington State University, Department of Geology.

Holder, G.A.M., 1985. Geology and Petrology of the Intrusive Rocks East of the Republic Graben in the Republic Quadrangle, Ferry County, Washington. Pullman: Washington State University, Department of Geology.

Hydro-Geo Consultants, Inc., 1996, Analysis of Stream Depletions Resulting from the Proposed Crown Jewel Project, September 27, 1996.

Hunt, W., 1989. The Overlook Deposit, Kettle River Project, northeast Washington. Northwest Mining Association, Annual Convention, 95th, Abstract Booklet, P. 25.

Knaack, C.M., 1991. Geology and Geochemistry of the Long Alec Creek Pluton, Ferry County, Washington. Pullman: Washington State University, Department of Geology.

Knight Piesold and Co., 1993. Battle Mountain Gold Company, Crown Jewel Project, Hydrogeologic Study of Proposed Tailing Disposal Facility, November 2.

Lyons, D.J., 1967. Structural Geology of the Boulder Creek Metamorphic Terrane, Ferry County, Washington. Ann Arbor: University Microfilms.

Office of Financial Management, 2002. Growth Management Population Projections, Intermediate Series. Washington State.

Oregon Climate Service, 2001. Spatial Climate Data Sets.

Phetteplace, T.M., 1954. Geology of the Chesaw Area, Okanogan County, Washington. Seattle: University of Washington.

Price, S.M., 1991. Geology of the Klondike Mountain Formation and Upper Sanpoil Volcanics in the Republic Mining District, Ferry County, Washington. Pullman: Washington State University, Department of Geology.

Rhodes, B.P., 1980. The Low Angle Kettle River Fault – The eastern contact of Kettle Dome, northeastern Washington. Geological Society of America Abstracts with Programs, 12(7), 508.

Smith, J.A., 1993. Precipitation. In, D.R. Maidment (ed.). Handbook of Hydrology. McGraw Hill, Inc., New York.

Sokolov, A.A. and T.G. Chapman, 1984. Methods for Water Balance Computations: An International Guide for Research and Practice. The Unesio Press, Paris, France.

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

Stoffel, K.L., 1990, Geologic map of the Republic 1:100,000 quadrangle, Washington: Washington Division of Geology and Earth Resources, Open File Report 90-10.

Stoffel, K.L., Joseph, N.L., Waggoner, S.Z., Gulick, C.W., Korosec, M.A., and B.B. Bunning, 1991, Geologic map of Washington – northeast quadrant: Washington Division of Geology and Earth Resources, Geologic Map GM – 39.

U.S. Census Bureau, 2000. Washington State Census 2000 Population by Age, Sex, and Race/Ethnicity.

U.S. Department of Agriculture. 1996. Tonata-Bamber Watershed Analysis. Portland: U.S. Department of Agriculture, Forest Service.

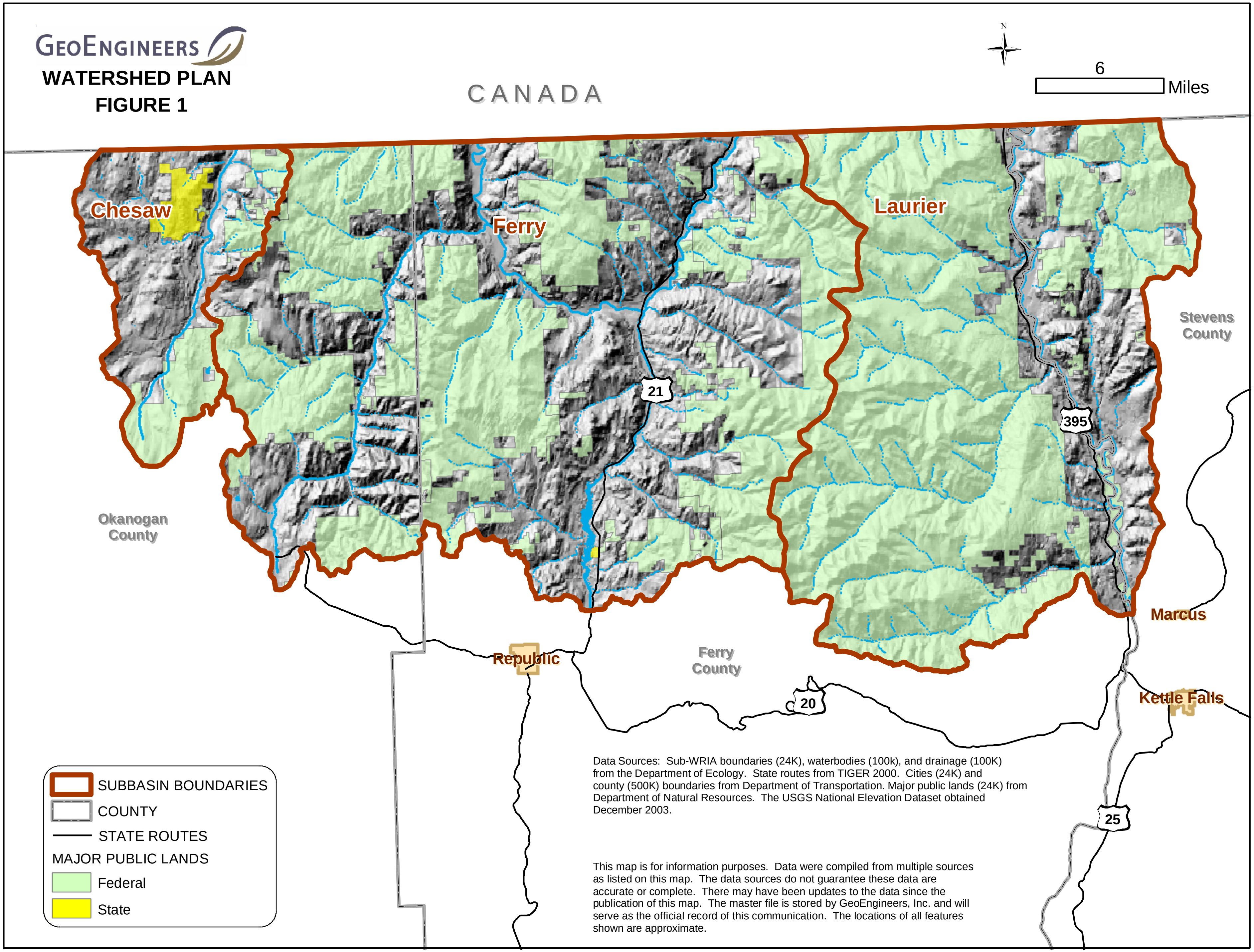
U.S. Geological Survey, 2003. Water Resources of the Ground-Water System in the Unconsolidated Deposits of the Colville River Watershed, Stevens County, Washington. Water Resources Investigations Report 03-4128.

U.S. Geological Survey, 1967. Geologic Map of the Bodie Mountain Quadrangle, Ferry and Okanogan Counties, Washington. Denver: U.S. Department of the Interior, U.S. Geological Survey.

U.S. Geological Survey, 1966. Geologic Map of the Wilmont Creek Quadrangle. Washington, D.C.: U.S. Geological Survey.

U.S. Geological Survey, 1964. Geology of the Curlew Quadrangle, Ferry County, Washington. Washington, D.C.: U.S.G.P.O.

WRCC, 2003. Historical Climate Information for Washington State. Desert Research Institute.



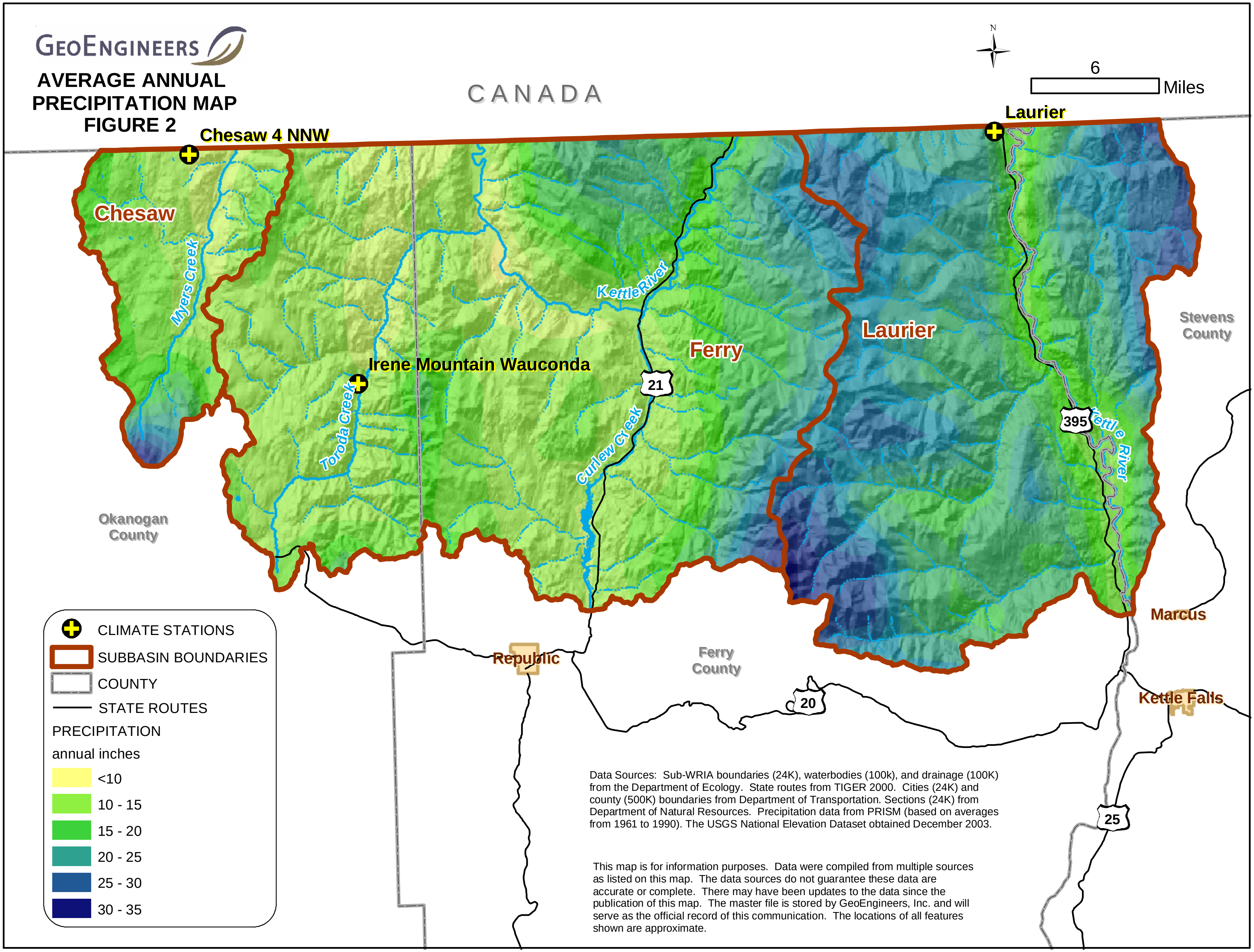
Map Revised: December 5, 2003

Path: P:\13\3595005\GIS\Figure1.mxd

RO: SPO

GeoEngineers

AVERAGE ANNUAL PRECIPITATION MAP
FIGURE 2



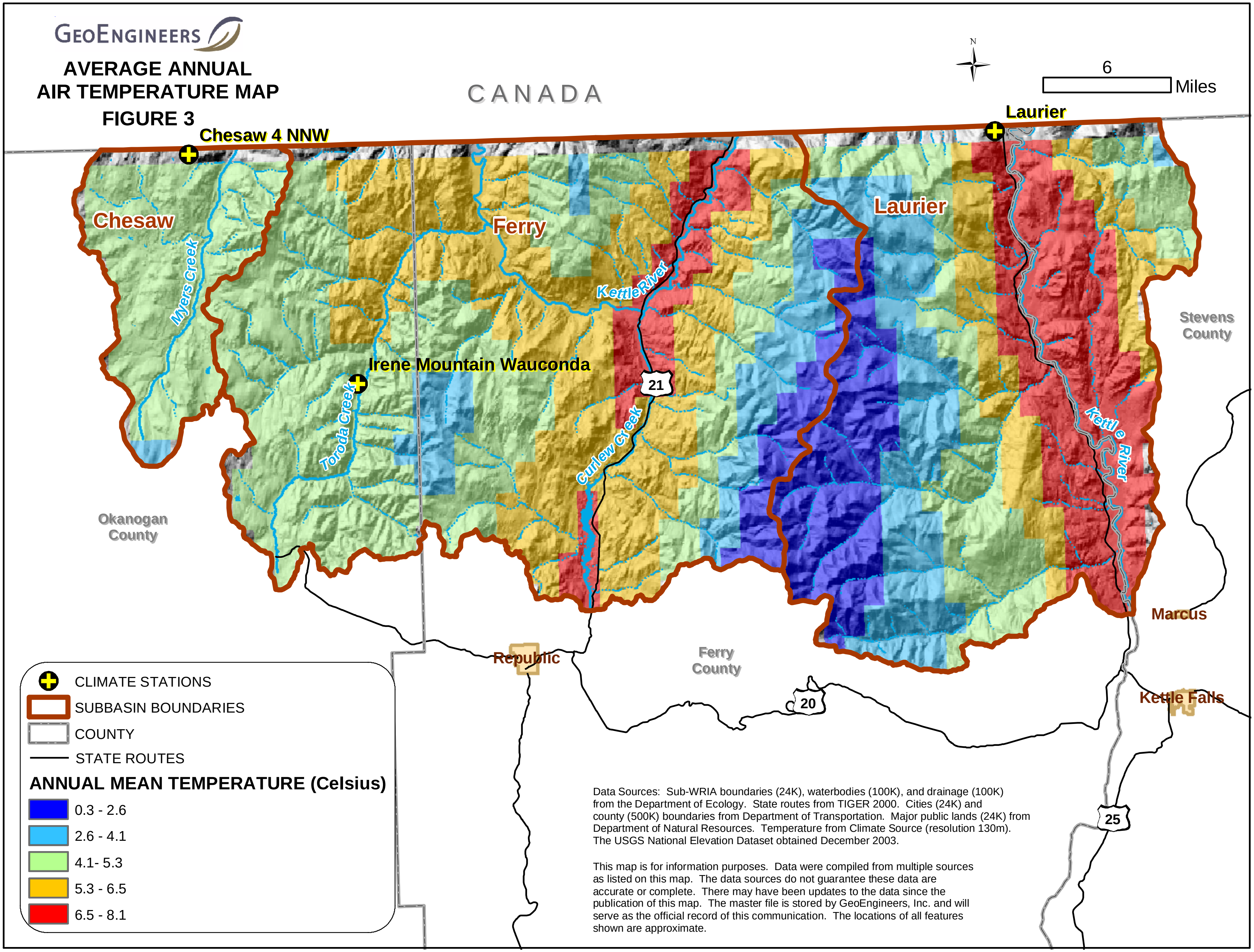
Data Sources: Sub-WRIA boundaries (24K), waterbodies (100k), and drainage (100K) from the Department of Ecology. State routes from TIGER 2000. Cities (24K) and county (500K) boundaries from Department of Transportation. Sections (24K) from Department of Natural Resources. Precipitation data from PRISM (based on averages from 1961 to 1990). The USGS National Elevation Dataset obtained December 2003.

This map is for information purposes. Data were compiled from multiple sources as listed on this map. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this map. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication. The locations of all features shown are approximate.

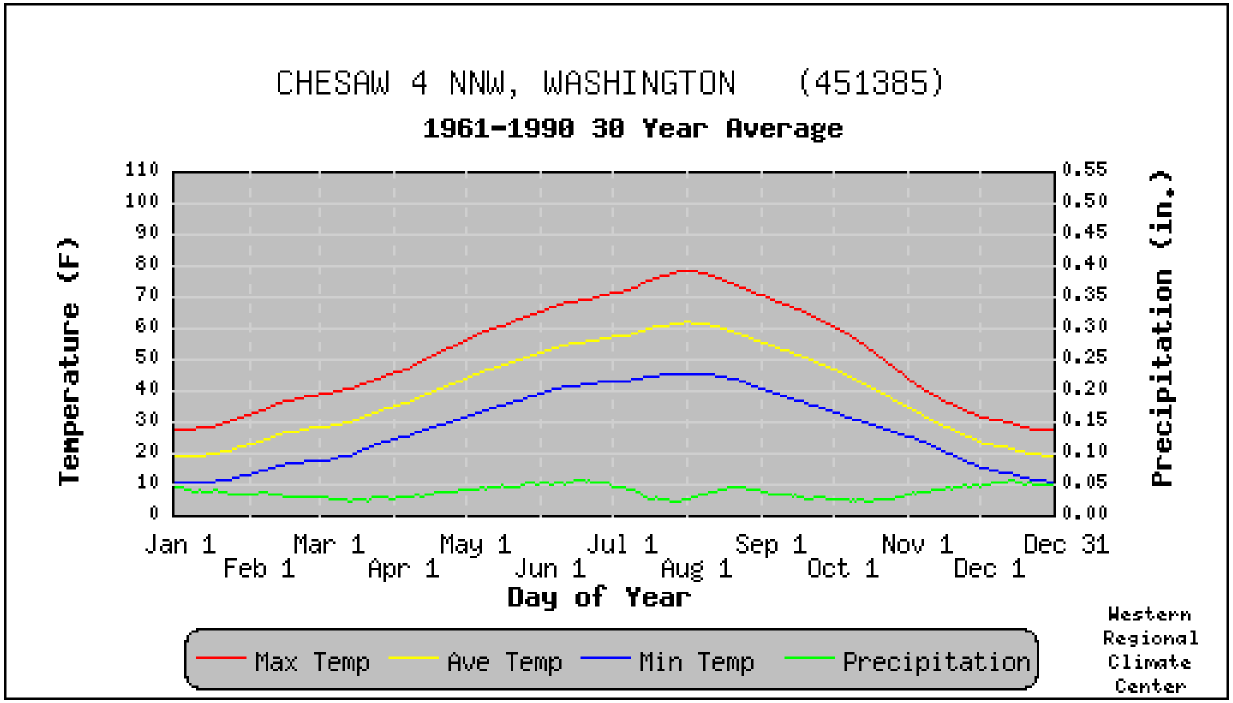
Map Revised: December 5, 2003

Path: P:\3\3595005\GIS\Figure2.mxd

RO: SPO



RO: SPO Path: P:\3\3595005\GIS\Figure3.mxd Map Revised: December 5, 2003



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

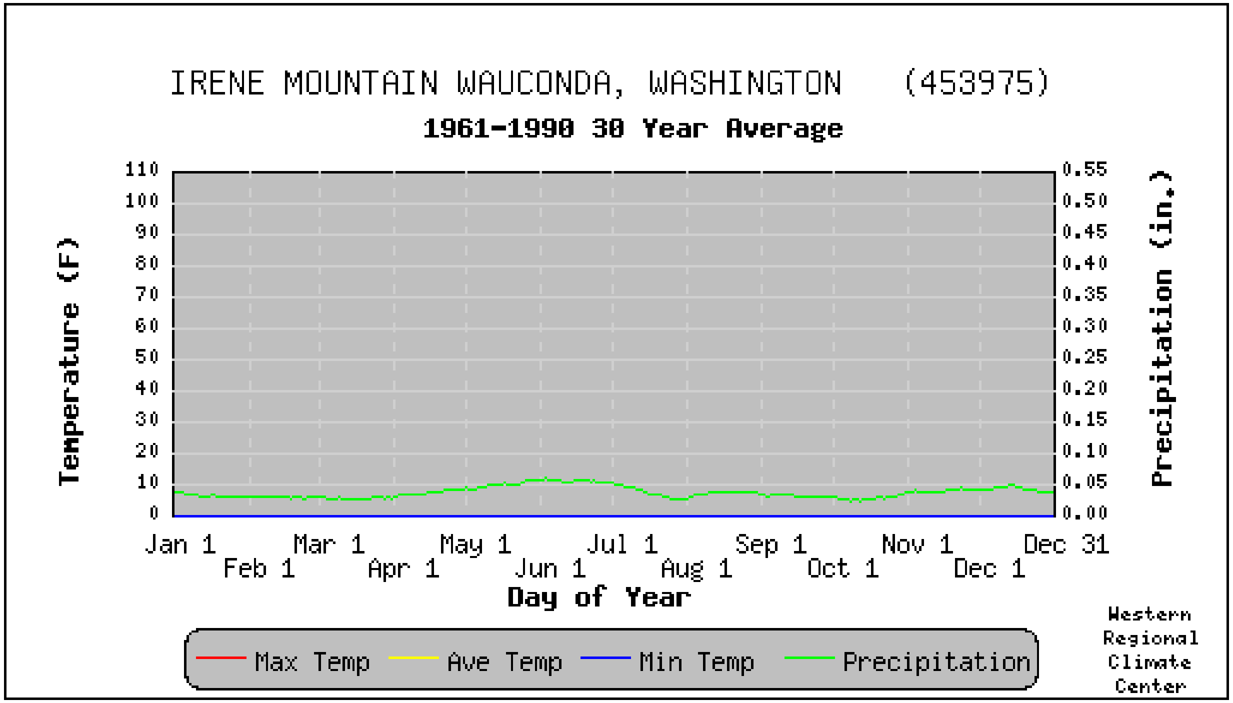
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GEOENGINEERS

CHESAW 4 NNW CLIMATE DATA

FIGURE 4

3595-005-00:120903: JER:tlm 3595005500FIG4.PPT



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

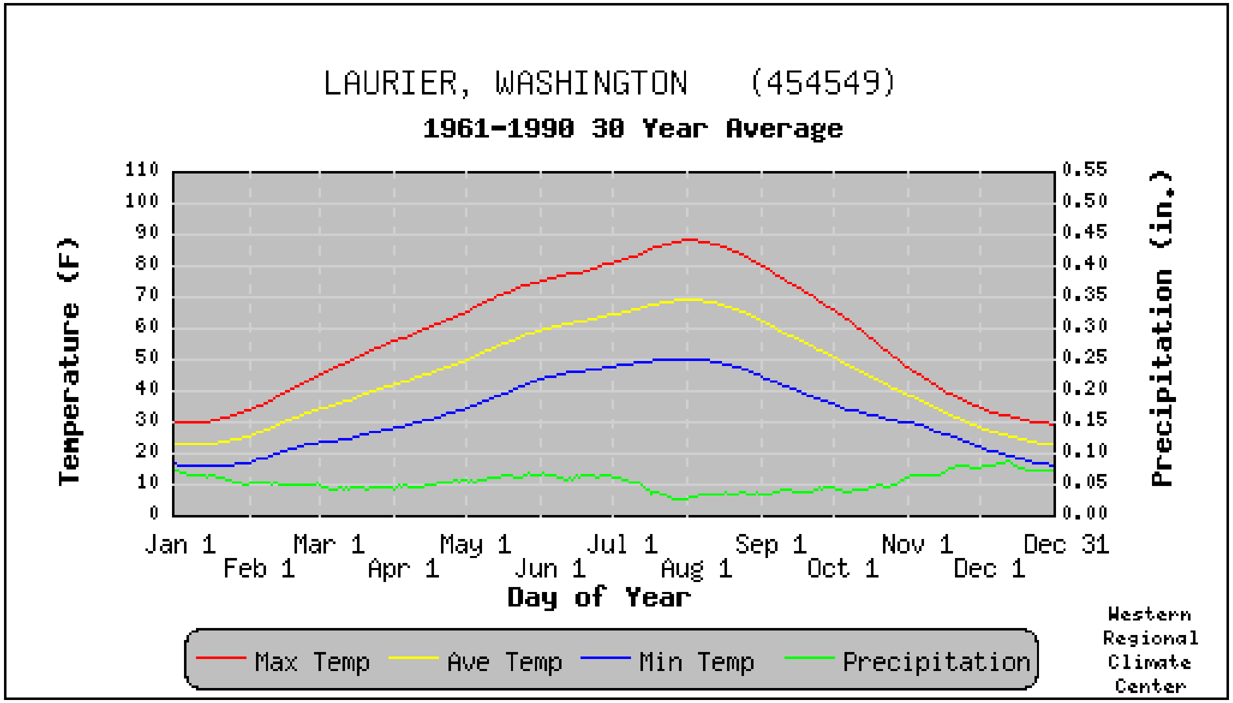
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GEOENGINEERS

IRENE MOUNTAIN WAUCONDA CLIMATE DATA

FIGURE 5

3595-005-00:120903: JER:tlm 3595005OOFIG5.ppt



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

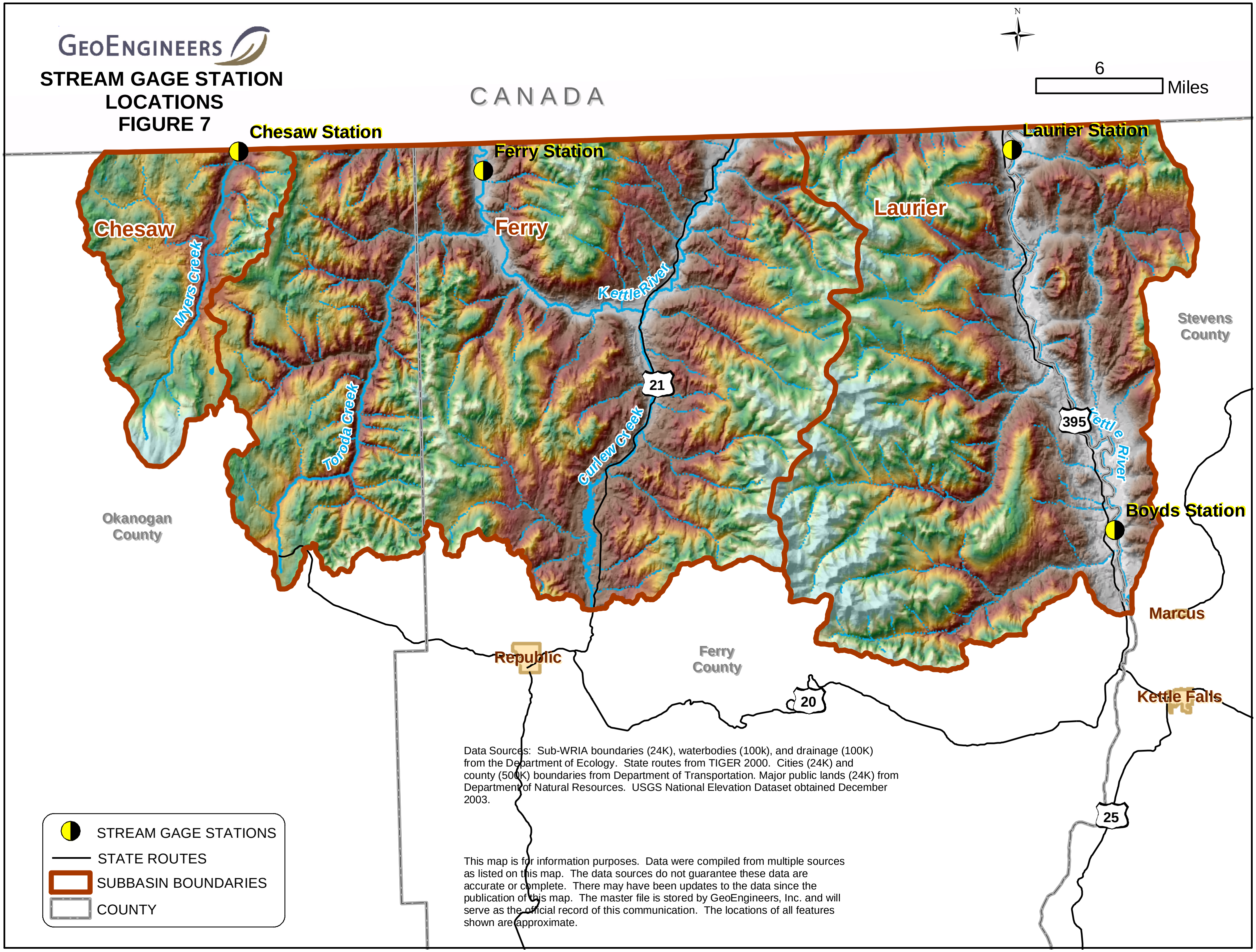
GEOENGINEERS

LAURIER CLIMATE DATA

FIGURE 6

3595-005-00:120903: JER:tim 359500500FIG6.PPT

STREAM GAGE STATION LOCATIONS
FIGURE 7



Data Sources: Sub-WRIA boundaries (24K), waterbodies (100k), and drainage (100K) from the Department of Ecology. State routes from TIGER 2000. Cities (24K) and county (500K) boundaries from Department of Transportation. Major public lands (24K) from Department of Natural Resources. USGS National Elevation Dataset obtained December 2003.

This map is for information purposes. Data were compiled from multiple sources as listed on this map. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this map. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication. The locations of all features shown are approximate.

Map Revised: December 12, 2003

Path: P:\3\3595005\GIS\Figure7.mxd

RO: SPO

FIGURE 8
Kettle River Near Ferry
Summary Hydrograph (WY 1929-2001)

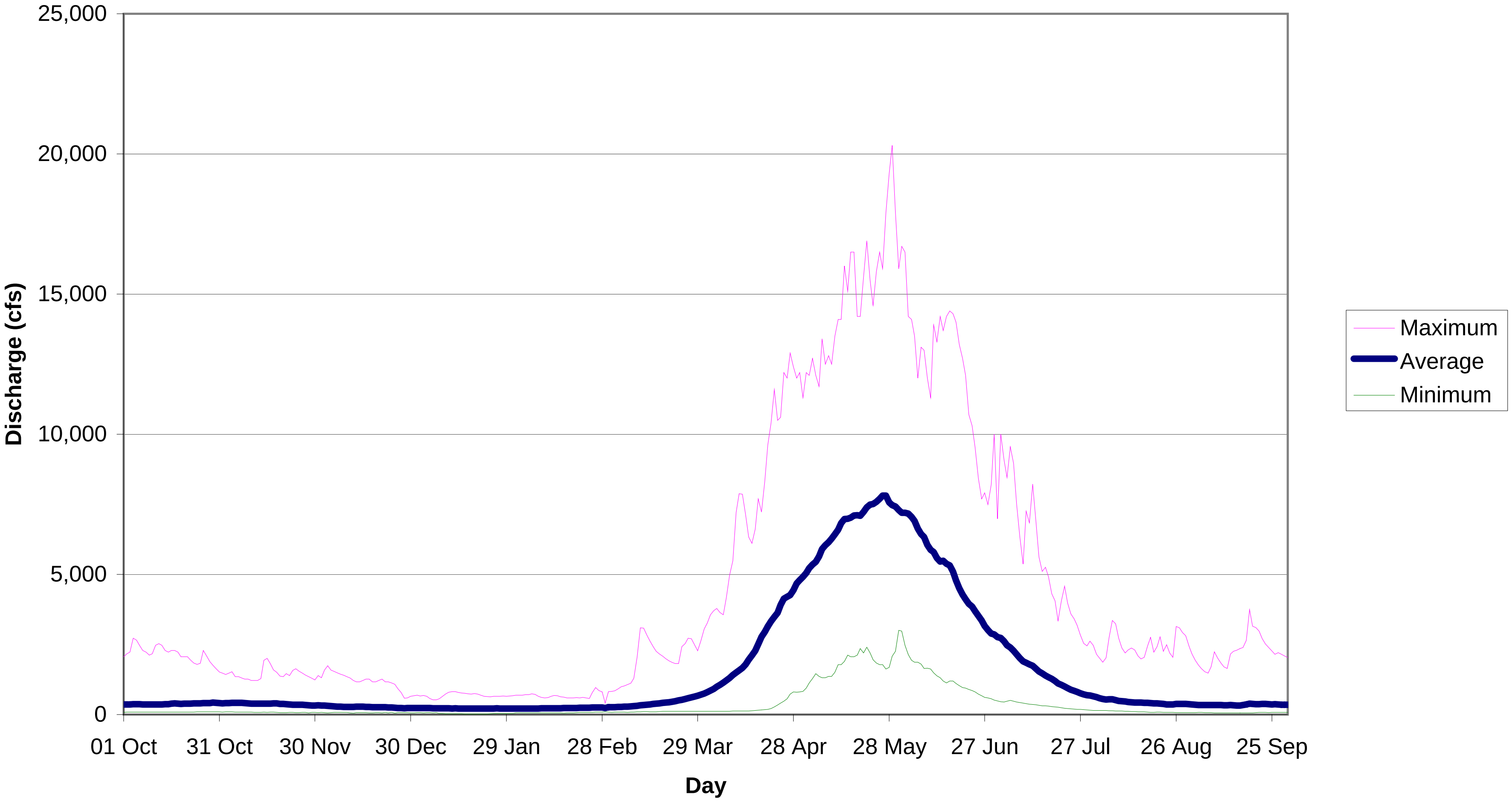


FIGURE 9
Kettle River Near Ferry
Monthly Exceedence Values (WY 1929-2001)

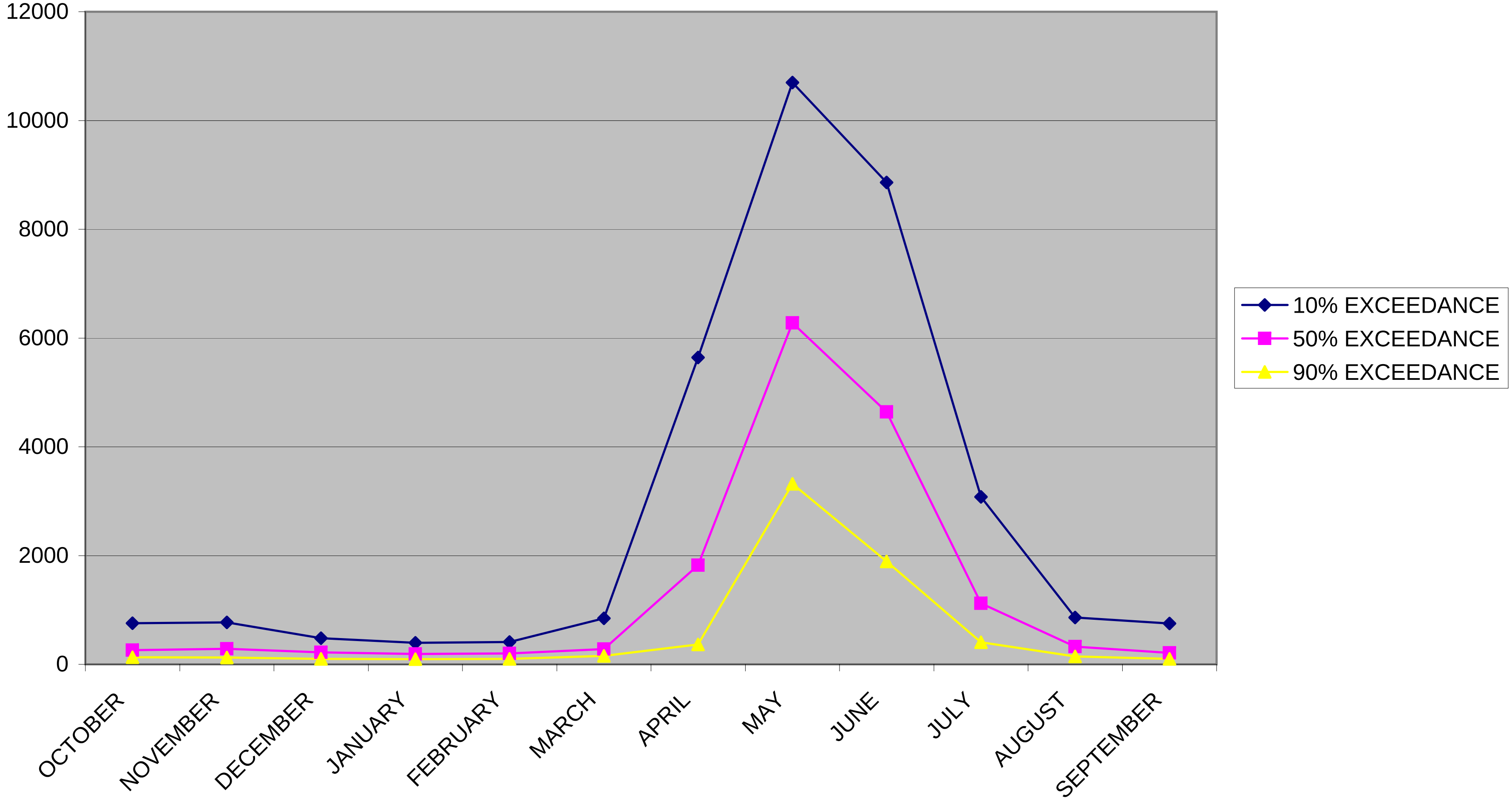


FIGURE 10
Kettle River Near Laurier
Summary Hydrograph (WY 1930-2001)

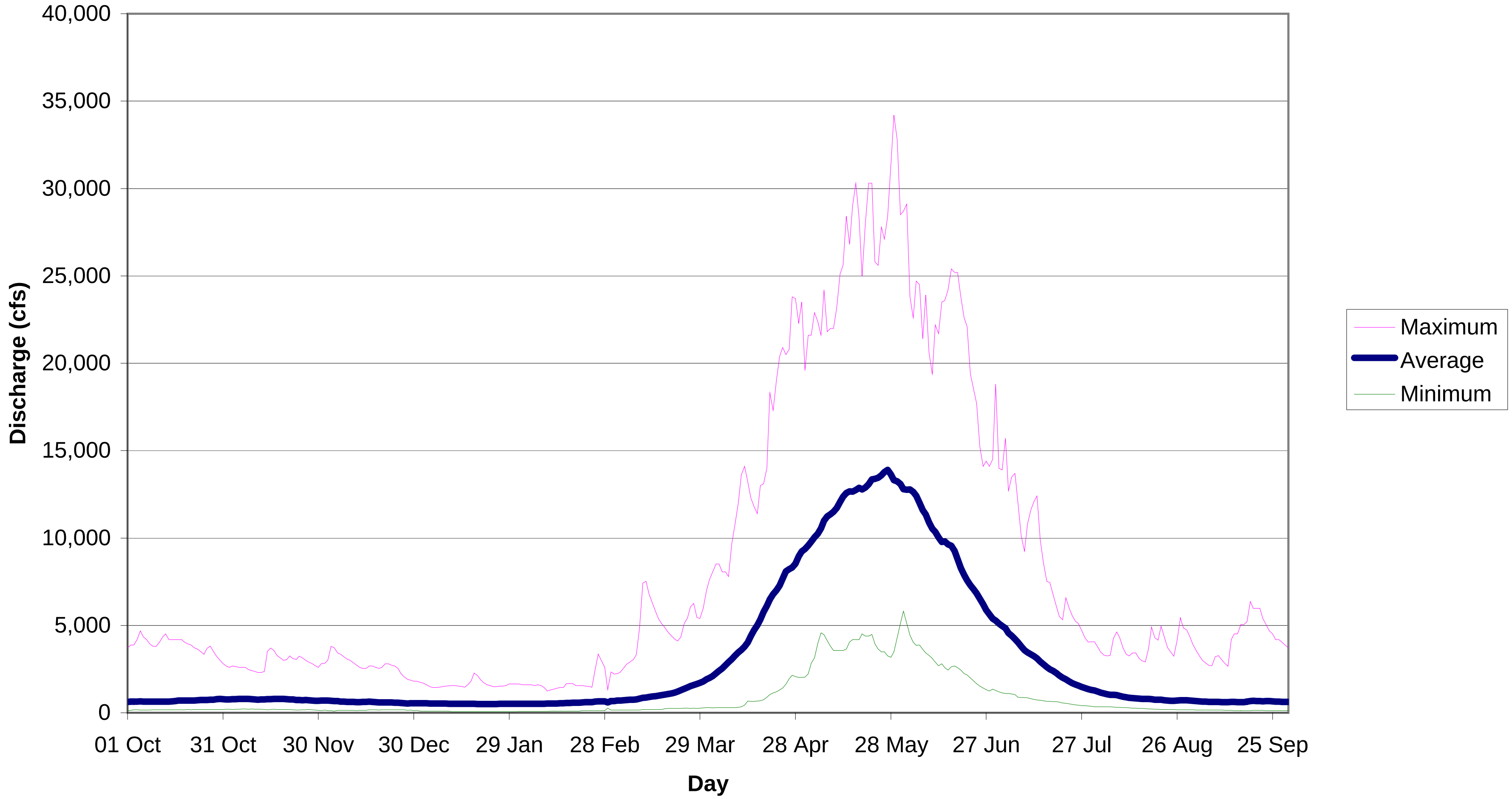


FIGURE 11
Kettle River Near Laurier
Monthly Exceedence Values (WY 1930-2001)

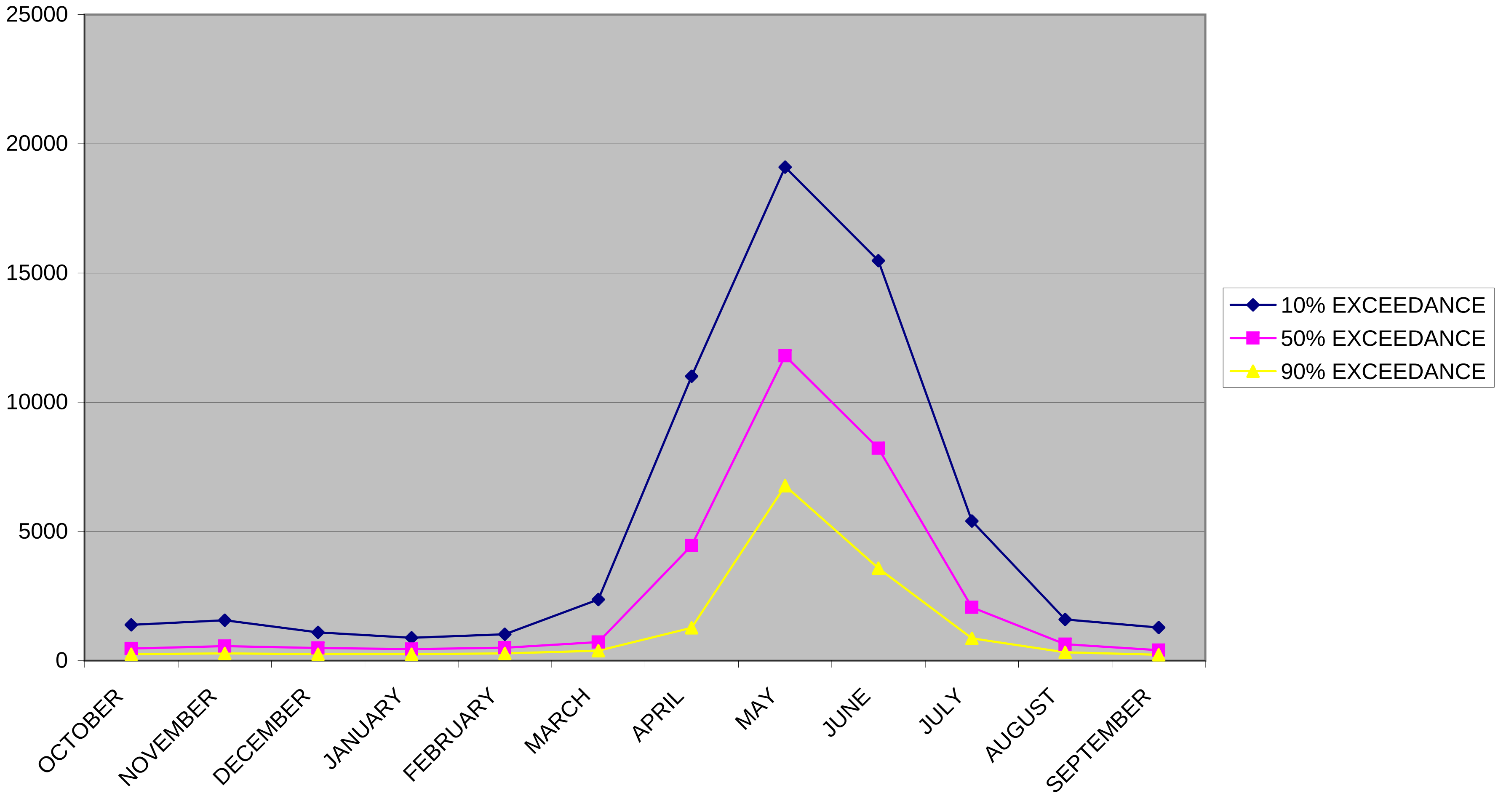


FIGURE 12
Kettle River at Boyds
Summary Hydrograph (1914-1915)

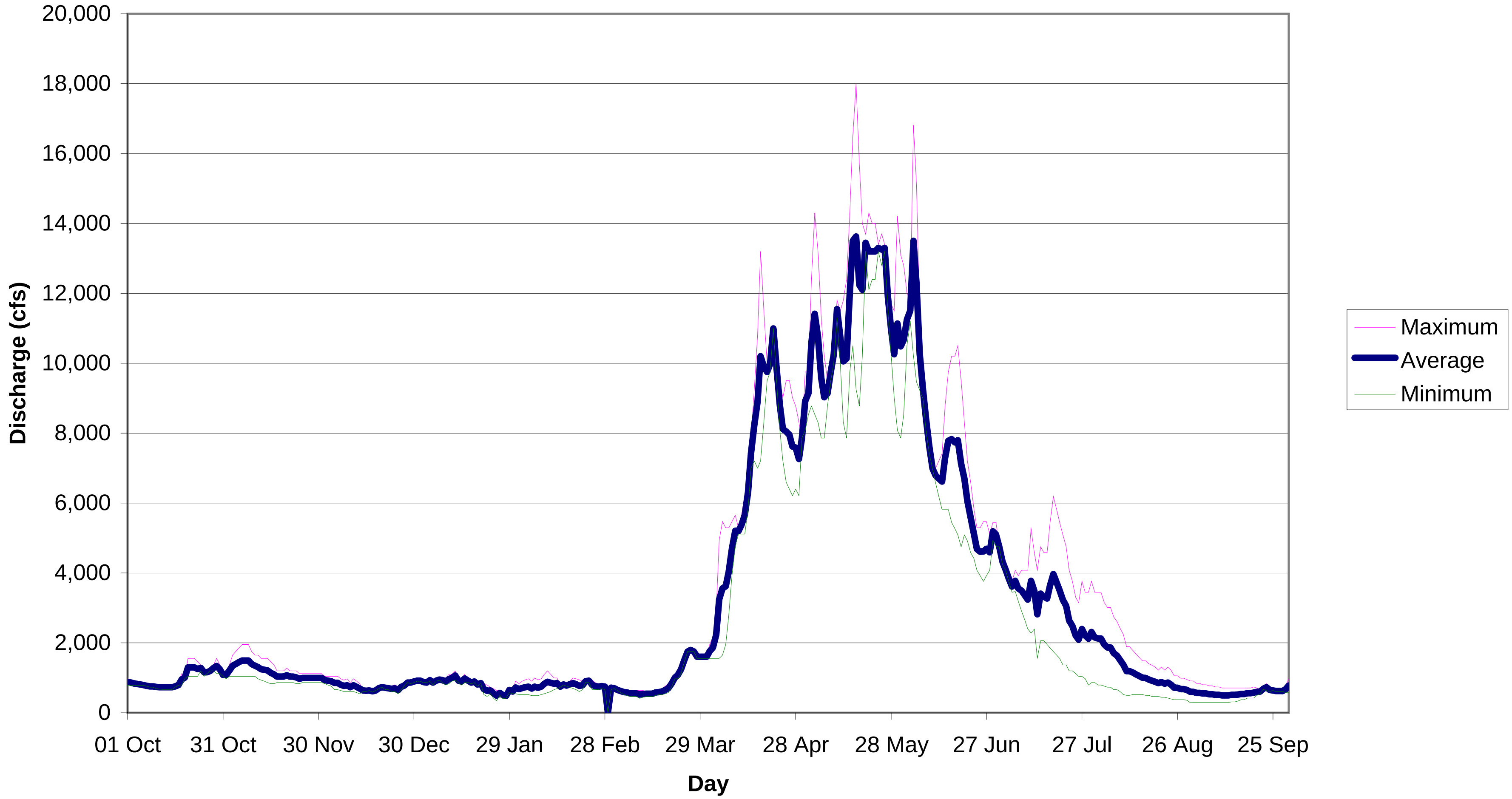
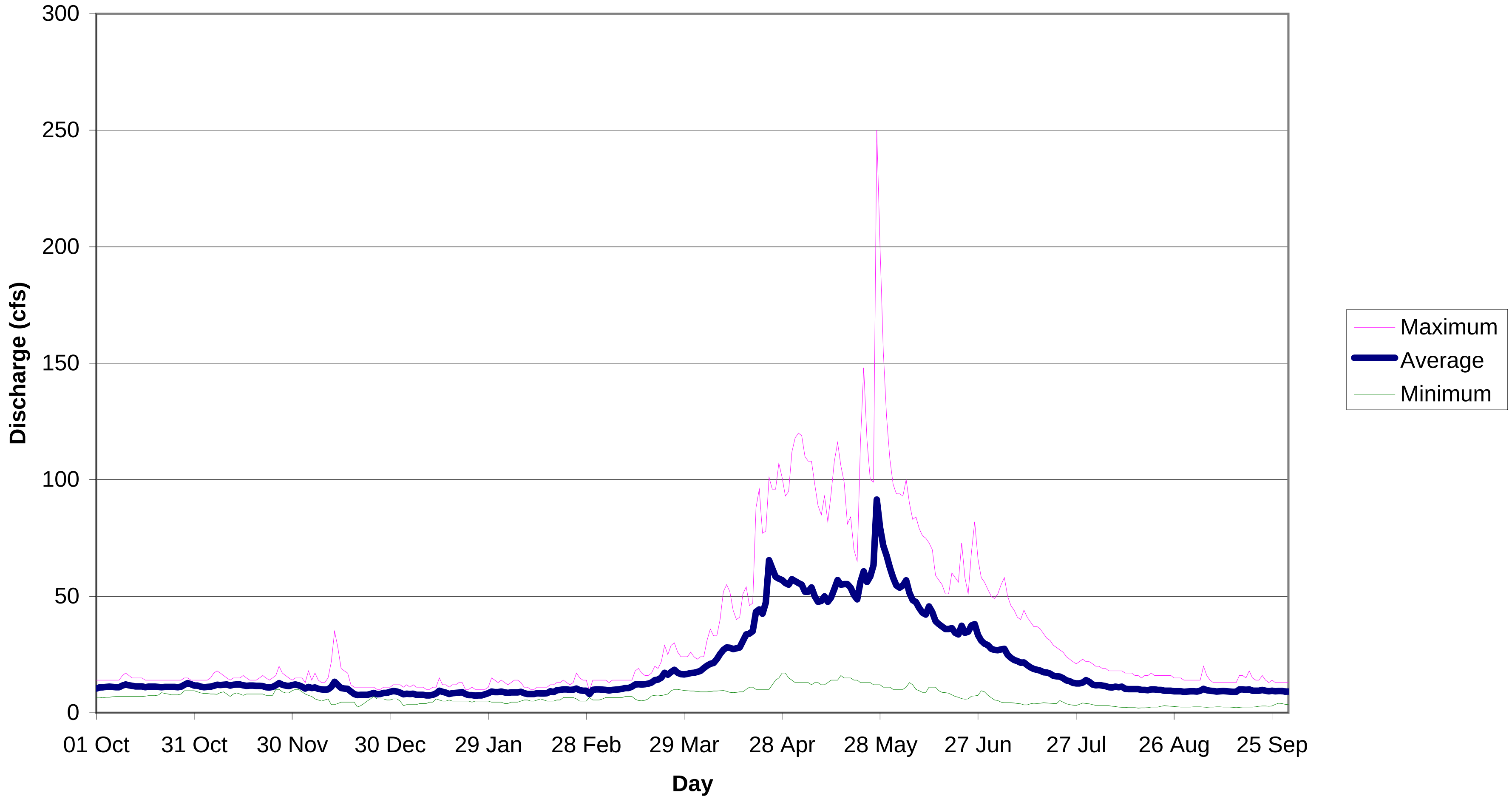
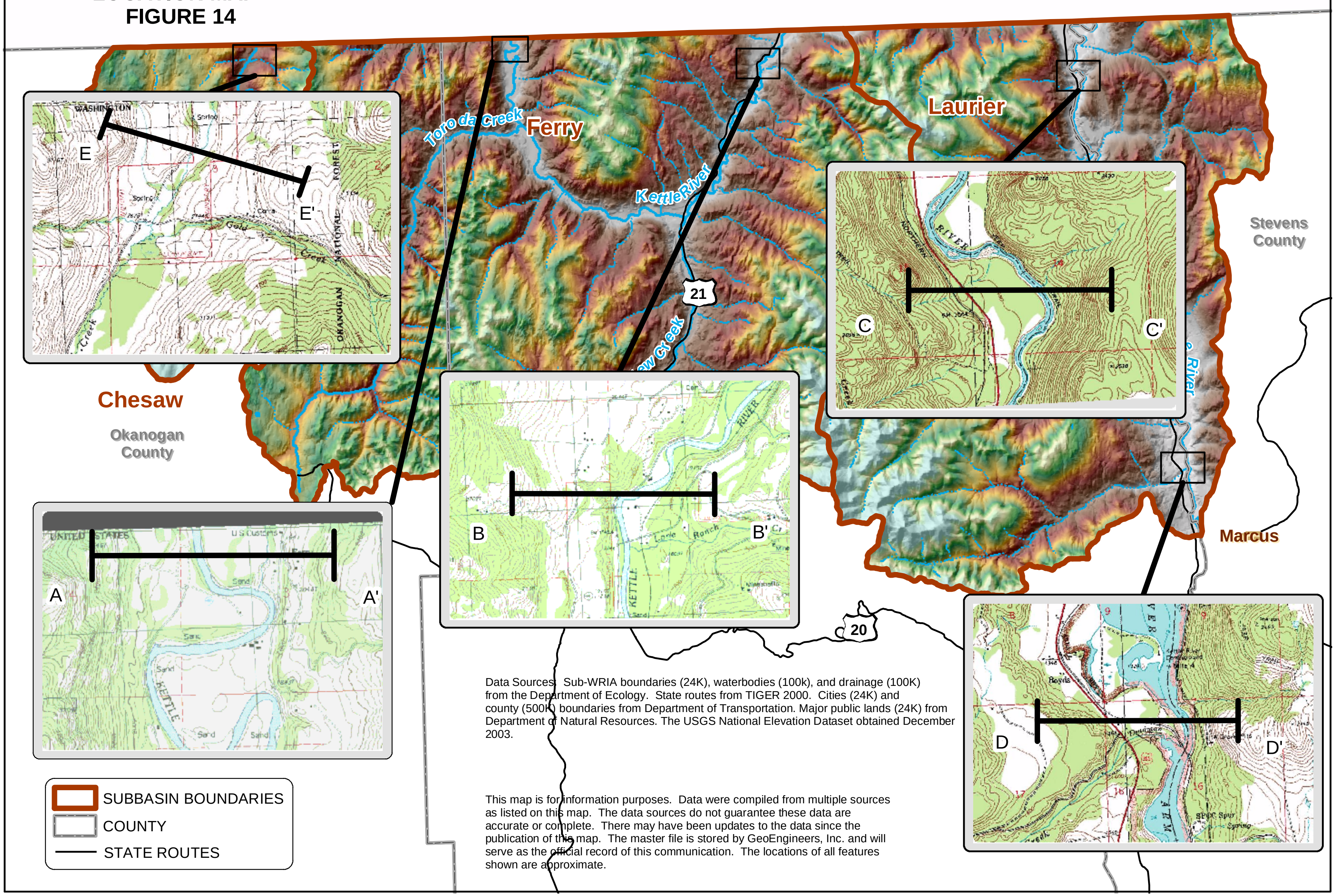


FIGURE 13
Myers Creek Near Chesaw
Summary Hydrograph (1996-2001)



GeoEngineers

HYDROGEOLOGIC SECTION LOCATION MAP
FIGURE 14



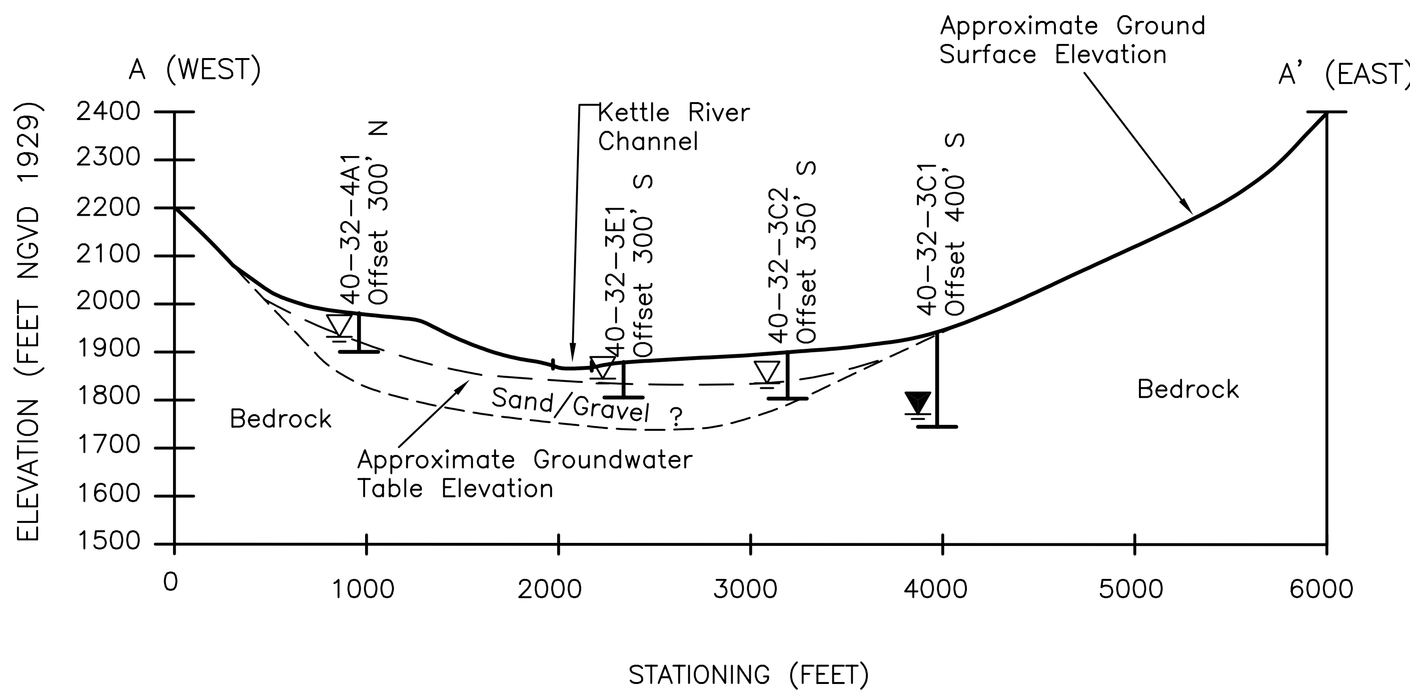
Data Sources: Sub-WRIA boundaries (24K), waterbodies (100k), and drainage (100K) from the Department of Ecology. State routes from TIGER 2000. Cities (24K) and county (500K) boundaries from Department of Transportation. Major public lands (24K) from Department of Natural Resources. The USGS National Elevation Dataset obtained December 2003.

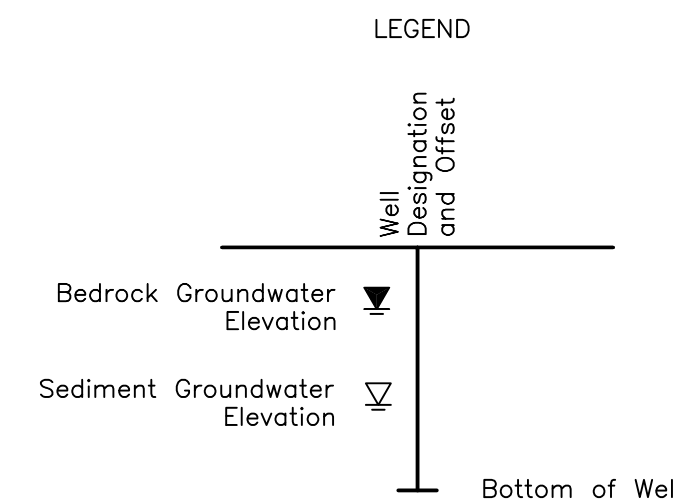
This map is for information purposes. Data were compiled from multiple sources as listed on this map. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this map. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication. The locations of all features shown are approximate.

Map Revised: December 12, 2003

Path: P:\3\3595005\GIS\Figure4.mxd

RO: SPO





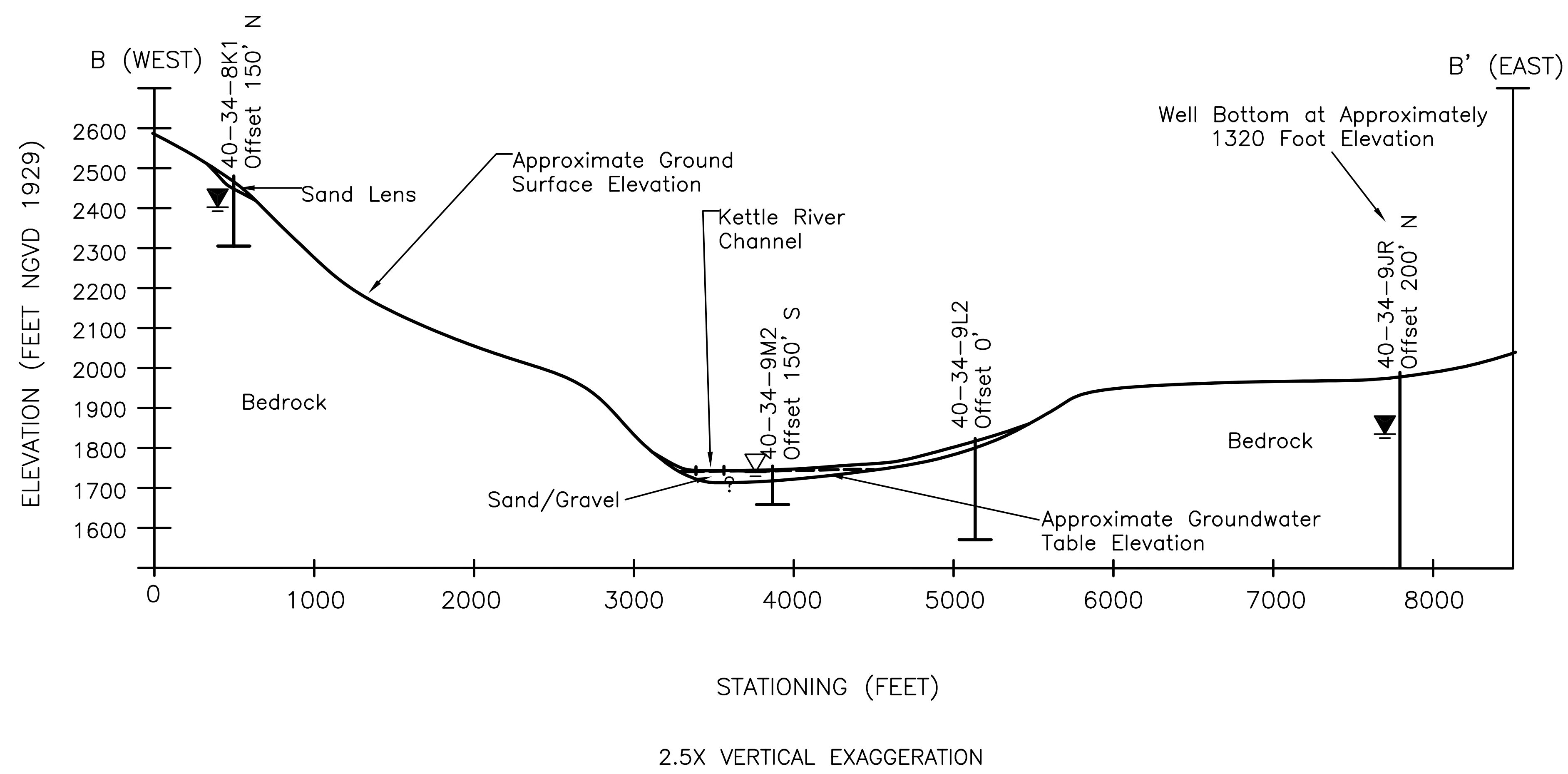
Notes:

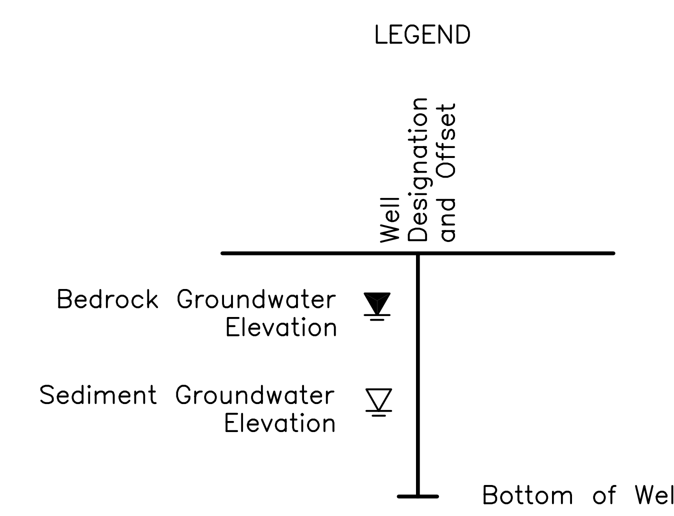
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

GeoEngineers

HYDROGEOLOGIC SECTION A-A' (FERRY)

FIGURE 15





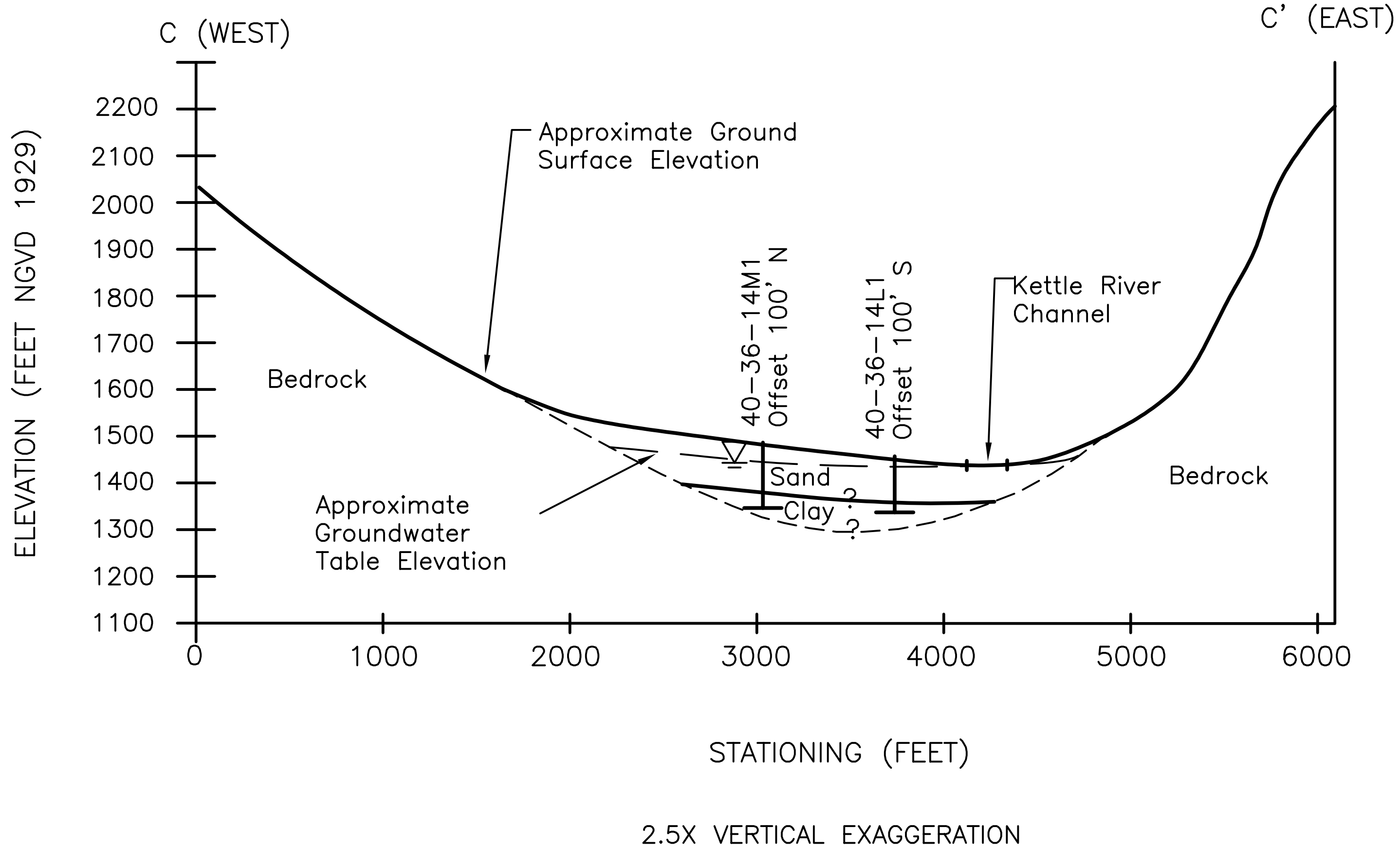
Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

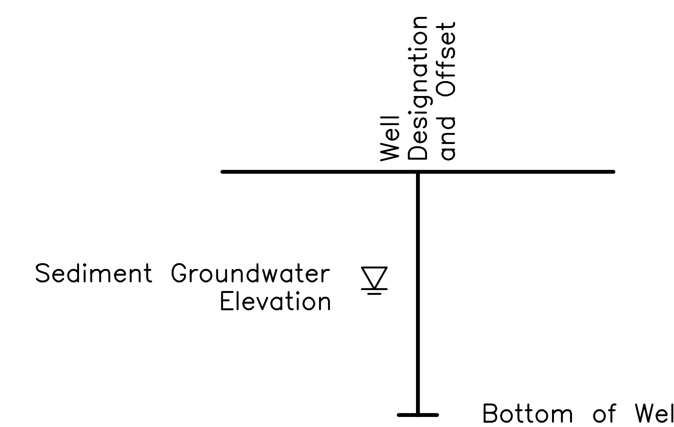
GEOENGINEERS

HYDROGEOLOGIC SECTION B-B' (DANVILLE)

FIGURE 16



LEGEND



Notes:

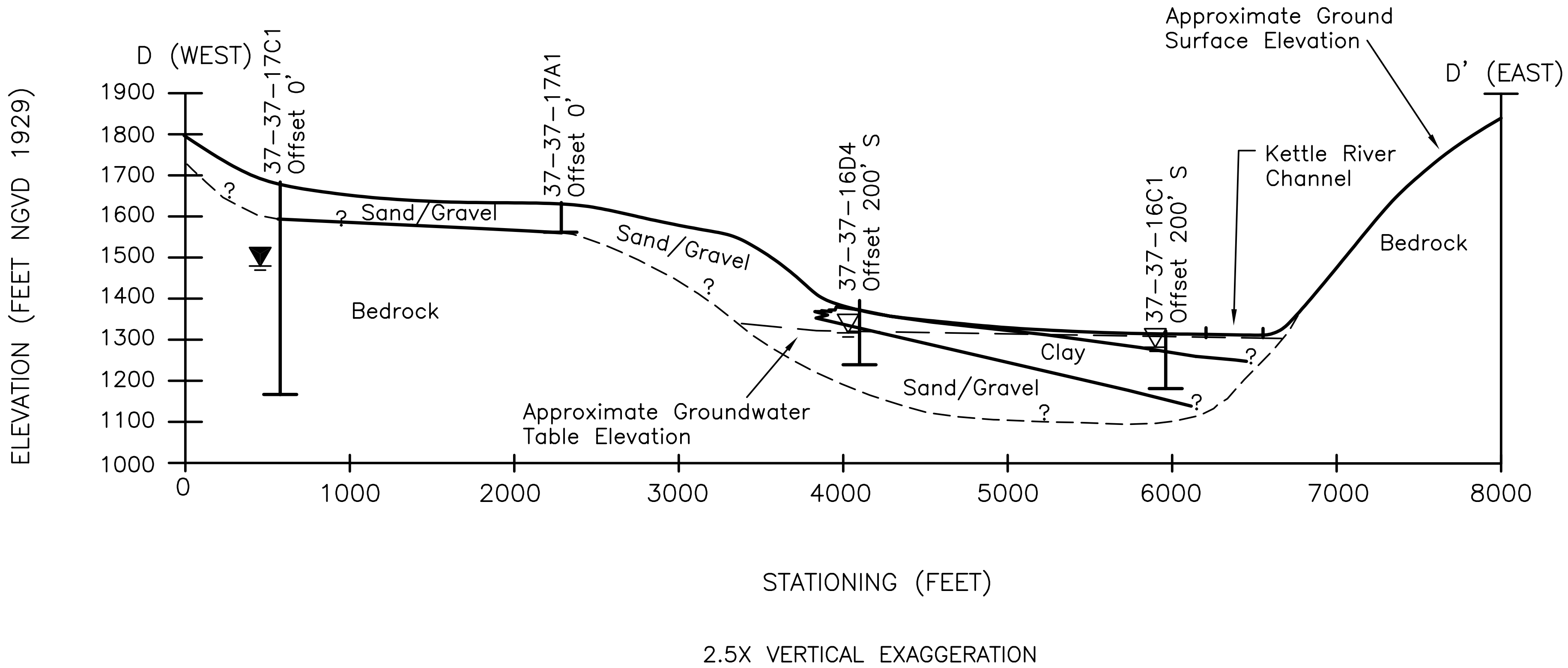
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

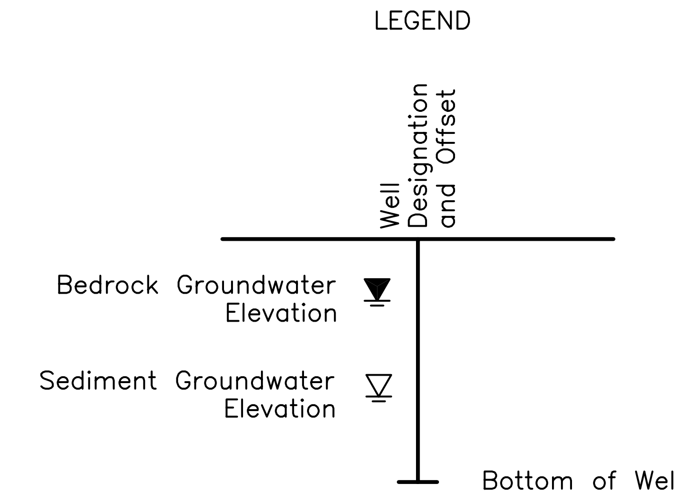
JER:TLM CROSS SECTION C-C FIG7.DWG 359500500:102403

GEOENGINEERS

HYDROGEOLOGIC SECTION C-C' (LAURIER)

FIGURE 17





Notes:

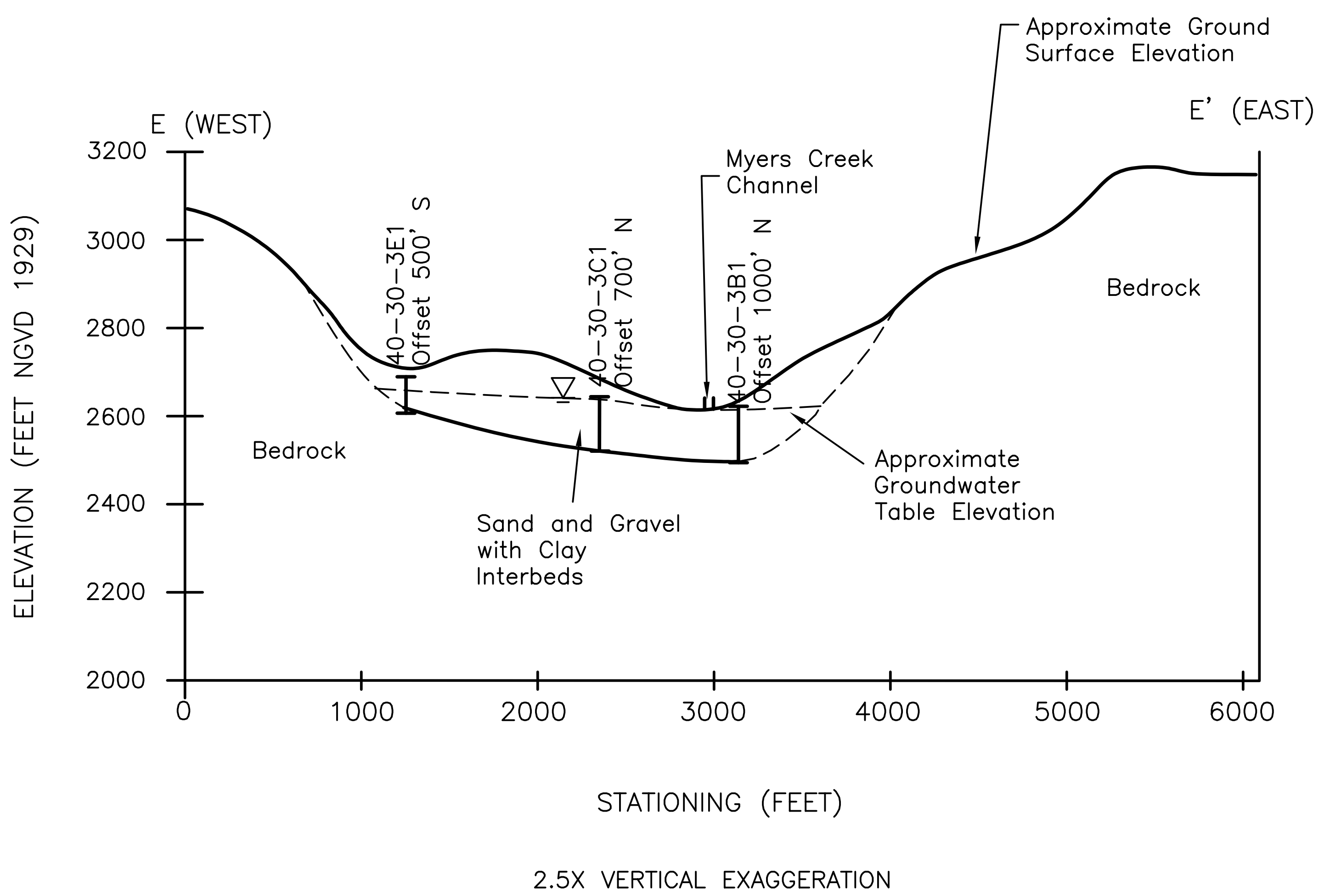
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

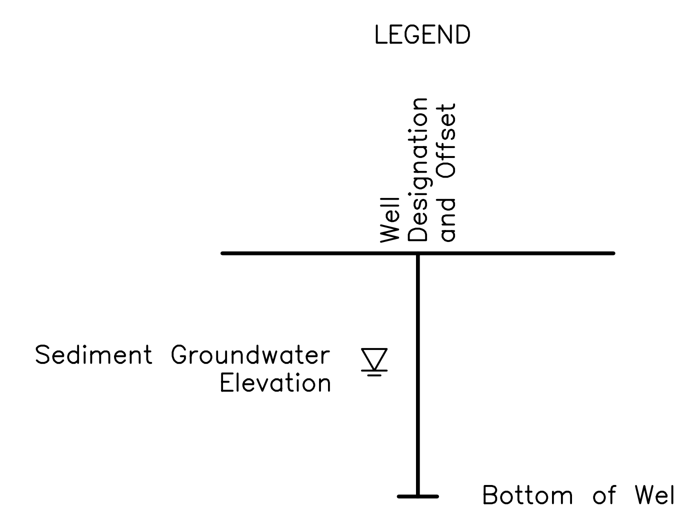
JER:TLM CROSS SECTION D-D FIG8.DWG 359500500:102403

GEOENGINEERS

HYDROGEOLOGIC SECTION D-D' (BOYDS)

FIGURE 18





Notes:

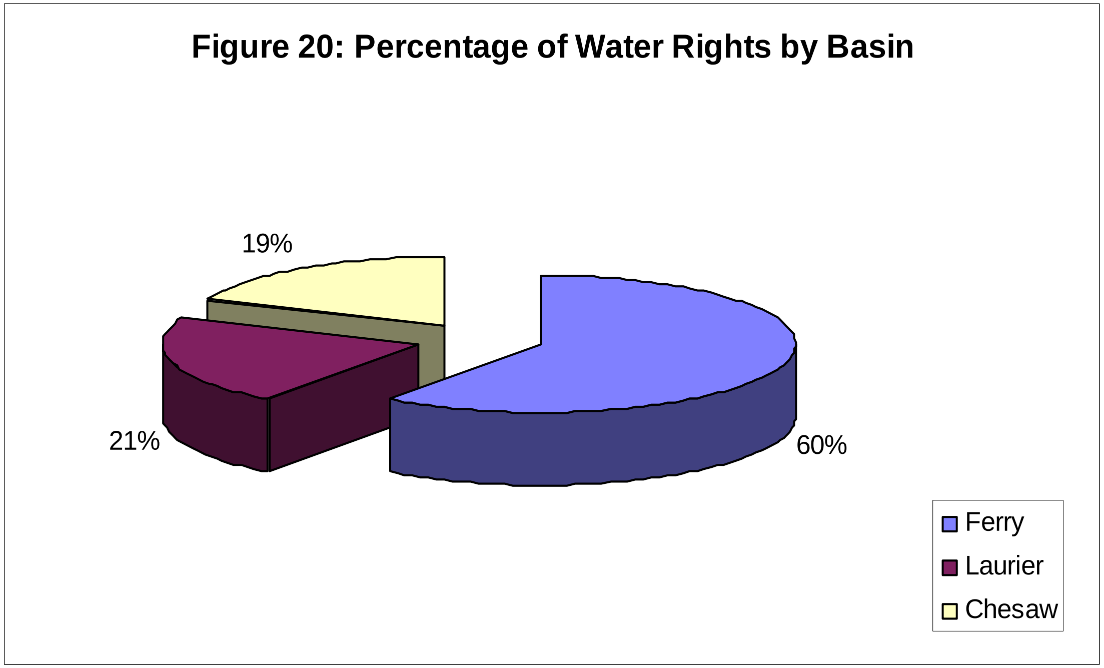
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

GEOENGINEERS

HYDROGEOLOGIC SECTION E-E' (CHESAW)

FIGURE 19

JER:TLM CROSS SECTION E-E FIG9.DWG 359500500:120103



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

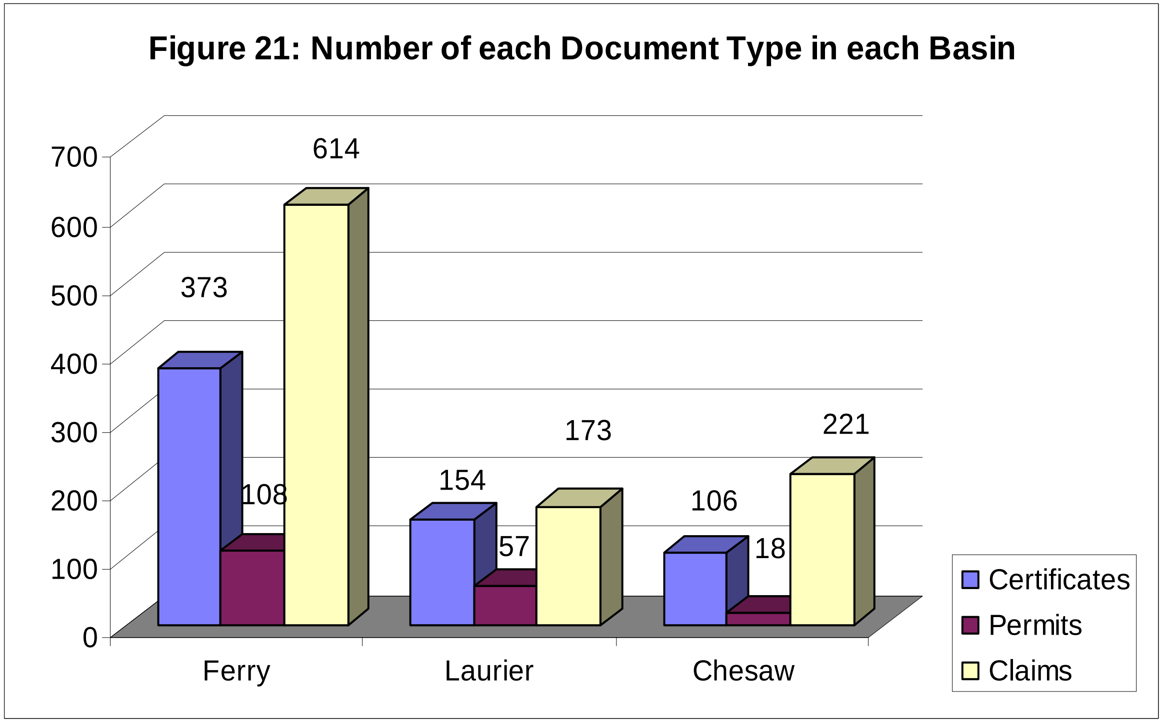
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GeoEngineers

PERCENTAGE OF WATER RIGHTS BY BASIN

FIGURE 20

3595-005-00:120903: JER:tlm 359500500FIG20.PPT



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

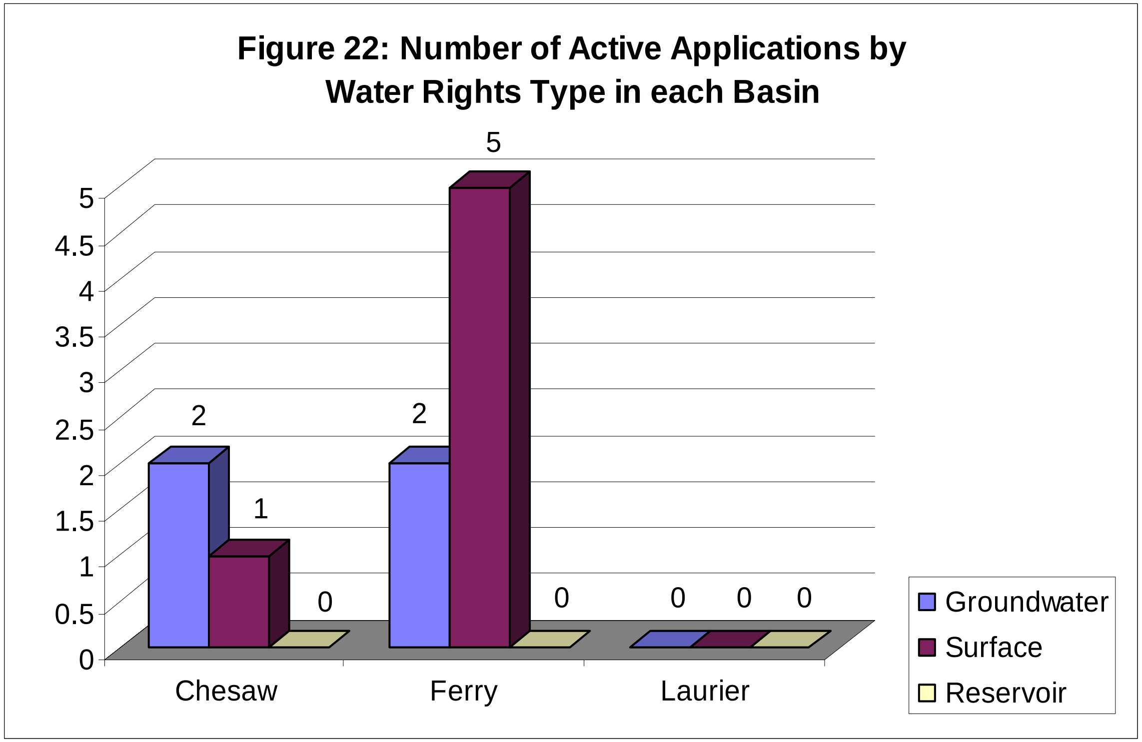
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GEOENGINEERS

NUMBER OF EACH DOCUMENT TYPE IN EACH BASIN

FIGURE 21

3595-005-00:120903: JER:tlm 359500500FIG21.PPT



3595-005-00:120903: JER:tlm 359500500FIG22.PPT

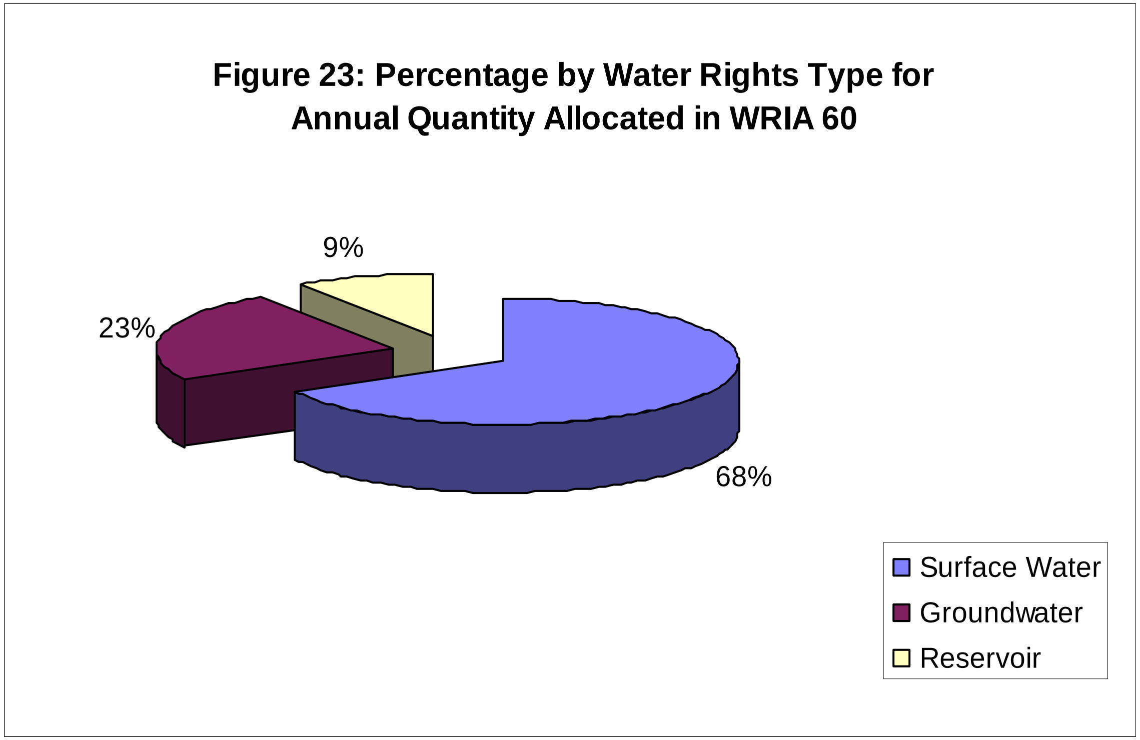
Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GeoEngineers

NUMBER OF ACTIVE APPLICATIONS BY WATER RIGHTS TYPE IN EACH BASIN

FIGURE 22



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

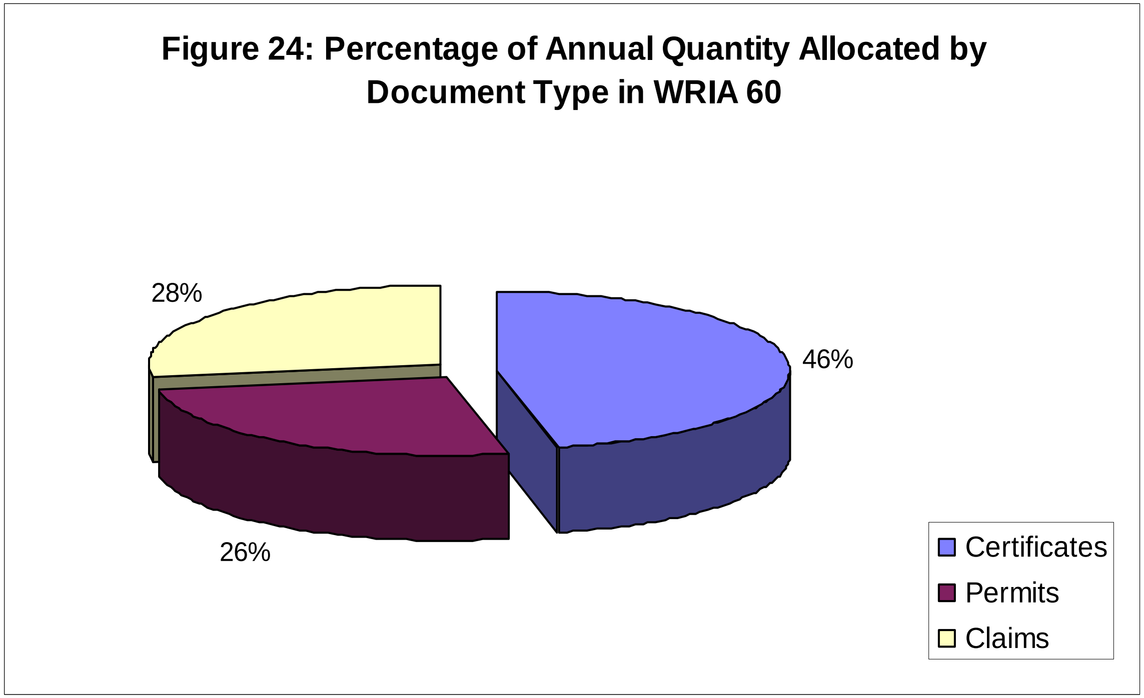
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GeoEngineers

PERCENTAGE BY WATER RIGHTS TYPE FOR ANNUAL QUANTITY ALLOCATED IN WRIA 60

FIGURE 23

3595-005-00:120903: JER:tlm 359500500FIG23.PPT



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

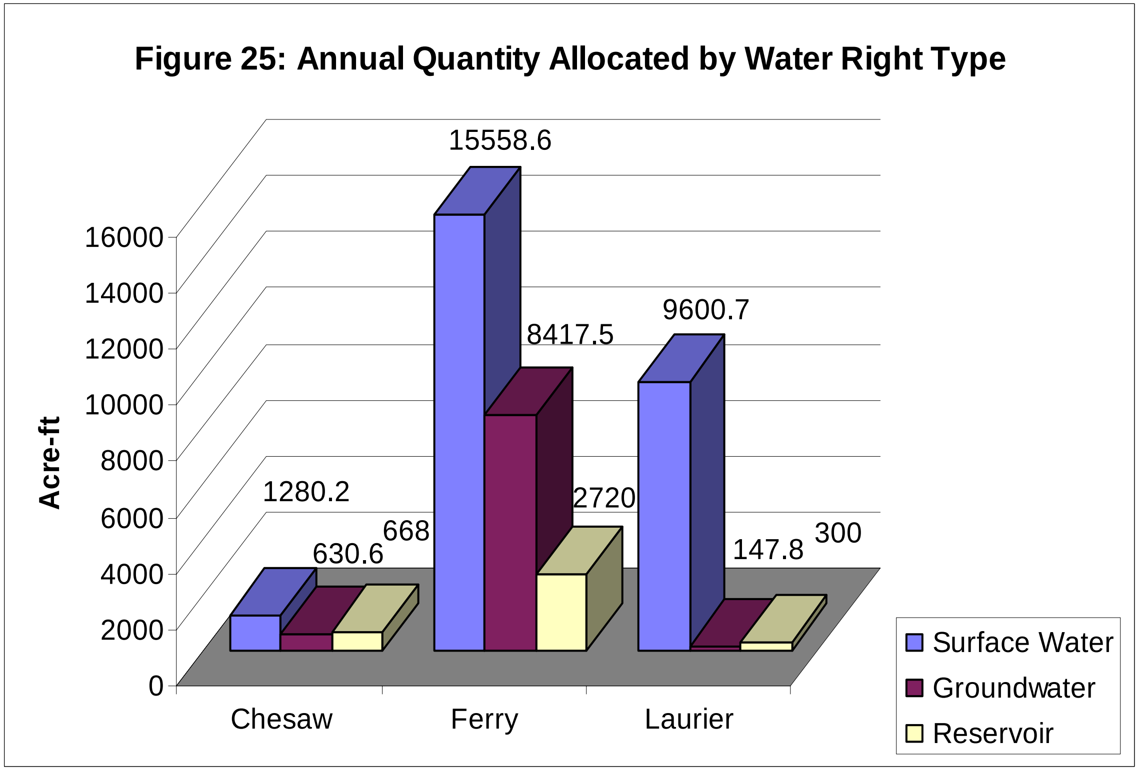
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GEOENGINEERS

PERCENTAGE OF ANNUAL QUANTITY ALLOCATED BY DOCUMENT TYPE

FIGURE 24

3595-005-00:120903: JER:tlm 3595000500FIG24.PPT



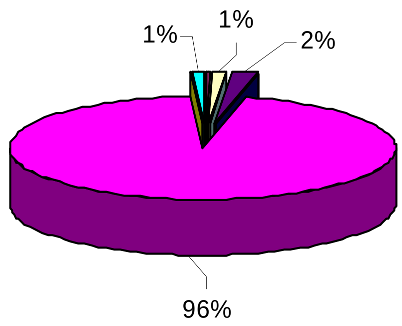
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GeoEngineers

ANNUAL QUANTITY ALLOCATED BY WATER RIGHT TYPE

FIGURE 25

Figure 26: Percentage of Allocated Groundwater by Purpose in Chesaw Basin



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

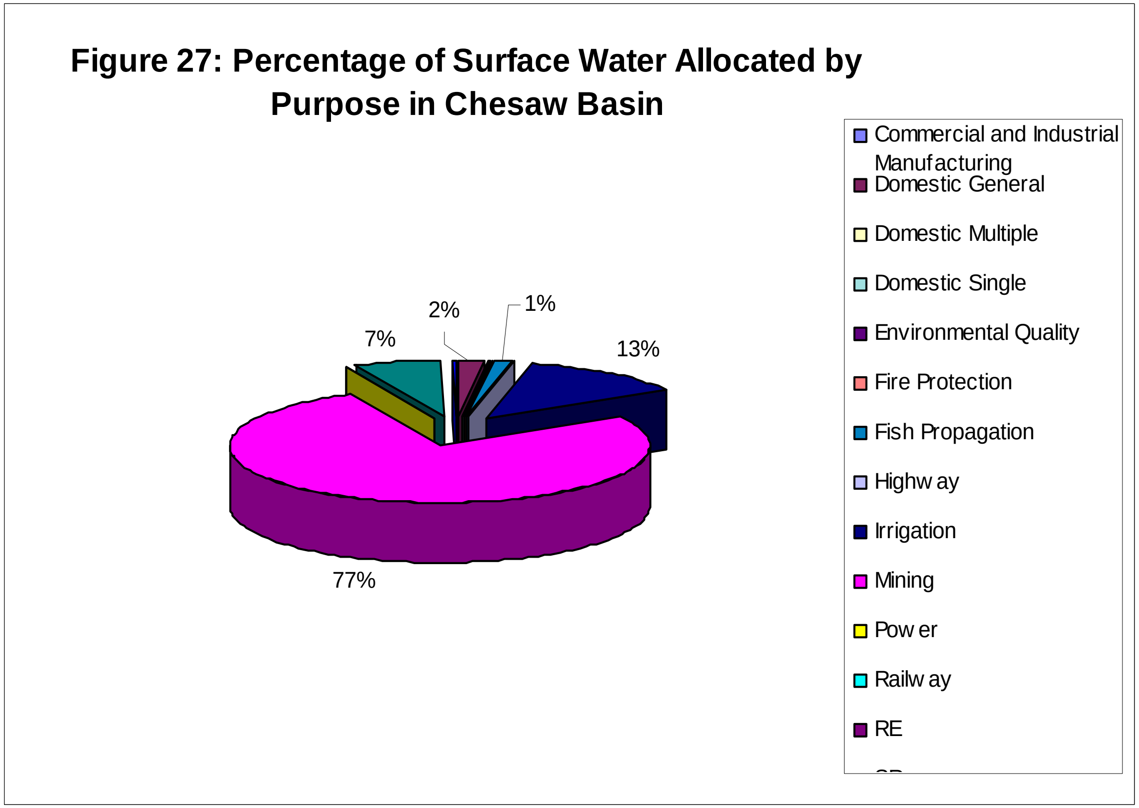
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GEOENGINEERS

PERCENTAGE OF ALLOCATED GROUNDWATER BY PURPOSE IN CHESAW BASIN

FIGURE 26

3595-005-00:120903: JER:tlm 359500500FIG26.PPT



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

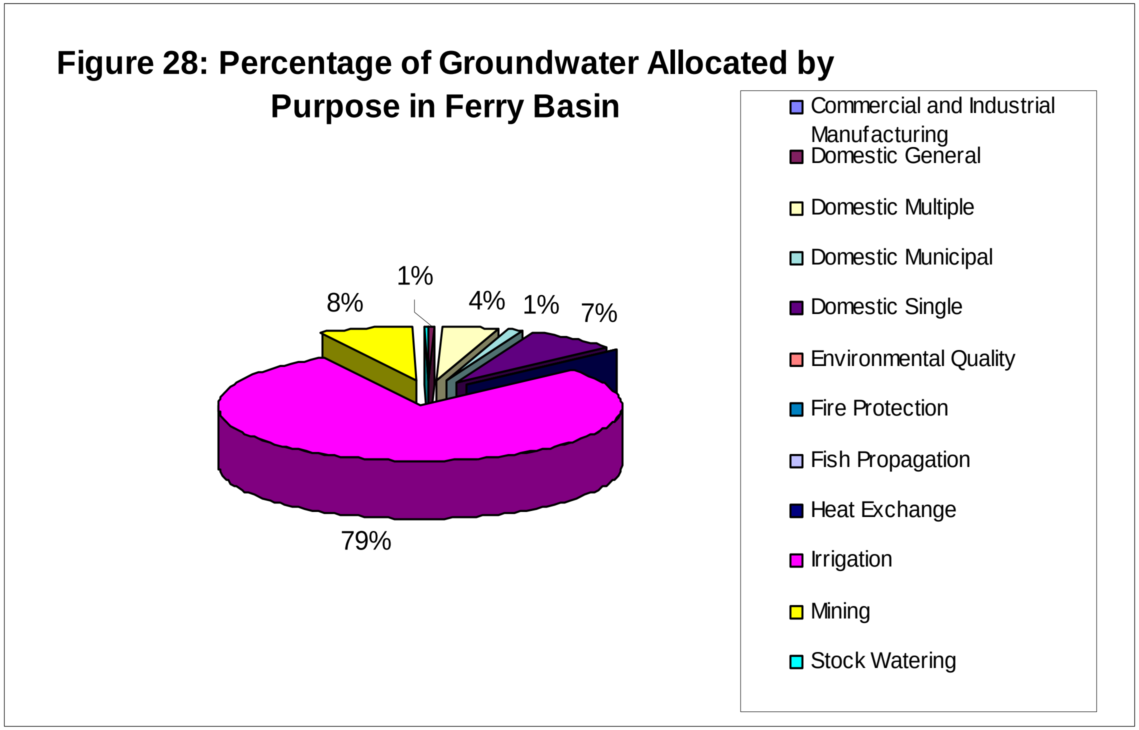
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GEOENGINEERS

PERCENTAGE OF SURFACE WATER ALLOCATED BY PURPOSE IN CHESAW BASIN

FIGURE 27

3595-005-00:120903: JER:tlm 359500500FIG27.PPT



Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

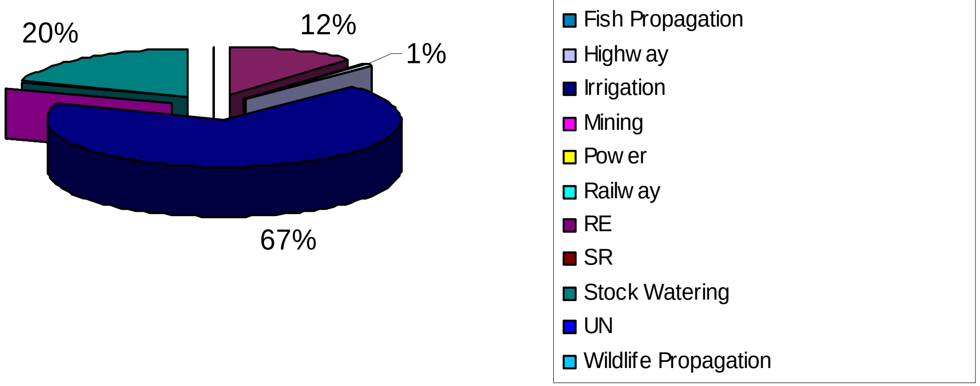
GEOENGINEERS

PERCENTAGE OF GROUNDWATER ALLOCATED BY PURPOSE IN FERRY BASIN

FIGURE 28

3595-005-00:120903: JER:tlm 359500500FIG28.PPT

Figure 29: Percentage of Surface Water Allocated by Purpose in Ferry Basin



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

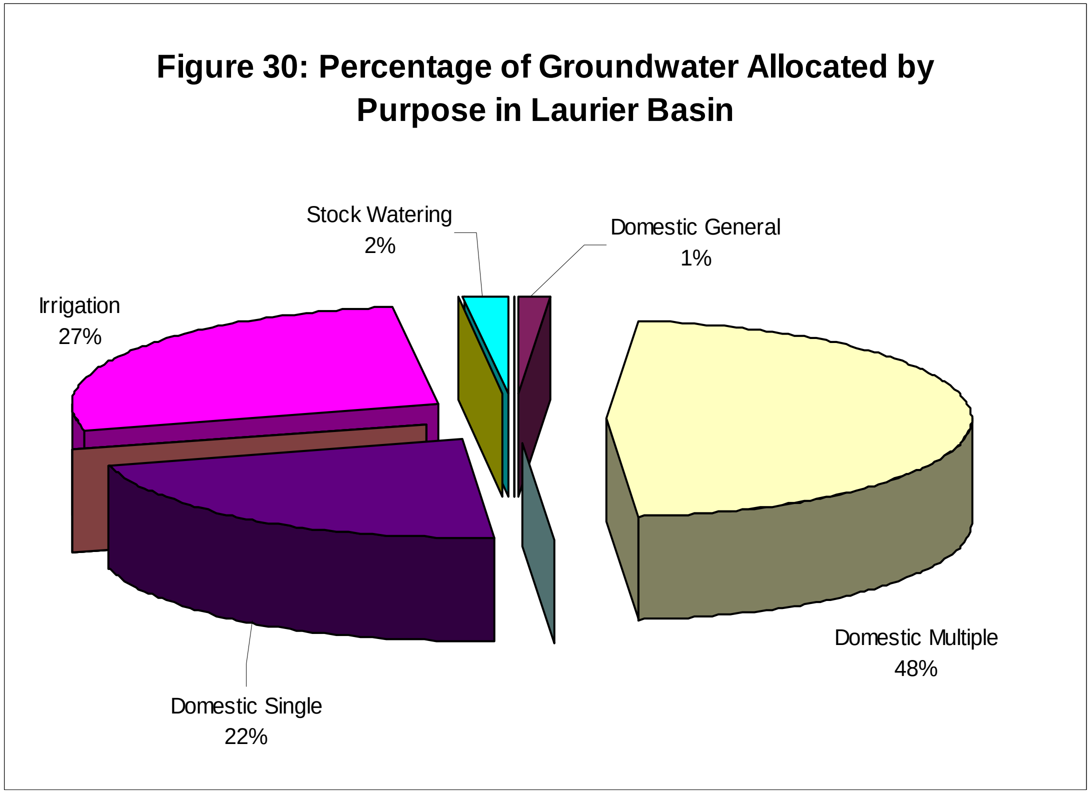
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GEOENGINEERS

PERCENTAGE OF SURFACE WATER ALLOCATED BY PURPOSE IN FERRY BASIN

FIGURE 29

3595-005-00:120903: JER:tlm 359500500FIG29.PPT



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

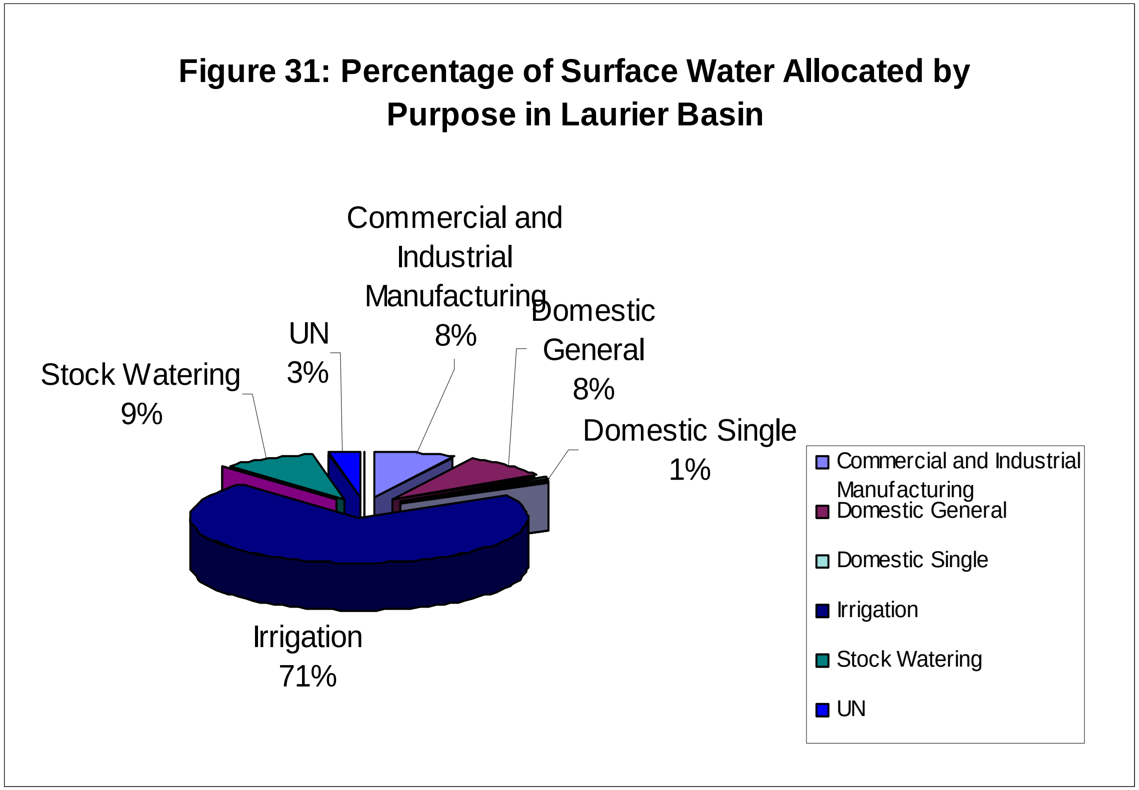
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GEOENGINEERS

PERCENTAGE OF GROUNDWATER ALLOCATED BY PURPOSE IN LAURIER BASIN

FIGURE 30

3595-005-00:120903: JER:tlm 359500500FIG30.PPT



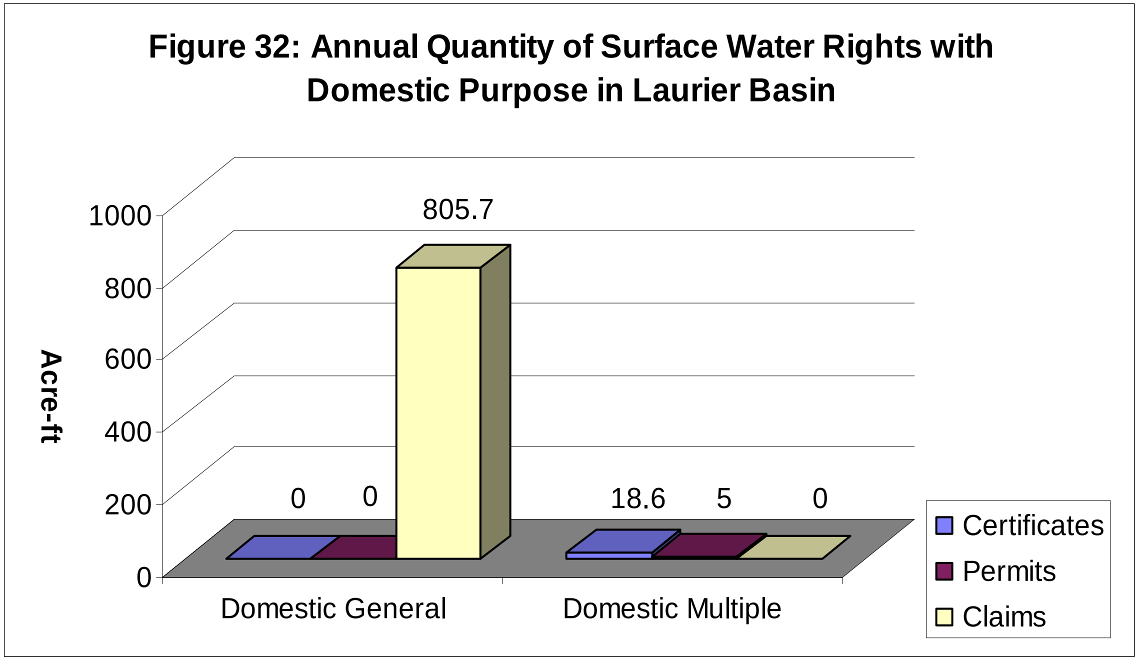
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GEOENGINEERS

PERCENTAGE OF SURFACE WATER ALLOCTAED BY PURPOSE IN LAURIER BASIN

FIGURE 31

3595-005-00:120903: JER:tlm 359500500FIG31.PPT



Disclaimer: This document and any attachments are only an electronic copy of a master file. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

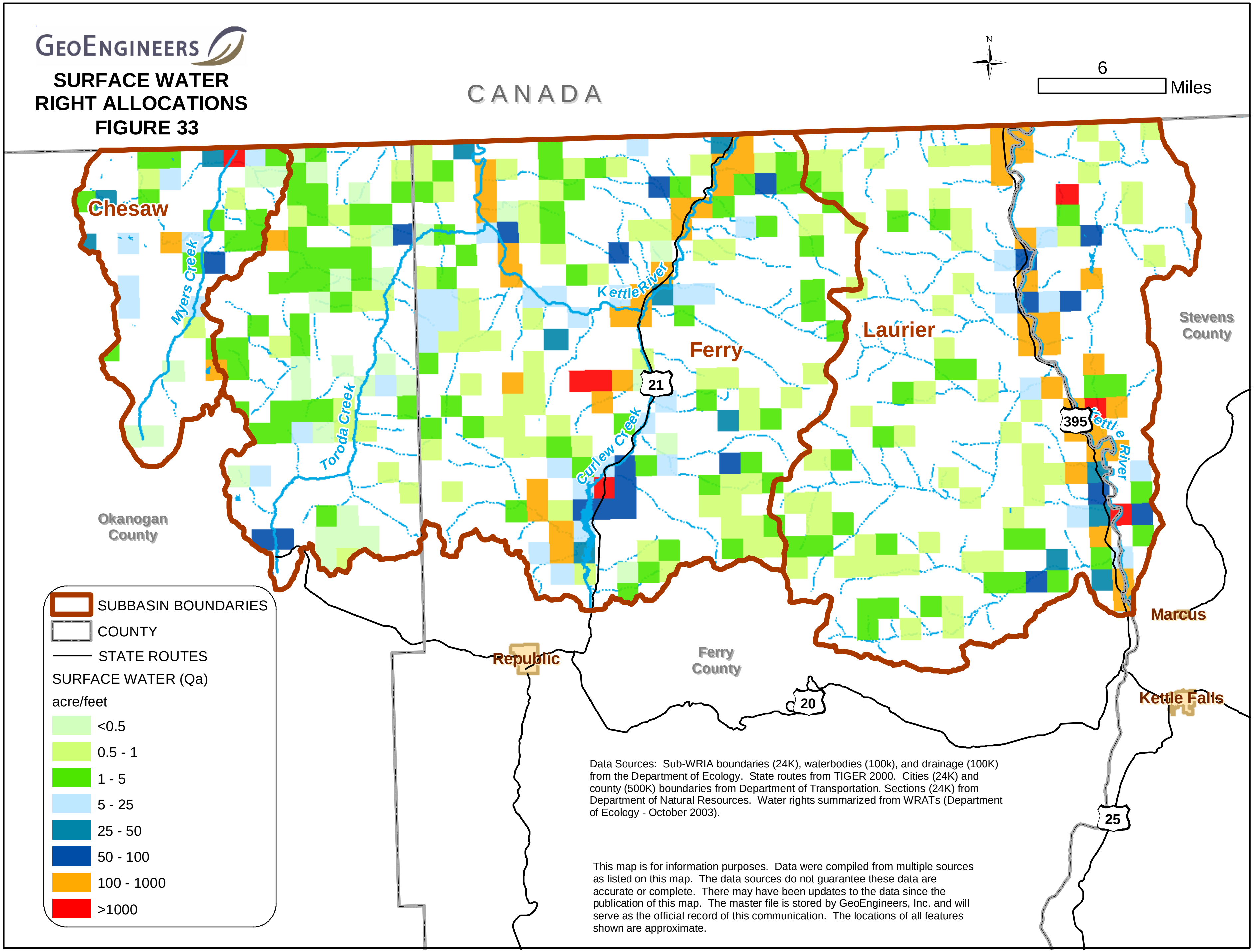
Reference: Graph obtained from the Western Regional Climate Center Desert Research Institute.

GEOENGINEERS

ANNUAL QUANTITY OF SURFACE WATER RIGHTS WITH DOMESTIC PURPOSE IN LAURIER BASIN

FIGURE 32

3595-005-00:120903: JER:tlm 359500500FIG32.PPT

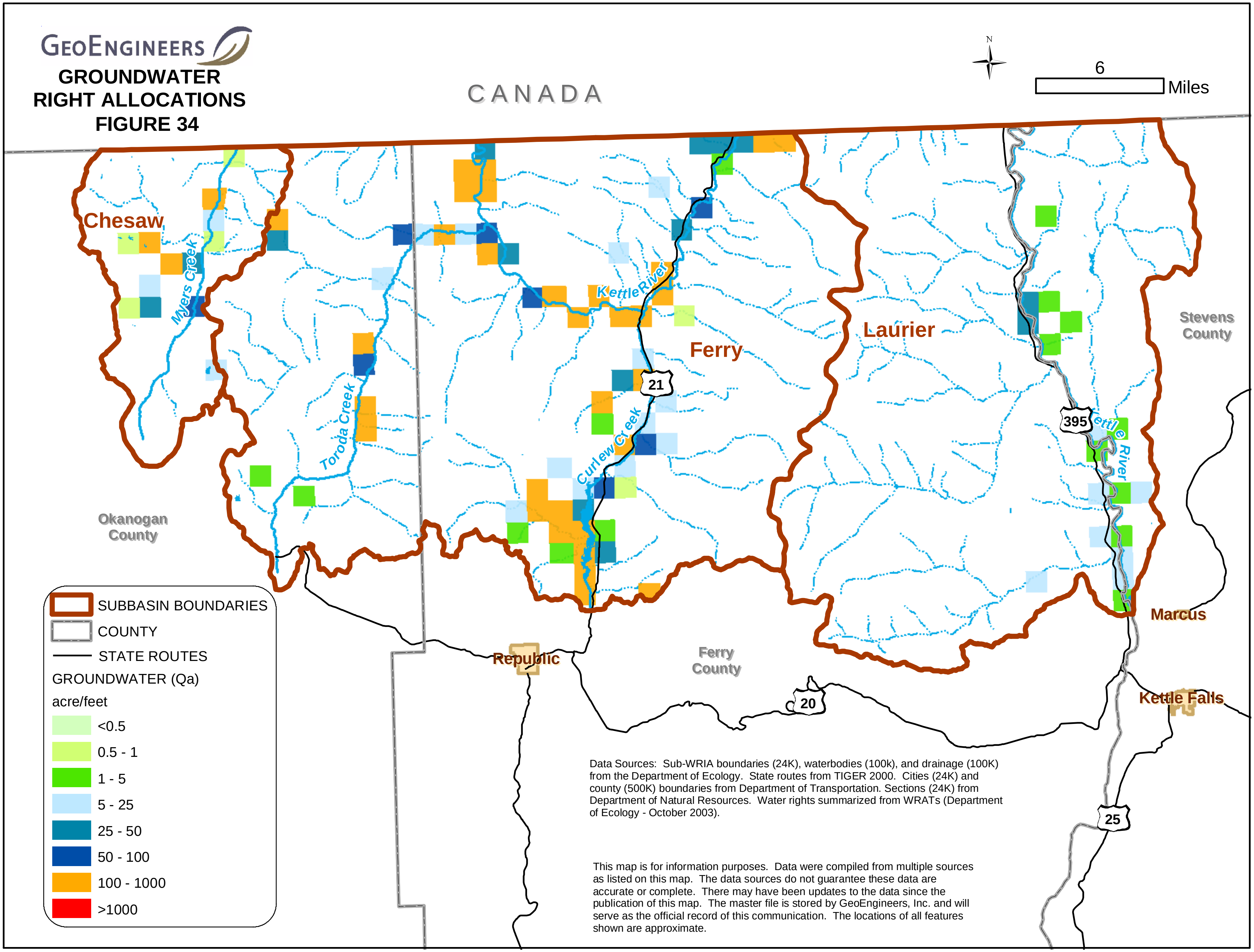


Map Revised: December 12, 2003

Path: P:\1\3595005\GIS\Figure9.mxd

RO: SPO

GROUNDWATER RIGHT ALLOCATIONS FIGURE 34



Data Sources: Sub-WRIA boundaries (24K), waterbodies (100k), and drainage (100K) from the Department of Ecology. State routes from TIGER 2000. Cities (24K) and county (500K) boundaries from Department of Transportation. Sections (24K) from Department of Natural Resources. Water rights summarized from WRATs (Department of Ecology - October 2003).

This map is for information purposes. Data were compiled from multiple sources as listed on this map. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this map. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication. The locations of all features shown are approximate.

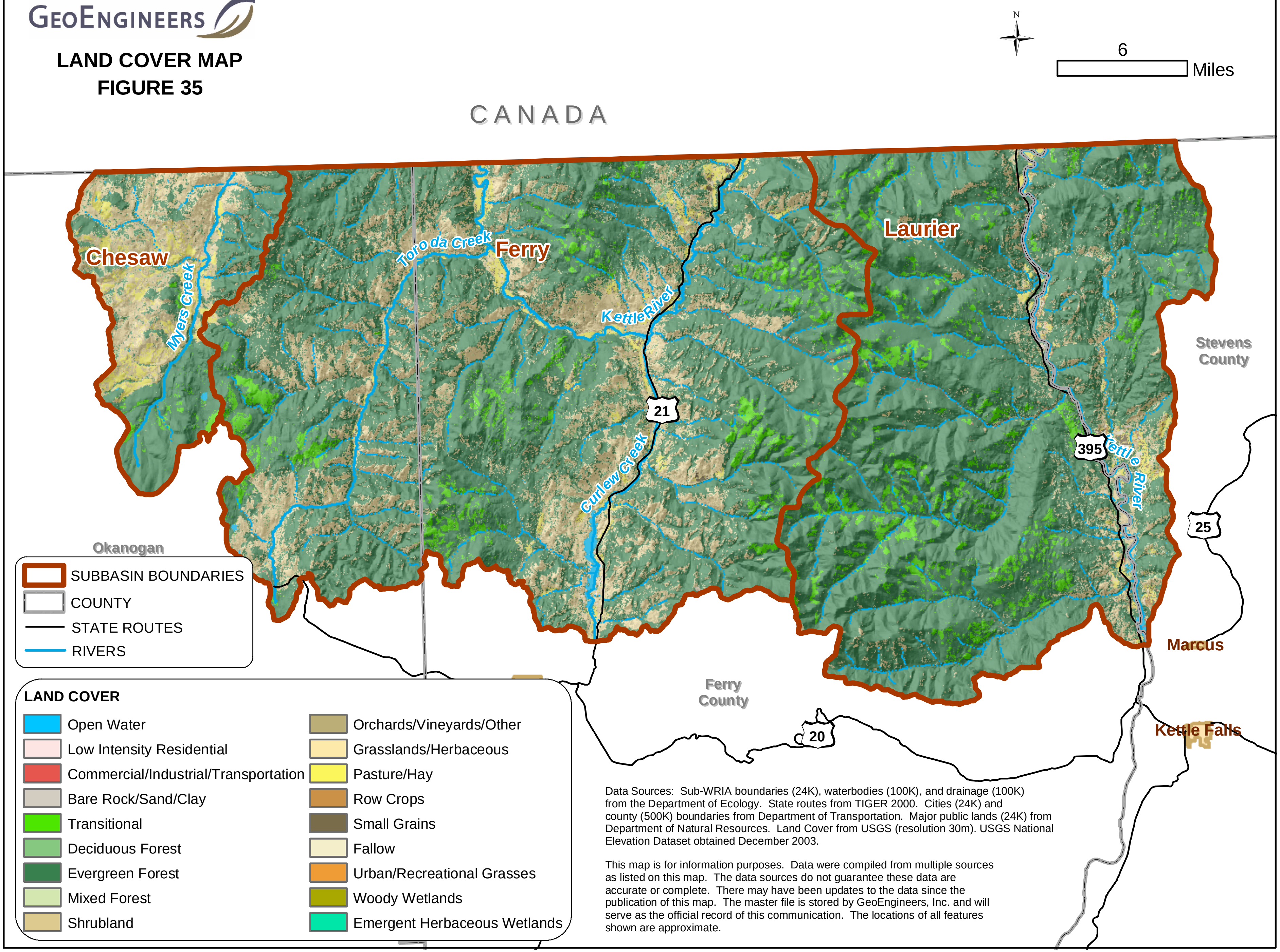
Map Revised: December 5, 2003

Path: P:\3\3595005\GIS\Figure10.mxd

RO: SPO

GeoEngineers

LAND COVER MAP
FIGURE 35



Data Sources: Sub-WRIA boundaries (24K), waterbodies (100K), and drainage (100K) from the Department of Ecology. State routes from TIGER 2000. Cities (24K) and county (500K) boundaries from Department of Transportation. Major public lands (24K) from Department of Natural Resources. Land Cover from USGS (resolution 30m). USGS National Elevation Dataset obtained December 2003.

This map is for information purposes. Data were compiled from multiple sources as listed on this map. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this map. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication. The locations of all features shown are approximate.

Map Revised: December 12, 2003

Path: P:\3\3595005\GIS\Figure11.mxd

RO: SPO

GeoEngineers

APPENDIX A

COMMENT RESPONSE TABLE FOR DRAFT LEVEL I TECHNICAL ASSESSMENT

Response to Comments Received on the WRIA 60 Draft Level 1 Technical Assessment submitted in December 2003.

In order to avoid repeated responses to similar or related comments some responses may address more than one comment.

1	**Comment:** I notice that all tables sequence the months from October thru September, which is probably OK although there does not seem to be any obvious reason for it; that is, does not represent a calendar year nor a budget fiscal year. When we have talked about the sequence for measuring flows, we generally talk about starting a year's worth of measurements in April or May to catch spring runoff. If Oct - Sept is some industry standard "water year", it would be good to include some note to that effect so the lay person does not have to wonder at why the months are sequenced that way.
	Response: Comment received for draft Water Balance. The sequence of months presented is the most commonly used water year. It also happens to correspond with the fiscal year of federal agencies.
2	**Comment:** Assuming that it is intentional to sequence all tables as October thru September, then I suggest verifying that the data is matched correctly to the months in Table 2. It cannot be correct that the lowest average temperature of the year occurs in October; nor that August temperature averages below freezing. The data appears to be sequenced as January thru December, and it is only the month labels that are October thru September.
	Response: Comment received for draft Water Balance. Table corrected accordingly.
3	**Comment:** Itemizing the data gaps encountered in preparing the balance--the means by which each data gap was handled; what modeling was used? What formulas were used? What is the known/estimated reliability for each methodology used in filling the data gap? What is the degree to which the estimation/modeling could affect the accuracy of each area where estimation/modeling was used (suggest stating this in "plus-or-minus percentage" format)? What degree to which the estimation/modeling combined effect of the data areas estimated affects the accuracy of the entire balance?

	Response: Comment received for draft Water Balance. Data gaps encountered will be documented in the Technical Memorandum: Recommendations for Level 2 data collection. These recommendations would improve the water balance's accuracy. The Level 1 Technical Assessment documents the modeling and formulas used to develop the water balance. The precision or accuracy of the methods used to approximate the water balance has less to do with the methods than the detail of the information available to use in the methodologies. The quality of the information used to estimate the various components of the water balance can affect its accuracy.
4	**Comment:** With this in mind, I would want the final Water Balance document to reflect this with wording like " estimated " to replace the wording " actual." I want the future readers of this document to know this was an educated guess and not hard science fact.
	Response: Comment received for draft Water Balance. A word search was performed on the document to identify and replace, when warranted, "actual" with "estimated."
5	**Comment:** First of all it is clear that a great deal of water that does fall on the WRIA 60 area does not flow into the Kettle River, but does flow directly into late Roosevelt. As a result this water must not be figured into the minimum instream flows of the Kettle River. I believe that the whole aspect of the overwhelming dynamics of the evapotranspiration can be addressed much easier. This could be achieved through a models based on averages, say 10 acres with in the mean environmental condition as per elevation etc. Within the remaining WRIA that acutely does flow into the Kettle River. In the data provided to GEO engineers weather conditions at lower elevations of Lambert creek have been provided. These records can be used to validate the NRCS data estimations. Considering that the mountain ranges run North and South, the resulting slopes face North and South as a result.
	Response: Comment received for draft Water Balance. Precipitation in WRIA 60 resulting in surface water flows run through tributaries to the Kettle River, and then to Lake Roosevelt. In response to the second comment, there are a multitude of approaches that may have been taken in attempting to quantify evapotranspiration rates in WRIA 60. The use of an empirical formula to quantify WRIA 60's evapotranspiration rate on an annual basis was a specific component of the scope of work.

6	**Comment:** The report notes but does not resolve the discrepancies between hydrologic and political boundaries for the study area. The lack of drainage data and watershed characterization for the mainstem Kettle River limits the usefulness of flow data for the two reaches. If the interest is mainstem flows, the inflow and outflow parameters need to be in context with upstream hydrologic conditions (including drainage area, slope, and storage effects) without regard to jurisdictional or political boundaries. If the interest is tributary flows, the drainage analysis units and watershed boundaries need to be defined at the larger scale.
	Response: Comment received for draft Water Balance. Comment noted. Determining interest in mainstem and/or tributaries flows was not part of the scope of the technical assessment.
7	**Comment:** The report notes discrepancies between groundwater divides and surficial watershed boundaries. It calculates groundwater flow from sedimentary units extrapolated from well log data and assumes negligible groundwater exchange from bedrock units. If the interest is low flows in mainstem Kettle River reaches, these discrepancies in contributing areas and aquifer characteristics need to be resolved to improve estimates of groundwater discharge. If the interest is low flows in tributary streams, groundwater discharge from bedrock sources in headwater areas may be even more significant.
	Response: Comment received for draft Water Balance. Comment noted. Again, determining interest in mainstem and/or tributaries flows was not part of the scope of the technical assessment.
8	**Comment:** The report would benefit from hydrographs of seasonal and annual changes in flow. Graphical characterization of seasonal variability in water balance components would highlight the water surplus and water deficit periods in a typical year.
	Response: Comment received for draft Water Balance. Figure 8 through 13 present hydrographs.
9	**Comment:** Page 1 Water Balance Components and Methodology 2nd paragraph – “The Kettle River enters ……Washington and again at Laurier Washington.”
	Response: Comment received for draft Water Balance. Text changed to reflect comment.
10	**Comment:** Page 2 RE: Water Balance and Methodology There is no groundwater monitoring in the WRIA to know if the premise - “This water balance assumes that on an annual basis, there is no change in water storage within the basin. Given this assumption, total annual basin inputs equal total annual basin outputs.” - is correct.
	Response: Comment received for draft Water Balance. Comment noted.

11	Comment: Page 4 RE: Domestic Use The estimated water demand per household of 3,044 gallons per day year around (3.41 acre/ft/yr) seems high.
	Response: Comment received for draft Water Balance. Comment noted. The use of the water demand calculated for the WRIA 59 document prepared by USGS was based on similar land use, activities, and climate in WRIAs 59 and 60.
12	**Comment:** Page 5 RE: Domestic Use Dept of Health's recommendation of 200 gallons per day equates to 0.22 acre-feet per year.
	Response: Comment received for draft Water Balance. Text will be changed to reflect comment.
13	**Comment:** Page 6 RE: Water Balance Summary List Formula, then numbers below; PPT + GWI + SWI = ET + ND + GWD + SWD 589k + 324 + 1121k = 327k + 21k + 11 + 1362k
	Response: Comment received for draft Water Balance. Table 14 presents this information and the text describes and explains discrepancies.
14	**Comment:** Table 7 Notes: What field in the table is Note 3 tied to?
	Response: Comment received for draft Water Balance. The Average Laurier Stream Flow Rate Column refers to Note 3.
15	**Comment:** This report is too technical for the general planning unit audience.
	Response: For the most part Planning Unit members have been repeatedly exposed to the terminology and concepts discussed and used in the report. The general public may have some difficulty following and understanding the report, but the target of this report is the WRIA 60 Planning Unit. In our opinion, the information presented is at a technical level which planning unit members can easily understand.
16	**Comment:** Lacks Surface Water Source Limitations information/analysis
	Response: The Limitations Section of the report discusses a number of issues related to surface water identified from the Level 1 analysis. In addition, a technical memorandum recommending prioritized data collection efforts to undertake to fill data gaps will be forthcoming.
17	**Comment:** Analysis of water allocation estimate from claims is approximately 1/3 of Ecology's estimate

	Response: Assuming the comment is referring to the Draft Initial Watershed Assessment performed for WRIA 60 in May 1995, our approach to estimating the water allocated was to sum the information currently available from Ecology's WRATS database. Our report notes the limitations and discusses how this information should be viewed. The Draft Initial Watershed Assessment attempted to calculate the quantity of water possibly allocated by claims through the application of a number of assumptions. Assumptions needed to calculate quantity of water used were developed in collaboration with the Department of Ecology. The Draft Initial Watershed Assessment also seems to make the presumption that all claims are valid. The scope of the current assessment is to summarize and identify the gaps or limitations in the existing information, not synthesize or develop new data in this regard. Funding and schedule were not allocated to develop assumptions representative of the WRIA 60 Planning Unit's understanding of the validity of the claims and/or amount of claimed water being used.
18	**Comment:** Lacks an analysis of how many days flow is <u>below</u> WDFW's recommended instream flow for the Kettle River.
	Response: Comment noted, but not within the scope of the assessment.
19	**Comment:** No minimum flow analysis.
	Response: Comment noted, but not within the scope of the assessment.
20	**Comment:** It appears that many citations are missing in the description of the watershed.
	Response: The description of the watershed will be reviewed to determine if citable information was used and, if such, citations have been made where appropriate.
21	**Comment:** Fahrenheit should be reported along with Celsius
	Response: Comment noted. Temperature in degrees Fahrenheit precedes Celsius in parenthesis in the reports text. Figures will remain in Celsius to simplify the legend and graphics.
22	**Comment:** GIS coverage of the geology would be helpful
	Response: Geology coverages for the WRIA have been collected and will be provided with the files created or compiled during this project. However, presentation of the surficial geology did not appear to facilitate any better understanding of the watershed's geology than the discussion contained in the report.
23	**Comment:** Hydrograph Figures should be broken out so that the scale for minimum flows can be read.
	Response: Due to the range of flows at the gage stations in WRIA 60, focusing on the scale for minimum flows does not allow the entire range to be properly displayed. Besides minimum and exceedance flows are discussed in each gage station section. Also, the spreadsheets used to develop the Hydrograph Figures will be delivered to Ferry County for future use or analysis.

24	**Comment:** Page 1, under "Physical Description": Toroda and Ferry are not "communities" found with the watershed. These were communities historically, but are now just place names on a map. Delete Toroda and Ferry and add Malo to the list of communities in WRIA 60.
	Response: Text changed to reflect comment.
25	**Comment:** Page 1, under "Physical Description": It is not appropriate to classify the geography of the study area as consisting of "…rugged upland regions with both forested and logged areas…" "Logged areas" is not a geographic description.
	Response: Text changed to reflect comment.
26	**Comment:** Page 2, under "Subbasin Delineation/Ferry subbasin": Tenas Mary, Emmanuel, and LaFluer Creeks are not "primary Kettle River tributaries". These streams typically flow subsurface when they enter the valley floor and do not flow directly into the Kettle River in the summer. Recommend removing these streams from the list of primary tributaries and adding Lambert, Lone Ranch, and West Deer creeks. Also, Curlew Lake is a significant water body in the Ferry subbasin and should be considered here.
	Response: Rather than discount seasonal surface water flows and subsurface contribution, "Primary" has been deleted. West Deer Creek and Long Ranch Creek have been added. Lambert Creek was not because it is a tributary of Curlew Creek. Curlew Lake had already been identified in this section.
27	**Comment:** Page 3, under "Climate": The last sentence of this paragraph indicates that precipitation as well as temperature increases with increasing elevation. Temperature generally decreases with increasing elevation in the watershed.
	Response: Text changed to reflect comment.
28	**Comment:** Page 6, under "Hydrologic Setting": Change the first sentence to read: "The primary surface water features within WRIA 60 are the Kettle River and Curlew Lake."
	Response: Text changed to reflect comment.
29	**Comment:** Page 7, under "Population": Census data is generally provided by county. How did the consultants determine what percentage of the Ferry, Stevens and Okanogan county population reside in WRIA 60?
	Response: Text added to explain how population data was collected.
30	**Comment:** Page 8, under "Land Use", 3rd paragraph: In second sentence, change "…primary land use is evergreen forest, …" to "…primary land cover is evergreen forest,…". Evergreen forest is not a land use.
	Response: Text changed to reflect comment.
31	**Comment:** Page 8, under "Land Ownership": Table 6 summarizes land ownership for all landowners not just "public" lands in WRIA 60 as described in the second sentence of paragraph.
	Response: Text changed to reflect comment.

32	**Comment:** Page 9, Table 6: The Department of Natural Resources manages a significant amount of land in the WRIA. This agency is missing from the table, despite the fact that data from DNR 2000 was cited as the reference for the data.
	Response: Comment noted. Amount of land DNR manages in the WRIA has been determined and added to the table.
33	**Comment:** Page 9/10, under "Existing Streamflow Studies/Ferry sub basin": As per comment 3 above, change list of "primary…tributaries."
	Response: Text changed as discussed above.
34	**Comment:** Page 9/10/11/12/13 under Surface Water Resources other sources of stream flow data are available; USFS, Ecology, and Ferry Conservation District.
	Response: Flow data from these sources were reviewed. The lack of surface water outflow data from the Ferry Subbasin limited the usefulness of flow data for tributaries from these sources. In addition, the completeness and period of record associated with some of this information limited its quality. Often flow data from these entities were taken for water quality monitoring purposes.
35	**Comment:** Page 11/12, under "Evaluation of Stream Gage Data": Why did the period of record used for the Ferry and Laurier stream gage data end in 2001? Why not 2002/03?
	Response: At the time flow information was collected only the period of record through 2001 was available. Collection of additional flow information was not part of the scope of the current contract for technical assessment services.
36	**Comment:** Page 18 under "Quantity of Water Allocated" – Water Right Permits and Certificates have been evaluated by Ecology staff. Claims are not verified by Ecology staff. Quantities for claims were not entered into any database and have to be estimated by claimed use.
	Response: Comment noted. Estimating quantities by claimed use was not available except for a few claims, which were reported.
37	**Comment:** Page 19, Table 9 – Permits and Certificate quantities are good; estimated quantities for claims however represent approximately 1/3 of Ecology's (J. Covert) 1994 estimate of 29,540 acft
	Response: Please see previous response (17) to this discrepancy.
38	**Comment:** Page 27 under Net Demand Domestic; 200 gallons per day does not equal 1.68 acre-feet per year, that number should be 0.22 acft/yr
	Response: Comment noted. Report changed to reflect correction.
39	**Comment:** Page 28 under Net Demand Non-Domestic Use; an estimate of irrigated acres in the watershed should be addressed here.
	Response: Comment noted. Since the number of acres being irrigated may fluctuate from year to year, the assessment presents an estimate of net demand for irrigation purposes based on quantity of water allocated minus recharge rather than attempting to calculate net demand from acres irrigated. This approach assumes water allocated is used.

40	**Comment:** Page 16 Table 14 Inputs; Surface Water Inflow at Ferry and Laurier should be labeled as USGS gages. The Surface Water Outflow for Ferry should be the Residual. 2126K + 507K – 203K = 2430K sw in + precip – ET = out Boyd out is figured at 2172K; 258K acft is missing
	Response: Use of USGS gages has been noted. Report notes the discrepancy between input and output in the Laurier Basin. An analysis of the various components or collection of data to resolve this discrepancy is outside the scope of this assessment.
41	**Comment:** Figures 4, 5, and 6 are unreadable.
	Response: Figures corrected.
42	**Comment:** Pg. 4-5, section "Basin-Scale Precipitation and Temperature Distribution", 2nd paragraph, correct the spelling of the word "annul", I think it's "annual".
	Response: Text changed to reflect comment.
43	**Comment:** Pg. 8, 1st paragraph, "LAND OWNERSHIP", second sentence says, "The largest land manager is the federal government, which owns approximately 58 percent of the WRIA." Explain and provide information on how the WRIA currently coordinates (or plans to coordinate) with the feds in order to manage the watershed.
	Response: Comment noted, but outside the scope of the assessment. Phase 3 should address this concern.
44	**Comment:** Pg. 8, 2nd paragraph, regarding the Crown Jewel Project, please provide the status of this project and its potential impacts to the watershed and how the planning unit will coordinate/work with Crown Jewel to manage the watershed.
	Response: Comment noted, but outside the scope of the assessment. Phase 3 should address this concern.
45	**Comment:** Pg. 14, GROUNDWATER RESOURCES, INTRODUCTION, 1st sentence that says "This section contains a summary of existing information for WRIA 60 regarding groundwater quantity." Is WRIA 60 also doing Water Quality? And will this be discussed elsewhere? If so, please refer the reader to the quality discussion (wherever it is).
	Response: WRIA 60 Planning Unit has not accepted the Water Quality Element.
46	**Comment:** Pg. 14-15, Basement Rock Aquifer, 4th paragraph identifies that "The basement rock aquifer(s) receive recharge from infiltration of precipitation in the highland areas." If this is true, will the planning unit focus some attention on these areas in order to manage what goes into the aquifers?
	Response: Comment noted, but outside the scope of the assessment. Phase 3 should address this concern.

47	**Comment:** Pg 15, Sedimentary Aquifer, last sentence "Groundwater inflow and outflow occurs at locations where the Kettle River valley and various tributaries enter and exit the WRIA". Again, will the planning unit focus on these areas for watershed management?
	Response: Comment noted, but outside the scope of the assessment. Phase 3 should address this concern.
48	**Comment:** Pg. 17, "WATER RIGHTS" INTRODUCTION, last paragraph discusses instantaneous rates assumed to be represented in the annual totals. Is it okay to ignore instantaneous rates?
	Response: Instantaneous rates are accounted for in the annual quantity. Also, the level of detail of the information available and the data gaps present do not allow for a detailed analysis that would utilize instantaneous rates.
49	**Comment:** Pg. 20, under the "NUMBER OF WATER RIGHTS AND APPLICATIONS" section, 3rd paragraph states that "96 percent of the groundwater allocated through the respective certificate and permit documents is for the purpose of irrigation". Nothing in the recommendations discusses working with irrigators on water use and management.
	Response: Comment noted, but outside the scope of the assessment. The development of the watershed plan would make recommendations on how to manage water resources.

50	**Comment:** Page 11, mid page, defining the concept of exceedance probability and the terms low flow, median, and high flow. This is difficult for me to understand; i.e., the statement that "low flow … is *equal to* the flow rate that occurred nine years out of 10 for a particular time of year" – I think, is not quite correct. I may not understand, but my thought is that a flow *equal to or higher than* the "low flow" occurred nine years out of 10 *over the long term*. Could this paragraph be worded something like: (First sentence as is – These statistical evaluations are used … based on the available gage records.) Then: *"Low flow" is estimated to occur only once in ten years as a monthly average for a given month of the year. Thus a flow higher than "low flow" would occur nine years out of ten; also designated as "90 percent exceedance flow".* *"High flow", also designated as "10 percent exceedance flow" is estimated to be reached only once in ten years as the average for a given month; thus for nine years out of ten the month will experience a flow lower than "high flow".* *During eight years out of ten, over the long term, the flows for a given month of the year are estimated to fall between "low flow" and "high flow". The median flow is represented by the 50 percent excedence probability; in any year, the average for the given month is equally likely to reach a flow higher than or lower than the median.* You can probably improve on it, but I feel that most readers need something to help comprehend the 90 / 50 / 10 % excedence graphs.
	Response: The text of the Technical Assessment was modified in response to the above comment.
51	**Comment: Table 6 – Page 9** The table includes acres only for public lands (not private lands) yet the percentages are derived from the total of public and private lands. Confusing. Could be helped by including a separate line for private lands, so that the percentages would add up. The totals of acres listed for the WRIA (public lands) total 391,124. From Table 5 on the previous page, you could retrieve the total acres in the watershed as 643,975, so the difference would be private lands. You may want to re-do the percentages; because they are close, but not quite right, for a base of 643,975 acres.

	Response: Table 6 contains a row for private lands. The Department of Natural Resource land ownership had been omitted. DNR's land ownership will be included in the Table 6, so percentages and acreage total similarly to Table 5.
52	**Comment: Labeling of Hydrogeologic Sections – Pg 16, 17** Pg 16, second to last paragraph, "section A-A was estimated 124,000 sq ft, should be Section C-C. Last line of page, C-C should be E-E. Pg 17 first paragraph, A-A should be E-E.
	Response: Text changed to reflect comment.
53	**Comment: Figure 5 – Missing Temperature Lines** Could be my printer, but I don't have any temperature lines on this figure.
	Response: The description of the Irene Mountain Wauconda Station on page 3 notes the fact that no temperature data was available, only precipitation. Figure 5 is based on the data available from this station.
54	**Comment: Why Not Reference the 1995 (Dames & Moore) Initial Watershed Assessment?** The first thing which struck me as I read the report was lack of any acknowledgement of the 1995 Dames and Moore report - Initial Watershed Assessment, Water Resource Inventory Area 60. This document is listed in the Master Bibliography, but is not included in references used for the Level-1 Analysis. However, it should be well-known to the consultant team. Since the purpose for the 1995 report was essentially the same as the purpose of the current Level-1 Analysis, I expected that the previous work would be incorporated where applicable, or at least used as one level of "reasonableness check" to identify areas where one or the other report suggested markedly different findings – or where both reports corroborated the same findings.
	Response: The Draft Initial Watershed Assessment for WRIA 60 (1995) was reviewed. Information unique to this report was not used in the Draft Level 1 Technical Assessment, so it was not cited. This draft report will be included in the references of the final report. Although the two reports might appear to have a similar purpose, there are several distinct differences including but not limited to when they were prepared and for whom they have been prepared. GeoEngineers did not attempt to corroborate the findings of this draft report, but to make an independent assessment of the data that currently exists today. The assessment GeoEngineers has prepared reflects the direction and limitations in scope, funding and schedule established by the project's owner and client. Individuals wanting to make direct comparisons of these two assessments need to acknowledge these distinctions.

55	**Comment:** Stream-flow (and possibly other factors) over time**.** The Dames and Moore report (pages 29 – 32) describes a technique used to evaluate the re-occurrence of low flows over time, with the finding that low flows were lower in the recent record (1966 – 1993) than had been the case over the entire time period beginning with 1928. The authors of that report suggested that increased recent water usage is impacting the average low flows. Our current Level-1 Analysis affords us the opportunity to add a more recent 10 year period (1994 – 2003) onto this evaluation of low-flow trend. This would seem to be a valuable, possibly critical, aspect of the analysis which has been overlooked. Although the water-rights analysis indicates little increase in Washington State water usage in the past 10 years, there is the great unknown as to water usage in British Columbia, where the greatest potentials for increased usage exist (domestic and industrial uses). The Dames & Moore technique, as described on page 29, was driven by flow difference between the Ferry Station and the Laurier Station and noticed an amount of flow which could not be accounted for, other than possibly withdrawals between those two points. It was pointed out that the quantity of water withdrawn in B.C. is an unknown.	
	Response: Comment noted. The current assessment did not allow for the evaluation of the low flow trend for the Kettle River. The scope of the current assessment was funded and scheduled only to fulfill the requirements of the water quantity element identified in RCW 90.82. The assessment of instream flows may provide an opportunity to update the work started in 1995.	
56	**Comment:** The Dames & Moore report also included some temperature analysis over time, which might be valid to extend for the most recent 10 years, given several years of drought conditions.	
	Response: Comment noted. The current assessment presents modeling results that utilize meteorological data through 2002. The model calculates temperature and precipitation values for the entire watershed based on monitoring data from the existing stations. The modeling effort presented is a more sophisticated analysis of existing data than that presented in the Draft Initial Assessment (1995).	

57	**Comment:** *"During average and high flow conditions, there appears to be ample water within the Kettle River to preserve senior water rights, beneficial uses, and still allow for additional appropriation. However, during low flow periods, especially during summer low flows … the Kettle River and tributaries to the Kettle probably cannot sustain significant amounts of additional appropriations, either surface water or ground water." (emphasis mine)* Is there anything in our current findings which would refute or moderate that conclusion? If so, it needs to be pointed out loud and clear. Otherwise, the Planning Unit needs to be put on notice that this is our situation, and that it is time to face the difficult issues of how to generate more flow (i.e., conservation or storage) or how to work towards reallocation of resources, if needed to accommodate future population and/or economic growth.
	Response: Current assessment would not necessarily support or refute a conclusion about additional appropriations. The current assessment identifies the strength of the existing information available. Questions of validity of water rights, measurement of flows, and characterization of the hydrogeology in WRIA 60 need to be more fully answered. In addition to strengthening existing information, the minimum flow needs to be established to evaluate the watershed's capacity for additional appropriations. These issues would be addressed when the optional instream flow element is conducted.
58	**Comment:** Several places in the Dames & Moore report, concern is expressed for tributaries which experience extreme low flow or zero flow during the summer (particularly in the Curlew Creek basin); and it is recommended that somebody should determine the causes and implications of these occurrences. Has our Level-1 analysis provided any insights into this concern / recommendation?
	Response: The current assessment did not allow for this level of detail in our analyses. The scope of the current assessment was funded and scheduled only to fulfill the requirements of the water quantity element identified in RCW 90.82. Phase 2 level 2 data collection may assist in understanding the existing situation better, and Phase 3 provides an opportunity to address the implications.

59	**Comment:** Several places in the document statements are made as to not having found any (or much) data on tributary flow. Example, page 10: "Limited streamflow studies exist within the Ferry subbasin." … goes on to say that the Golder Associates studies on Toroda Creek are the only ones. The consultant team was advised, several times, that there had been 14 months of recent flow data collected at several locations on Lambert, St. Peters and Lambert Creeks during the Conservation District's Kettle Tri-Watershed study. Also, the appendices to the Dames and Moore report include data for several years monitoring on a number of tributaries to the Kettle. Certainly nobody will claim that these are the ideal data sets, but some creative analysis techniques should be able to coax some findings from the data.
	Response: Text will be revised accordingly to provide the reader a better understanding of the current information. The data sets identified were collected and reviewed. The actual studies completed were identified. However, the presence of significant data gaps at the basin scale did not allow for a more detailed analysis at the tributary level. In addition, the data sets referred to were often a result of water quality monitoring efforts. Relatively limited flow data is needed for assessing water quality. The period of record and monitoring program associated with these data sets limit their usefulness in establishing an understanding of flow regime for a tributary.
60	**Comment:** Several places in the Level-1 Analysis are statements as to the extreme limits of data regarding aquifers (see specifically the first paragraph of page 14). I have to question whether the authors made full use of the aquifer study done for Ferry County in 1992 by Graham, Buchanan et al. My memory of perusing that study (and its accompanying detailed maps) is that it provides considerable insight into depths to water and extent of the aquifers. The maps accompanying the Graham-Buchanan study specifically address areas where ground water and surface water are in continuity in the tributary and river valleys – again, an area where the Level-1 Analysis states that there is no or little information.
	Response: The study referred to in the comment documents the use of a model to forecast the potential impact of the release of pollutants from septic systems on the unconfined aquifers in Ferry County. The model allows users to make a number of assumptions about the characteristics of the aquifer. When location specific information was not available the users of the model input assumed information. The information used to model the northern portion of Ferry County was for the most part assumptions, and not based on actual field studies of hydrogeology in the area.

61	**Comment:** Suggest that you re-examine your findings of 183 water rights by the Permit document type. I have worked with the spreadsheet provided by Mentor Law Group, and it appears to me that almost all of the permits are noted as being "Permit cancelled". Looking at just the non-cancelled permits, and eliminating duplicates, I find only 7 ground water permits and 8 surface water permits. Could it be that your intent was to continue carrying the cancelled permits, on the assumption that people may still be making the withdrawals despite the cancellation? In that case it would be good to state the rationale.
	Response: The spreadsheet developed by Mentor Law Group was not used in our examination of water rights for WRIA 60 because no documentation was provided that discussed how the information obtained from the Department of Ecology had been modified or to what degree their analysis was complete. As a result of starting over, the scope of the water rights analysis performed for the current assessment was limited to provide a minimum level of understanding. Thereby, minimizing the funding needed to complete this work. The Level 1 Technical Assessment discusses the Water Rights Analysis performed and its limitations.
62	**Comment:** If the number of permits were adjusted to eliminate those indicated as cancelled, then a close correlation is found between the current Water Rights Analysis and the 1995 (Dames & Moore) analysis, which gives a good feeling of reasonableness. Number of Rights by Document Type / 1995 Analysis / Current Analysis / With Permits Adjusted Claims: 1101 / 1008 / Certificates And Permits: 634 / 633 + 183 = 816 / 633+15 = 648 Note: Of the 15 non-cancelled permits, all but one were issued after 1995, which would make an exact correlation between the two studies (634 vs 633).
	Response: Comment noted. There needs to be some acknowledgement that water right document numbers may have changed since 1995. The water rights analysis documents that data assessed was obtained from the Department of Ecology, corrected, and reported accordingly. The effort required to confirm cancellation of permits was beyond the scope of the analysis. Verification of cancelled permits may be undertaken as a Level 2 data collection effort.

Number of Rights by Document Type	1995 Analysis	Current Analysis	With Permits Adjusted
Claims	1101	1008	
Certificates And Permits	634	633 + 183 = 816	633+15 = 648

63	**Comment:** Comment Regarding Amount of Water Allocated: The Level-1 Water Rights Analysis is correct in pointing out that the tables stating amounts of water allocated should be viewed as a minimum figure. On page 28, first paragraph, you state that "claims without annual quantities were not included." Considering the large number of claims, for which the data does not include annual quantities, I have to ask why you did not consider using a surrogate/default amount for claims as was done in the 1995 report, and whether this might have brought the water rights usage amounts to a more realistic level? In the 1995 study, a formula for computing a surrogate figure was suggested by the Department of Ecology to be used for any claim not stating the water allocation amounts (based on number of irrigated acres, if stated, or default if zero acres). Using these surrogate or default values, the Dames & Moore report calculated allocations of 46,497 acre feet (18 percent higher than the Level-1 analysis calculation of 39,323 acre feet). Suggest that you consider including such a default / surrogate factor for claims, or as an alternative, using an 18 (or 20) percent increase as one way of suggesting the possible magnitude of the missing allocations in the Level-1 report.	
	Response: Please see the response to comment #17	
64	**Comment:** The team is to be congratulated on this section of the study (page 25 and 26); this appears to be an excellent methodology for capturing the magnitude of this piece of the puzzle. The fact that water well reports were used in constructing the hydrogeologic cross sections adds credibility to the resulting estimates. It is a bit disappointing that other places in the document you make statements implying that the approach to groundwater quantification may not be credible. (Example: Page 29, "…the groundwater flow system boundary conditions are complex, and the groundwater boundaries may not be identical to the surface water boundaries …." We need to keep in mind that the current consultant team was selected, in major part, based on personal expertise and experience with ground water flow patterns. If, in the judgment of the professional team, the cross sectional analysis represents the major component of ground water flow, then this should be stated without so much waffling and qualifying.	
	Response: The approach used was selected because of the resources available to assess groundwater's role in the water balance. The approach and data available are not without limitations. These limitations are warranted to provide readers a complete understanding of the quality of information presented.	

65	**Comment:** Regarding the lack of data for water exiting the Ferry subbasin, we need a far stronger statement than: "surface water outflow data is not available for the Ferry subbasin". This needs to be EMPHASIZED. The lack of a gage at Danville forces the water balance to use an acknowledged weak assumption, that water out at Ferry is the residual of the known or calculated factors. This was stated as a glaring weakness in the 1995 report. Now it is nine years later and we are still continuing to bring this up as a question, as to whether or not the Planning Unit thinks something should be done about it.
	Response: The strength of the statement of fact and the actions taken to correct the current situation seem to be more the scope of the planning unit than the consultant.
66	**Comment:** Climate Data: Planning unit members have made it known that there are local, privately operated weather stations – one on Lambert Creek, one in Orient, possibly others. Although these stations do not have long historical data sets available, it should be possible to do some "side studies" to see if any anomalies jump out.
	Response: Comment noted. For purposes of the Level 1 Technical Assessment, readily available data was reviewed for presentation in the report. Additional studies might collect this data, assess the equipment and methods used to record measurements, and compare the data with model results presented in the Level 1 Technical Assessment.
67	**Comment:** Snowpack data: Although the SnoTel site has only been in operation now for a part of a season, there were / are several manually monitored Snow Course sites for which historical record should be available: These are listed on the US. Conservation Service web site and include stations called Butte Creek, Goat Creek, and Summit – all tributary to the Kettle.
	Response: The precipitation information presented in the Level 1 Technical Assessment is based on the currently available data from a number of sources, including the NRCS snotel information.
68	**Comment:** How do you identify water rights for a *reservoir* source? I could not see anything designated as a reservoir. It could not be Lake Roosevelt or Curlew Lake, because there are too many water rights in the database for those sources?
	Response: Reservoir water rights are designated by the applicant or user. These types of rights are recorded in the Department of Ecology WRATS database. These types of rights are not granted for natural lakes but may be required when the storage capacity of a natural lake is artificially increased. The reservoir rights recorded are likely not associated with either Lake Roosevelt or Curlew Lake.
69	**Comment:** Do you have a translation table for the 2-character use codes in the water rights data base? I put together the following by insight and guessing, but can't quite match up all the categories that you use in the report.

	Response: Below is the legend for the 2-character use codes obtained from the Department of Ecology's website. A reference to this legend will be incorporated into the Level 1 Technical Assessment. **CI**--Commercial and Industrial Manufacturing (includes food processing and packaging, sand and gravel processing, asphalt plant, metal processing and manufacturing, pulp and paper manufacturing, aquatic plant culture, petroleum refining, car washes, and laundries) **DG**--Domestic General (use of water for all domestic uses not specifically defined in the water right record or not defined by the other specific domestic use categories. Includes sewage treatment, farm supply, and laboratory use) **DM**--Domestic Multiple (more than one dwelling, i.e. motels, trailer courts, campgrounds, parks, schools, port districts, public utility districts, diking and drainage districts, water districts, reclamation districts, and counties, none of which are under municipal control) **DS**--Domestic Single (one dwelling with lawn and garden, up to one-half acre) **EN**--Environmental Quality (includes pollution control, dust control, flood control, or any water use which improves or maintains the quality of the environment) **FP**--Frost Protection (frost protection other than cranberries) **FR**--Fire Protection (includes sprinkling log storage facilities) **FS**--Fish Propagation (includes water service to ponds, reservoirs, hatcheries, and all other facilities involved in the overall purpose of fish propagation) **HE**--Heat Exchange (use of such equipment as heat pumps, refrigeration equipment, and other cooling devices) **HW**--Highway (maintenance and construction) **IR**--Irrigation (includes cranberry farming, lawn/garden watering with definite acreage, golf courses, greenhouses, etc.) **MI**--Mining (includes washing coal, dredge mining, and hydraulic mining) **MU**--Domestic Municipal (serves general domestic, commercial, and industrial needs of an incorporated municipality, i.e. cities, towns, and outlying areas) **PO**--Power (includes hydro-electric, hydraulic ram, and thermo-electric) **RB**--Recreation and Beautification (includes beautifying private and public grounds and supplying water to swimming pools, boating ponds, etc.) **RW**--Railway (use of water to serve railway equipment and facilities) **ST**--Stock Watering (includes domestic uses of water for dairy/cattle farms, game bird farming, poultry farming, and fur-bearing animal farming) **WL**--Wildlife Propagation (includes water to service non-domesticated animals such as birds, game and non-game species)

70	**Comment:** Primary purpose of water rights. In your assignment of water rights by purpose, how did you deal with those which have several categories of use listed (more than half I would say)? Did you just assign to the first listing? If so, you would miss a lot of irrigation, as the "IR" tends to come after ST and DS in many cases. Or did you assign the entire quantity to each use? Or split the quantity between uses?
	Response: As stated in the Level 1 Technical Assessment, the designation of primary purpose should be viewed as a rough indicator of what water appears to have been allocated for based on the information within the WRATS database. The assigning of a primary purpose was completed using a simple rule that designates the purpose most likely to use the greatest amount of water as primary. For the sake of simplicity, the entire quantity was then allocated to the primary purpose. Text has been added to explain the designation of primary purpose.