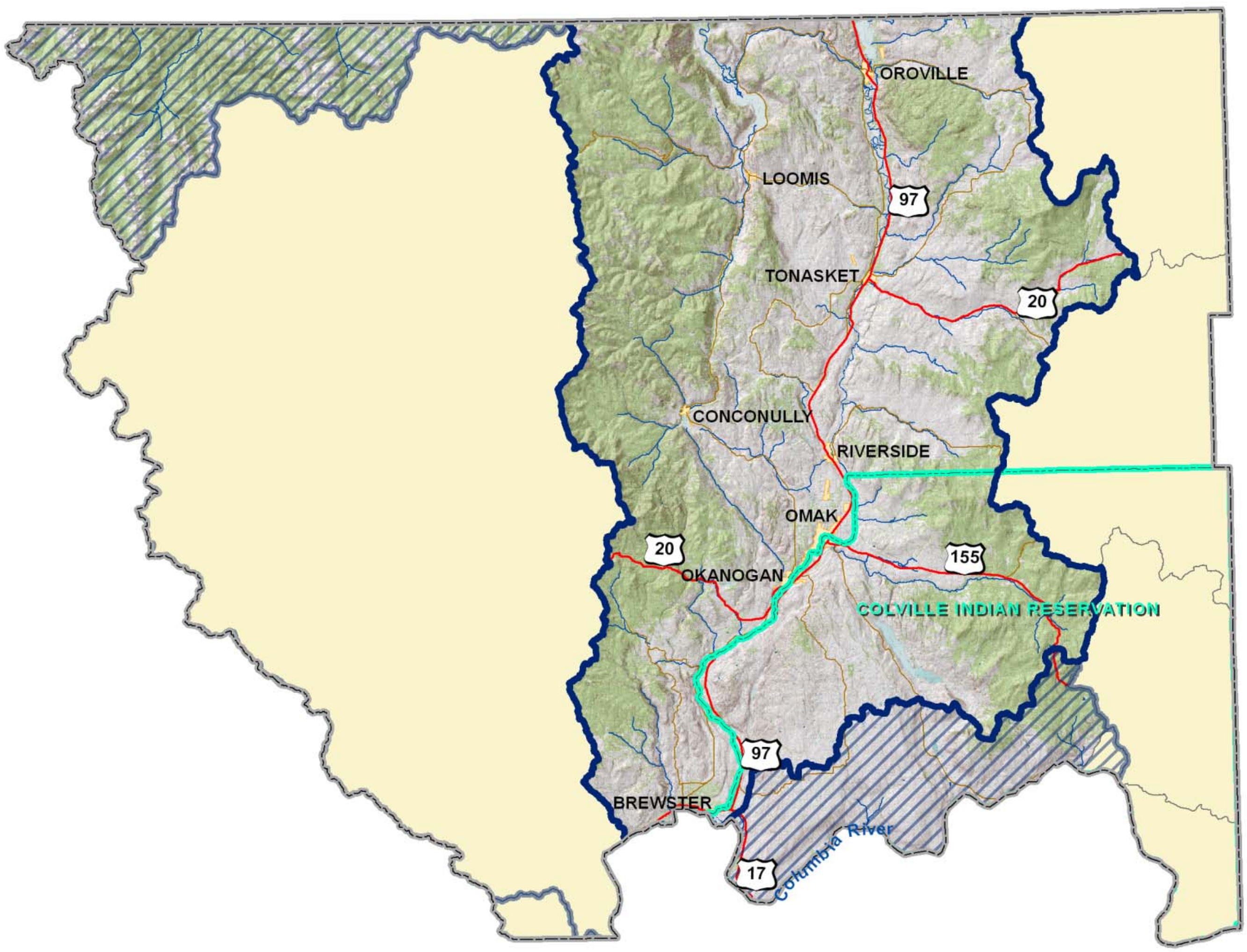
OKANOGAN WATERSHED PLAN

Level 1 Technical Assessment



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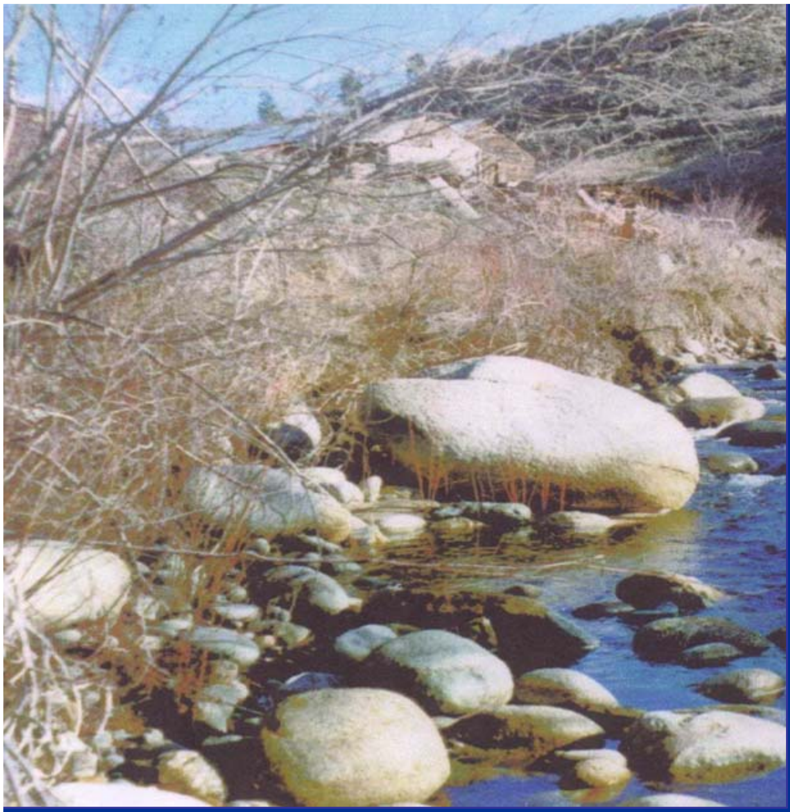
Level 1 Watershed Technical Assessment



FINAL REPORT

Okanogan River Watershed Resource Inventory Area 49

September 2006

Project No. 4138301

Prepared for:

Okanogan Watershed Planning Unit

Prepared by:

ENTRIX, Inc.
Seattle, WA

OKANOGAN RIVER WATERSHED RESOURCE INVENTORY AREA 49

Level 1 Watershed Technical Data Assessment

Prepared for:

Okanogan Watershed Planning Unit
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List of Acronyms

AF	acre-feet
AFY	acre-feet per year
ASR	aquifer storage and recovery
BIBI	Benthic Index of Biological Integrity
BOD	biochemical oxygen demand
BOR	Bureau of Reclamation
CCT	Colville Confederated Tribes
CDAP	cumulative departure from average precipitation
cfs	cubic feet per second
CI	Commercial and Industrial
CRT	Columbia River Treaty
CWD	Coarse Woody Debris
CWSP	Coordinated Water System Plan
DDE	Dichlorodiphenyldichloroethylene
DDT	Trichloro-2,2-bis-(4'-chlorophenyl)ethane
DO	dissolved oxygen
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EMAP	Environmental Monitoring and Assessment Program
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
FWSS	future water supply strategies

GDU	Genetic Diversity Unit
GIS	Geographical Information Systems
gpm	gallons per minute
GWIS	Ground Water Information System
HCU	hydrologic unit code
HPA	Hydraulic Project Approval
HUC	hydrological unit criteria
IBI	Index of Biological Integrity
IFIM	Instream Flow Incremental Methodology
JTU	Jackson Turbidity Unit
LFA	Limiting Factors Assessment
LOD	Large Organic Debris
LSR's	Late-Successional Reserves
LWD	large woody debris
MAF	mean annual flow
MAP	Mean annual precipitation
MDD	maximum demand day
MGY	million gallons per year
MLSR	Managed Late-Success ional Reserves
NASS	National Agricultural Statistics Service
NCDC	National Climate Data Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic Atmospheric Association

NRCS	National Resource Conservation Service
NTU	nephelometric turbidity unit
NWPPC	Northwest Power Planning Council
OBMEO	Okanogan Baseline Monitoring and Evaluation Program
OCD	Okanogan Conservation District
OWC	Okanogan Watershed Committee
PCPs	Polychlorinated Biphenyls
PFC	properly functioning conditions
RCW	Revised Code of Washington
RM	river mile
RWC	Regulation of Washington
SaSI	Salmonid Stock Inventory
SASSI	Salmon and Steelhead Habitat Inventory
SAV	submerged aquatic vegetation
SCS	Soil Conservation Service
SHB	State House Bill
SOSCP	South Okanagan-Similkameen Conservation Program
SRA	Salmon Recovery Act
SRFB	Salmon Recovery Funding Board
SSHEAR	Salmonid Screening Habitat Enhancement and Restoration
SSHIAP	Salmon, Steelhead Habitat Inventory and Assessment Project
TAG	Okanogan Technical Advisory Group
TDS	total dissolved solids

TMDLs	Total Maximum Daily Loads
TSS	total suspended solids
TWR	Trust Water Right program
USACE	Army Corps of Engineers
USFS	United States Forest Service
USGS	US Geological Survey
WAC	Washington Administrative Code
WAU	watershed assessment unit
WCC	Washington Conservation Commission
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WDOE	Washington Department of Ecology
WNDR	Washington Department of Natural Resources
WQI	water quality index
WRATS	Washington Department of Ecology Water Right Application Tracking System
WRCC	Western Region Climate Center
WRF	Water Resources Forum
WRIA	Water Resource Inventory Areas
WSA	Watershed Analysis
WSP	Wild Salmon Policy
WWTIT	Western Washington Treaty Indian Tribes

Glossary of Terms

303 (d) List – The federal Clean Water Act requires states to maintain a list of stream segments that do not meet water quality standards. The list is called the 303(d) list because of the section of the Clean Water Act that makes the requirement.

A

abiotic factors – Physical environmental factors (i.e. water, temperature, soil, light) that influence the composition and growth of an ecosystem.

acre-foot – A measurement of water. The volume of water required to cover 1 acre of land to the depth of 1 foot.

adaptation – A specific structure or behavior that helps an organism survive and reproduce in a particular environment; the process that enables organisms to become better suited to their environment.

Adaptive management – Monitoring or assessing the progress toward meeting objectives and incorporating what is learned into future management plans.

Adfluvial – Migratory between lakes and rivers or streams or, life history strategy in which adult fish spawn and juveniles subsequently rear in streams but migrate to lakes for feeding as subadults and adults. *Compare fluvial*.

adjudication – A determination by the State Superior Court of the relative rights of the various claimants to use water from a water source.

Administratively Withdrawn Areas – A land management designation for federally-administered lands within the range of the northern spotted owl (LJSFS and BLM 1994). Administratively Withdrawn Areas are identified in current Forest and District Plans or draft plan preferred alternatives and include recreation and visual areas, back county, and other areas where management emphasis precludes scheduled timber harvest.

aerobic – Living, active, or occurring in the presence of oxygen. For instance, soil microorganisms which degrade sewage effluent from septic systems need oxygen in order to function.

aggradation – The geologic process of filling and raising the level of the streambed or floodplain by deposition of material eroded and transported from other areas.

agriculture – The science or process of farming or cultivating the soil for the production of plants and animals that will be useful to humans in some way.

alderfly – An aquatic macroinvertebrate of the order *Megaloptera*. Alderfly larvae have projections or filaments, but no wings. They are somewhat sensitive to pollution.

alevins (also sac fry or yolk-sac fry) – Larval salmonid that has hatched but has not fully absorbed its yolk sac, and generally has not yet emerged from the spawning gravel. Absorption of the yolk sac, the alevin's initial energy source, occurs as the larva develops its mouth, digestive tract, and excretory organs and otherwise prepares to feed on natural prey.

algae – Varied aquatic protists (single celled phytoplankton members of the plant community with nuclei); they lack vascular tissue, and are usually photosynthetic.

algal bloom – An explosive population increase in algae that occurs when large amounts of phosphates and/or nitrates enter a body of water in the presence of warm temperatures.

Allocation – Designation by Dept. of Ecology of specific amounts of water resource for specific beneficial uses. (WAC 173-500-050).

Alluvial fan – A relatively flat to gently sloping landform composed of predominantly coarse grained soils, shaped like an open fan or a segment of a cone, deposited by a stream where it flows from a mountain valley onto a plain or broader valley, or wherever the stream gradient suddenly decreases. Alluvial fans typically contain several to many unconfined, distributary channels that migrate back and forth across the fan over time. This distribution of flow across several stream channels provide for less erosive water velocities, maintaining and creating suitable rearing salmonid habitat over a wide range in flows. This landform has high subsurface water storage capacity. They frequently adjoin terraces or floodplains.

Alluvial – Originated through the transport by and deposition from running water. An example is a deposit of sand or mud.

Alluvium – Sediment such as clay, silt, sand, gravel of other sediments deposited by running water.

ambient monitoring – Monitoring that is done to determine existing environmental conditions, contaminant levels, rates, or species in the environment, against which future conditions can be compared.

anadromous fish – Species, such as salmon and steelhead, which hatch in fresh water, spend a large part of their lives in the ocean, and return to fresh water rivers and streams to spawn.

anaerobic – Lacking or not needing oxygen.

andesitic – pertaining to a volcanic igneous rock containing plagioclase feldspar with a sodium to calcium ratio in the andesine range.

annelids – Aquatic macroinvertebrates of the phylum Annelida; segmented worms with bilateral symmetry, closed circulatory systems, and complete digestive systems; includes leeches.

apparent color – The color given to water by dissolved substances and suspended matter (i.e. metallic ions, plankton, algae, industrial pollution, and plant pigments). Apparent color provides useful information about the water's source and content.

appropriation – The process of legally acquiring the rights to specific amounts of water for application to beneficial uses. (WAC 173-500-050)

aquaculture – The production of fish, shellfish, invertebrates, and plants in marine, brackish, or freshwater.

aquatic – Living or growing in or on the water.

aquatic ecosystem – Any body of water, such as a stream, lake or estuary, and all organisms and nonliving components within it functioning as a natural system.

aquatic worms – Aquatic macroinvertebrates without legs, including flatworms (planaria), roundworms (nematodes), and freshwater earthworms (oligochaetes). They can tolerate pollution.

Aquifer Protection Areas – A special district allowing monthly fees on water withdrawals or on-site sewage disposal to finance the protection, preservation, and rehabilitation of ground water. Aquifer Protection Areas are created when County legislative authorities resolve to submit a ballot proposition to registered voters within the proposed protection area and voters approve the measure by a simple majority.

Aquifer – The underground layer of rock or soil in which groundwater resides capable of yielding a significant amount of water to wells or springs. Aquifers are replenished or recharged by surface water percolating through soil.

aquitard – A layer of rock or unconsolidated sediments that will not yield water in a usable quantity, and retards vertical flow.

arrow arum – *Peltandra virginica* or duck corn. Arrow arum is emergent vegetation found in freshwater wetlands; its seeds develop in spike-shaped pods.

artesian wells – Wells that tap confined aquifers and whose static water level is higher than the level of the aquifer.

assessment – An evaluation.

atmosphere – The gaseous mass or envelope surrounding the earth.

attenuation – The process of reducing the amount and concentration of contaminants in water. Includes physical, chemical, and biological processes as well as dilution.

autumn-flowering clematis – *Clematis terniflora*, exotic invasive plant that grows in intermittently flooded lowland forests.

B

bacteria – (singular bacterium) Phytoplankton; single-celled prokaryotic organisms.

bald eagle – *Haliaeetus leucocephalus*, a North American eagle, having a dark body and a white head and tail. The white head develops once they are mature at age 5.

banded killifish – *Fundulus diaphanous*, a native fish found in major river drainage areas.

bank erosion – The process in which individual soil particles of a stream bank are carried away as the stream channel moves. The amount of erosion is affected by vegetation, soil composition of the bank, flow of water in the stream, and runoff from the land.

bank slumping – An indication of the degree of bank erosion. A healthy habitat has gentle bank slopes and no evidence that the stream is undercutting the bank. *See bank erosion*.

bank vegetation – Trees, shrubs, grasses, and other vegetation growing on the stream bank.

bar scalping – Removal of gravel from river gravel bars to prevent bed aggradation for flood control and/or as a source of commercial gravel.

basalt – A fine-grained, dark-colored rock, formed by solidification from a molten or partially molten state.

base flow – Regulatory base flow: A level of streamflow established in accordance with provisions of Ch. 90.54 RCW required in perennial streams to preserve wildlife, fish, scenic, aesthetic, and other environmental, or navigational values. (WAC 173-500-050) 2) Hydrologic base flow: That portion of stream flow sustained by ground water seeping into stream rather than directly from storm runoff. (*see hydraulic continuity*)

basin – The area of land that drains water, sediment and dissolved materials to a common point along a stream channel.

bay – A body of water partly enclosed by land, but having a wide outlet to the sea.

bedload – A description of a process whereby stream flows, channel shape, and sediments are in constant interaction working to come to an equilibrium. Sediments moving through the system causing changes in channel shape until they are flushed out of the system or deposited in stable areas are called also called bedload. When additional levels of sediment are put into a stream (i.e, through landslides, road construction), a bedload can mean the amount of material being transported through the system.

beefsteak plant – *Perilla frutescens*, an exotic invasive plant, originally from Asia, that grows in a clearing (meadow or field).

beetle – An aquatic macroinvertebrate with larvae that have lateral filaments off their sides, a hook at the end of their body, and no wings. Adults have outer wings and are often black in color. The larvae are somewhat sensitive to pollution.

bend – A change in the direction of a stream channel and the flow of water in the stream.

beneficial uses – Uses of water for domestic, stock watering, industrial, commercial, agricultural, irrigation, hydroelectric power production, mining, fish and wildlife maintenance and enhancement, recreational, and thermal power production purposes, and preservation of environmental and aesthetic values, and all other uses compatible with the enjoyment of the public waters of the state.
(WAC 173-500-050).

Benthic Index of Biological Integrity (BIBI) – is a benthic macroinvertebrate multimetric index designed and calibrated for use in Puget Sound Lowlands.

benthic plants – Aquatic plants that grow attached to or rooted to the bottom of the body of water and withdraw nutrients from the sediment.

benthos – Organisms that live on or in the bottom sediments of a water body.

best management practices (BMP) – Methods, measures, or practices designed to prevent or reduce water pollution. Not limited to structural and nonstructural controls, and procedures for operations and maintenance. Usually, BMPs are applied as a system of practices rather than a single practice.

biochemical oxygen demand (BOD) – A measure of the quantity of oxygen used by organisms to decompose organic matter, usually measured at the end of a five-day period.

biodegradation – The conversion of organic compounds into simpler compounds through biochemical activity. Toxic compounds can sometimes be converted into non-toxic compounds through biodegradation. Unfortunately, in some cases, complex compounds are first converted into intermediate substances that can be more toxic than the original substance.

biodiversity – Refers to variety of organisms, their genetic information and the biological communties where they live.

biological diversity (biodiversity) – Variety and variability among living organisms and the ecological complexes in which they occur; encompasses different ecosystems, species, and genes.

biological treatment: A wastewater treatment process that uses heavy growth of microorganisms for the purpose of oxidizing, absorbing, and absorbing wastewater impurities, both organic and inorganic. Secondary treatment plants usually provide biological treatment.

biotic integrity – Capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region; a system's ability to generate and maintain adaptive biotic elements through natural evolutionary processes.

C

caddisflies – Aquatic macroinvertebrates of the order *Trichoptera*. Larvae have three pairs of legs, hooks on the end of their abdomen, and no wings. Larvae are sensitive to pollution.

candidate species – Those plants and animals that are being considered by the USFWS for listing as threatened or endangered under the Endangered Species Act.

canopy – Overhanging tree cover.

carnivore – A meat eater; a consumer that eats other consumers.

casing – A metal or plastic pipe installed in a well to maintain the well opening, especially in loose or unconsolidated formations.

cattails – *Typha spp.*, emergent vegetation of freshwater marshes and wetlands; tall perennial plants.

channel stability – Tendency of a stream channel to remain within its existing location and alignment.

channelization – Straightening the meanders of a river; often accompanied by placing riprap or concrete along banks to stabilize the system.

channelized stream – A stream that has been straightened, runs through pipes or revetments, or is otherwise artificially altered from its natural, meandering course.

check dams – Series of small dams placed in gullies or small streams in an effort to control erosion, commonly built during the 1900s.

Chelan Agreement – An unsigned agreement in 1990 between State government, the Tribes, and other water resource interests outlining a consensus-based approach to water resource issues. The agreement called for the creation of a state-level Water Resources Forum and 2 pilot planning projects to test the approach and was funded by the Washington State Legislature.

chlorinated – Water treated with chlorine as a disinfectant.

cistern – large, permanent structure designed to catch, filter, and divert rain water into a storage area. Catchments include house, barn, and shed roofs, parking lots, paved surfaces or specially constructed impervious surfaces. Stored water is generally used for irrigation.

clam – An aquatic macroinvertebrate of the *phylum Mollusca*, the clam is enclosed within two shells and feeds by filtering stream water through its shells; it is somewhat sensitive to pollution.

Clarity – Clearness.

clay – Suspended sediment, streambed or soil component material with a particle size of 0.00024-0.004 mm in diameter, smaller than a grain of sand.

cleanup activities – ions taken by a public agency or a private party to correct an environmental problem. Activities can include either the prevention of pollution by the treatment or control of contaminants (for example, treatment of wastewater before discharge) or the removal from the environment of contaminants introduced by past practices (for example, digging up and incinerating soil contaminated with dioxin).

cloud cover – The amount of sky covered by clouds, usually characterized as: partly cloudy (10 percent to 50 percent of sky covered by clouds); or cloudy (50 percent to 90 percent of sky covered by clouds).

coagulation – The process in which chemicals react with suspended particles in a liquid to form a sticky precipitate.

coliform bacteria – A type of bacteria which includes many species. Fecal coliform bacteria are those coliform bacteria which are found in the intestinal tracts of mammals. The presence of high numbers of fecal coliform bacteria in a water body can indicate the release of untreated wastewater, and/or the presence of animals, and may indicate the presence of pathogens.

common reed – *Phragmites australis*, an exotic invasive plant that grows in intermittently flooded lowland forest.

community – Two or more populations of different species living and interacting in the same area.

community water system distribution structures – *Group A* water systems have 15 or more service connections or serve an average of 25 or more people per day for 60 or more days a year. *Group B* water systems have less than 15 connections and serve an average of less than 25 people each year. (WAC 246-290) cone of depression: The depression in the water table or potentiometric surface around a pumping well caused by water withdrawal.

competitors – Individuals or species that both require the same limited resource to survive.

compost – A mixture of decaying organic matter, such as leaves and manure, that can be used as a plant fertilizer.

confined aquifer – An aquifer overlain by a confining bed in which the water level in a well drilled into the aquifer stands above the base of the confining bed: A geologic unit with low permeability (hydraulic conductivity) that restricts movement of water into or out of the aquifer.

confluence – Joining.

consumer – An organism that eats other organisms because it is unable to make its own food; a heterotroph.

consumptive use – Use of water where there is diversion or diminishment of the water source.
(WAC 173-500-050).

contaminant – A substance that is not naturally present in the environment or is present in unnatural concentrations or amounts and which can, in sufficient concentration, adversely alter an environment.

control – A condition in a scientific experiment that remains the same.

coontail – A submerged aquatic vegetation (SAV), *Ceratophyllum demersum*; abundant in lakes, streams, marshes, and ditches in a depth of up to 18 feet; tolerant of nutrient-rich water and fluctuating water levels. It has leaves in whorls of 5-12 and can form thick masses.

Coordinated Water System Plan (CWSP) – A plan for public water systems within a critical water supply service area which identifies the present and future water system concerns and sets forth a means for meeting those concerns in the most efficient manner possible. (Ch. 248-56-200).

cordillera – A group of mountain ranges including valleys, plains, rivers, lakes, etc., having one general direction.

crab – An aquatic macroinvertebrate of the *phylum Arthropoda*, class *Crustacea*. The crab is a bottom-dwelling predator.

crane fly – An aquatic macroinvertebrate of the order *Diptera*, a true fly. The larvae are large and fleshy with short tentacles at one end. Crane flies are somewhat sensitive to pollution.

crayfish – An aquatic macroinvertebrate of the *phylum Arthropoda*, class *Crustacea*. Crayfish have more than three pairs of legs and two pairs of antennae, with eyes on stalks and a hard covering on the back; somewhat sensitive to pollution.

Cretaceous – pertaining to the Cretaceous Period, the third and latest of the three periods on the geologic time scale comprising the Mesozoic Era. Can also be used to describe rock units formed during the Cretaceous Period.

critical areas – A category of land for protection under the Growth Management Act of 1990 including aquifer recharge, critical fish and wildlife habitat, seismic hazard, wetland, and flood hazard areas.

critical stocks – Stocks of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.

croplands – Land used for agriculture.

crustacean – An aquatic macroinvertebrate of the *phylum Arthropoda*, class *Crustacea*; includes crayfish and crabs. They have more than three pair of legs and two pairs of antennae. *See crayfish*.

cultivate – To prepare land for crops by plowing and fertilizing.

cultural eutrophication – Human-caused eutrophication; usually a very rapid process that can result in the death of an ecosystem.

cumulative effects – Those effects on the environment that result from the incremental effect of the action when added to the past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.

D

damselfly – An aquatic macroinvertebrate of suborder *Zygoptera*. The larvae have three pairs of legs, one pair of antennae, and wing pads with feathery gills protruding from the abdomen. Larvae are somewhat sensitive to pollution.

daphnia – Genus *Daphnia*; small freshwater crustaceans.

data – Recorded observations and information.

data analysis – An evaluation of collected observations and information.

debris torrent – Rapid movements of material, including sediment and woody debris, within a stream channel. Debris torrents frequently begin as debris slides on adjacent hillslopes.

decomposers – A group of organisms, mainly fungi and bacteria, that digest organic material and release nutrients into the environment.

decomposition – The process of decay; the breaking down of organic matter into its component parts.

degradation – The lowering of the streambed or widening of the stream channel by erosion. The breakdown and removal of soil, rock and organic debris.

degrade – To reduce; to decompose by stages; to wear away by erosion.

degrees of latitude/longitude – Angular units defined by circular lines around the Earth; used to measure distance north or south of the Equator (latitude) and east or west of the Prime Meridian (longitude).

density – The mass of a substance per unit volume; the number of inhabitants per unit in a geographical region; the degree to which anything is filled or occupied; the degree of thickness.

dependent variable – A responding variable; a factor or condition that might change as a result of a change in a manipulated independent variable.

deposition – The accumulation of riverborne sediments when energy of the stream decreases below the level required for sediment transport.

depressed stocks – A stock of fish whose production levels are below expected levels based on available habitat and natural variation in survival rates, but above the level where permanent damage is likely. (SASSI)

detention – The process of collecting and holding back stormwater for later release to receiving waters.

diatoms – Phytoplankton of the class *Bacillariophyceae*. Diatoms are minute, unicellular or colonial algae having siliceous cell walls consisting of two overlapping, symmetrical parts.

dinoflagellates – A type of protist that includes photosynthetic forms in which two flagella project thorough armor-like plates. Abundant in oceans, these sometimes reproduce rapidly, causing "red tides".

discharge – The release of wastewater or contaminants to the environment. Direct discharge of wastewater flows directly into surface waters, while an indirect discharge of wastewater enters a sewer system.

dissolved load – Sediment made up of organic and inorganic material carried in solution by moving water.

dissolved oxygen (DO) – Oxygen which is present (dissolved) in water and therefore available for fish and other aquatic animals to use. If the amount of DO in the water is too low, marine animals suffer from suffocation. Wastewater often contains oxygen-demanding substances that can consume dissolved oxygen if discharged into the environment. The amount of oxygen dissolved in water; varies with water temperature and pressure; measured in milligrams of oxygen per liter of water, parts per million, or percent saturation.

distillation – A process used to clean water. Steam from a sample of boiling water is almost completely free of impurities. In distillation, the steam is collected and allowed to condense back into water.

diversity – Variety; difference.

diving beetle – Predatory aquatic beetles from the family *Dytiscidae*.

DNA – Deoxyribonucleic acid; nucleic acid macromolecule that stores and transmits the genetic information of all living cells from one generation to the next.

doctrine of prior appropriation – The right to use water acquired earlier in time is superior to a similar right acquired later in time. "First in time, first in right."

domestic wastewater – The wastewater that flows from sinks, toilets, showers, and other facilities that are routinely used by people.

dragonfly – An aquatic macroinvertebrate of the suborder Anisoptera. The larvae have three pair of legs, one pair of antennae, and wing pads. Larvae are somewhat sensitive to pollution.

drainage basin – A watershed; the land area where precipitation runs into streams, rivers, lakes, and reservoirs. It can be identified by tracing a line along the highest elevations, often a ridge, between two areas on a map. Also called the watershed of the receiving water body.

drainage divide – A boundary line along a hilly or mountainous area that separates two adjacent drainage basins.

drawdown – A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping groundwater from wells.

dredging – Any physical digging into the bottom of a water body. Dredging can be done with mechanical or hydraulic machines and either changes the shape and form of the bottom or removes sediment that has been deposited over the bottom.

dungeness Water Users Association – Purveyors of agricultural water comprised of 9 representatives from irrigation districts and companies. The association functions by consensus agreement.

E

E. coli – *Escherichia coli* of the family Enterobacteriaceae; fecal coliform bacteria. E. coli is present in the lower intestine of humans and warm-blooded animals, but rarely present in unpolluted waters.

ecological restoration – Involves replacing lost or damaged biological elements (populations, species) and reestablishing ecological processes (dispersal, succession) at historical rates.

ecology – The study of the interrelationships of organisms with each other and their nonliving environment.

ecosystem – community of living organisms interacting with one another and with their physical environment. A system such as Puget Sound can also be thought of as the sum of many interconnected ecosystems such as the rivers, wetlands, and bays. Ecosystem is thus a concept applied to communities of different scale, signifying the interrelationships that must be considered.

ecosystem management – Management that integrates ecological relationships with sociopolitical values toward the general goal of protecting or returning ecosystem integrity over the long term.

eel grass – Submerged aquatic vegetation (SAV) of the genus Zostera; found in coastal areas; has narrow, grass-like leaves and grows in dense masses.

effective impervious surface – se impervious surfaces that are connected via sheet flow of discrete conveyance to a drainage system.

effluent – liquid waste of sewage and industrial processing.

embayment – An indentation in a shoreline forming an open bay.

emergent vegetation – Benthic plants that grow partly in water and partly emerging from water (i.e. cattails, arrow arum, pond lily, phragmites).

encroach – To intrude gradually upon the area of another; to advance beyond proper limits.

endangered species – Any species of plant or animal defined through the Endangered Species Act as being in danger of extinction throughout all or a significant portion of its range, and published in the Federal Register. Means any species which is in endanger of extinction throughout all or a significant portion of its range other than a species of the Class *Insecta* as determined by the Secretary to constitute a pest whose protection under would provide an overwhelming and overriding risk to man.

Endangered Species Act (ESA) – A 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife, and plants be protected and restored.

english ivy – *Hedera helix*, an exotic invasive plant, originally from Europe, that grows at the wood's edge.

english plantain – *Plantago lanceolata*, an exotic invasive plant, originally from Europe, which grows in a clearing (meadow or field).

Environmental Impact Statement (EIS) – A document that discusses the likely significant impacts of a development, project, or a planning proposal, ways to lessen the impacts, and alternatives to the project or proposal. EISs are required by the National and Washington State Environmental Policy Acts.

environs – Surroundings; environment.

eocene – Second geologic epoch of the Tertiary Period, 37-54 million years ago. The series of strata deposited during that epoch.

eradicate – To remove all traces of; to erase.

erosion – Process by which earth material is transported from one area to another by an agent such as water or wind.

erosion – Wearing away of rock or soil by the gradual detachment of soil or rock fragments by flowing water, wind, freeze/thaw cycles, landslides, bedrock decomposition, and other weathering.

escapement – The number of adult fish that survive or "escape" fishing gear to migrate upstream to spawning grounds.

esker – Eskers or kames are rudely stratified accumulations of gravel, sand, and waterworn stones which occur in long ridges, mounds, and hummocks. Serpentine ridges of gravel and sand, believed to mark channels in the decaying ice sheet through which streams washed much of the finer drift, leaving the coarser gravel between the ice walls.

estuarine – A partly enclosed coastal body of water that has free connection to open sea, and within which seawater is measurably diluted by fresh river water.

estuary – A coastal water body where ocean water is diluted by out-flowing fresh water.

eutrophic – Water body rich in dissolved nutrients, photosynthetically productive, and often deficient in oxygen during warm periods. Compare *oligotrophic.*

eutrophication – A natural process in which there is an enrichment of water by nutrients, causing accelerated growth of algae and higher forms of plant life.

evapotranspiration – That portion of the precipitation returned to the air through direct evaporation and by transpiration of plants.

evolution – Any change in the overall genetic composition of a population of organisms from one generation to the next.

Evolutionary Significant Unit (ESU) – A definition of a species used by National Marine Fisheries Service (NMFS) in administering the Endangered Species Act (ESA). An ESU is a population (or group of populations) that (1) is reproductively isolated from other nonspecific population units, and (2) represents an important component of the evolutionary legacy of the species.

exceedance – failure to meet a numeric water quality criteria or guideline. Values may be above a threshold (e.g., temperature), or below the recommended criteria (dissolved oxygen). In this report, both would be considered an exceedance of the criteria.

exempt wells – Domestic water wells not requiring a water right from a state department of ecology. Under current law use from one well must be less than 5000 gpd and used for domestic purposes and/or the irrigation of no more than one-half acre of lawn or non-commercial garden.

exoskeleton – A hard, external body covering that provides support for tissues and organs and protects the organism from predators. Arthropods have exoskeletons.

exotic species – Non-native plants and animals living in the wild in areas outside their native boundaries.

extinct – A species with no living members. All members of a species are dead; the end of a species.

extinct stock – A stock of fish that is no longer present in its original range, or as a distinct stock elsewhere. Individuals of the same species, but different stock, may be observed in very low numbers in the extinct stock range, consistent with straying from other stocks. (SASSI)

extirpation – The elimination of a species from a particular local area.

F

fish-bearing streams – Any stream containing any species of fish for any period of time.

fisheries enhancement – Fisheries enhancement is an action taken to create conditions in the biological environment that optimizes survivorship of the fish population in question.

flood – An abrupt increase in water discharge; typically flows that overtop streambanks.

flood plain – Land bordering a stream or river and subject to flooding.

floodway – The channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment, such as artificial fill, in order that the 100-year flood be carried without substantial increases in flood heights.

flow line – The theoretical path followed by groundwater.

flow rate – The volume of flow per time (e.g., gallons per minute/gpm, or cubic feet per second/cfs).

fluvial – Of or belonging to rivers.

forest practice – Any activity conducted on or directly pertaining to forest land and relating to growing, harvesting, or processing timber. These activities include but are not limited to road and train construction; final and intermediate harvesting; precommercial thinning: reforestation; fertilization, prevention and suppression of disease and insects; salvage of trees: and brush control.

fecal coliform – *Escherichia coli, E. Coli*; of the family *Enterobacteriaceae*; bacteria naturally abundant in the lower intestine of humans and other warm-blooded animals, but rare in unpolluted waters.

fertilizer – Natural or synthetic materials used to increase the fertility of soil. A significant ingredient in urban and agricultural runoff that stimulates the growth of algae and other aquatic plants.

filtration – The process of removing suspended particles from untreated water by passing the water through porous substances; part of the process to convert raw water into higher quality water.

fishfly – An aquatic macroinvertebrate of the order *Megaloptera;* larvae have many filamentous appendages on each side of the abdomen, two hooked tails, six jointed legs, and large pinchers for mouth parts; somewhat sensitive to pollution.

flocculation – Part of a water-cleaning process in which small sticky particles clump together to make larger and heavier particles (floc). The larger particles eventually sink to the bottom of a containment area and can then be removed.

fluoridation – Part of the water treatment process in which hydrofluorosilicic acid is added to untreated water. The presence of fluoride in water reduces tooth decay.

folding – the bending of rock layers (stratigraphic units) due to deviatoric stresses such as tectonic forces or subsidence.

food chain – A series of steps from producers to consumers to decomposers; one possible way food and energy are transferred through an ecosystem.

food web – All feeding relationships of organisms in an ecosystem.

forage – The act of searching for food or provisions.

forest – A dense growth of trees, together with other plants, covering a large area.

fossil – The preserved remains or evidence of ancient organisms. Impressions of body forms or markings made by organisms may be preserved in rock, petrified bones, or wood.

fossil fuel – Substances derived from the decomposition of prehistoric plants an animals that can be burned to produce energy (i.e. coal, oil, and natural gas).

freshwater – Water that is not saline or brackish. Water that is low in salts, containing less than 1,000 mg/L of dissolved solids.

fungus (plural fungi) – A type of phytoplankton; made of eukaryotic cells with cell walls; obtain food by absorbing organic substances.

G

geologic map – A map showing the aerial distribution of geologic units and the attitude or structure of those units.

geomorphic – Pertaining to the form or shape of those processes that affect the surface of the earth.

GIS – Geographic Information System.

glaciation – Alteration of the earth's solid surface through erosion and deposition by glacier ice.

glacier – A mass of ice with definite lateral limits, with motion in a definite direction, and originating from the compaction of snow.

graben – n elongate crustal block that is relatively depressed (downdropped) between two fault systems.

granitic – pertaining to a plutonic igneous rock consisting essentially of alkali feldspar and quartz.

gravel trap – Holes of almost any size dug along side the river during a low flow period in areas of excessive bedload movement. In times of high water the holes fill with sediment moving down stream, thereby lessening bed aggradation.

grey water – Waste water from clothes washers, dish water, and bathing.

groundwater – All waters that exist beneath the land surface or beneath the bed of any stream, lake, or reservoir, or other body of surface water, whatever may be the geologic formation or structure in which such water stands or flows, percolates, or otherwise moves. (Ch. 173-100 WAC) Ground water is created by rain which soaks into the ground and flows down until it is collected and stored at a point where the ground is not permeable, forming natural underground water supplies. Ground water then usually flows laterally toward a river, lake, or the ocean, where it discharges.

groundwater advisory committee – A committee appointed by the Department of Ecology to assist in the development of a ground water management program. (Ch. 173-100 WAC)

groundwater divide – A line separating two regions of diverging flow.

groundwater flow – The movement of water through openings in sediment and rock.

groundwater management – comprehensive program designed to protect ground water quality, to assure ground water quantity, and to provide for efficient management of water resources while recognizing existing ground water rights and meeting future needs consistent with local and state objectives, policies, and authorities within a designated ground water management area or subarea and developed pursuant to Ch. 173-100

groundwater management zone – Any depth or stratigraphic zone separately designated by the Department of Ecology in cooperation with local government for ground water management purposes within a ground water management area. Ground water management zones may consist of a specific geologic formation or formations or other reasonable bounds determined by Ecology consistent with Ch. 173-100 WAC. Also known as groundwater management area.

H

habitat – The specific area or environment in which a particular type of plant or animal lives. An organism's habitat must provide all of the basic requirements for life and should be free of harmful contaminants. It is the physical template upon which communities express themselves and the distribution of species and communities across the landscape is a direct response to the distribution of habitat types.

habitat assessment – Habitat assessment is a problem analysis process to develop and document a scientifically based understanding of the processes and interactions occurring within a watershed which affect fish habitat.

habitat enhancement – Habitat enhancement is an action taken to create conditions in the physical environment that optimize survivorship of the population in question.

habitat protection – Habitat protection means an action taken or a decision made that protects the physical and/or biological environment in a watershed.

habitat restoration – Habitat restoration means an action taken to correct specific problems identified through watershed analysis or other full watershed inventory processes.

hardness – A measure of the amount of calcium, magnesium, and iron dissolved in the water.

harvesting – The process of gathering a crop.

hazardous waste – Any solid, liquid, or gaseous substance which, because of its source or measurable characteristics, is classified under state or federal law as hazardous and subject to special handling shipping storage, and disposal requirements. Washington state law identifies two categories, dangerous and extremely hazardous. The latter category is more hazardous and requires greater precautions.

head, total – The sum of the elevation head, the pressure head, and the velocity head at a given point in an aquifer.

healthy stock – A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock. (SASSI)

hellgrammite – An aquatic macroinvertebrate of the order *Megaloptera*; also called dobsonfly. Larvae have three pair of segmented legs and four terminal hooks on their abdomen; sensitive to pollution.

herbicide – A pesticide which is usually toxic used to destroy or inhibit growth of vegetation.

herbivore – An organism that eats only plants; a primary consumer.

heterogeneous aquifer – An aquifer having different characteristics in different locations. A synonym is nonuniform.

homogeneous aquifer – An aquifer having identical characteristics everywhere. A synonym is uniform.

humus – Decayed remains of organisms. The addition of humus to soil enriches it with organic material and increases the capacity of the soil to hold air and water.

hybridization – The interbreeding of fish from two or more different stocks.

hydraulic conductivity – A measure of the rate at which water will move through soil or a rock layer.

hydraulic continuity – The natural interconnections between groundwater and surface waters.

hydraulic gradient: Change in head between two points divided by the distance between the points (i.e., slope).

Hydraulic Project Approval (HPA) – Under the Hydraulic Code Rules, approval is required from WDFW for certain activities in state waters that support fish life. A project approval is required for such activities affecting state waters such as certain forest practices; culvert construction, bridge, pier, and piling construction; bulkheads; boat launches; dredging; and gravel traps.

hydrilla – Submerged aquatic vegetation (SAV), *Hydrilla verticillata*; non-native invasive plant with branched stems up to 25 feet long; found in all types of water bodies.

hydrogeology – The study of the interrelationships of geologic materials and processes with water, especially ground water.

hydrograph – Chart of water levels over time.

hydrologic base flow – See *base flow*.

hydrologic cycle – The continual cycling of water between the land, the sea, and the atmosphere through evaporation, condensation, precipitation, absorption into the soil, and stream runoff.

hydrologic unit code (HUC) – A hydrologic unit is a reference to the area of land upstream from a specific point on a surface waterbody and is defined by a hydrologic boundary that includes the area draining to that point; it is a delineation of a catchment or watershed. Hydrologic Unit Codes reference the scale of watershed delineation (hydrologic boundary), and are conventionally described at 'field' levels. Increasing HUC numbers define more discrete areas. Subbasins in the Okanogan (e.g., Joseph Subbasin) are mapped at the fifth-field (HUC-5) scale, and capture within them several HUC-6 tributaries.

hydrostratigraphic unit – A formation, part of a formation, or a group of formations in which there are similar hydrologic characteristics allowing for grouping into aquifers or confining layers.

hypothesis – A possible, testable explanation, based on an educated guess and previous observations; a proposed solution to a scientific problem.

hypsithermal period – Postglacial warm interval extending from about 7000 to 600 BC responsible for the last 6-foot rise of world-wide sea level.

I

immiscible – Incapable of blending or mixing. In part of the process of converting untreated water into drinkable water, the water must be held undisturbed for a period of time to allow the immiscible pollutants to separate from the water.

impervious – Not capable of being passed through, damaged, or disturbed. (Water is not able to flow through asphalt roads, concrete sidewalks, etc.)

Inchoate water right – a water right that has been permitted but not yet perfected in use and thus not certificated (only municipal water rights may be held in inchoate status without relinquishment).

incinerator – An apparatus used for burning waste at very high temperatures; a furnace.

independent variable – A manipulated variable; a factor or condition that changes naturally or is intentionally manipulated by the investigator to observe the effect.

Index of Biological Integrity (IBI) – is a synthesis of diverse biological information which numerically depicts associations between human influence and biological attributes. It is composed of several biological attributes or 'metrics' that are sensitive to changes in biological integrity caused by human activities. The multi-metric (a compilation of metrics) approach compares what is found at a monitoring site to what is expected using a regional baseline condition that reflects little or no human impact.

indicator – Any of a variety of substances used to demonstrate the presence, absence, or concentration of a substance.

industrial – Related to the commercial production of goods.

inorganic – Compounds derived from non-living things that do not contain carbon.

instream flow – A base flow adopted into Washington State regulations used to condition water rights. A water right for instream resources such as fish, wildlife, recreation, esthetics, navigation, stock watering, and water quality with a priority date set when the instream flow rule was adopted.

Instream Flow Incremental Methodology (IFIM) – A method of quantitatively relating stream flow to fish or wildlife habitat area. The IFIM combines curves describing the suitability of certain velocities and water depths for selected species and life stages, with measurements of current, depth, and wetted channel width in the area of study, to produce a table relating usable habitat area to stream flow.

interbed – A typically thin bed of rock material alternating with contrasting thicker beds of rock.

interdependent – Organisms that need each other for survival.

intermittent stream – Any non-permanent flowing drainage feature having a definable channel and evidence of annual scour or deposition. This includes what are sometimes referred to as ephemeral streams if they meet both criteria.

intrusions – bodies of igneous rock that invade older rock, either as plastic rock masses or as magma.

invasive species – Organisms that spread, encroach upon, and take over the habitat of native species.

invertebrates – Animals that do not have a backbone.

Ions – An atom or group of atoms carrying a positive or negative charge as a result of having gained or lost one or more electrons.

irrigation – The application of water to soil for crop production or for turf, shrubbery, or wildlife food and habitat. Provides water requirements of plants not satisfied by rainfall.

irrigation district – A cooperative, self-governing public corporation set up as a subdivision of the state, with definite geographic boundaries, organized to obtain and distribute water for irrigation of lands within the district; created under authority of the state legislature with the consent of a designated fraction of the landowners or citizens and having taxing power.

irrigation return flow – The part of applied water that is not consumed by evapotranspiration and that migrates to an aquifer or surface water body.

isohyetal – Marking the amounts of rainfall.

isotropy – The condition in which hydraulic properties of the aquifer are equal in all directions.

J

Jackson turbidity unit (JTU) – A unit of measure for turbidity (derived from the original "Jackson Tube"). Turbidity is measured by determining the amount of light that is reflected off particles suspended in water.

Japanese honeysuckle – *Lonicera japonica*, an exotic invasive plant, originally from East Asia, which grows at the wood's edge.

junior right – A water right that is more recent in relation to other water rights, and in times of limited water is legally able to be satisfied only after other senior rights have been fulfilled.

Jurassic – pertaining to the Jurassic Period, the middle of three periods on the geologic time scale comprising the Mesozoic Era. Can also be used to describe rock units formed during the Jurassic Period.

K

key watershed – As defined by USFS and BLM fish biologists, a watershed containing: 1) habitat for potentially threatened stocks of anadromoussalmonids or other fish, or 2) greater than 6 square miles with high-quality water and fish habitat.

kilogram – Metric unit of weight equal to 1000 grams or 2.2 pounds.

kilometer – Metric unit of measure equal to 1000 meters or 0.62 miles (a square kilometer equals 0.4 square miles or 2.47 acres).

kudzu – *Pueraria thunbergiana*, an exotic invasive bean-like vine, originally from China and Japan.

L

lacustrine – pertaining to sediments deposited in fresh water lake environments, or anything else that is associated with fresh water lakes.

lake – A large inland body of salt or fresh water.

land use – The way land is developed and used in terms of the types of activities allowed (agriculture, residences, industries, etc.) and the size of buildings and structures permitted. Certain types of pollution problems are often associated with particular land use practices, such as sedimentation from construction activities.

landfill – A huge pit in the ground that is lined with clay or plastic and filled with garbage. Layers of garbage are spread out and alternated with layers of dirt or plastic.

large woody debris (LWD) – Large woody material that has fallen to the ground or into a stream. An important part of the structural diversity of streams. Usually refers to pieces at least 20 inches (51 cm) in diameter.

larva (plural larvae) – The immature stage of an organism that usually looks different than the adult form of the organism.

latitude – The angular distance on Earth's surface north or south of the Equator, expressed in degrees, minutes, and seconds.

leachate – A soluble material, such as organic and mineral salts, which is washed out of a layer of soil or debris.

leeches – An aquatic macroinvertebrate of the *phylum Annelida*, class *Hirudinea*; aquatic worms that do not have legs; tolerant of pollution.

leopard frog – *Rana pipiens*. Found all over the United States; lives in scrub, desert, ponds, rivers, and meadows, but prefers swamps in the summer; brown or green with small spots on the side; usually 2-3.5 inches long.

limiting factor – Single factor that limits a system or population from reaching its highest potential.

liter – A metric unit of volume equal to 1000 cubic centimeters or 1.06 quarts.

lithology –The study and description of rocks. Also the physical character of a rock as determined by observations made with the naked eye or with the aid of a low-power magnifier.

longitude – The angular distance on Earth's surface east or west of the Prime Meridian at expressed in degrees, minutes, and seconds.

low flow – Stream flow level limitations appearing as provisions on permits and certificates issued by the Department of Ecology or its predecessors. (WAC 173-500-050)

M

macroinvertebrates – Invertebrates (organisms) lacking a backbone and are large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods).

marsh – A wetland with few trees and woody shrubs.

mass failure – Movement of aggregates of soil, rock and vegetation down slope in response to gravity.

maximum habitat flow – See *optimum instream flow*.

mayfly – An aquatic macroinvertebrate of the order Ephemeroptera; larvae have three pair of legs, one pair of antennae, three long tail filaments, and feathery or plate-like gills on their abdomen; sensitive to pollution.

mean annual flow – The average of all flows measurable in a river system over the course of a calendar year, or hydrologic year.

medium, media – In pollution control programs, media are the components of the environment that may be contaminated with a substance. A program that handles lead contamination in all media is a cross-media program. Thus, lead can be discharged to the air, to the water, or on the land.

metals – Elements, such as mercury, lead, nickel, zinc, and cadmium, that are of environmental concern because they do not degrade overtime. Although many are necessary nutrients, they are sometimes magnified in the food chain, and they can be toxic to life in high enough concentrations.

metamorphosed sedimentary rock – sedimentary rock that has been changed (metamorphosed) through either heat or pressure or a combination of both.

meter – A metric unit of length equal to 3.28 feet or 1.09 yards (a square meter equals 10.7 square feet; a cubic meter equals 35.3 cubic feet or 1.3 cubic yards).

microbe – A microorganism; a minute life form.

microgram: A metric unit of weight equal to 1,000,000th of a gram.

microorganism – An organism of microscopic size; especially a bacterium or protozoan.

midge – An aquatic macroinvertebrate of the order *Diptera*; a true fly; larvae are very small, often C-shaped and have a spastic, squirming movement; attach themselves to debris with tiny legs; larvae are tolerant of pollution.

milligram – A metric unit of weight equal to 1000th of a gram.

minute of latitude/longitude – A unit of measurement equal to 1/60 of a degree. One minute equals 60 seconds latitude/longitude.

mixed stock – A fish stock whose individuals originated from commingled native and non-native parents, and/or by mating between native and nonnative fish (hybridization); or a previously native stock that has undergone substantial genetic alteration.

moisture content – Amount of wetness.

moiety – a molecule of similar structure, but with different atomic substitutions.

monitor – To systematically and repeatedly measure something in order to track changes. For example, nitrates in an aquifer might be *monitored* over a period of several years to identify any trends in concentration.

moratorium – A delay of action; a suspension.

municipal discharge – Effluent from a sewage treatment plant that is usually publicly owned.

N

native stock – An indigenous stock of fish that has not been substantially impacted by genetic interactions with non-native stocks or by other factors, and is still present in all or part of its original range. In limited cases, a native stock may also exist outside of its original habitat (i.e. captive broodstock programs).

native – Occurring naturally in a habitat or region; not introduced by humans.

nephelometric turbidity unit (NTU) – A unit of measure for turbidity (as measured by a nephelometer). Turbidity is measured by determining the amount of light that is reflected off particles in the water.

niche – The unique role of an organism in an ecosystem.

nitrate – A stable form of nitrogen, which is a chemical element that is a major component of proteins, and is essential to all forms of life. Ingestion of water with high concentrations of nitrate causes methemoglobanemia in infants, and may be carcinogenic to adults. One form of nitrogen plants use as a nutrient. One ion of nitrate is composed of one nitrogen atom and three oxygen atoms.

nitrogen – An non-metallic element designated with the chemical symbol N. All organisms need nitrogen to build protein.

nonconsumptive use – A type of water use where either there is no diversion from a source body, or where there is no diminishment of the water source. (WAC 173-500-050)

non-native species – A species that has been imported or brought into an area.

nonpoint source pollution – Pollution that enters water from dispersed and uncontrolled sources, such as surface runoff, rather than through pipes. Nonpoint sources, such as forest practices, agricultural practices, on-site sewage disposal, and recreational boats, may contribute pathogens, suspended solids, and toxicants.

noxious weed – A plant that is undesirable because it is harmful to other plants.

NPDES – National Pollutant Discharge Elimination System. A part of the General Clean Water Act which requires point source dischargers to obtain permits. These permits are referred to as NPDES permits and are administered by the Washington State Department of Ecology.

nutrients – Essential chemicals needed by plants or animals for growth, primarily nitrogen and phosphorus. Excessive amounts of nutrients in water can lead to degradation of water quality and the growth of excessive numbers of algae. Some nutrients can be toxic at high concentrations. *See nitrogen*

O

observation – The use of the five senses to note a phenomenon.

odor – The smell or scent of something. Chemicals from waste discharges, microbial activity, or natural sources may cause a body of water to have an odor.

off-channel habitat – Channels or ponds in a floodplain, at least seasonally connected to the primary channel, that are in addition to and frequently parallel the primary flowing channel. These generally occur in unconstrained reaches.

omnivore – An organism that eats both plants and animals.

one-half acre rule – No water right permit is required for the withdrawal of up to 5000 gallons per day from a well when the water is being used for one of several uses including the irrigation of no more than one half acre of lawn or noncommercial garden.

on-site sewage disposal system – A sewage treatment system where waste is treated on the owner's property, generally by means of bacterial breakdown in an underground septic tank and disposal of wastewater through a drainfield.

optimum instream flow – The amount of stream flow determined by IFIM to be needed to provide maximum usable fish habitat. What is optimum instream flow in any given month also depends upon the species in question. Also called maximum habitat flow. If Toe Width Method is used instead of IFIM, optimum instream flow represents spawning habitat only.

organic matter – Plant and animal residues; substances made by living organisms; contains carbon.

organic – Pertaining to or derived from a living organism; a chemical containing a carbon complex.

organism – An individual living thing.

orthophosphate – Chemistry-based term that refers to an organic phosphate where the phosphate is attached on the ortho position in a benzene ring.

outcrop – The exposure of bedrock or strata projecting through the overlying cover of weathering rocks and soil.

outwash – Rock material transported by a glacier and deposited by melt-water streams beyond active glacier ice.

overwintering ponds – Off-channel ponds linked to the river or slow-moving side channels, either naturally occurring or artificially created. Overwintering ponds offer protection from floods or any juvenile salmonids that winter over before migrating out to sea, spawning, and for primary rearing areas.

oxidation – Process by which an atom becomes more positively charged. Reactions with oxygen are the most common (e.g., formation of rust on iron).

oxygen demand – The amount of molecular oxygen required for biological and chemical processes in water.

oxygen saturation – The maximum amount of oxygen that will dissolve in water at a given temperature. Oxygen saturation is determined by pairing the temperature of the water with the dissolved oxygen value, after first correcting the dissolved oxygen measurement for the effects of atmospheric pressure.

P

PAH – Polycyclic (polynuclear) aromatic hydrocarbon. A class of complex organic compounds, some of which are persistent and cancer-causing. These compounds are formed from the combustion of organic material and are ubiquitous to the environment. PAHs are found in fossil fuels such as coal and oil and are formed by incomplete combustion of organic fuels like gasoline, wood, and oil. They are commonly formed by forest fires, wood stoves, and internal combustion engines. They often reach the aquatic environment through atmosphere fallout and highway runoff.

palustrine – A geologic term pertaining to material deposited in a wetland environment.

parameter – A characteristic substance or factor that is measured in order to describe a system. Numerous parameters, such as pH and electrical conductivity, are measured in order to gain an understanding of water quality in streams and aquifers.

parasite – An organism that lives in or on another organism, causing it harm.

pathogen – A disease-producing agent, usually applied to a living organism, especially microorganisms such as viruses, bacteria, or fungi which can be present in municipal, industrial, or nonpoint source discharges into the Sound.

PCB – Polychlorinated biphenyls including about 70 different, but closely related, man-made compounds made up of carbon, hydrogen, and chlorine. They persist in the environment and can biomagnify in food chains because they are not water soluble. PCBs are suspected of causing cancer.

peak flow – The highest amount of stream or river flow occurring in a year or from a single storm event.

penetrate – To enter or force a way into; to spread or flow throughout an area.

perched groundwater – The water in an isolated, saturated area located in the unsaturated zone. It is the result of the presence of a layer of material of low hydraulic conductivity, called a perching bed. A perched aquifer will have a perched water table.

percolation test – A test which measures the rate of movement of water into the soil and helps determine the ability of the soil to absorb waste.

perennial stream – A stream that typically has running water on a year-round basis.

perfected water right – A water right to which the owner has applied for and obtained a permit, has complied with the conditions of the permit, and has obtained a water right certificate.

permeability – The ability of a material to allow a liquid to pass through it. Permeable materials, such as gravel and sand, allow water to move quickly through them.

persistent – Compounds which are not readily degraded by natural, physical, chemical, or biological processes.

pesticide – A general term used to describe any substance-usually chemical-used to destroy or control organisms. Pesticides include herbicides, insecticides, fungicides, insecticides, and others.

pH – A scale from 0 to 14 used to measure relative acidity or alkalinity. A pH measurement less than 7 is “acidic”, 7 is neutral, and greater than 7 is “basic” or “alkaline”.

phosphate – A form of phosphorous; an essential nutrient for plants and animals; usually present in natural waters as phosphate. Phosphate is an ion composed of one phosphorus atom and four oxygen atoms.

phosphorous – A non-metallic element designated with the chemical symbol P; an essential nutrient for plants and animals; usually present in natural waters as phosphate.

photosynthesis – A series of chemical reactions in producers, usually plants, in which light energy is used to make chemical energy in the form of food.

phytoplankton – Microscopic photosynthetic protists (i.e. bacteria and algae); form the basis of freshwater and marine food webs; the main producers in the open ocean.

pile wall – Metal sheets driven into the ground to provide structural stability.

plankton – Microscopic organisms that drift freely with water currents; phytoplankton are producers; zooplankton are animals.

plume – A contaminated portion of an aquifer extending from the original contaminant source.

pod – A seed vessel or fruit of a plant.

point source pollution – Pollution coming from a single point (e.g., sewage-outflow pipe).

point source – A source of pollutants from a specific pipe. Generally, any pipe which is regulated by NPDES is considered to be a point source.

pollination – Sexual reproduction in plants in which pollen is transferred from anther to stigma of either the same plant or another plant.

pollutant – A contaminant that adversely alters the physical, chemical, or biological properties of the environment. The term includes pathogens, toxic metal, carcinogens, oxygen-demanding materials, and all other harmful substances. Particularly with reference to nonpoint sources, the term is sometimes used to apply to contaminants arising in low concentrations from many activities which collectively degrade water quality.

pollution – Contamination of air, water, or soil by toxic organic or inorganic substances (e.g., industrial or agricultural waste by-products, engine exhausts, factory emissions, or human waste). Pollution can come from a single source (point-source) or be discharged over a wide area from many sources (non-point source).

pond lily – An emergent vegetation; water lily of the genus *Nymphaea*; has floating leaves.

pond snails – Aquatic macroinvertebrate; *phylum Mollusca*, order *Gastropda*; organism is enclosed within one shell; tolerant of pollution.

pool – A deeper area of water in a stream; usually quiet and often with no visible flow.

population – A group of organisms of the same species living in the same area.

porcelain-berry – *Ampelopsis brevipedunculata*; an exotic invasive plant that grows in intermittently flooded lowland forest.

porosity – The percent of space or pores between sediment particles; indicates the amount of water the sediment can hold.

potable – Ability to be used as drinking water.

potentiometric surface – An imaginary surface representing the total head of an aquifer. The total head consists of the elevation head and pressure head.

PPB – Parts per billion; one part per billion by weight or one milligram per metric ton.

PPM – Parts per million; one part per million, or one gram per metric ton.

precipitation – Condensed water vapor that falls to or forms on the surface as rain, snow, hail, sleet, dew, and frost.

predator – An organism that kills and eats other organisms.

pretreatment – The treatment of wastes to remove contaminants prior to discharge into municipal sewage systems.

prey – A creature hunted or caught for food.

primary consumer – An organism that feeds on producers; an herbivore.

primary productivity – The amount of energy trapped by photosynthesis. This quantity determines how much life a region will support.

primary treatment – A wastewater treatment method that uses settling, skimming, and chlorination to remove solids, floating materials, and pathogens from wastewater. Primary treatment removes about 35 percent of BOD and less that half of the metals and toxic organic substances.

priority pollutants – Substances listed by the EPA under the Clean Water Act as toxic and having priority for regulatory controls. The list includes toxic metals, inorganic contaminants such as cyanide and arsenic, and a broad range of both natural and artificial organic compounds. The list of priority pollutants probably includes substances which are not of concern in Puget Sound and does not include all known harmful compounds.

pristine environment – An environment remaining in a pure or uncorrupted state.

producer – An organism that makes its own food; a photosynthetic organism; an autotroph.

production type – The method of spawning and rearing that produced the fish that constitute a stock.

production zone – The depth interval in a water supply well from which water is being obtained.

propagation – Increased or spread by natural reproduction.

Public Benefit Rating System – A point system to determine the current use value of lands classified as open space lands in the Jefferson County Open Space Tax Program. The system considers prioritization of resources, access, transfer of development rights, and fulfillment of County policy goals.

Public Trust Doctrine – A judicial doctrine under which the state holds its navigable waters and underlying beds in trust for the public and is required or authorized to protect the public interest in such waters. All water rights issued by the state are subject to the overriding interest of the public and the exercise of the public trust by state administrative agencies.

pumping test – A test made by pumping a well for a period of time and observing the change in hydraulic head in the aquifer. A pumping test may be used to determine the capacity of the well and the hydraulic characteristics of the aquifer. Also called aquifer test.

Q

Q factor – A rating scale that translates water quality test results to a number from 0-100.

R

random – Having no particular pattern or order.

rapids – An extremely fast-moving part of a river, caused by a steep descent in the riverbed.

reach – The length of stream channel from a riffle into a pool, usually 1 to 1 1/2 times the width of the channel. (See figure I.7)

rearing habitat – Areas required for the successful survival to adulthood by young animals.

recharge – Surface water which enters into a ground-water system. This can be natural recharge, such as from precipitation or artificial recharge, such as from irrigation or dry wells.

recovery – The return of an ecosystem to a defined condition after a disturbance.

recurved spit – A spit with the end strongly curved inward.

recycling – The process by which wastes can be reused or converted into other materials or products. The process by which materials and substances are reused.

redd – The spawning area or nest of salmonids. The nest is dug into stream gravel to allow water to provide oxygen to the developing embryos and flush out biological wastes.

Referendum 38 – (Ch. 43.99E RCW and Ch. 173-170 WAC) Approved by voters in 1980, this measure provides financial assistance to public bodies operating agricultural water supply facilities to assist in improving their efficiency of water use beyond current levels. Before implementation of a conservation project the public body must develop a Comprehensive Water Conservation Plan, which evaluates the current system for alternative managerial or structural water conservation improvements. Planning and implementation grants and loans are administered through the Dept. of Ecology.

refuse – Waste products, including both wet and dry materials.

regulatory base flow – See *base flow*.

relinquishment – Water rights reverting to the State for reappropriation because of failure to beneficially use all or part of the right for a five-year period. (see RCW 90.14.160)

resident fish: Fish species that complete their entire life cycle in freshwater.

residential – Land used for human dwellings and activities.

respiration – The process that involves the transfer of oxygen to cells and the breakdown of food to release energy. In complex animals, respiration involves the intake of oxygen and the discharge of carbon dioxide.

resting / holding pools – Slow-water off-channel pools which adult salmonids use to rest while migrating upstream to spawn. Resting pools occur naturally or are artificially created as a temporary measure during habitat restoration.

restoration – The act of putting something back to a prior condition.

return flows – That part of diverted water which returns to the source through seepage, spills, deep percolation, or discharge.

riffle – A rapid, turbulent flow of water over a shallow area in a stream. Riffles add oxygen to the water as water is churned, and provide habitat for many invertebrates.

riffle beetle – An aquatic macroinvertebrate of the order Coleoptera; larvae are specially adapted to cling to smooth rocks in fast-flowing water (riffles); sensitive to pollution.

riffle – A segment of the river channel which has moderate to steep gradient, shallow depth, and has higher flows.

riparian area – The land adjacent to streams, rivers, or other bodies of water that directly affects, or is affected by, the water. A unique habitat that exists in mutual balance with the river channel.

riparian area (1) – The area between a stream or other body of water and adjacent upland identified by soil characteristics and distinctive vegetation. It includes wetlands and those portions of floodplains which support riparian vegetation.

riparian area (2) – The terrestrial areas immediately adjacent to a stream or river where the vegetation complex and microclimate conditions are products of the presence and influence of water. Riparian areas can vary in width from as little as 20 feet to more than 300 feet from the water.

riparian doctrine – The system of law dominant in Great Britain and the eastern United States, in which owners of lands along the banks of a stream or water body have the right to reasonable use of the waters and correlative right protecting against unreasonable use by others that substantially diminishes the quantity or quality of water. The right is appurtenant to the land and does not depend on prior use.

riparian – Pertaining to the banks and other adjacent, terrestrial (as opposed to aquatic) environs of freshwater bodies, watercourses, and surface-emergent aquifers, whose imported waters provide soil moisture significantly in excess of that otherwise available through local precipitation – soil moisture to potentially support a mesic vegetation distinguishable from that of the adjacent more xeric upland.

riprap – Large rocks, broken concrete, or other structure used to stabilize streambanks and other slopes.

river – A large natural stream of water emptying into an ocean, lake, or other body of water, and usually fed along its course by converging tributaries.

river basin – The land area drained by a river and its tributaries; a watershed.

river mile (RM) – a measurement of river corridor length beginning at the mouth of the river.

rubbish – Refuse, trash, waste.

run (a) – An area of swiftly flowing water, without surface agitation or waves, which approximates uniform flow and in which the slope of the water surface is roughly parallel to the overall gradient of the stream reach.

run (b) – Fish stocks grouped together on the basis of similar migration times.

runoff –That part of the precipitation, snow melt, or irrigation water that appears in uncontrolled surface streams, rivers, drains, or sewers. Runoff may be classified according to speed of appearance after rainfall or melting snow (direct or base runoff) or according to source (surface runoff, storm interflow, or ground-water runoff).

runoff – The portion of precipitation or irrigation water that moves across land as surface flow and enters streams, ditches, drains, or other surface receiving waters. Runoff occurs when the precipitation rate exceeds the infiltration rate.

S

salinity – Concentration of dissolved salts in water or soil water.

salmonid – A fish belonging to the family Salmonidae, including salmon, trout, char, and allied freshwater and anadromous fishes.

sediment – Materials in streams or other bodies of water including boulders, cobbles, gravel, sand, silt, and clay. Sediment may suspended in water, transported by water, or settling to the bottom of the water.

senior right – A water right that is older in relation to other water rights, and is legally able to be satisfied before others in times of limited water.

secondary treatment: A wastewater treatment method that usually involves the addition of biological treatment to the settling, skimming, and disinfection provided by primary treatment. Secondary treatment may remove up to 90 percent of BOD and significantly more metals and toxic organics than primary treatment.

siltation – The process by which a river, lake, or other water body becomes clogged with sediment. Silt can clog gravel beds and prevent successful salmonid spawning.

sinuosity – Degree to which a stream channel curves or meanders laterally across the land surface.

sludge – Precipitated or settled solid matter produced by sewage treatment processes.

soil permeability – The ease with which gasses, liquids, or plant roots penetrate or pass through a layer of soil.

sorption – The process whereby dissolved substances physically or chemically bind to the surface of particles.

smolt – A seaward migrating juvenile salmonid, silvery in color, that has become thinner in body form and is physiologically prepared for the transition from fresh to saltwater.

spawning population – Synonymous with the term "stock."

species – Includes any subspecies of fish, wildlife or plants, and any distinct population segments which interbreeds when mature. Sec. 3 (15) Endangered Species Act (as amended by the 100th Congress).

specific capacity – An expression of the productivity of a well, obtained by dividing the rate of discharge of water from the well by the drawdown of the water level in the well.

specific conductance – The ability of water to transmit an electrical current. It is related to the concentration and charge of ions present in the water.

stock – The fish spawning in a particular lake or stream(s) at a particular season, which fish to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season.

stock origin – The genetic history of a stock.

stock status – The current condition of a stock, which may be based on escapement, run-size, survival, or fitness level.

storm water – Water that is generated by rainfall and is often routed into drain systems or irrigation ditches to prevent flooding.

streambed – That part of the channel usually not occupied by perennial terrestrial plants, but including gravel bars, and lying between the base or toe of the banks.

subduct – In plate tectonics, the depressing and passing of one plate margin of the earth under another plate.

subduction – The process of descent of one tectonic unit under another.

subduction zone – An elongated region along which a crustal block descends relative to another crustal block. Deep oceanic trenches occur along subduction zones.

sample – A portion, piece, or segment regarded as representative of a whole.

sand – Suspended sediment or bed material with a particle-size of 0.062-2.0 mm in diameter.

scrubland – A growth or tract of stunted vegetation.

scrup-shrub – A plant community dominated by drought-tolerant sage and ponderosa pine communities.

secondary consumer – An organism that feeds on primary consumers; a carnivore.

second of latitude/longitude – A unit of measure equal to 1/60 of a minute latitude/longitude.

sediment – Loose materials such as rock fragments and mineral grains that have been transported by wind, water, or glaciers.

sediment load – Total sediment in a sample of water. There are three categories of sediment: suspended load, dissolved load, and bed load.

sediment particle size – The diameter, in millimeters, of sediment. Particle-size classifications are: 0.00024-0.004 mm (clay); 0.004-0.062 mm (silt); 0.062-2.0 mm (sand); 2.0-64.0 mm (gravel).

sedimentation – The action or process of forming or depositing sediment.

sensitive to pollution – Organisms that are easily harmed by low levels of pollutants. They are good indicators of clean water because they cannot survive in polluted water.

sewage – Solid and liquid human and animal wastes.

shellfish – An aquatic animal having a shell or shell-like exoskeleton (i.e. mollusk, crustacean).

silt – Suspended sediment or bed material with a particle-size of 0.004-0.062 mm in diameter.

siltation - To become choked or obstructed with silt.

soil compaction – A process that occurs as soil is squeezed repeatedly, decreasing the air spaces between soil particles and making the soil very hard.

sow bugs – An aquatic macroinvertebrate; an isopod of the *phylum Arthropoda*, class *Crustacea*; somewhat sensitive to pollution.

spawn – To produce or deposit eggs.

species – A group of organisms that share similar characteristics and can interbreed with one another to produce fertile offspring.

spring peeper – *Hyla crucifer*. A small brownish tree frog, found in eastern North America, having a shrill high-pitched call.

speed – The rate that water flows. *See stream.*

stewardship – To be responsible for managing property or resources; the individual's responsibility to manage his/her life and property with proper regard for the rights of others.

stonefly – Aquatic macroinvertebrate; order Plecoptera; nymphs have three pair of legs, a pair of antennae, and two long tail filaments; typically found on or near stones in the stream; sensitive to pollution.

stream – A body of water flowing in a natural channel and containing water at least part of the year.

striped bass – *Roccus saxatilis*. A food and game fish of North American coastal waters, having dark longitudinal stripes along the sides.

submerged aquatic vegetation (SAV) – Benthic plants that grow totally under water. (e.g., hydrilla, coon tail, wild celery, eel grass).

suburban – The area or communities surrounding a major city.

suspended load – Sediment that contains organic and inorganic particulate matter suspended in and carried by moving water.

suspended sediment (solids) – Very fine soil particles that remain in suspension in water for a considerable period of time without contact with the bottom, due to the upward components of turbulence and currents.

swamp – A wetland that contains trees and woody shrubs.

T

taxa – Categories in the biological classification system for all living organisms. They are used to help organize information about the natural world.

tectonic – Pertaining to, or designating the rock structure and external forms resulting from the deformation of the earth's crust. As applied to earthquakes, it is used to describe shocks not due to volcanic action or to collapse of caverns or landslides.

tertiary consumer – A carnivore that feeds on other carnivores.

thalweg – The deepest part or middle of the river or stream channel. The thalweg remains constant through both low and high flows, until it is changed by gravel movement in high flows.

threatened species – Those plant or animal species likely to become endangered species throughout all or a significant portion of their range within the foreseeable future. A plant or animal identified and defined in accordance with the 1973 Endangered Species Act and published in the Federal Register.

thrust faulting – a type of rock faulting wherein the hanging wall of the fault is moved upward, in contrast to normal faulting wherein the hanging wall goes downward.

Timber/Fish/Wildlife Agreement – A 1987 cooperative agreement between Tribal, Forestry, and State interests. The agreement establishes a natural resource management process for forest practices on state and private lands in Washington State.

toe width – A method used to estimate instream flows necessary to provide habitat for salmon and steelhead. It was developed in the 1970s in western Washington by the U.S. Geological Survey (USGS), in cooperation with the Washington Department of Fisheries (WDF) and the Washington Department of Game (WDG). The method is based on statistical regressions of habitat, as measured in pilot studies based on actual fish habitat selection, on stream channel widths measured between the toes of the banks. Toes of the bank in riffle areas are indicated by change in cross-section slope, change in substrate, and sometimes by vegetation change. The toe width (usually an average of multiple measurements) is plugged into formulas for juveniles and spawners of different species of salmon and steelhead.]

tolerance – The ability to endure; resistance to toxic substances or other pollutants.

topographic – refers to physical relief features or surface configuration of land.

topsoil – The surface layer of soil, usually rich in humus.

total dissolved solids (TDS) – total dissolved materials in the water column; material left behind after a water sample is filtered and evaporated. Rainwater will have TDS less than 10ppm; municipal water systems will have TDS less than 500 ppm.

total phosphorus – A test that measures all the forms of phosphorus in a sample.

total suspended solids (TSS) – The total concentration of dissolved and suspended solids in water (see *suspended solids*).

toxic – A substance that is harmful or, in some cases, poisonous, if ingested or touched. A substance that damages the pristine state of the environment.

transect – A long, narrow sample study area.

transfer – A movement of water or water rights that involves a change in point of diversion, a change in type of use, or a change in location of use.

trash – Dry waste material, such as boxes and cans.

tributary – A smaller river or stream that flows into a larger river or stream. Usually, a number of smaller tributaries merge to form a river.

Trust Water Right program (TWR) – A Dept. of Ecology program created by the Washington State legislature in 1991 to facilitate the voluntary transfer of water and water rights, including conserved water, to provide water for presently unmet and emerging needs. Possible methods for transfer include dry year lease options, temporary or permanent changes in the place or type of use of a water right (i.e. from off-stream uses to instream flows), water banking managed by the state, the transfer of water conserved by a water conservation project or by gift.

turbidity – The amount of solid particles suspended in water that cause light rays shining through the water to scatter. It is a surrogate measure to TSS for the amount of material suspended in the water column. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity may be harmful to aquatic life and fail federal water quality standards. Turbidity is measured in nephelometric turbidity units (NTUs) or Jackson turbidity units (JTUs).

U

unbiased – Impartial; without prejudice.

unconsolidated sediments – sediments that have not become firm and coherent through a variety of earth processes. Sediments consolidate through processes that include compression, dewatering, interstitial cementing, deep burial and associated heating, and deviatoric pressure.

unknown stock – This description is applied to stocks where there is insufficient information to identify stock origin or stock status with confidence. (SASSI)

urban – Pertaining to or constituting a city.

usual and accustomed area – A provision of the treaties between Indian Tribes and Isaac Stevens, Washington Territorial Governor, which allowed the Tribes the continuing right to take "fish at usual and accustomed" areas "in common with all citizens of the United States." These areas were further delineated based on historical information for each Tribe in 1974 after State Supreme Court Judge Boldt reaffirmed and clarified the treaty rights.

V

variable – A condition in a scientific experiment or observation that is subject to change. A variable factor in which change occurs naturally or is made to occur by the investigator is called the independent variable; a variable that changes as a result of change in the independent variable factor is called the dependent variable.

vegetation – Plants or plant life, in general. The condition of the vegetation around a stream is a good indication of the health of the aquatic environment.

velocity of a stream – The speed and direction of the water flowing in a stream, an important factor in determining what organisms can live in the stream. Measured in units such as feet/sec or meters/sec.

verge vegetation – Vegetation that starts at the top of the stream bank and extends from the bank to the next major vegetation or land use change.

W

Watershed Assessment Unit (WAU) – Watershed areas delineated by Ecology for the purpose of watershed planning. WAU's in the Okanogan are generally consistent with a fifth field HUC delineation (i.e., HUC-5).

water penny – Aquatic macroinvertebrate of the family *Psepheridae*; larvae are very flat oval or round shapes and are tan, brown, or black in color; have six small legs and cling to the undersides of rocks; sensitive to pollution.

water quality index (WQI) – A method for measuring water quality in rivers. Nine parameters are measured and weighted to develop the index: dissolved oxygen, fecal coliform, pH, biochemical oxygen demand, temperature change, total phosphates, nitrates, turbidity, and total solids.

Water Resource Inventory Areas (WRIA) – In the early 1970's Washington State was divided by Dept. of Fisheries into 62 watershed areas which have since been used by state agencies to organize water-related information and define planning projects. Eastern Jefferson County (WRIA 17), and Eastern Clallam County (WRIA 18) comprise the DQ Project area.

Water Resources Forum (WRF) – Designed by the 1990 Chelan Agreement and funded by the Washington State Legislature, the Water Resources Forum is a planning group representing the Statewide interests of agriculture, business, the environment, fisheries, local government, recreational users, state government, and the tribes. The Forum's task was to address the issues groundwater recharge, instream flow, and hydraulic continuity and write policy applicable State-wide.

water right application – An application by a prospective water user to the Department of Ecology for a water right permit. It is required to divert any amount of surface water or withdraw ground water in amounts greater than 5000 gallons per day or to irrigate more than a half acre of land. The application requires publication of legal notice to announce application, a 30-day public protest period, and a field examination by Ecology recommending approval or denial of the permit.

water right certificate – The final stage in establishment of a water right under state law after filing an application, receiving a development permit, and putting the water to a beneficial use. The certificate states the quantitative and locational parameters of the water right. Certificates are also issued at the conclusion of an adjudication. Once a certificate is issued or perfected, no further expansion is allowed under that water right.

water right claim – A water right claim is not a water right. It is a registration with the State by the property owner regarding water use not authorized by a permit or certificate. A claim may represent a valid water right if it describes a water use existing prior to water codes: 1917 for surface water and 1945 for ground water. Claims registered are evaluated for sufficient evidence to satisfy the Dept. of Ecology that a valid water right would be confirmed if the claim were adjudicated.

water right permit – An approval of an application by the Dept. of Ecology, allowing construction of a water system and use of water.

water right – The legal right to use a specific quantity of water on a specific time schedule, at a specific place and for a specific purpose. In 1917 legislation was passed providing that all surface water (and in 1945 all ground water) within the State belonged to the State, and any right to use the water could be obtained by filing an application and being granted a permit for the development of the water system.

water snipe – Aquatic macroinvertebrate; family *Athericidae*; pale green tapered body with many caterpillar-like legs, conical head, feathery "horns" and back end; somewhat sensitive to pollution.

water table – The upper surface of ground water, or the level below which the soil is saturated with water.

waterfowl – Birds whose primary habitat is aquatic.

watershed – The geographic region within which water drains into a particular river, stream, or body of water. A watershed includes hills, lowlands, and the body of water into which the land drains. Watershed boundaries are defined by the ridges of separating watersheds.

weed – A plant considered unattractive, undesirable, or troublesome.

wetland – A lowland habitat, such as a marsh, swamp, or bog where the influence of surface or ground water has resulted in development of plant or animal communities adapted to aquatic or intermittent wet conditions. Wetlands generally require the following three conditions: hydric plants, hydric soils, and hydrology. Wetlands generally include, but are not limited to, swamps, marshes, bogs, and similar areas.

wild celery – A native SAV, *Vallisneria americana*. It is found in freshwater rivers and tributaries of the Chesapeake Bay. It has linear ribbon-like leaves, 1.5 m long and 1 cm wide, emerging from the base of the plant.

wild stock / fish – A stock that is sustained by natural spawning and rearing in the natural habitat, regardless of parentage (includes natives).

wildlife / wildlife resources – Birds, fishes, mammals, and all other classes of wild animals and all types of aquatic and land vegetarian upon which wildlife depend. (Fish and Wildlife Coordination Act)

wildlife habitat – Waters of the State used by fish, other aquatic life, and wildlife of any life history, stage, or activity. (see WAC 173-205-025)

wildlife – Species of the animal kingdom whose members exist in the wild state. This includes mammals, birds, reptiles, amphibians, fish and invertebrates. (see RCW 77.12.020 / RCW 77.16.120 for classifications on predatory and game birds and protected wildlife.)

Z

zooplankton – A diverse group of small protists and animals, such as tiny crustaceans, that serve as food for larger freshwater and marine invertebrates.

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EXECUTIVE SUMMARY

INTRODUCTION

The Level 1 Watershed Technical Data Assessment for WRIA 49 (Okanogan) provides the Planning Unit with a survey and compilation of existing information that may be useful in watershed planning. It is a tool intended to summarize the extent and quality of existing data, identify data gaps, and help the Planning Unit bring issues of concern into focus and decide on next steps in the watershed planning process.

The Level 1 Report is available on CD and can be downloaded from the Lotus QuickPlace website established for the Planning Unit. It includes a summary report intended to be user friendly, an Atlas of Maps, and a set of appendices (available only on CD) which provide the detailed information and data from which the Level 1 summary is drawn.

Chapter 1 of the Level 1 report provides an overview of the watershed planning process and the history of watershed planning in WRIA 49. Chapter 2 provides an overview of information at a watershed scale to develop a water balance. Chapters 3 through 6 address water quantity, water storage, water quality, and aquatic habitat, respectively. Chapter 7 very briefly summarizes data gaps and recommendations.

The Level 1 Report appendices include information and data files on water quantity (Appendix A); water quality (Appendix B); water storage (Appendix C); climate, water temperature and streamflow (Appendix D); and methods used in compiling the Level 1 Report (Appendix E). Appendix F contains the full bibliography of resources considered for the Level 1 Report. Many of the reports listed in this bibliography, while topical to the basin, provided essentially no information of applicability to the current Level 1 assessment and were not reviewed. We have attempted to reflect the usefulness of the information identified from the basin obtainable from these reports, including data quality and reliability, in the file provided in this Appendix. However, a thorough quality assurance and control audit of the hundreds of reference sources with some information and/or data about the Okanogan basin was well beyond the scope of the current effort. As will be seen from reviewing the extensive bibliography, very few of the data sources actually provided or contained original data of applicability to tasks such as water quality, habitat, water quantity and/or flow assessment. Our review focused on these sources, as well as more recent data sources and/or data repositories, some of which have yet to be released to the public domain.

The five major watershed assessment unit (WAU) subbasins delineated for WRIA 49 by Ecology and used in this report include: (1) Joseph, Salmon, Omak, Sinlahekin, and Osoyoos basins. Smaller scale subbasin delineations are possible using hydrological unit criteria (HUC) that delineate specific tributaries captured within the broader subbasins, and these are reflected in the GIS maps provided with the report. In this

Level 1 report, data are collected and presented at the lowest level of detail appropriate and available.

WATERSHED OVERVIEW AND WATER BALANCE (CHAPTER 2)

This section highlights key findings identified from the review of existing information regarding the physical presence and availability of surface and ground water in WRIA 49, and the overall water balance of the watershed.

WRIA 49 is comprised of five major subbasins (Sinlahekin, Osoyoos, Salmon, Omak, and Joseph). These subbasins are defined by hydrology, using a scale called "hydrologic unit criteria, or HUC." They collectively comprise 33 smaller individual drainage basins that either discharge directly into the Okanogan River or discharge into a major stream that drains to the Okanogan or Columbia Rivers. Data compilation and review were organized based first on the five major subbasins and second on individual drainage basins.

Precipitation data indicate that the Sinlahekin and Salmon Subbasins receive significantly more water (124 to 166 percent more) than do the other three subbasins. Over the past 100 years, significant long-term dry periods occurred in the 1920's and 1960's and have had a significant effect on cumulative surface water storage and/or groundwater storage.

Although the Similkameen River is considered a major tributary to the Okanogan River, its flow, on average, is actually more than 4.4 times the flow of the Okanogan. The Sinlahekin streams have the greatest average annual streamflows and have flows approximately three to four times greater than those in the Omak subbasin, which have the lowest annual average. This is due to such factors as higher overall elevation, greater precipitation (including snowmelt), and more favorable rocktypes in the Sinlahekin subbasin.

In general, throughout WRIA 49 peak discharges occur during the period from April through July and reflect primarily snowmelt or snow on rain events, when streams contribute about 70 to 80 percent of their average annual discharge. Low flows occur from August to October and reflect the relatively low summer rainfalls and depleted groundwater storage, which occurs primarily in unconsolidated sediments of the major stream valleys throughout the Okanogan Watershed.

Water balances were computed for each major subbasin using precipitation map data, mean annual streamflow data, and assumptions regarding evapotranspiration and recharge processes. In general, the calculations indicate that, depending on subbasin location, 82 percent to 98 percent of precipitation is returned to the atmosphere via evapotranspiration. Because the Sinlahekin and Salmon subbasins not only receive more total water per unit area but also have lower evapotranspiration rates, more water is available to recharge groundwater and support higher streamflows in these subbasins. Thus, mean annual streamflow is signficantly higher in the Sinlahekin subbasin – an order of magnitude higher than in the Osoyoos and Omak subbasins, and two orders of magnitude higher than in the Joseph subbasin.

Throughout the Okanogan Watershed, the availability of groundwater in the Omak subbasin is limited to unconsolidated sediments of the major stream valleys. Groundwater recharge is roughly estimated to ranges from a low of 1.5 percent of precipitation in the Joseph subbasin to a high of 5 percent of precipitation in the Salmon and Sinlahekin subbasins. Similarly, the percentage of runoff as precipitation is roughly estimated to range from a low 0.2 percent in the Joseph subbasin to a high of 12.8 percent in the Sinlahekin subbasin. Calculations of water balance and water availability are presented in Chapter 2.

WATER QUANTITY ASSESSMENT (CHAPTER 3)

This section highlights key concerns identified from the review of existing information concerning water rights and water use. They include concerns related to subbasins, water systems, the City of Oroville water supply, agricultural water supply, rivers and creeks in the WRIA, and Canadian water issues.

Subbasins of Concern

WRIA 49 Subbasins of Concern are defined as areas where current demands or projections of future demand equal or exceed the supply of water.

Level 1 assessment suggests that several WRIA 49 subbasins may be overappropriated in both surface and ground water (that is, more water rights may have been issued than can be sustainably supported). However, preliminary water use information suggests that while these waters may be overappropriated, they may not be overused. Appropriation data by subbasin are summarized in Appendix A-1.2b.

Figures ES-1 and ES-2 compare net runoff to streams (defined as described in Chapter 2 and Appendix E) to surface water appropriations. The Joseph and Osoyoos subbasins appear to be overappropriated for both surface and ground water, while the Salmon subbasin appears to be overappropriated only for ground water. Projecting appropriations to meet water demand to 2026, the Salmon subbasin would also become overapproriated for surface water in 20 years, but appropriations in the Sinlahehin and Omak subbasins would remain well below the available surface and ground water.

Water Systems of Concern

WRIA 49 Water Systems of Concern are defined as those which are experiencing deficits in ability to meet peak or annual water demand, or which do not have sufficient water rights to serve these demands. These concerns may exist now, or may be projected to occur within the next 20 years.

Figure ES-1: Current Appropriation of Surface Water (AFY)

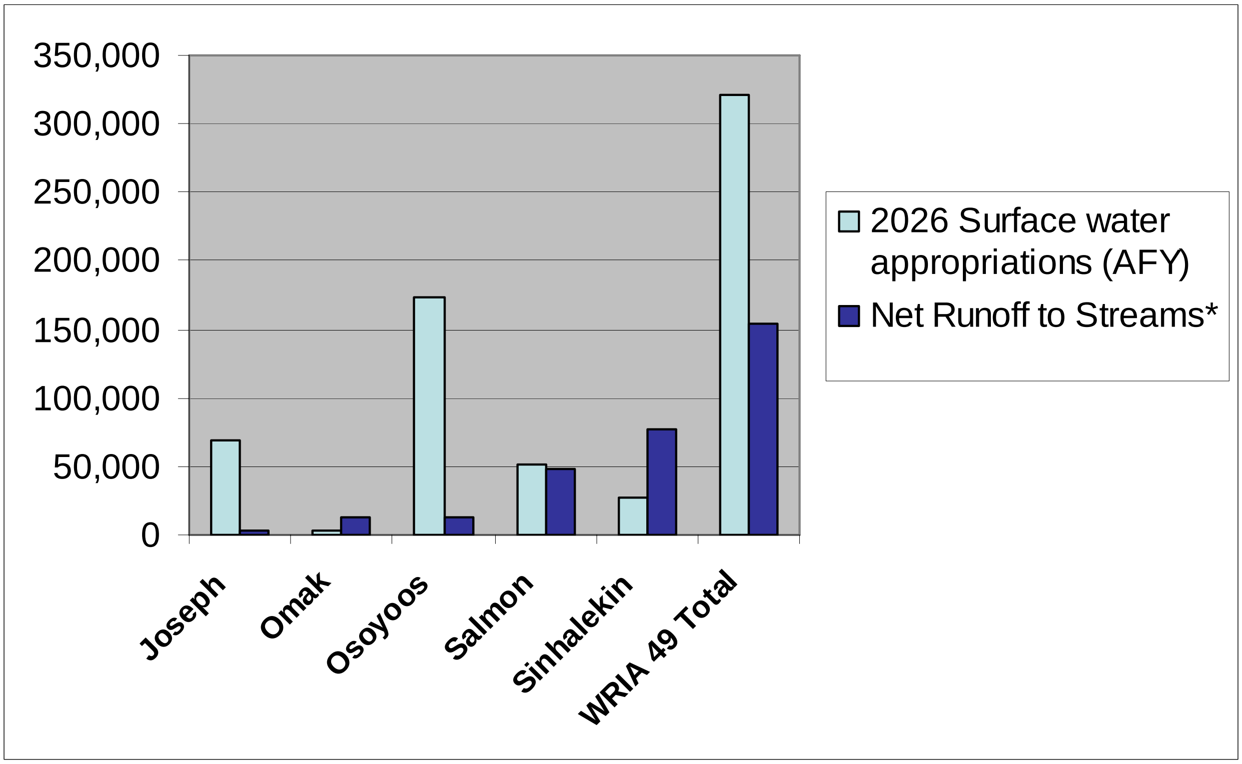
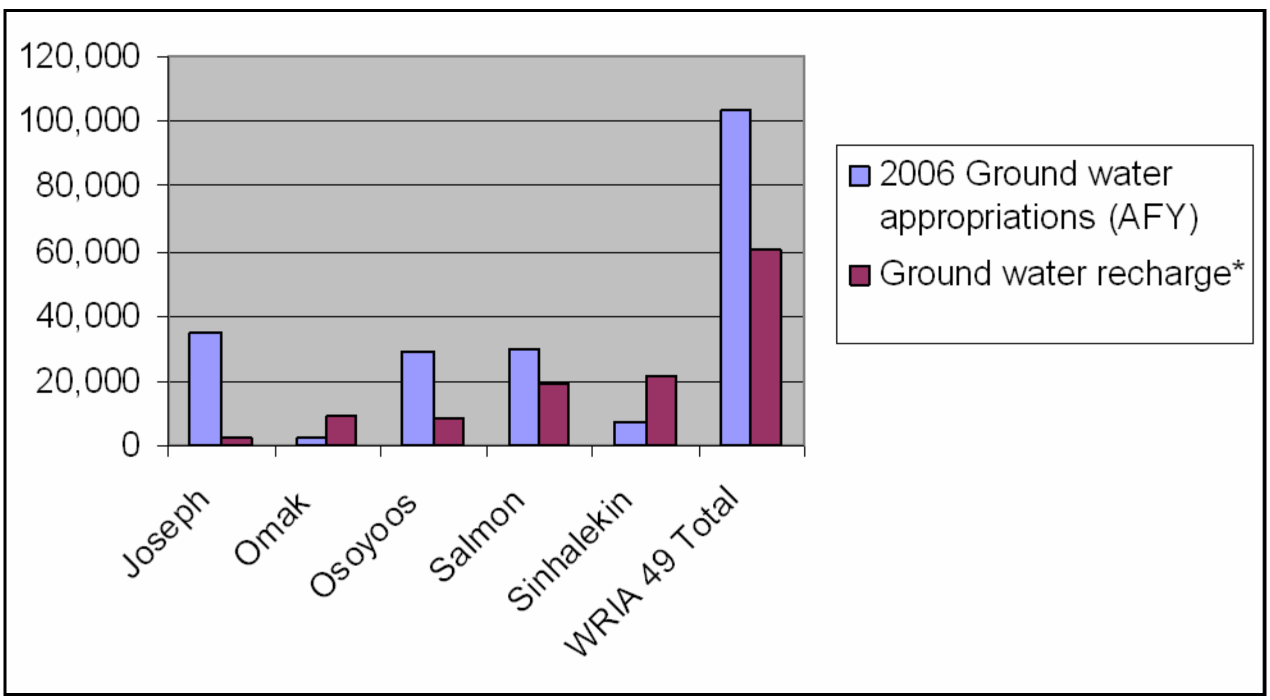


Figure ES-2: Current Appropriation of Groundwater



Comprehensive Water System Plans were reviewed for the six major Group A water systems in WRIA 49 (Brewster, Okanogan, Omak, Oroville, Riverside, and Tonasket). Data are summarized in Appendices A-3.1 and A-3.2. All of these systems currently have adequate source capacity and water rights to meet current demand on both an annual and a peak basis. Projecting to 2026, all seven systems have adequate source capacity to meet annual demand, but Brewster, Okanogan, Oroville, and Riverside would need to develop additional pumping capacity (Figure ES-3).

Turning to water rights, by 2026 Okanogan would have nearly fully used its instantaneous water rights, and both Brewster and Riverside would need additional instantaneous water rights (Figure ES-4). Brewster's deficit would be small (45 gpm), but Riverside, with an existing 650 gpm in water rights, would need to add an additional 433 gpm.

The greatest concern lies with the water systems' annual water rights. Brewster has already fully used its existing water right of 1,205 acre-feet per year (AFY), and by 2026 is projected to need an additional water right of 887 AFY (Figure ES-5). Oroville (279 AFY), Riverside (227 AFY), Okanogan (137 AFY), and Tonasket (78 AFY) would also need additional annual water rights. The City of Oroville water system, serving the high-growth north end Lake Osoyoos area, is of particular concern and is addressed in more detail below.

City of Oroville

The City of Oroville is located at the south shore of Lake Osoyoos, just north of the confluence of the Okanogan and Similkameen Rivers. A summary of the City's water system and water supply capacity is provided in Appendix A-3.4. The City draws its municipal water supply through four wells, all tapping an aquifer that is recharged by the Similkameen River. Combined, the City's wells can pump up to 2,700 gpm out of the Similkameen aquifer.

The City's water rights currently total 1,095 AFY and 2,775 gpm. Anticipating future growth around Lake Osoyoos, in 1985-86 the City applied to the Washington Department of Ecology for primary and supplemental water rights from the Similkameen Aquifer. Ecology has not acted on these applications, and they are among the oldest pending applications in the State.

The City has entered into an agreement with Legend Resorts to provide water to the Veranda Beach resort development on Lake Osoyoos in exchange for an unperfected water permit intended to serve the development. However, Ecology determined that this source is in continuity with Lake Osoyoos and denied the transfer. Developing new sources within the permitted area of withdrawal has proven difficult due to the requirement for expensive water treatment. (By contrast, the City is not required to treat its withdrawals from the Similkameen Aquifer at all.)

Figure ES-3: Source Capacity Pumping Surplus/Deficit (2026)

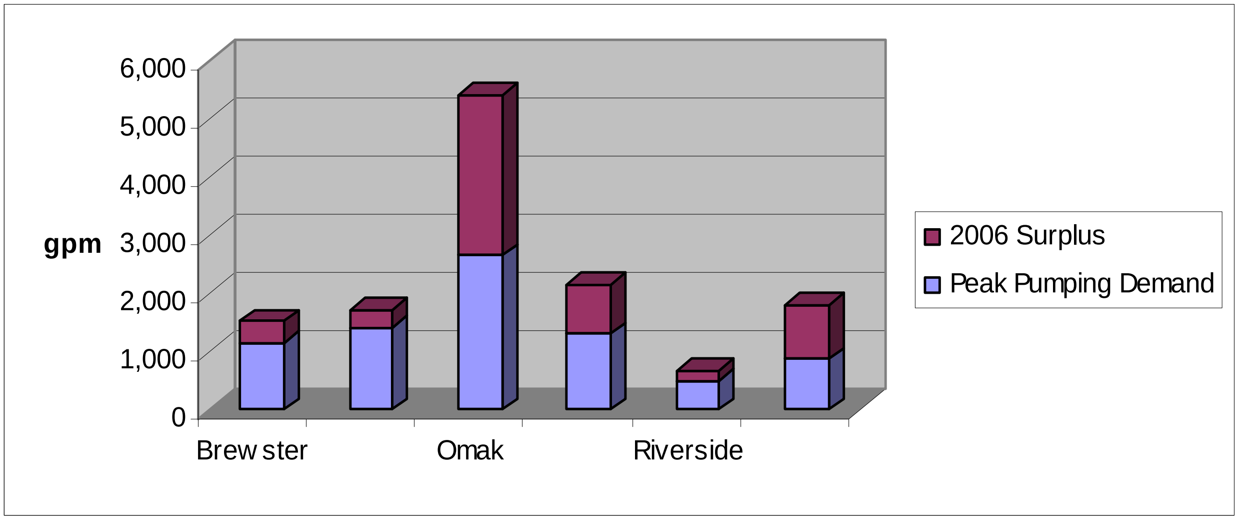


Figure ES-4: Instantaneous Water Rights Surplus/Deficit (2026)

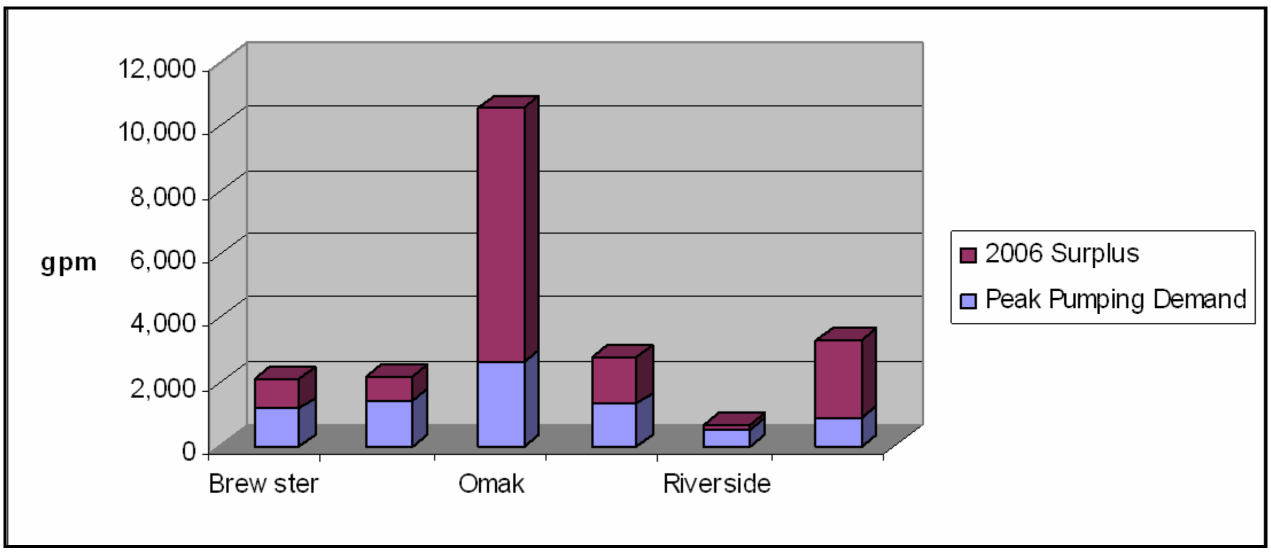
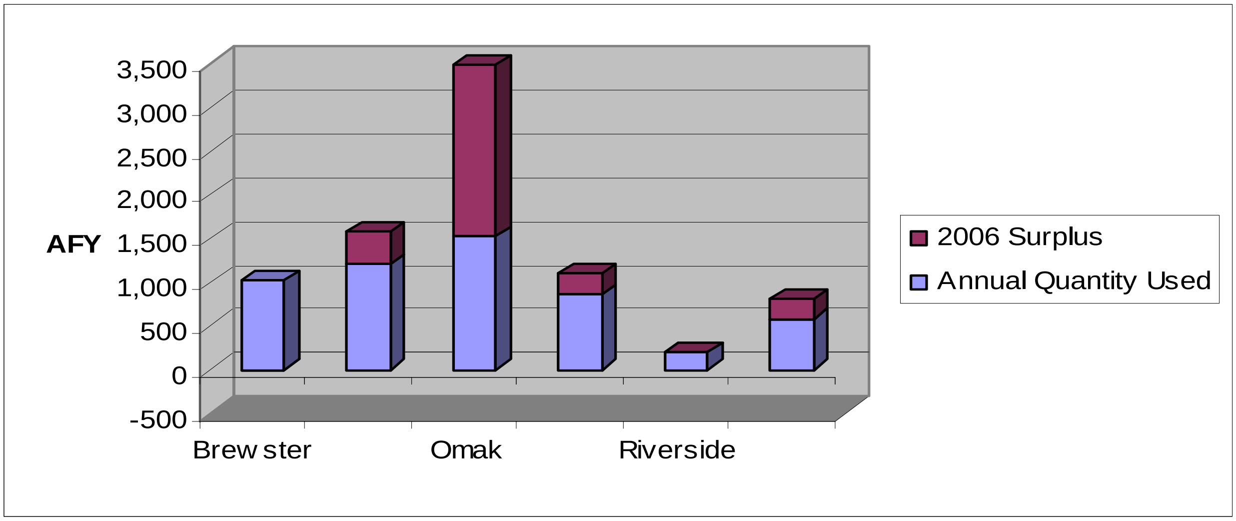


Figure ES-5: Annual Water Rights Surplus/Deficit (2006)



Interest in additional development around the Lake has rapidly increased, driven in part by the planned construction of a 12-inch water line and 10-inch sewer line on the east shore. Additionally, the Okanogan Valley in British Columbia has experienced rapid growth, and Canadian developers are looking for opportunities to purchase water from American sources. The City has long anticipated the economic boost of this development, as agriculture and timber production decline.

The City had ample source and water rights capacity to serve its projected 20-year population growth only a few years ago. Growth on East Lake Osoyoos was projected in the City's water plan at 3 percent, but recent trends indicate that this projection is probably considerably understated. Recent inquiries made to the City regarding annexation indicate that this rate could double within the next year or two. This, coupled with the Veranda Beach development, indicates that demand in the urban growth area and related service area can be expected to increase substantially.

The City's water rights could be consumed by new demand outside the City limits, affecting economic development opportunities and leaving property owners within the City unable to access water for development. Responding to this concern, the Oroville City Council has invoked a moratorium on additional connections outside the City until the uncertainty concerning water rights addressed. Currently, there are 30 pending applications for water connections in the service area outside the City that are subject to the moratorium. In the meantime, several short plats have been approved that will result in exempt wells, and the City has been advised by Okanogan County that at least one long plat application has been vested that will require a community system or similar arrangement within their water service area.

In summary, within 20 years the City is projected to have a 200 gpm deficit in their ability to pump water to meet peak-hour capacity under their existing water rights. This projection does not consider the acceleration of growth and development interest within the past year for the Lake Osoyoos area, which could double new demand and substantially increase the projected deficit.

Agricultural Water Supply Concerns

WRIA 49 agricultural water supply concerns are related to the adequacy and reliability of water supply for agricultural purposes.

No concerns regarding the adequacy of the agricultural water supply were highlighted by the Level 1 assessment, for two reasons: (1) it appears that farmland conversion is occurring, taking land out of production and reducing the overall future water demand for agriculture; and (2) in-depth analyses of WRIA 49 irrigation districts' water balances are available only for Okanogan Irrigation District. However, the conversion of agricultural land into other uses does not eliminate the demand for water on those lands, and could even increase it. Chapter 6 identifies data gaps and recommendations for Planning Unit consideration to assess the rate of agricultural land conversion, estimate water demand for lands converted from farm use, and develop water balances for the major irrigation districts.

Rivers and Creeks of Concern

WRIA 49 Rivers and Creeks of Concern are defined as those which are overappropriated (water rights exceed mean annual flow or low flow), or which exceed key water quality parameters making their waters unsuitable for human consumption or for habitat.

Appropriation of surface flow was used to identify rivers and creeks of concern in the Level 1 assessment. The evaluation of concern is based on the comparison of appropriated flow with mean annual flow or, better, low flows (fish habitat and other concerns are better reflected by the proportion of flow appropriated during the low flow season). Level 1 assessment identified important gaps in our ability to identify streams from which water has been appropriated. About 28 percent of WRIA 49 water rights to divert from streams do not name the stream from which water is diverted. A total of 126 streams are named in water rights. ENTRIX summarized data for the 23 named streams that have more than 1 cfs of flow appropriated (Appendix A-1.2b); of these we have flow data for only 13. Flow data for 9 of the 13 suggest that these streams may be overappropriated (Table ES-1), and part of a tenth stream (Lower Salmon Creek) is dewatered by irrigation diversions every summer. In addition, unquantified water claims could affect a much longer list of streams.

Canadian Water Issues

Water tension has risen between Canada and U.S. as population growth puts more pressure on shared resources. Statistics Canada has identified the Okanagan-Similkameen region as having the lowest amount of water available per person in Canada (Alexander et. al. 2005). Rapid development in Canada and the drive to increase orchard yields in the U.S. have discovered the basin's limiting factor: water. The Canadian Water Resource Association suggests that, at present rates, the water resources of the basin will be completely allocated in fewer than 25 years. Several Okanogan communities are already experiencing shortages in drought years and are taking steps toward demand management. On the US side, minimum instream flow targets have not been met for some years (Plan of Study for Renewal of the International Joint Commission Osoyoos Lake, January 29, 2006 Glenfir Resources).

Table ES-1: Rivers and Creeks of Concern

STREAM	APPROPRIATED FLOW (CFS)	MEAN ANNUAL FLOW (CFS)	PERCENT APPROPRIATED	LOW MONTHLY SUMMER FLOW	PERCENT APPROPRIATED
ANTOINE CREEK	8.87	no data	no data	0.01	88700%
BONAPARTE CREEK	16.475	5	330%	0.04	41188%
JOHNSON CREEK	23.30	5.00	466%	0.8	2913%
LOUP LOUP CREEK	3.13	1.60	195%	0.01	31250%
PEONY CREEK	2.56	2	128%	0.5	512%
SALMON CREEK	15.97	30	53%	2	799%
SINLAHEKIN CREEK	364.77	53.5	682%	12.1	3015%
TOATS COULEE CREEK	115.55	45.8	252%	9.6	1204%
TONASKET CREEK	379	3.22	11770%	0.7	54143%
TUNK CREEK	1.3	3.1	42%	0.1	1300%

Note: does not include water claims; all flows below the OID Diversion Dam are normally appropriated.

Although the Okanagan serves as an ecological corridor, human use of the basin is anything but continuous. The basin simply looks different on either side of the border. To the North, the Okanagan region is one of British Columbia's most densely populated regions, with one of the fastest growing populations in Canada, exploding from 195,000 in 1976 to almost 400,000 today. On the American side of the border, Washington's Okanogan has been called on of the last outposts of frontier life and its population is as disparate as that image connotes – all of Okanogan County (of which the basin comprises about 67 percent) has only 38,000 residents.

Osoyoos Lake is an international water body located on the Okanogan River, with its upper portion in Canada and lower portion, including the structure that controls lake outflow, in the United States. Both the City of Oroville on the south side of the Lake and Osoyoos in the Canadian mid-lake region are experiencing rapid growth in population centers around the lake. Growth is leading to concerns on both sides of the border about the future availability of water, and about the effects of actions on each side on water supply for the other side. The situation appears to be ripe for collaborative development of future water supplies.

INTERNATIONAL COOPERATION ON WATER

An International Joint Commission was established under the 1909 Boundary Waters Treaty to prevent and resolve disputes between the United States of America and Canada. Among other functions, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects. Cooperation continued with the formation of the International Pacific Salmon Fisheries Commission in 1937 for the protection and preservation of sockeye and pink salmon in the Fraser River system (renamed and extended in 1985 to include Washington, Oregon, Idaho, British Columbia and southeast Alaska). In 1964 Columbia River Treaty (CRT) addressed declining sockeye population, and in 1969 the Canadian federal government and the Province of B.C. begin study to develop framework for management of water resources in the Okanagan Basin. In 1996 Douglas County approached Canadian resource managers about potential collaboration and 1997 the Okanagan Basin Technical Working Group formed. The Canadian Okanagan Basin Technical Working Group is a tri-partite working group dealing with technical issues associated with management of salmon and resident fish stocks and their associated habitat requirements in the Canadian portions of the Okanagan River basin. In 2000 the South Okanagan-Similkameen Conservation Program (SOSCP), was created by the Ministry of Environment Lands & Parks, and Environment Canada.

WATER STORAGE ASSESSMENT (CHAPTER 4)

Two previous studies of potential water storage opportunities were identified, one in the Salmon Subbasin and the other on the Similkameen River. The Salmon Creek study was completed in 1998-1999 and provided a “fatal flaw” level of screening considering the timing and amount of water potentially available at each storage site, the cost and timeframe to develop storage at the site, engineering feasibility, regulatory requirements, and environmental costs and benefits. This study was completed for a Joint Committee comprised of the Colville Confederated Tribes (CCT) and Okanogan Irrigation Districts (OID). It was particularly sensitive to environmental conflicts, because environmental restoration (of Salmon Creek) was the goal of the project. This study considered aquifer storage and recovery (ASR), and several specific surface sites, as well as a new reregulating reservoir for OID. Brown Lake and a high dam at Salmon Lake were considered the most feasible among the surface storage sites. Data for evaluating groundwater storage (ASR) were quite limited, but was considered capable of producing a firm yield of 800 AFY at a cost of approximately $2.5 million.

Storage opportunities on the Similkameen River have been studied historically by the Army Corps of Engineers (USACE), OTID, and have been more recently considered by the Okanogan PUD. Storage using flashboards at Enloe Dam remains under consideration as part of the FERC License Application for the project, but has not been decided. The WRIA 49 Planning Unit endorsed studying this concept, but the grant application to do so was not funded by Ecology.

OTID and its predecessor (West Okanogan Valley Irrigation District) studied and obtain rights to storage at Palmer Lake. The projects appeared feasible; it is not clear why they did not move forward.

In 1948, the Corps issued a study of major storage and hydro opportunities on the Columbia River and its tributaries. A high dam at Shanker's Bend was included in that study, but was not constructed (although most, if not all, of the other projects were). The site continued to be studied in the 1950's, 1970's and 1980's. The site appears to offer potentially regional storage benefits, providing hydroelectric generation, water storage, and flood control, as well as potential improvements to fish habitat in the Okanogan. Various configurations of the project have entailed as much as 1.6 MAF of flood storage, 84 MW of electric power generation, and 162,000 AF of usable water storage.

WATER QUALITY ASSESSMENT (CHAPTER 5)

The water quality assessment provided in Chapter 5 summarizes existing water quality monitoring data collected from the Okanogan River and its tributaries by the Colville CCT, the OCD, the US Geological Survey (USGS), and the Washington State Department of Ecology (Ecology). Where data were available, the source water quality data from the mainstem Okanogan and each of its tributaries were examined and compared against existing water quality criteria promulgated (made into law) by the State of Washington. Other relevant biological or physical metrics were used in cases where no specific criteria have been promulgated.

Previous studies that have attempted to synthesize existing water quality information for the entire basin (e.g., Montgomery Water Group et al. 1995, Golder and ENTRIX 2001, NWPPC 2004, OCD 2005), were limited in their conclusions by the availability of quantitative data. However, consistent with the objectives of the Okanogan Water Quality Management Plan (OCD 2005) recent efforts over the past five years have produced baseline water quality measurements in most of the major tributaries in the basin from which to gauge conditions. The type of information available for any given location in the basin is highly variable and depends on land ownership patterns, resource status, and study objectives. Although various data sets were collected using different methods, this information, they can be used in conjunction to form a comprehensive understanding of baseline water quality conditions in the Okanogan basin.

Water quality data reviewed for this assessment were primarily recorded at the individual tributary scale, consistent with the HUC-6 level. Principal findings of the assessment follow.

Dissolved oxygen did not meet water quality criteria in more than 10 percent of samples analyzed in lower Tunk Creek, Salmon Creek, Johnson Creek, Bonaparte Creek, Antoine Creek, Tonasket Creek, and Ninemile Creek. That so large a number of tributary systems failed to meet Class A DO criteria could be problematic, as oxygen deficits severely limit the functional value of aquatic systems to support aquatic life.

Class A temperature standards were exceeded in the Okanogan mainstem and in multiple monitoring stations in Omak, Tunk, Salmon Creek, and Wannacut creeks, and at the lower Sinlahekin, Bonaparte, Antoine, and middle Tonasket creek monitoring stations. This essentially basin-wide finding is not new. In part, it relects natural conditions of WRIA 49. The potential to enhanced riparian cover in tributary systems to provide shade and lower temperatures could be explored through additional habitat analysis. The degree to which temperature affects fish use and other aquatic life has been poorly explored in the past.

The Okanogan mainstem and tributaries are almost uniformly alkaline (well above neutral readings of 7). The degree to which pH is affected by land use activities is unknown, but could be explored in subsequent analyses.

Fecal coliform exceeded water quality criteria relatively often in the mainstem and in some tributaries (e.g., Bonaparte). This appears to be a consistent and chronic problem. Exceedances may arise from multiple sources, and are likely most easily addressed at the tributary scale. Many tributaries have not been sampled for this parameter, so identifying sources will require more sampling. However, sampling in the mainstem in particular exhibited seasonal trends, with counts highest between May and October. This seasonal pattern may reflect greater direct contact with the water by livestock and wildlife during the late spring to early fall months.

Dichlorodiphenyltrichloroethane (DDT) and related compounds (DDE, DDD, etc.,) and PCBs appear to remain a problem in some isolated areas. However, current evidence does not suggest these persistent organic pollutants, for which Total Maximum Daily Limit (TMDL) studies have been conducted, are a problem basin-wide. Other organic pollutants, such as pesticides typically persistent in historic agricultural areas (e.g., chlordane) have not been sampled to the same degree throughout the basin.

Collectively, the results of the metals sampling conducted by Ecology and the OCD do not suggest there are basin-wide issues with metal contamination. Detectable metals have only been found in Tunk Creek sampling. However, sampling has not been conducted in many tributary basins, including some with a mining legacy.

AQUATIC HABITAT ASSESSMENT (CHAPTER 6)

Data-driven aquatic habitat assessments from the Okanogan basin are largely lacking from past research and reports of the Okanogan basin. Limited studies were done in some tributaries by the USFS, WDNR, and CCT on lands they manage (e.g., USFS 1998, USFS 1999, WDNR 1996, CCT 1995). These studies provide some empirical data on aquatic and/or riparian conditions from which to gauge the functionality of the habitat in select watersheds (e.g., Siwash, Tonasket, Bonaparte creeks) and will be useful for further consideration in the final watershed plan.

No new studies were identified or brought forward from these agencies to allow for an expanded review over that which was conducted in these previous reports. These and other references were previously reviewed for the Okanogan Limiting Factors Assessment (LFA) (ENTRIX and Golder 2001). Because of data limitations, the habitat factors of concern identified in the LFA were often based on professional judgment of the attainability of “properly functioning conditions” (PFC’s).

The term ***properly functioning conditions (PFCs)*** is used by NOAA/NMFS to characterize how physical and chemical characteristics measurable within surface water or adjacent riparian habitat may affect salmonid fishes. These factors are not formal criteria, but rather “guidelines” that have a strong basis in the fisheries and water quality literature, and reflect the current understanding of the physiological limitations and preferences of salmonid fishes. They do not necessarily account for localized acclimation of salmonid stocks to naturally extreme conditions, such as may occur within portions of the Okanogan basin. The interpretation of properly functioning habitat used for the LFA, and the principal habitat assessment conclusions in that report, are tabulated in Attachment 3 of this report.

Due to the limitations discussed above, this section summarizes preliminary findings and analysis of habitat data collected recently from the mainstem Okanogan and portions of the basin, by the CCT in 2004 and 2005. A full integration of this new analysis with past findings could be considered under Level 2 assessment.

Based on the CCT data, and related water quality and flow data, impacts to aquatic habitats of importance to fish, wildlife and human recreation appear to be interrelated to flow and water demand — consistent with ‘Rivers and Creeks of Concern’ summary above. Habitat is affected by reduced and/or absent flow in several tributaries where flow may have been over-allocated. This affects not only the tributaries, but also the quality of the mainstem Okanogan habitat where cooler water entering from tributaries no longer is available to buffer mainstem temperatures.

Only a limited portion of the data collected by the CCT in 2004-2005 were recorded in a form that allows comparison to previously collected data, or to synthesized expert opinions. Level 2 work may consider normalizing this data into forms that can be more useful in characterizing existing habitat quality. Data from several tributaries on the western side of the Okanogan basin are lacking, as these systems have not as yet been a major focus of the current efforts of the CCT.

The Okanogan Limiting Factors Assessment (ENTRIX and Golder 2001) indicated that some level of habitat impairment can be found in most tributaries of the Okanogan watershed. On the positive side, however, much of the mainstem habitat and several tributaries are sufficiently intact to support self-sustaining populations of salmon and steelhead trout, particularly if access barriers, including artificially depressed flows, are removed.

The tributaries identified in the Okanogan LFA that were of primary importance to recovery included: Omak Creek, Salmon Creek, and the Similkameen River. These tributaries were previously identified as central foci for salmon recovery efforts. Nothing has changed since the publication of the LFA document to alter that conclusion, although additional tributaries have been found to support significant steelhead spawning (please refer to Attachment 2 — Fish Distribution Maps). Tributaries found to support spawning include Ninemile Creek and Bonaparte Creek, if only in the small reaches accessible to them (Arterburn et al. 2005).

Omak Creek is the only tributary of the Okanogan River that historically contained steelhead and that is currently not blocked by man-made barriers or access-limited by low flows resultant from water withdrawals. Other tributaries of importance to salmon recovery with significant historical salmonid use and potential include: Salmon Creek, Tonasket Creek, Tunk Creek, Bonaparte Creek, Antoine Creek, Siwash Creek, and Loup Loup Creeks. Many of these tributaries currently have either natural barriers close to their confluence, flows that are severely reduced from irrigation diversions or nearby wells, and/or substantial habitat issues such as sedimentation (e.g., Bonaparte Creek.) that preclude significant numbers of salmonids from effectively using the habitat available.

DATA GAPS & RECOMMENDATIONS (CHAPTER 7)

Data gaps and recommendations are organized in Chapter 7 following the above outline (water quantity, water storage, water quality, and aquatic habitat). The gaps and recommendations listed in Chapter 7 are intended to provide a beginning point for Planning Unit consideration as possible options for Level 2 work and as possible foci for watershed planning. They are not listed in any order of priority.

Chapter 1.0: Introduction and Planning Framework

This section introduces watershed planning and describes its framework. It describes Level 1 work within that framework, and identifies the role and use of the Level 1 Report in the watershed planning process.

1.1 OVERVIEW OF WATERSHED PLANNING

1.1.1 Enabling Legislation

Watershed planning occurs under enabling legislation passed in 1998, and is closely tied to planning for other water and watershed resources, including salmon recovery, local land use planning, water system planning, stormwater management, and a host of other federal, state, regional and local laws, regulations, and planning initiatives.

In 1998 the Washington State Legislature passed Engrossed Substitute House Bill 2514, the Watershed Planning Act (Revised Code of Washington (RCW) 90.82) to provide a framework for locally-based watershed planning and resource management. The primary goals of local watershed planning are to assess the status of water resources within Washington's WRIA 62 and determine how to address competing demands for water within each WRIA. A stated purpose of the statute is "...*to develop a more thorough and cooperative method of determining the current water situation in each water resource inventory area of the state and to provide local citizens with the maximum possible input concerning their goals and objectives for water resources management and development*."

The Watershed Planning Act mandates certain steps for the watershed planning process, particularly in organizing and adopting the plans. The law also sets forth certain questions and broad parameters to be addressed in the plans. However, the legislature chose to leave local watershed groups with a great deal of flexibility in carrying out their work, and does not mandate a particular approach to watershed planning.

1.1.2 Planning Unit

The Watershed Planning Act establishes a process to create local "Planning Units," which carry out the planning process. A WRIA 49 Planning Unit was established in 2005, facilitated by the Okanogan Conservation District. Its membership represents Okanogan County, major cities (Okanogan, Omak, Oroville, Tonasket, Conconully), Okanogan PUD No. 1, well drillers, irrigation districts and irrigators outside districts, the business community, Grange, sportsmen, environmental community, Cattleman's Association, Horticulture Association, Central Okanogan County Farmers, north and south county landowners, recreation, Okanogan Resource Council, Okanogan Farm Bureau, mining and logging, Osoyoos Lake Water Quality Society (B.C.), and a member at large. Advisory state and federal agencies include USFS, BLM, and WDFW.

1.1.3 Plan Elements

Watershed Plans may assess current and future water supply and water use, address water quality and habitat issues, and recommend instream flows for streams and rivers in each WRIA. These four – water quantity, water quality, habitat, and instream flows – are the basic elements of 2514 watershed planning. As salmonid stocks occupying large areas of Washington habitat have come under the protection of the Endangered Species Act (ESA), watershed plans may incorporate salmon recovery and develop strategies to address these listings.

While watershed planning itself is not mandatory, once a decision is made to undertake planning the Act requires some elements and allows Planning Units discretion in undertaking others. Watershed Plans must address water quantity and strategies for water supply; water quality, habitat and instream flows are optional. Instream flows may be referred to the Washington Department of Ecology (Ecology) for action, if desired. By unanimous vote, Ecology may be requested to change an existing instream flow. With unanimous agreement of governmental members and majority support of non-governmental members of a Planning Unit, Ecology will adopt a rule to implement an instream flow on a stream where a minimum flow has not yet been set (RCW 90.82.080).

1.1.4 Initiation

Watershed planning may be initiated only by counties with jurisdiction within a WRIA, by the largest city or town located within the WRIA, and/or by the water purveyor that obtains the largest quantity of water from the WRIA. These “initiating governments” must invite Native American Tribes with reservation lands within the WRIA to join them. The Colville Confederated Tribes were invited to join the WRIA 49 Planning Unit, but declined by Council Resolution. Other affected tribes must also be invited, including those with federal fisheries resource rights in the WRIA, federally reserved water rights claims on WRIA resources, or federally-approved water quality standards in the WRIA or affected by waters of the WRIA. If Tribes choose to join, they too become initiating governments.

The initiating governments choose a lead agency (Okanogan Conservation District, in the case of WRIA 49), and undertake an organizing phase (Phase 1), which includes developing a planning process; determining a scope of work; convening a Planning Unit broadly representative of water resource interests in the WRIA; developing necessary interlocal agreements; and applying for watershed assessment (Phase 2) and watershed planning (Phase 3) grants. The initiating governments, Tribes, and other members of the planning unit have considerable flexibility to set the planning process, focus watershed inventories and plans on key issues of local importance, assess water resources and needs, and recommend management strategies. Planning generally must be complete within four years after receipt of Phase 2 grant funds.

1.1.5 Limitations and Obligations

The Watershed Planning Act also imposes certain restrictions on what a watershed plan may do. Among them, watershed plans may not:

- Conflict with law or tribal treaty rights;
- Impair or diminish a water right;
- Affect or interfere with water rights adjudication; and
- Modify habitat restoration or enhancement projects under the Salmon Recovery Act (SRA).

Plans may recommend changes in state, regional, or local regulations, policies or plans; however, they may not themselves change existing local ordinances or state rules. Entities that participate in the planning process and agree to be obligated by a watershed plan are bound by it. Existing law or regulation may be changed only where Planning Unit participants (including federal agencies that participate in an advisory capacity) agree to be obligated by a watershed plan and to take appropriate action in accordance with plan provisions.

1.1.6 Expanded Planning Funds

Under legislation enacted in 2001, Planning Units became eligible for additional funding to finance further Phase 2 assessment activities in the areas of instream flows, water quality, and detailed assessments of water storage. WRIA 49 is eligible to receive additional funding in all three categories.

1.1.7 Approval

Approval of a watershed plan requires, at a minimum, the unanimous agreement of the local, State and tribal governmental members and a majority vote of non-governmental members of a Planning Unit. If approved, the Plan is submitted to the county governments with territory in the WRIA for ratification by majority vote of each elected governing body in joint session.

The Watershed Planning Act directs Planning Units to review planning, projects, and activities already completed or underway regarding natural resource management or enhancement in the area and incorporate their products as appropriate so as not to duplicate work already performed or underway.

1.1.8 Implementation

Watershed management will require a substantial public investment to accomplish the goals established in state law. The Watershed Planning Act was amended in 2003 to provided funding for a Phase 4, Implementation. This phase requires a ten percent match requirement for the grant recipient (this may include financial contributions or in-kind goods and services directly related to coordination and oversight functions). The match can be provided by the planning unit or by the combined commitment from federal agencies, tribal governments, local governments, special districts, or other local organizations. The phase four grant may be up to $100,000 for each planning unit for each of the first three years of implementation. At the end of the three-year period, a two-year extension may be available for up to $50,000 each year.

RCWs 90.82.043 and 048 (Attachment A) lay out the requirements for Watershed Implementation Plans. Under Section 043, requirements include strategies to provide sufficient water; clear definition of coordination and oversight responsibilities, requirements for interlocal agreements, rules, ordinances, or permits; consultation to assure eliminate duplication or inconsistencies. Under Section 048, they deal with the planned use of inchoate municipal water rights. Implementation planning should use and build on the strategies developed in the watershed plan and should be tied directly to the Watershed Plan recommendations.

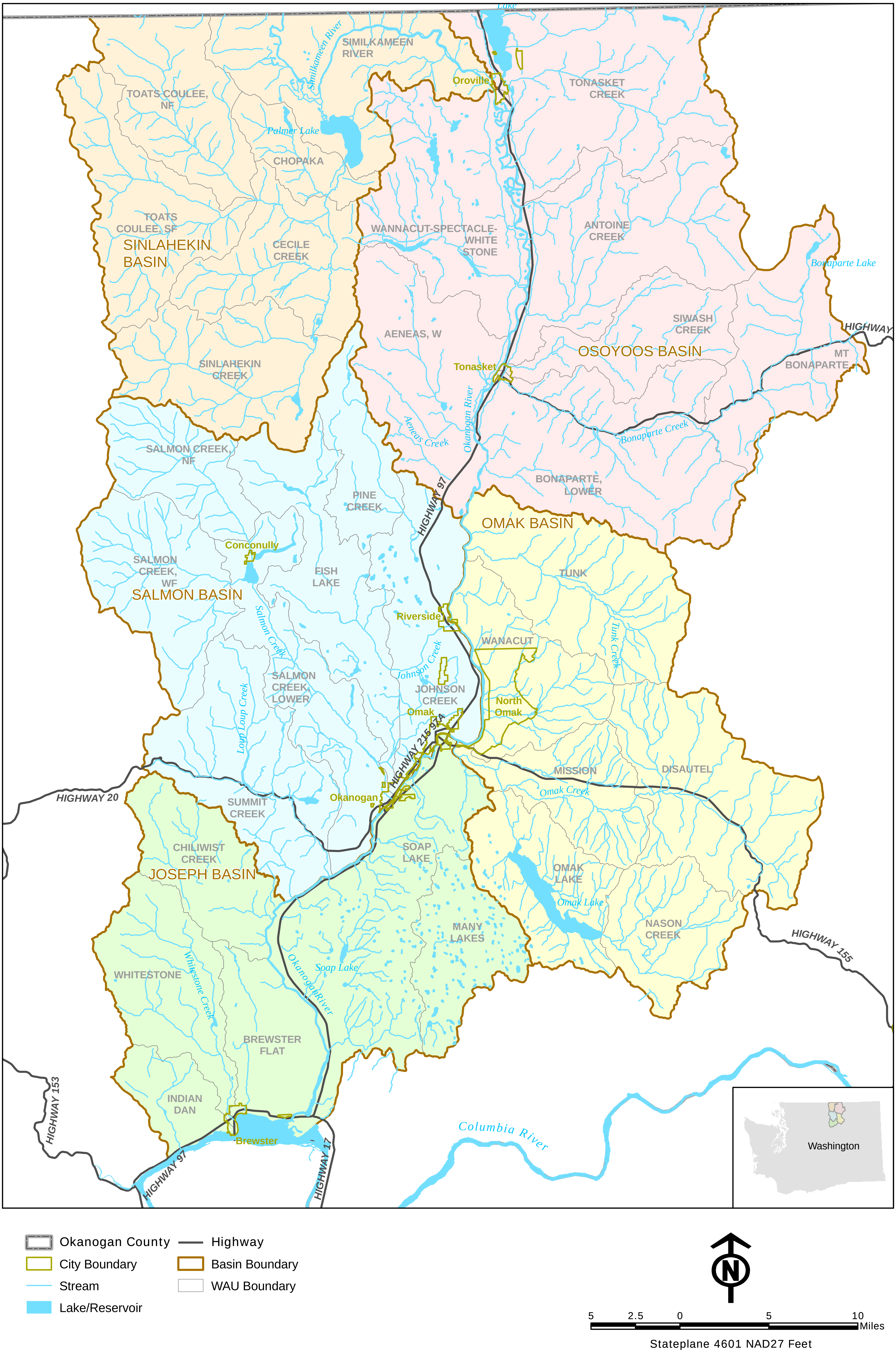
THE LEVEL 1 REPORT

This Level 1 Report summarizes existing information for WRIA 49, the Okanogan River Basin (Figure 1.1-1). Level 1 is the first step in Phase 2 of the watershed planning process, which focuses on an assessment and inventory of watershed resources. During Level 1, Planning Units gather and review existing information, to determine its reliability and adequacy for characterizing the WRIA and analyzing priority issues. An outcome of Level 1 should be an identification of data gaps and recommendations to guide new studies and research. These new studies and research activities comprise Level 2, the second step of Phase 2 watershed planning. Together, Levels 1 and 2 provide the basis for the development of the watershed plan itself (Phase 3).

The Level 1 Report is a “way station,” a product that is used in developing a watershed plan; it is not an end in itself. The WRIA 49 watershed planning unit has chosen to address water quantity, water quality, habitat and instream flows. The report is prefaced by an Executive Summary, which includes a Summary of Concerns covering Subbasins of Concern, Water Systems of Concern, Agricultural Water Supply Concerns, Rivers & Creeks of Concern, Habitats of Concern, and Canadian Water Issues.

Several scales of subbasins or subwatersheds have been defined for WRIA 49 (Figure 1.1-2). As characterized by the Washington State Department of Ecology, the five major or “watershed assessment units” (WAU’s) of the WRIA are the Joseph, Salmon, Omak, Sinlahekin, and Osoyoos subbasins.

WRIA 49



SIMILKAMEEN RIVER
TOATS COULEE, NF
TONASKET CREEK
CHOPAKA
TOATS COULEE, SF
SINLAHEKIN BASIN
CECILE CREEK
WANNACUT-SPECTACLE-WHITE STONE
ANTOINE CREEK
SIWASH CREEK
OSOYOOS BASIN
MT BONAPARTE
AENEAS, W
SINLAHEKIN CREEK
SALMON CREEK, NF
PINE CREEK
BONAPARTE, LOWER
OMAK BASIN
SALMON CREEK, WF
SALMON BASIN
FISH LAKE
TUNK
WANACUT
SALMON CREEK, LOWER
JOHNSON CREEK
MISSION
DISAUTEL
SUMMIT CREEK
CHILIWIST CREEK
JOSEPH BASIN
SOAP LAKE
OMAK LAKE
MANY LAKES
NASON CREEK
WHITESTONE
BREWSTER FLAT
INDIAN DAN
Oroville
Tonasket
Conconully
Riverside
North Omak
Omak
Okanogan
Brewster
Similkameen River
Palmer Lake
Bonaparte Lake
Bonaparte Creek
Aeneas Creek
Okanogan River
Salmon Creek
Johnson Creek
Tunk Creek
Loup Loup Creek
Omak Creek
Omak Lake
Whitestone Creek
Soap Lake
Columbia River
HIGHWAY 97
HIGHWAY 20
HIGHWAY 215/97A
HIGHWAY 155
HIGHWAY 153
HIGHWAY 17
HIGHWAY
Washington
Okanogan County
City Boundary
Stream
Lake/Reservoir
Highway
Basin Boundary
WAU Boundary
N
5 2.5 0 5 10
Miles
Stateplane 4601 NAD27 Feet

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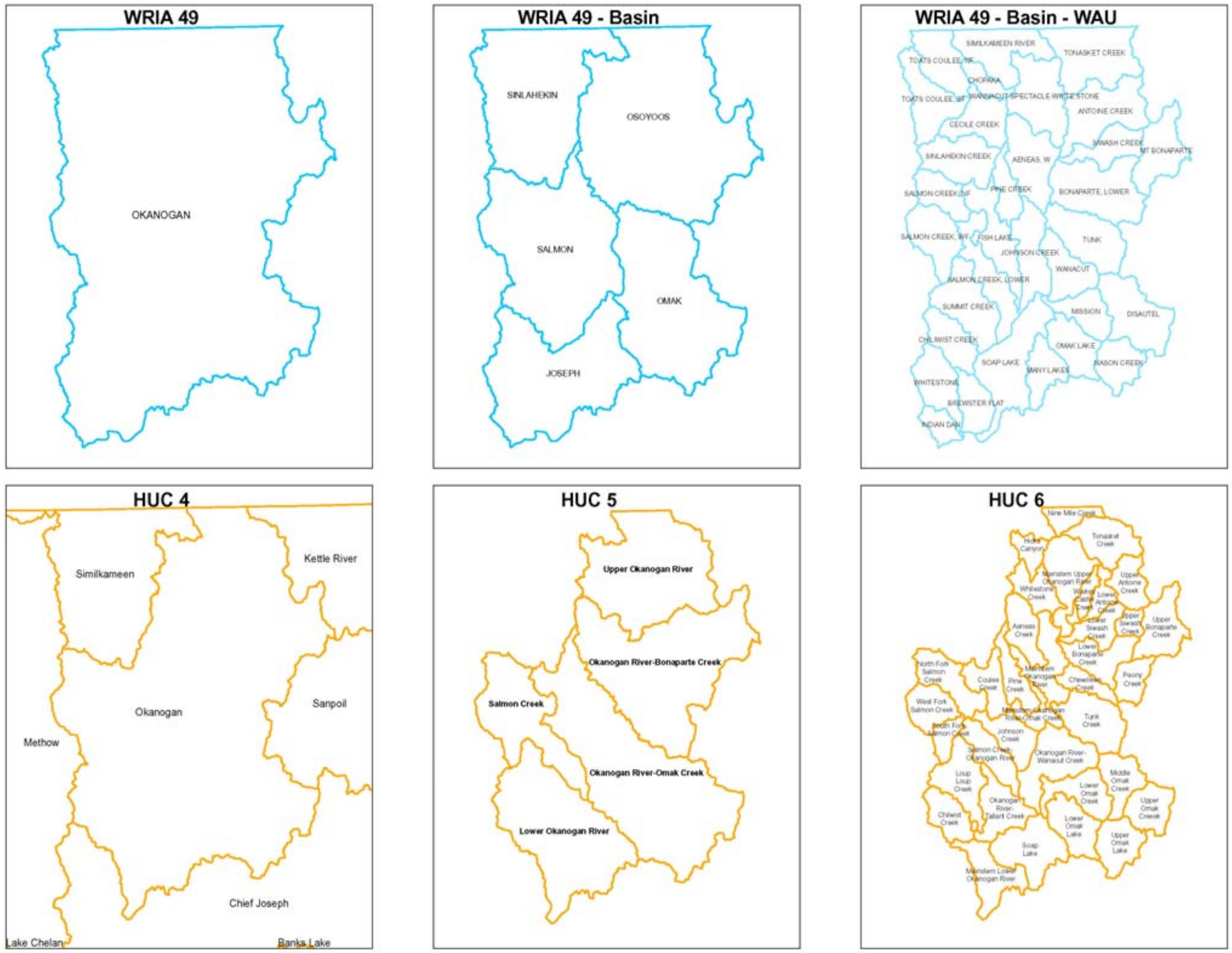
Figure 1.1-2 WRIA 49 Subbasins Comparison

WRIA Data Source: WADOE



HUC Dataset Source: PNW Hydrography Project

These subbasins are representative of the fifth-field hydrologic unit criteria scale (HUC-5) and generally combine several independent tributaries within the geographic scale addressed. However, in the Level 1 report, information has been gathered and analyzed at the smallest appropriate scale at which data exist, and, where possible, was evaluated at the finer HUC-6 scale which corresponded to the Generally, for water quality, habitat, and instream flows, this is at the smallest hydrologic scale, the individual stream, or tributary. In each of these topical areas, the subbasin or subwatershed information is discussed comparatively.

For water quantity, the appropriate scale depends upon the nature and use of the information. Water rights, for example, are tied as closely as possible to the individual water source. For surface water sources, this means the individual stream, lake or spring. (However, many water rights records do not name the source, which may be identified as “unnamed stream” or “spring,” etc.) However, public water systems and irrigation districts, the two largest sectors of water user in WRIA 49, do not normally either develop or supply water on a HUC-6 or WAU basis. Service areas may have little to do with hydrologic boundaries. Groundwater aquifers may extend beneath a number of HUC or WAU units. For these elements of water quantity, analysis is provided at the WRIA or major subbasin scale.

Because voluminous data exist in these areas, the Level 1 Report consists of two parts: an overview narrative report and a CD data appendix. Data appendices are provided, so that those who wish to follow up with a more detailed exploration of the data should be able to find their way quickly and easily from the discussion to the data. It should be recognized, however, that many of the data files contained in these appendices are working files used by (and in use by) the analysts who have prepared this report. Thus, the contents contained in each differ broadly dependent on subject matter, and they may not represent the ‘final word’ on the analysis of the subject matter. They are provided simply to ensure that all readers can have access to the data and data management exercises that were performed, and with the thought they would be revisited for subsequent Level 2 watershed planning efforts.

Chapter 2.0: Watershed Overview and Water Balance

This section summarizes existing information at a watershed scale, building a basis for understanding data and issues related to water quantity, water quality, habitat and flows. The section first discusses climate and physiography, which provide the groundwork for subsequent consideration of surface and ground water. Flow data is combined in the discussion of physiography due to the influence of land form on surface flows, and the discussion geology and hydrogeology and combined for similar reasons. These data lead into the estimation of an initial (and very preliminary) WRIA 49 water balance.

Three sources of precipitation data from individual stations in WRIA 49 were obtained and reviewed, including annual and monthly totals available from the National Climate Data Center (NCDC) and the Western Region Climate Center (WRCC), and a contour map of mean annual precipitation available from the National Resource Conservation Service (NRCS) website.

The NRCS precipitation contour map is based on NOAA Cooperative Station normals (1961-1990), NRCS SNOTEL station normals, and supplemental data provided by regional and state climatologists and designated reviewers (e.g., elevation-precipitation trends, other factors including statistical treatments for reducing bias). Thus, the NRCS contour map was the best source of data for computing water balances on a watershed scale. Individual station precipitation data is compiled in Appendix D-1 (Climate Data). The locations of the individual stations and a WRIA-wide precipitation contour map are provided in Figure 2.1-1.

Streamflow data for 68 separate gaging stations were obtained and compiled from four principal sources including the OCD, CCT, USGS, and Washington Department of Ecology (Ecology). For some of these stations, however, the exact gage location was not available or may have been reported by more than one source, so may actually be a duplicate or partial record. As a result, the quality of the data records ranges from poor to good; from the available data, however, only the USGS has rated the quality of data.

USGS, Ecology, Okanogan County NRCS and WDNR reports, maps and websites were reviewed to obtain up-to-date physiographic and hydrogeologic descriptions and conditions of WRIA 49.

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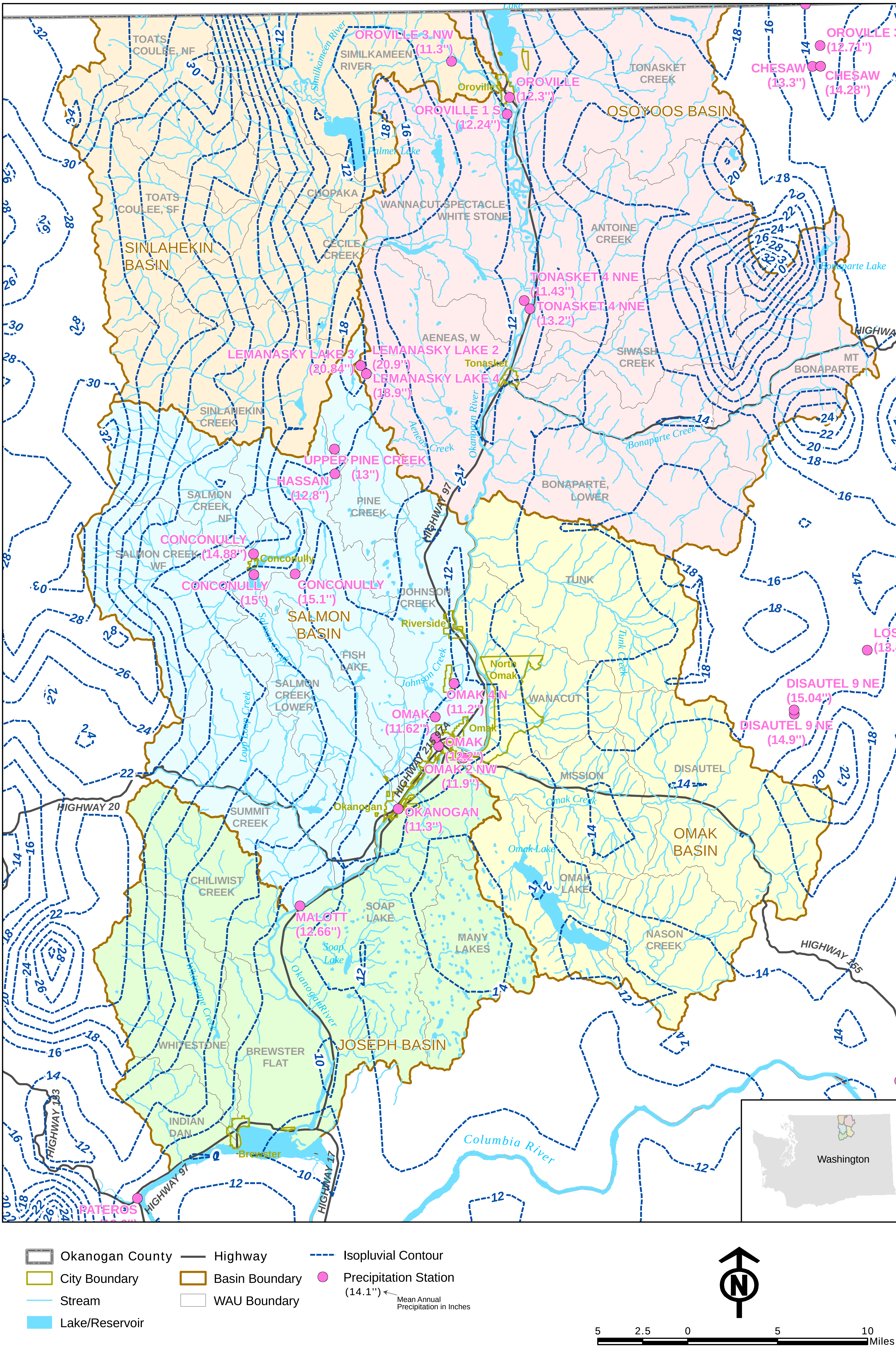
WRIA 49 Precipitation Map



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2.1 CLIMATE

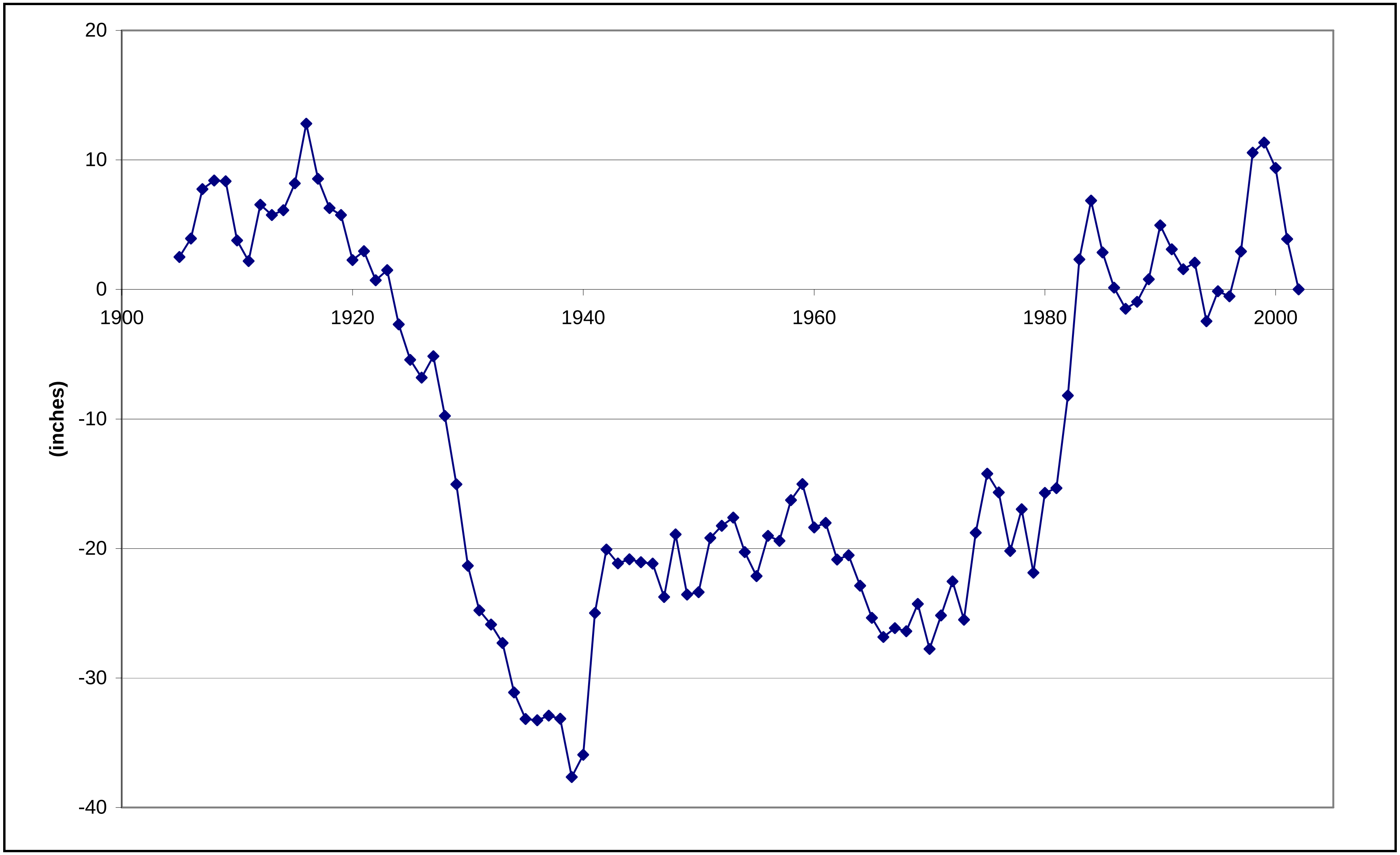
The climate of the Okanogan River valley is semiarid in the lower valleys and subhumid in the mountains. Depending on location, daily temperature extremes can be substantial. At higher elevations, temperatures are lower and precipitation is usually greater (Walters 1974:7).

Mean annual precipitation (MAP) ranges from 11 inches per year at lower elevations in the Okanogan River valley to approximately 30 inches at higher elevations within the Sinlahekin and Salmon Creek Subbasins. Winter season snowfall varies from 30 to 70 inches. Snow can be expected after the first of November and remains on the ground from the first of December until March or April. Snow accumulates to a depth of about 10 to 20 inches in the valley, and up to 40 inches at higher elevations. Precipitation data for weather stations located in the WRIA are provided in Appendix D.1. The locations of the stations and a WRIA-wide precipitation contour map are included Appendix D-1 (Climate Data). Maps provided in the Map Atlas (Attachment 2) show climate stations at the HUC-5 subbasin level.

Significant trends in wet or dry periods have been observed over the past 100 years, and the effects of these trends on water availability should be considered in watershed planning. For example, the long-term MAP at Omak is 11.8 inches, but during a 23-year period from 1917 through 1939, MAP averaged 9.6 inches (or 2.2 inches below average per year). For a four-year period within that same timeframe (1928 to 1931), MAP averaged only 6.9 inches. These long-term dry periods have a significant effect on cumulative water storage. This is depicted in Figure 2.1-2 which shows the cumulative departure from average precipitation (CDAP) for Omak. The ‘zero’ line reflects the average, hence the date is reflected here. Points above this line reflect above average precipitation, and those below reflect below average precipitation for the year indicated.

In general, shallow (e.g., < 50 ft below ground surface) groundwater levels and groundwater storage are somewhat related to the rise and fall of CDAP. When CDAP is increasing more water is available to recharge groundwater, so that water tables rise (i.e., assuming no well withdrawals); similarly, water tables decline when CDAP decreases. For example, CDAP decreased about 50 inches over the 23-year period noted above, indicating reduced recharge over this time period, which probably resulted in low water tables (although no data were available to support this inference).

Figure 2.1-2: Cumulative Departure from Average Precipitation – Omak (1904-2002)



The average January maximum temperature is between 28° and 32° F, and the minimum temperature varies from 15° to 20° F. Minimum temperatures from 0° to -15° F occasionally occur in the winter, and readings as low as -30° F have been recorded in the colder locations. In July, the average maximum temperature ranges from 85° to 90° F, and the minimum temperatures are in the lower 50's. Maximum temperatures sometimes reach 100° F or higher in the summer (113° F is the maximum recorded). Weather station temperature data are included in Appendix D.

In some cases station location data are inconsistent or multiple locations have been identified for an individual station. The data sources also at times provide varying values for the same statistic (e.g., mean annual precipitation). This is likely because these statistics have been calculated for different periods of record. If better precipitation data (i.e., refining water balance calculations or establishing trends for wet and dry periods) are desired, the Planning Unit may consider establishing weather monitoring stations at accurately known locations and taking the data for comparable periods of record.

2.2 PHYSIOGRAPHY AND SURFACE WATER

The Okanogan River basin originates in British Columbia and flows through four lakes (Okanogan, Skaha, Vaseaux and Osoyoos) before crossing into the State of Washington. The watershed encompasses about 2,600 square miles in the State of Washington, and 6,300 square miles within British Columbia (Ecology 1995). From its confluence in the Columbia River (Col. River mile 533.5) to Lake Osoyoos, the river stretches approximately 79 miles (ENTRIX, Inc. and Golder 2001) The eastern and western boundaries of the basin are steep, ranging in elevation from 1,500 to 5,000 feet above the basin floor. Some individual peaks are 7,000 to 8,000 feet above sea level. Lateral ridges extend toward the valley floor and taper to more gently sloped hills at lower elevations.

Runoff fed streams from rain and snow flow between the lateral ridges to the valley floor. The average width of the drainage area of the mainstem is 35 miles (ENTRIX and Golder 2001). The Okanogan River floodplain is about one mile wide. The floodplain descends from 920 feet at the Canadian border to approximately 780 feet at the confluence with the Columbia River. The northernmost four miles of the valley floor is occupied by Lake Osoyoos, which also extends into Canada. Glacially formed natural terraces are present at 500 feet above the valley floor and at the base of and in between lateral ridges (Walters 1974:7).

WRIA 49 is comprised of five major subbasins (Sinlahekin, Osoyoos, Salmon, Omak, and Joseph) that are comprised of the individual drainage basins as summarized in Table 2.2-1. These subbasins were originally outlined as Watershed Assessment Units (WAU) by Ecology for administrative purposes and represent watershed delineations at the fifth field HUC (i.e., HUC-5)**.**

Although the Similkameen River is considered a major tributary to the Okanogan River, its flow is, on average, is actually more than 4.4 times the flow of the Okanogan where the two rivers join at Oroville (Figure 2.2-1). About 90 percent of the Similkameen River drainage basin is in Canada; only the last approximately 10 percent of the drainage basin (or the last approximately 24 miles) (occur in the Sinlahekin subbasin. The Similkameen River receives almost all of its incremental flow within Washington from the Sinlahekin Creek and its primary tributary Toats Coulee Creek, as well as from other streams (Paysaten and Ashnola) that lie outside WRIA 49 boundaries. Sinlahekin Creek drains into Palmer Lake, which empties into the Similkameen River through Palmer Creek.

Table 2.2-1 Primary Subbasin and Drainage Basin Breakdown

PRIMARY SUBBASIN	DRAINAGE BASIN	TRIBUTARY TO:	AREA (SQ MI)
Sinlahekin	Sinlahekin Creek	Similkameen River	127.2
	Similkameen River	Okanogan River - Middle	91.9
	Toats Coulee Creek	Sinlahekin Creek	134.6
	Chopaka Lake	Sinlahekin Creek	16.8
		subtotal	**370.5**
Osoyoos	Nine Mile Creek	Okanogan River - Upper	14.8
	Tonasket Creek	Okanogan River - Upper	60.3
	Antoine/Whiskey Cache Creek	Okanogan River - Middle	75.8
	Siwash Creek	Okanogan River - Middle	44.6
	Bonaparte Creek	Okanogan River - Middle	146.4
	Chewilken Creek	Okanogan River - Lower	26.7
	Okanogan River - Upper	Okanogan River - Middle	16.5
	Horse Springs Coulee	Okanogan River - Middle	38.7
	Mosquito Creek	Okanogan River - Middle	7.5
	Whitestone Lake	Okanogan River - Middle	54.7
	Whitestone Coulee	Okanogan River - Middle	11.5
	Aeneas Creek	Okanogan River - Middle	8.6
	Baker Creek	Canada	7.0
		subtotal	**513.1**
Salmon	Loup Loup Creek (Summit Creek)	Okanogan River - Lower	62.5
	Tallant Creek	Okanogan River - Lower	12.8
	Salmon Creek	Okanogan River - Lower	167.4
	Johnson/Scotch Creek	Okanogan River - Lower	77.5
	Pine Creek/Wa on Road Coulee	Okanogan River - Lower	69.5
	Duck Lake	Johnson Creek	5.3

Table 2.2-1 Primary Subbasin and Drainage Basin Breakdown, continued

PRIMARY SUBBASIN	DRAINAGE BASIN	TRIBUTARY TO:	AREA (SQ MI)
	Okanogan River - Middle	Okanogan River - Lower	82.0
		subtotal	**477.0**
Omak	Tunk Creek	Okanogan River - Lower	71.0
	Wannacut Creek (CIR)	Okanogan River - Lower	19.0
	Omak Creek (CIR)	Okanogan River - Lower	133.2
	Omak Lake (CIR)	Okanogan River - Lower	229.9
		subtotal	**453.1**
Joseph	Chiliwist Creek	Okanogan River - Lower	40.8
	Whitestone (Swamp) Creek	Columbia River	57.0
	Indian Dan Canon	Columbia River	17.1
	Okanogan River - Lower	Columbia River	155.2
	Starzman Lake	Okanogan River - Lower	17.4
		subtotal	**287.5**
		TOTAL	**2101.2**

There are numerous other important tributaries that drain directly into the Okanogan River and these were examined as distinct HUC units in previous planning efforts focused on salmon recovery (ENTRIX and Golder 2004). Some of the more significant and larger ones draining from the west are Johnson, Salmon, Loup Loup, and Chiliwist Creeks. Dams impound Salmon Creek in Conconully Lake and Conconnuly Reservoir for irrigation. Important tributaries from the east include Tonasket, Antoine, Siwash, Bonaparte, Tunk, and Omak Creeks.

Most lakes in the basin are small except for Omak Lake, which has no direct surface water outlet to the Okanogan River and drains its own basin (it is a “terminal” basin). Omak Lake has a larger surface area than any other lake on the U.S. side of the Okanogan except Osoyoos Lake (which straddles the US-Canadian border). East of the Okanogan River, Bonaparte Lake drains into Bonaparte Creek, and water from Sidley Lake near the Canadian border enters the Tonasket Creek system. West of the Okanogan River, in addition to Palmer Lake, Blue Lake drains into Sinlahekin Creek.

There are several data sets with long-term continuous records (continuous hydrographs of more than 10 years), short-term continuous records, individual point data from throughout the year, or only very short-term seasonal data. Specifically, Ecology began collecting point and continuous flow data on the Similkameen River near Oroville in 1996, and then at six other locations in 2002. The OCD began collecting point data in 2000. OCD has 25 stations in all (many of them upper and lower on the same creek); these OCD stations also double as water quality sampling stations. Subbasin summaries of the continuous recorded data are provided in Table 2.2-2, and other streamflow data (individual point measurements) in Table 2.2-3. A compilation of streamflow data for the stations listed in Tables 2.2-2 and 2.2-3 is included in Appendices D-2 and D-3.

In addition to the Ecology and OCD data, flow data have been collected by the CCT, the BOR and the USGS. The CCT began collecting continuous flow data on the Okanogan River in 1977. A number of other gaging stations were added in 2002. CCT has ten stations in all. BOR also has a record of mean monthly flows for one station on Johnson Creek from 1903 to 1962. The USGS has records for 25 stations, but most of these records cover only a short time period. Only ten stations have more than 10 years of record. USGS began recording in 1903 with two stations but only a few years of data were collected. From 1911 to 1930 there were up to four stations. Some long-term records began in 1928 on the Similkameen River, in 1911 on the Okanogan at Tonasket, and in 1942 on the Okanogan River at Oroville to present. Five other stations were active during 1957 to 1971. Only four USGS stations are currently operating today. One is located on the Similkameen and three others on the Okanogan (at Malott, Tonasket and Oroville). Only one station not on the mainstem, Tonasket Creek, has more than 20 years of record from 1967 to 1991. Because many of the flow sampling locations were also used for water quality sampling, these stations are depicted in the map showing those locations in Chapter 5 (Figure 5.1-1). The quality of the source data cannot be ascertained from the data reviewed, as such quality control would require cross-sectional and velocity profiles used to measure flow. We assumed flows were measured using these standard practices and were therefore reliable. These data allow for interpretation of flow changes over time, at least to some extent.

For those streams for which data are available, the estimated mean annual flows per square mile are highest in the Sinlahekin (160 to 478 ac-ft/sq mi) and Salmon (50 to 491 ac-ft/sq mi) subbasins and lowest in the Osoyoos (21 to 39 ac-ft/sq mi) and Omak (21 to 66 ac-ft/sq mi) subbasins (excluding flow in the mainstem Okanogan). There are no mean annual flow data for streams in the Joseph Subbasin, but it is likely that flows per unit area are also very low there (Table 2.2-4). Peak discharges typically occur during the 4-month period from April through July (Figures 2.2-1 to 2.2-4), reflecting primarily snowmelt or snow on rain events, when streams contribute about 70-80 percent of their average annual discharge. Low flows generally occur from August (e.g., Johnson Creek) to October (e.g., Okanogan River) depending on the stream, but prior to the beginning of autumn rainy periods. In some cases, the streamflow hydrographs are influenced by upstream diversions or regulation (e.g., Whitestone Creek on Figure 2.2-2). Some smaller streams freeze up during winter and have no flow until the spring flaw.

Figure 2.2-1: Okanogan and Similkameen Rivers – Monthly Mean Flows

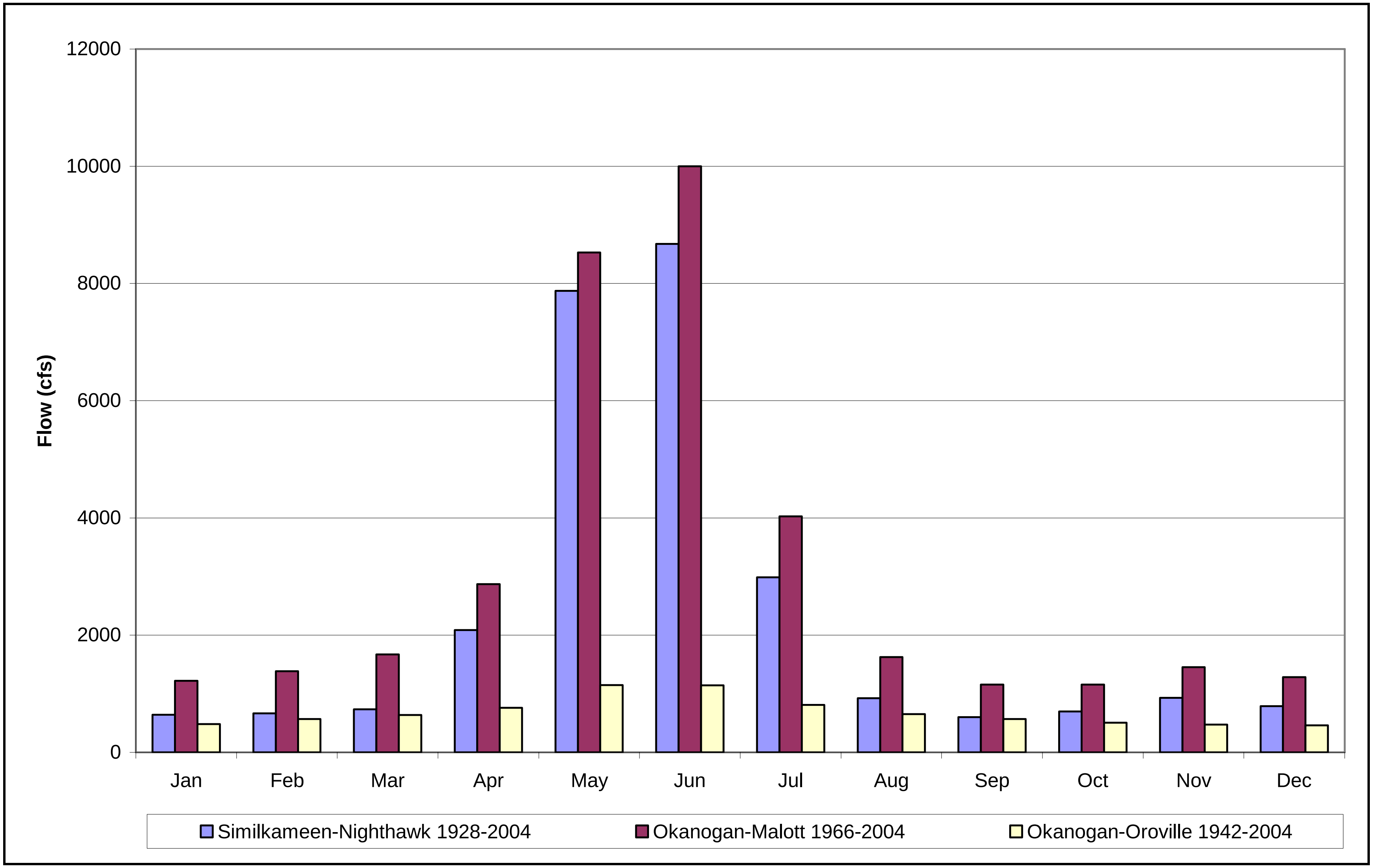


Figure 2.2-2: Whitestone, Bonaparte and Tonasket Creeks – Monthly Mean Flows

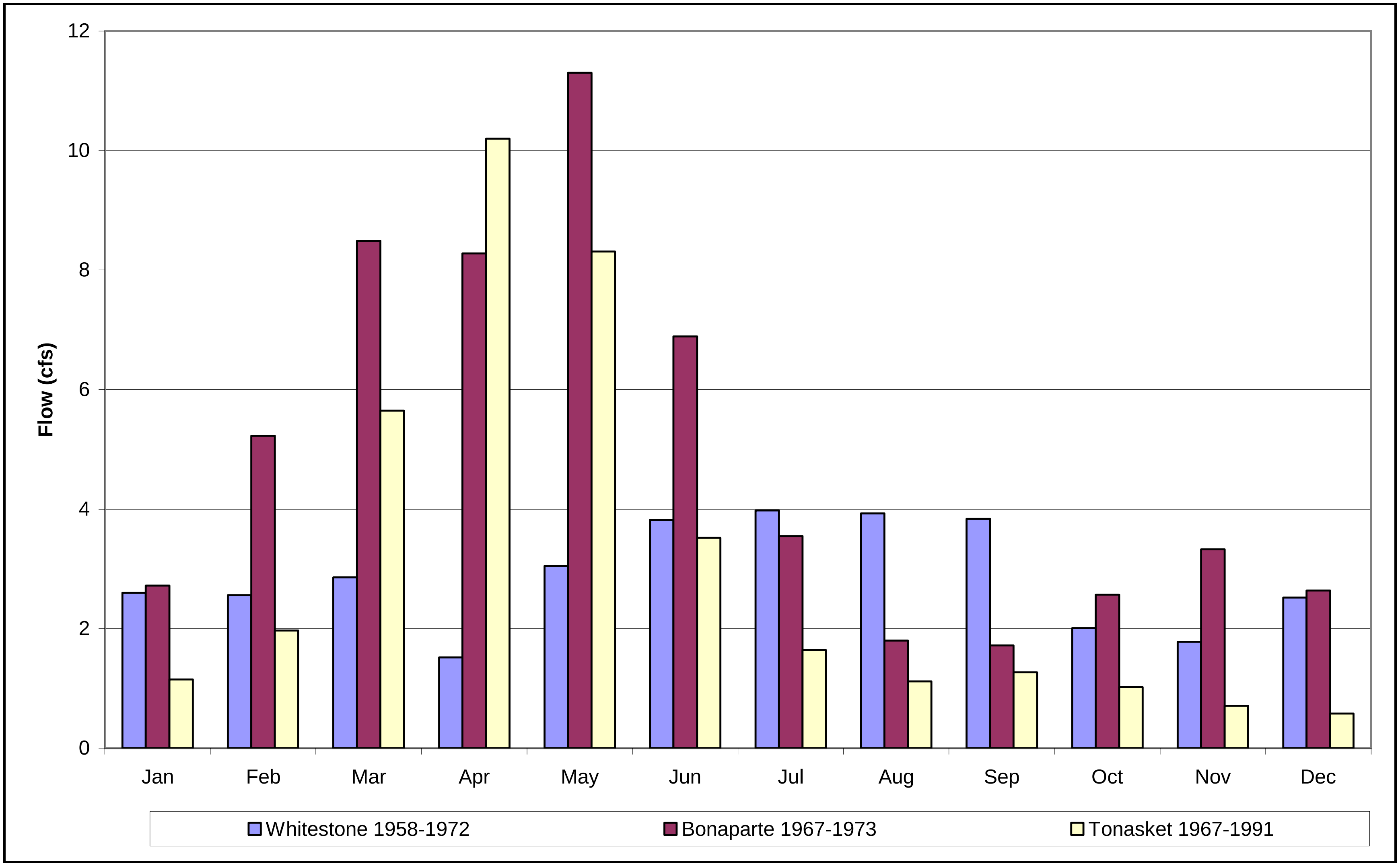


Figure 2.2-3: Sinalhekin, Johnson and Tunk Creeks – Monthly Mean Flows

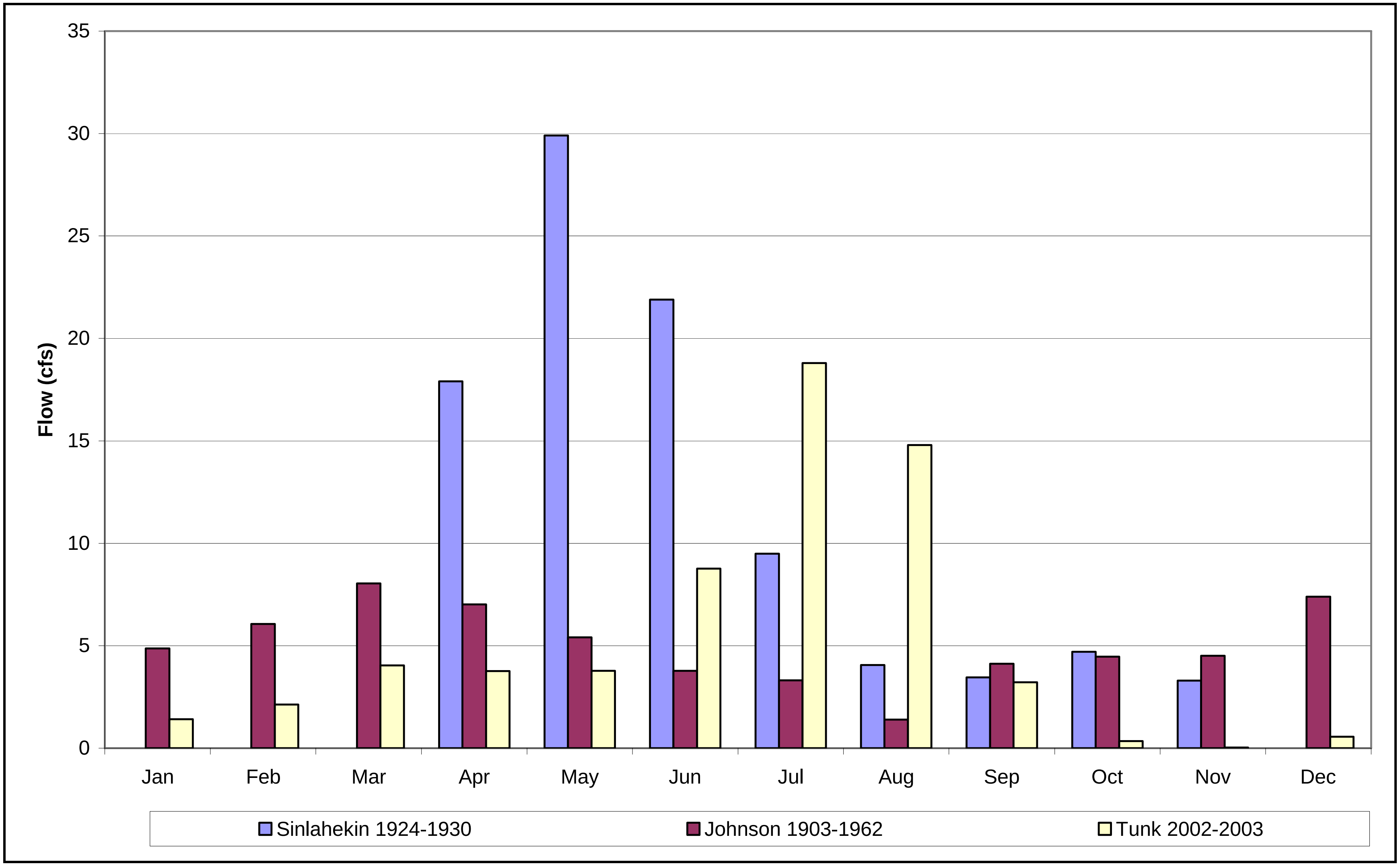


Figure 2.2.4: Ninemile Creek – Monthly Mean Flows

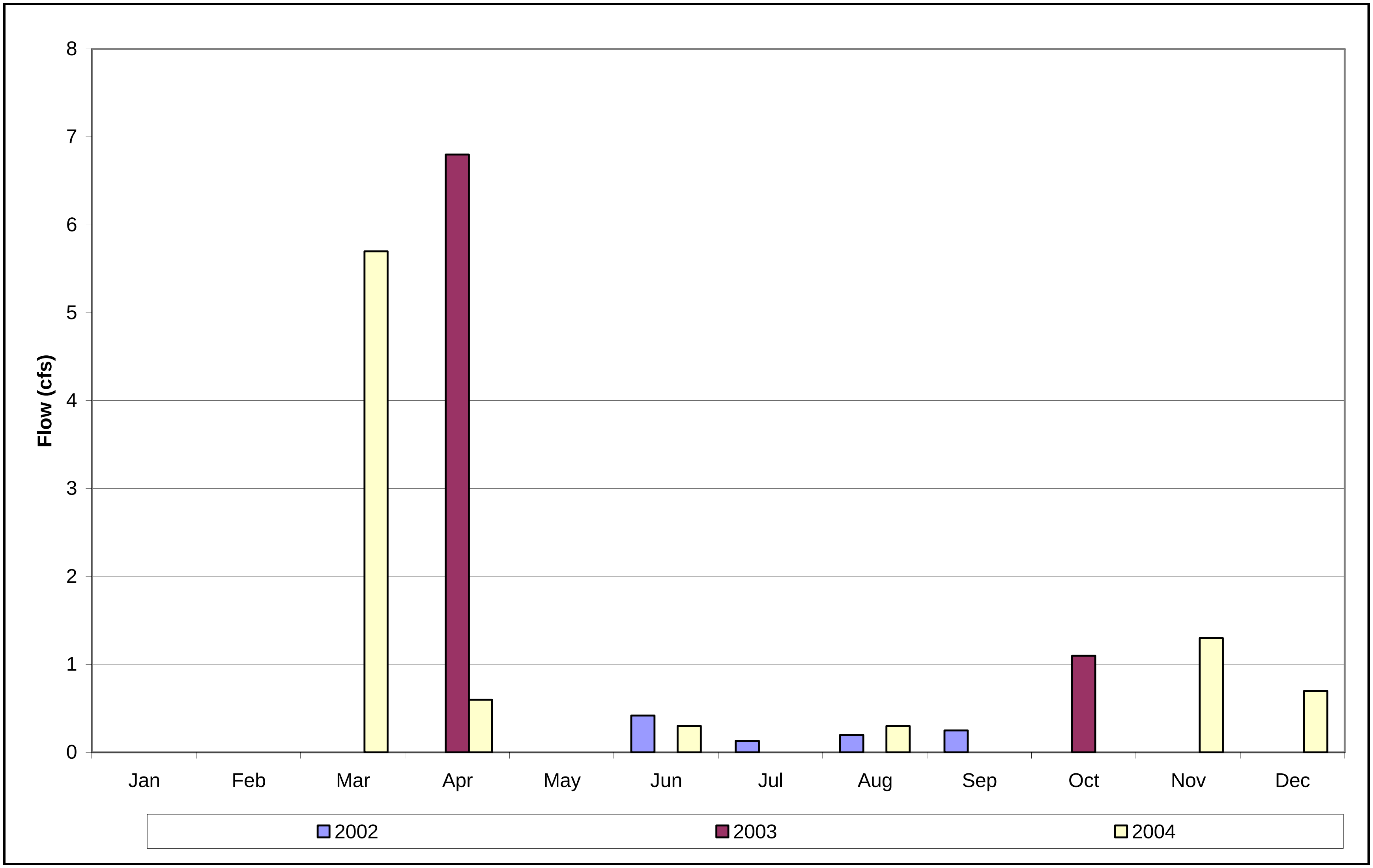


Table 2.2-2: Summary of Continuous Data – WRIA 49 Streams

STREAM NAME	SOURCE OF DATA	GAUGE ID	PERIOD OF RECORD	ANNUAL MEAN FLOW (CFS)	MAX	MIN	RANGE	YEARS OF RECORD
Sinlahekin Subbasin								
Similkameen River, Nighthawk	USGS	12442500	10/28-9/2004	2308	4840	1100	3740	75
Similkameen River Near Oroville	USGS	12443500	6/1911-9/28	2,121	3138	871	2267	16
Similkameen River at Oroville	Ecology	49B070	2001/02	265				
			2003/04	2440B				
			2004/05	901				
Toats Coulee Creek Near Loomis	USGS	12442000	10/20 to 7/26	45.8	67.4	24.2	43.2	12
Toats Coulee Creek Near Loomis	Ecology	49K090	2001/02	6.45				
			2002/03	57.5J				
			2003/04	56.5J				
			2004/05	42.6J				
Sinlahekin Creek Near Loomis	Ecology	49L100	2001/02	6.02B				
			2002/03	16.5J				
			2003/04	9.50B				
			2004/05	25.0!				
Sinlahekin Creek above Blue Lake Near Loomis	USGS	12440000	5/24-9/30	ND				6.3
Sinlahekin Creek Near Loomis	USGS	12441500	6/1903-3/1905	53.5	53.5	53.5	0.0	1.8
Sinlahekin Creek at Twin Bridge Near Loomis	USGS	12441000	5/1921-10/1921	2.8				0.4
Sinlahekin Creek AB Chopaka Creek Near Loomis	USGS	12442300	5/57-10/65	56.6	96.6	23.3	73.3	7
Joseph Subbasin								
Okanogan River (Okanogan)	USGS	12446000	6/1911-9/25	2907	4018	2148	1870	12
Okanogan River (Malott)	USGS	12447200	1/66-9/2004	3049	6337	1438	4899	38
Okanogan River (Near Malott)	USGS	12447300	4/58-7/67	3005	4663	1981	2682	8

Table 2.2-2: Summary of Continuous Data – WRIA 49 Streams, continued

STREAM NAME	SOURCE OF DATA	GAUGE ID	PERIOD OF RECORD	ANNUAL MEAN FLOW	MAX	MIN	RANGE	YEARS OF RECORD
Osoyoos Subbasin								
Tonasket Creek at Oroville	USGS	12439300	4/67 to 9/91	3.22	11.3	0.57	10.7	23
Bonaparte Creek Near Wauconda	USGS	12444490	12/67-6/73	4.99				5.6
Bonaparte Creek at Tonasket	Ecology	49F070	2001/02	1.26				
			2002/03	6.98U				
			2003/04	4.17U				
			2004/05	4.93U				
Okanogan River (Oroville)	USGS	12439500	10/42 to 9/2004	683.0	1407	194	1213	60
Okanogan River (Tonasket)	USGS	12445000	6/1911-9/25	2,942	6042	1149	4893	86
Whitestone Irrigation Canal Near Loomis	USGS	12442200	5/57-10/57	13.9	16.2	11.0	5.2	11
Whitestone Creek Near Tonasket	USGS	12444100	10/58-9/72	2.86	4.08	2.31	1.77	13
Salmon Subbasin								
N.F. Salmon Creek near Conconully	Ecology	49M100	2001/02	2.85B				
			2002/03	22.8J				
			2003/04	23.7J				
			2004/05	22.2J				
Johnson Creek near Riverside	BOR	NA	1903-62	3593				
			1918-62	3419				
			1903-17	4114				
Salmon Creek near Okanogan	USGS	12447000	10/1903-6/1910	51.5	78.3	34.0	44.3	5
Salmon Creek near Conconully	USGS	12446500	10/1911-9/22	32.8	67.3	11.0	56.3	10
			2004/05	2.01				

Table 2.2-2: Summary of Continuous Data – WRIA 49 Streams, continued

STREAM NAME	SOURCE OF DATA	GAUGE ID	PERIOD OF RECORD	ANNUAL MEAN FLOW	MAX	MIN	RANGE	YEARS OF RECORD
Omak Subbasin								
Tunk Creek near Riverside	Ecology	49E080	2001/02	0.22U				
			2002/03	5.14*				
			2003/04	2.40F				
Omak Creek near St. Mary's Mission	Ecology	49C100	2001/02	2.48*				
			2002/03	28.2J				
			2003/04	8.17B				
			2004/05	5.29!				
Omak Creek Near Omak	USGS	12445900	3/72-10/78	10.9	10.9	10.9	0.0	1
No Name Creek Diversion Near Omak	USGS	12445940	9/76-9/87	0.18	0.18	0.18	0.0	1
No Name Creek Diversion Return Near Omak	USGS	12445942	9/76-10/78	0.006	0.006	0.006	0.000	2.1

Notes for Ecology values:

!: Data not yet checked

[]: Data not recorded

A: Above rating, reliable extrapolation

B: Below rating, reliable extrapolation.

I: Ice-impacted data

J: Estimated data

U: Unknow flow, less than value shown

F: Filtered data to remove excess noise

~ : Provisional data

Ecology = Department of Ecology

USGS = U.S. Geological Survey

BOR = Bureau of Reclamation

Table 2.2-3: Data Summary of Point Flow Data

STREAM NAME	GAUGE ID	DATA SOURCE	PERIOD OF RECORD	TOTAL NUMBER OF MEASUREMENTS	MEDIAN FLOW (CFS)	MAXIMUM FLOW (CFS)	MINIMUM FLOW (CFS)	MEAN FLOW (CFS)
Sinlahekin Subbasin								
Similkameen River at Oroville	49B070	DOE	10/96-9/97	11	1310	15900	0	3841
			10/97-9/98	18	1165	12500	299	2659
			10/98-9/99	19	961	19100	378	3768
			10/99-9/00	13	970	10000	603	2296
Upper Sinlahekin	NA	OCD	5/00-4/03	36	7.3	24.7	0.0	7.7
Lower Sinlahekin	NA	OCD	5/00-4/03	36	12.0	83.2	0.0	13.4
Joseph Subbasin								
Johnson Creek at Riverside	49D080	DOE	6/02-7/02	5	0.4	0.2	0.7	0.44
			4/03-6/03	4	1	0.1	8.1	2.55
			10/03-8/04	7	0.3	0.1	0.9	0.4
			11/04-9/05	14	0.5	0.0	1.6	0.4
Lower Johnson Creek	NA	OCD	5/00-4/03	36	1.6	5.9	0.0	1.7
Upper Johnson Creek	NA	OCD	5/00-4/03	36	6.1	16.6	0.0	6.2
Osoyoos Subbasin								
Antoine Creek North Mouth	49G060	DOE	6/02-8/02	8	1.3	4.0	0.0	1.5
			2/04-8/04	8	0.9	1.5	0.0	0.9
			11/04-9/05	15	0.7	2.8	0.0	1.1
Lower Antoine Creek	NA	OCD	5/00-4/03	36	1.0	6.1	0.0	1.2
Upper Antoine Creek	NA	OCD	5/00-4/03	36	0.0	6.9	0.0	0.5
Upper Chiliwist	NA	OCD	5/00-4/03	36	0.0	1.7	0.0	0.2
Lower Chiliwist	NA	OCD	5/00-4/03	36	1.2	8.5	0.0	1.5
Bonaparte Creek @ Aeneas Valley Rd	49F150	DOE	6/02-9/02	5	2.4	3.8	0.3	2.1
			4/03-7/03	3	4.2	10.0	0.9	5.0
			10/03-8/04	9	4.1	6.3	0.6	3.5
			11/04-9/05	17	3.9	6.7	0.0	3.4
Lower Bonaparte Creek	NA	OCD	5/00-4/03	36	3.9	14.7	0.0	4.3
Upper Bonaparte Creek	NA	OCD	5/00-4/03	36	1.2	14.5	0.0	2.3
Upper K Bonaparte Creek	NA	OCD	5/00-4/03	36	0.0	1.4	0.0	0.2
Lower Siwash Creek	NA	OCD	5/00-4/03	36	0.0	2.0	0.0	0.2
Upper Siwash Creek	NA	OCD	5/00-4/03	36	0.9	4.3	0.0	1.2
Tonasket Creek Near Oroville	49H080	DOE	6/02-7/02	7	0.4	2.0	0.0	0.6

Table 2.2-3: Data Summary of Point Flow Data, continued

STREAM NAME	GAUGE ID	DATA SOURCE	PERIOD OF RECORD	TOTAL NUMBER OF MEASUREMENTS	MEDIAN FLOW (CFS)	MAXIMUM FLOW (CFS)	MINIMUM FLOW (CFS)	MEAN FLOW (CFS)
			4/03-7/03	3	5.8	12.7	0.2	6.2
			3/04-5/04	5	0.3	1.3	0.0	0.6
			11/04-8/05	14	2.1	7.6	0.0	2.4
Lower Tonasket Creek	NA	OCD	5/00-4/03	36	0.0	10.7	0.0	1.1
Upper Tonasket Creek	NA	OCD	5/00-4/03	36	0.1	7.9	0.0	1.1
Ninemile Creek Near Oroville	49J060	DOE	6/02-9/02	11	0.3	0.5	0.1	0.3
			4/03-4/03	2	6.8	10.7	2.9	6.8
			10/03-8/04	9	0.6	5.7	0.0	1.2
			11/04-9/05	18	1.3	2.9	0.0	1.3
Upper Ninemile Creek	NA	OCD	5/00-4/03	36	0.6	6.9	0.0	1.5
Lower Ninemile Creek	NA	OCD	5/00-4/03	36	0.6	8.7	0.0	1.3
Salmon Subbasin								
Johnson Creek at Riverside	49D080	DOE	6/02-7/02	5	0.4	0.7	0.2	0.44
			4/03-6/03	4	1	8.1	0.1	2.55
			10/03-8/04	7	0.3	0.9	0.1	0.4
			11/04-9/05	14	0.5	1.6	0.0	0.4
Lower Johnson Creek	NA	OCD	5/00-4/03	36	1.6	5.9	0.0	1.7
Upper Johnson Creek	NA	OCD	5/00-4/03	36	6.1	16.6	0.0	6.2
W.F. Salmon Creek @ Mouth	49N050	DOE	9/02-9/02	2	3.8	3.8	3.7	3.8
			4/03-7/03	5	15.2	35.1	5.5	19.4
Lower Loup Loup	NA	OCD	5/00-4/03	36	0.0	20.7	0.0	1.6
Upper Loup Loup	NA	OCD	5/00-4/03	36	0.3	20.0	0.0	1.7
Upper Talant	NA	OCD	5/00-4/03	36	0.0	17.5	0.0	3.3
Lower Talant	NA	OCD	5/00-4/03	36	0.0	1.3	0.0	0.1
Omak Subbasin								
Upper Tunk Creek	NA	OCD	5/00-4/03	36	1.1	9.3	0.0	2.0
Lower Tunk Creek	NA	OCD	5/00-4/03	36	1.2	15.3	0.0	2.5

Notes

NA: Not Available

OCD: Okanogan Conservation District

DOE: Department of Ecology

Table 2.2-4: Sinlahekin Creek above Blue Lake Near Loomis

PRIMARY SUBBASIN/STREAM NAME	PERIOD OF RECORD	ANNUAL MEAN FLOW		AREA AT GAGE	ANNUAL VOLUME/AREA	UPSTREAM DIVERSIONS
		Cfs	***ac-ft***	***sq mi***	***ac-ft/sq mi***	
Sinlahekin Subbasin						
Similkameen River, Nighthawk	10/1928-9/2004	2308	1672060	3500	478	
Similkameen River Near Oroville	6/1911-9/1928	2,121	1536586	3550	433	2900 ac in WA, 10,700 ac in BC
Toats Coulee Creek Near Loomis	10/20 to 7/26, 1957-70	45.8	32839	130	253	none
Sinlahekin Creek above Blue Lake Near Loomis	5/1924-9/1930	11.8	8556	41.7	205	
Sinlahekin Creek Near Loomis	6/1903-3/1905	53.5	38759	86.6	448	unknown
Sinlahekin Creek AB Chopaka Creek Near Loomis	5/1957-10/1965	56.6	41005	256	160	Whitestone Canal and some irrigation
Joseph Subbasin						
Okanogan River (Malott)	1/1966-9/2004	3049	2209092	8100	273	55,000 ac in BC, 22,000 ac in WA
Okanogan River (Near Malott)	4/1958-7/1967	3005	2177011	8200	265	55,000 ac in BC, 22,000 ac in WA
Osoyoos Subbasin						
Tonasket Creek at Oroville	4/1967 to 9/1991	3.2	2333	60.1	38.8	some irrigation
Whitestone Creek Near Tonasket	10/1958-9/1972	2.9	2072	55.4	37.4	regulated at Whitestone Lake

Table 2.2-4: Sinlahekin Creek above Blue Lake Near Loomis, continued

PRIMARY SUBBASIN/STREAM NAME	PERIOD OF RECORD	ANNUAL MEAN FLOW		AREA AT GAGE	ANNUAL VOLUME/AREA	UPSTREAM DIVERSIONS
		Cfs	***ac-ft***	***sq mi***	***ac-ft/sq mi***	
Bonaparte Creek Near Wauconda	12/1967-6/1973	5.0	3617	96.6	37.4	several small diversions
Bonaparte Creek at Tonasket	2002/2003	7.0	5057	136	37.2	
Bonaparte Creek at Tonasket	2003/2004	4.2	3021	136	22.2	
Bonaparte Creek at Tonasket	200420/05	4.9	3572	136	26.3	
Bonaparte Creek	2003	6.6	4774	136	35.1	
Bonaparte Creek	2004	4.0	2864	136	21.1	
Okanogan River (Oroville)	10/1942 - 9/2004	683	494808	3210	154	44,000 ac in BC
Okanogan River (Tonasket)	6/1911-9/1925, 2004	2,942	2131370	7280	293	55,000 ac in BC, 10,700 in WA
Salmon Subbasin						
N.F. Salmon Creek near Conconully	2001/2002	2.9	2065	35	59	
N.F. Salmon Creek near Conconully	2002/2003	22.8	16518	35	472	
N.F. Salmon Creek near Conconully	2003/2004	23.7	17170	35	491	
N.F. Salmon Creek near Conconully	2004/2005	22.2	16083	35	460	
Johnson Creek near Riverside	1903-1962	5.0	3595	68.2	52.7	

Table 2.2-4: Sinlahekin Creek above Blue Lake Near Loomis, continued

PRIMARY SUBBASIN/STREAM NAME	PERIOD OF RECORD	ANNUAL MEAN FLOW		AREA AT GAGE	ANNUAL VOLUME/AREA	UPSTREAM DIVERSIONS
		cfs	*ac-ft*	*sq mi*	*ac-ft/sq mi*	
Johnson Creek near Riverside	1918-1962	4.7	3422	68.2	50.2	
Johnson Creek near Riverside	1903-1917	5.7	4116	68.2	60.4	
Salmon Creek near Okanogan	10/1903-6/1910	51.5	37310	147	254	
Salmon Creek at Conconully Lake	1904-2002		21635	121	179	
Salmon Creek near Conconully	10/1911-9/1922	32.8	23762	121	196	unknown
Omak Subbasin						
Tunk Creek near Riverside	200220/03	5.1	3724	71	52.4	
Tunk Creek near Riverside	2003/2004	2.4	1739	71	24.5	
Tunk Creek near Riverside	2004/2005	2.0	1456	71	20.5	
Omak Creek Near Omak	3/1972-10/1978	10.9	7897	119	66.4	many small diversions

2.2.1 Sinlahekin Subbasin

Long-term mean annual flow data are available for the Similkameen River. Toats Coulee and Sinlahekin Creeks flow data are only available for the short-term. There are no available streamflow records for Chopaka, Sarsapkin and Cecile Creeks. Some of the mean annual flow data may be reduced by irrigation deliveries, but in some cases such as Toats Coulee and Sinlahekin Creek, the irrigation diversions are apparently below the points where flow has been measured (J. Barnes, personal communication, Okanogan Planning Unit). Deep snowpack, high drainage densities (the sum of all stream lengths per unit area) and higher elevations in this subbasin generally result in greater mean annual flows. On average, the data indicate that the mean annual flow (MAF) for the Similkameen River at Oroville ranges between 2200 to 3800 cubic feet cfs.

2.2.2 Osoyoos Subbasin

There is a good, moderate-term mean annual flow record for Tonasket Creek. Some short-term mean annual flow data are available for Whitestone and Bonaparte Creeks. Some partial short-term data are also available for Antoine, Siwash and Nine mile Creeks. There are no streamflow data for Chewiliken, Horse Springs, (drains Horse Springs Coulee area into Aeneas Lake and is located between Aeneas Creek and Whitestone Coulee) and Aeneas Creeks.

2.2.3 Salmon Subbasin

The Salmon Subbasin is comprised of a wide range of landscapes (variable physiography with low to high drainage densities) and climate zones, which means that there will be a wide range in recharge and runoff characteristics. For Johnson and Salmon Creeks, older (50 to 100 year old), good quality data were available. Good quality long-term modeled mean annual flow data were available for Salmon Creek. Some partial short-term records for Loup Loup and Tallant Creeks were also available. There was no data for the Pine Creek area.

2.2.4 Omak Subbasin

Estimates of mean annual flow are available, based on some partial short-term data, for Tunk and Omak Creeks. In general, though, the number of creeks in the subbasin is limited (i.e., there is a low drainage density) which means that overall runoff potential from the area is low; this may equate to higher evapotranspiration and higher recharge rates for some soil/rock-types (e.g., alluvium, glacial outwash) and lower recharge for other soils/rock-types (e.g., low permeability bedrock).

2.2.5 Joseph Subbasin

There are no mean annual flow data for streams in the Joseph subbasin including the Indian Dan, Whitestone and Swamp Creek drainages. Some partial short-term data are available for Chiliwist Creek. Drainage density in the subbasin is low and drainage systems are less developed with a high number of small lakes. This is likely due to resistant and low permeability properties of the bedrock

2.3 GEOLOGY AND HYDROGEOLOGY

Bedrock in the Okanogan River Basin consists principally of granitic, andesitic, basaltic, and metamorphosed sedimentary rocks (see Glossary for definition of these terms).. The Project Area experienced intense folding, thrust faulting, and intrusions in the Jurassic and Cretaceous periods, resulting in highly fractured bedrock.

During the last glaciation, more than 10,000 years ago, the Okanogan Lobe of the Cordilleran ice sheet covered much of the Okanogan Basin and rerouted ancestral streams. The retreating glacier left behind thick deposits of unconsolidated silt, sand, gravel, and cobbles as valley fill and terraces. These glacial deposits are estimated at more than 500 feet thick in certain areas (Ecology 1995).

The unconsolidated glacial deposits provide the primary water storage in the Project Area. The fractured bedrock contains only very low yield aquifers (Ecology 1974). Maps C1-C5 in Attachment 2 (Hydrogeology and Well Location by Subbasin Maps) provide an illustration of documented water producing wells (by well depth) in the basin in relation to the general rock-type (i.e., alluvium, glacial outwash, glacial till/drift, surficial deposits and bedrock) of the aquifer from which the water is drawn.

Rainfall/snowmelt provides the primary form of recharge for the aquifers. Groundwater and surface water interact throughout the watershed (Ecology 1995). Irrigation infiltration is an artificial recharge where irrigation is common practice (e.g., Pogue Flats and the Duckwater Groundwater Basin)

2.3.1 Sinlahekin Subbasin

Much of this subbasin is mountainous and used for timber harvest and grazing (ENTRIX and Golder 2001, WDNR 1996). Groundwater in this subbasin is generally limited to glacial and alluvial deposits in abandoned or partially abandoned valleys. An abandoned valley is once through which a stream once ran, but no longer does. For example, the Similkameen River once flowed through the valley now occupied by Sinlahekin Creek. During the last glaciation the river was rerouted through several temporary channels until it finally settled into its current channel as the glacier retreated. Glacial and alluvial deposits in the original channel and the temporary channels are several hundred feet thick with moderate to high yield aquifers. In contrast, due to a lack of glacial or alluvial deposits, groundwater is scarce in the current Similkameen River valley above Nighthawk to near Oroville (Ecology 1974).

2.3.2 Osoyoos Subbasin

The Osoyoos Subbasin includes much of the Okanogan River Valley from about five miles south of Tonasket (at the confluence with Chewiliken Creek) to the Canadian border. Glacial, alluvial, and lacustrine deposits (see glossary for definitions) are present in widely varying depths throughout the valley. Well yields also vary widely according to depth to bedrock or an impermeable blue-clay layer.

Bedrock is exposed in much of the area to the east of the Okanogan River Valley. Significant water storage is limited to the current and ancestral major stream valleys such as the Okanogan River, the lower three miles of Antoine Creek, and Bonaparte Creek where consolidated sediments may be up to 300 feet deep (although depths vary widely).

2.3.3 Salmon Subbasin

Much of the western half of the Salmon Subbasin is mountainous and located within the Okanogan National Forest. Most of the groundwater use in the subbasin is concentrated in the Pogue Flat, Johnson Creek and Scotch Creek areas, and along the Okanogan River Valley near the towns of Omak and Okanogan. Glacial and alluvial deposits in these areas are anywhere from several feet thick up to 100 feet thick. Unconsolidated sediments in the area of Spring Coulee and the Salmon Creek Valley can be up to 300 feet thick with some groundwater use surrounding Conconully Lake. Most other valleys in the subbasin have very little unconsolidated sediments and therefore limited water storage.

2.3.4 Omak Subbasin

As with the other areas of the Okanogan Watershed, the availability of groundwater in the Omak subbasin is limited to unconsolidated sediments of the major stream valleys. In this subbasin, most of the water use is in the Tunk Creek Valley, where sediments are likely less than 100 feet thick and composed mostly of till. In the Omak Creek Valley, unconsolidated deposits are mostly impermeable clay mixed with sand and gravel layers, with low yield.

2.3.5 Joseph Subbasin

In general, fractured basalt, such as that found in the southeastern portion of the Joseph subbasin, is known to have very high water storage capabilities. However, in this subbasin the basalt flow is an extension of the Columbia River basalt flows and is likely not thick enough to have the large water storage capabilities for the subbasin.

Wells in the Chiliwist Creek Valley have penetrated as much as 200 ft of unconsolidated sediments with high yields.

2.4 WATER BALANCE

Mean annual precipitation values were computed for each major subbasin following the methods and assumptions described in Appendix E and are summarized in Table 2.4-1 below.

Table 2.4-1: Computed Mean Annual Precipitation per Subbasin

PRIMARY SUBBASIN	MAP (INCHES)
Sinlahekin	22.1
Osoyoos	15.4
Omak	13.3
Salmon	19.1
Joseph	14.0

The precipitation data indicate that the Sinlahekin and Salmon Subbasins receive significantly more (124 percent to 166 percent) water than the other three subbasins. Water balances were computed for each major subbasin using these precipitation values and following the methods and assumptions described in Appendix E (Water Balance). The results are summarized in Table 2.4-2. Detailed calculations are provided in the water balance spreadsheet (Appendix D).

Table 2.4-2: Subbasin Water Balances (values in thousand acre-ft per year)

PRIMARY SUBBASIN	PRECIPITATION	ET	RECHARGE**	MEAN ANNUAL FLOW	
				Groundwater Discharge	Rainfall and Snowmelt Runoff
Sinlahekin	436	359	22	22	56
Osoyoos	416	402	10	10	3
Omak	322	309	8	8	5
Salmon	402	367	20	20	15
Joseph	215	212	3	3	0.4
		Percentage of Precipitation			
		As ET	**As Recharge (Gr)**	**As Groundwater Discharge (Gd)**	**As Runoff (R)**
Sinlahekin		82%	5.0%	5.0%	12.8%
Osoyoos		97%	2.5%	2.5%	0.8%
Omak		96%	2.5%	2.5%	1.5%
Salmon		91%	5.0%	5.0%	3.8%
Joseph		98%	1.5%	1.5%	0.2%

In general, the calculations indicate that, depending on subbasin location, 82 percent to 98 percent of precipitation is returned to the atmosphere via evapotranspiration. The Sinlahekin and Salmon subbasins not only receive more total water per unit area, but evapotranspiration rates are also lower, indicating that more water is available to recharge groundwater and support higher streamflows (per unit area). Thus, mean annual streamflow (Gr + R) is signficantly higher in the Sinlahekin subbasin – an order of magnitude higher than in the Osoyoos and Omak subbasins and two orders of magnitude higher than in the Joseph subbasin.

A simple accounting of water in the Okanogan River was developed using measured mean annual flow (MAF) for the three USGS stations on the river and comparing these measured flows to the total surface water available, as calculated from the water balance described above. Table 2.4-3 indicates that the measured mean annual flow of the Okanogan River at Tonasket was 49,000 af/yr less than the total calculated total surface water available. It is likely that water diversions from tributary streams and the Okanogan River, and well production from valley aquifer (in hydraulic connection with the Okanogan River) contribute to this net loss. In other words, this loss may be due to well production from the valley aquifer This net loss is reduced to about 21,000 ac-ft/yr at Malott, where return flow from tributary streams, diversions and groundwater discharge have likely made up some of the deficit.

Table 2.4-3: Okanogan River Water Balance (all values in thousand acre-ft per year)

	TRIBUTARY BASINS		OKANOGAN RIVER		
Major River/Subbasin	**Calculated Total Surface Water Available**	**Measured Total Surface Water Available**	**Calculated Total Surface Water Available**	**Measured Total Surface Water Available**	**Net Loss/Gain**
Okanogan River at Oroville				494	
Similkameen River from Canada	1,594				
Contribution from Sinlahekin Subbasin	77				
Similkameen River (at Nighthawk)		1,672	2,167		
Contribution from Osoyoos Subbasin	14				
Okanogan River at Tonasket			2,180	2,131	-49
Contribution from Omak Subbasin	13				
Contribution from Salmon Subbasin*	37				
Okanogan River at Malott			2,230	2,209	-21
Contribution from Joseph Subbasin	4				
Okanogan River at Columbia River			2,234		

- includes portion not included in subbasin calculations referred to as Okanogan River - Middle

Chapter 3.0: Water Quantity

This section presents water rights and water use information for WRIA 49 and its major subbasins. These data provide a picture of the extent to which water that is physically available has been legally appropriated for human use (Chapter 3.1), and the actual extent of use (as opposed to the amounts legally appropriated; Chapter 3.2). An assessment of surface water (Chapter 3.3) and ground water (Chapter 3.4) appropriations is also included.

Water rights data were obtained from the Washington Department of Ecology WRATS and GWIS database. The accuracy of these data for water right permits and certificates are fair to good, although the databases have a history of providing somewhat inconsistent results when queried several times. They are not updated with current water right ownership information, and they do not reflect whether the water rights recorded remain perfected in use (“wet” water rights) or have been lost due to non-use (“paper” water rights). Also, the database contains numerous duplicate records and requires great familiarity to use without errors. Many water rights have multiple purposes, but the amount of water appropriated by purpose is not allocated.

Data (GWIS) provided by Ecology did not map the locations of new water right applications or include a WRIA 49 subbasin identifier, so it was not possible to assess potential new water rights by subbasin without much more extensive analysis of individual water right records. However, the effect of new applications is taken into account in the growth forecast (Chapter 3.5).

Water claims are also recorded in the Ecology databases, but the quality of information is poor. Issues include the existence of numerous spurious and false claims; data errors; highly inaccurate records (which are filled out by the individuals registering a claim). More than 70 percent of surface sources from which the right to divert water is claimed are unnamed in the claims. There is no “fix” for these issues short of adjudication.

Water use data were obtained for the domestic and municipal (water systems and exempt wells); commercial/industrial/Institutional; and agricultural sectors from such sources as Group A water system comprehensive plans (WSCPs), irrigation districts, Washington Department of Health Group A and B reports, the Washington Department of Ecology well-log database, and both local and national statistical sources of agricultural water use data.

The quality of data available to characterize municipal and domestic water use is generally fairly good. Data from WSCP’s are not directly comparable as the dates of the plans vary and there are no data for smaller Group A’s and Group B’s beyond the number of connections served. There are no good sources of data to characterize commercial, industrial and institutional water use. This information can be inferred to a limited degree from County Assessor land use data and water rights with pertinent purposes listed in the Ecology databases, or from representative average data elsewhere.

The well-log database has generally good quality data. About 2 percent of the wells are not water wells and the use of the well-log data as a proxy for exempt well use double counts water-righted wells (these duplicates could be screened out in Level 2 work if desired). Some data are missing and there are coding errors. These issues can be fixed by comparing the well log data to the water rights database and eliminating duplicates.

Agricultural water use data were obtained from irrigation districts; the USDA; and County Assessor land use codes. The quality of this data is poor to good. Generally, there was little accurate, current data from made available from WRIA 49 irrigation districts and County data does not disaggregate discrete acres by crop. NASS data is not fine grained (it is aggregated for the County as a whole). The County Assessor's data includes orchard, irrigated alfalfa, vineyards, irrigated pasture, and other irrigated crops, but multiple codes apply to most parcels and the breakout among crops is unknown. These issues would need to be addressed by survey work in Level 2.

3.1 WATER RIGHTS

3.1.1 Overview of Water Rights

WRIA 49 water rights are mapped by subbasin in Attachment 2 Map Atlas. Water rights data are presented in Appendix A-1. A primer on water rights is provided in Appendix A-1.1.

Figures 3.1-1 and 3.1-2 show the WRIA 49 water rights and claims[1] by type (certificates, permits, applications, and claims), and by type of source (surface and ground water). Data on certificates and permits is contained in Appendix A-1.2, including the full Ecology WRATS/GWIS database (Appendix A-1.2a) and the filtered data analyzed for the Level 1 Report (Appendix A-1.2b). There are a total of 1867 certificates and permits (including change certificates and permits), 324 new applications, and 4,756 water claims. Figure 3.1-2 indicates the predominance of water claims, which represent more than 68 percent of the records. There are 2.5 times as many claims as certificates and permits, which total about 27 percent of all records.

[1] Claims are statements that water use existing before the surface and ground water codes established the water rights system – people may go on using water in amounts and for purposes that existed before the codes were passed into law, but must register a formal "claim".

Figure 3.1-1: WRIA Water Rights and Claims

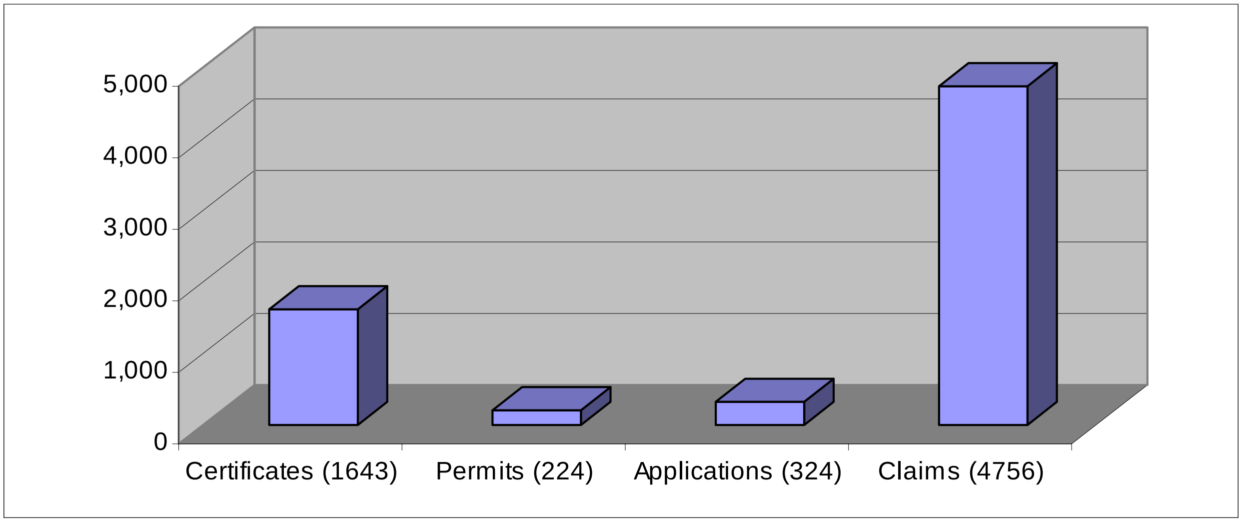
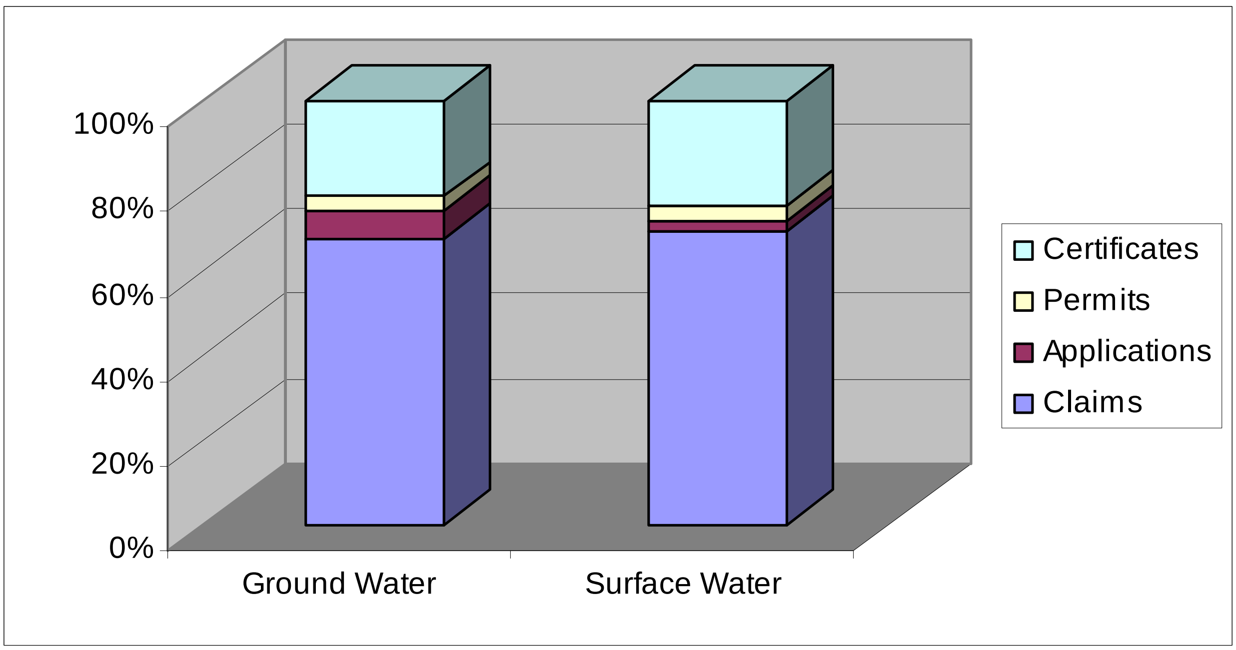


Figure 3.1-2: WRIA 49 Water Rights and Claims by Source Type



New applications are summarized in Table 3.1-1. Data are presented in Appendix A-1.3 New applications appear to focus on meeting peak needs or providing supplemental water (to backup primary water sources), because relatively little additional annual volume is requested (1,689 AFY, equivalent to about 0.6 percent of existing water rights). Ground water is emphasized over surface water in new applications: if all applications were approved, diversions from streams would increase by 2.5 percent but pumping would increase by 49 percent over current levels.

Table 3.1-1: New Applications by Source Type

NEW APPLICATIONS	NUMBER	CFS	GPM	AFY	ACRES IRRIGATED
Ground Water	240	0	91,640	9	9,923
Surface Water	84	73.25	0	1,680	3,159
TOTAL	324	73.25	91640	1689	13082

Water claims are mapped in Attachment 2 Atlas Maps, and data are provided in Appendix A-1.4a. Claims, which represent statements that water was in use prior to the establishment of the surface and ground water codes, comprise an unknown – and potentially large – commitment of water resources. Most claims are not quantified, and many may be invalid. As an example, Table 3.1-2 and Appendix A-1.4b show the results of an investigation of claims for Salmon Creek. Only 0.02 percent of claimed flows (cfs) and 0.21 percent of claimed annual quantities of water were valid.

Table 3.1-2: Water Claims Example: Salmon Creek

	CFS	AFY	ACRES IRRIGATED
CLAIMS REGISTRY	8,626.39	321,286	100,279
VALID CLAIMS	1.81	668	5,032
% VALID	**0.02%**	**0.21%**	**5.02%**

The validity of claims can only be established through adjudication (court determination of legal water rights), which can be a lengthy and expensive process if done on a large scale. An unusually large proportion of WRIA 49 water rights have already been in adjudicated in various subbasins (for example, Johnson Creek): 23 percent of all certificates, including 17 percent of ground water and 30 percent of surface water have been decided by the courts (Figure 3.1-3). Data on WRIA 49 adjudicated water rights is given in Appendix A-1.5.

Figure 3.1-4 indicates the total amounts of ground water (103,041 AFY) and surface water (186,900 AFY) appropriated in WRIA 49. Data on the largest WRIA 49 water rights is summarized in Appendix A-1.6, which lists water rights appropriating more than 10 cfs, more than 1,000 gpm, and more than 1,000 AFY. As compared to many other WRIAs, average water rights in WRIA 49 are relatively modest and are not greatly concentrated in large rights. With few exceptions, the largest WRIA 49 water rights do not appear to have critical effects on the sources that supply them.

Figure 3.1-3 WRIA 49 Adjudicated Rights

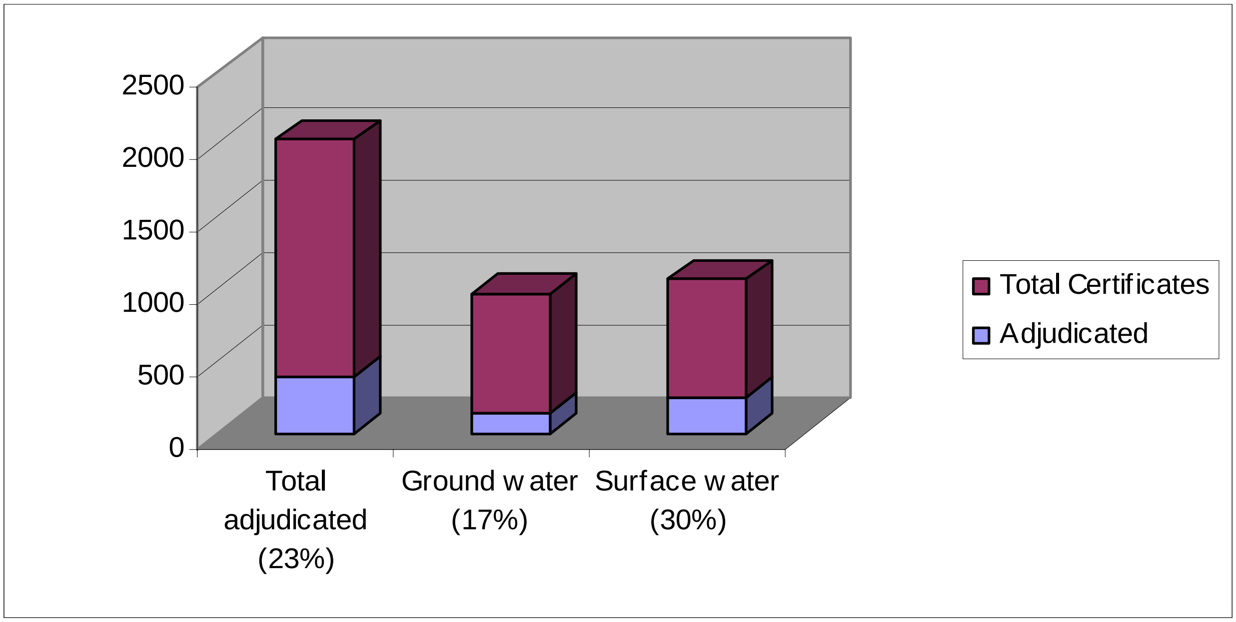
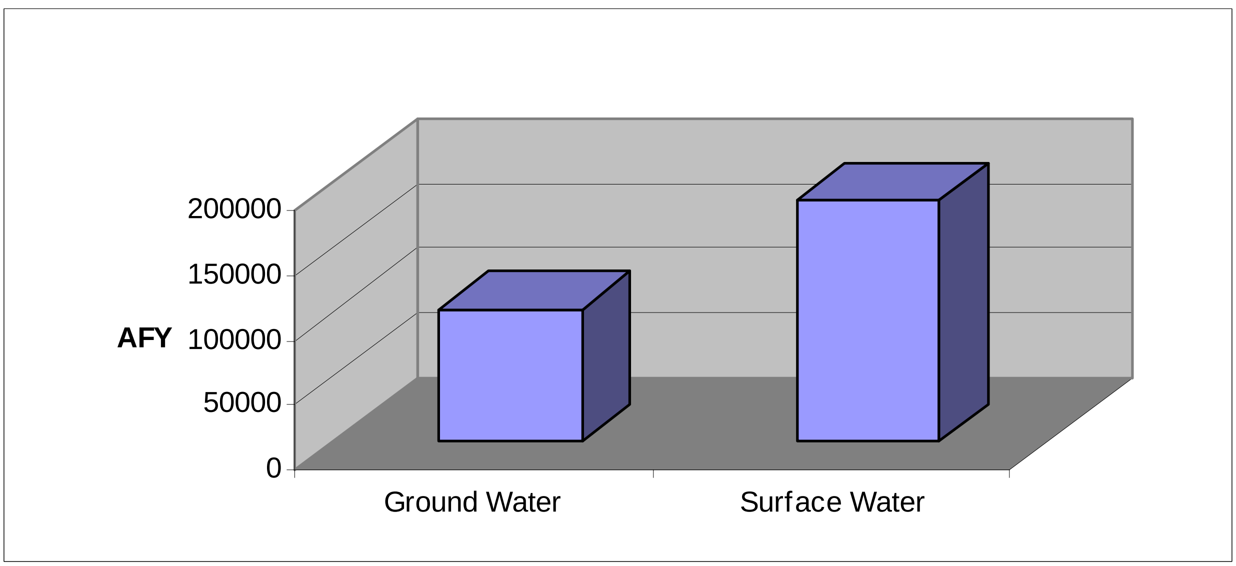


Figure 3.1-4 WRIA 49 Ground and Surface Water Rights



Of the 27 water rights appropriating 10 cfs or more, only three appear to be of concern. Twelve are from the Okanogan River or mainstem lakes and represent a small proportion of mean and low flows. Four appear to have been converted to a ground water source. Four are listed on the Similkameen River, and three of these are known to be inactive or transferred to other sources (in the case of the OTID water right). The fourth Similkameen water right is a non-consumptive right, for run-of-river power generation at Enloe dam (Okanogan PUD). Two, at Duck Lake and Johnson Creek, are water rights owned by Okanogan Irrigation District in an adjudicated basin; the Johnson Creek water right is junior to other rights and is rarely exercised. Two 168 cfs water rights on Sinlahekin Creek in the name of the Sinlahekin Water Users Association, and appear not be in use or to be at most used only in small part, because these are storage rights (which require secondary permits to divert the water and put it to use). A 1984 change certificate indicates that the Sinlahekin Rights are now associated with Whitestone Reclamation District for the storage of 2,400 AF of water in Blue Lake and diversion of 3.3 cfs for irrigation. The remaining three include a right for 375 cfs on Tonasket Creek issued to a private irrigator in 2003; a right for 105 cfs granted to Whitestone Reclamation District with a 1913 priority date; and a 14.7 cfs diversion from Spectacle Lake, also owned by Whitestone Reclamation District (1924 priority). The Tonasket Creek and Toats Coulee Creek rights should be checked, as neither has the flow to support such a level of use. (The water rights may specify seasonal limitations, for example.)

Level 1 data does not suggest a concern with the effect of any of the 28 ground water rights larger than 1,000 gpm. The two largest, each for 5,000 gpm, are both in the Joseph Subbasin. One is owned by Crown Zellerbach and has a commercial purpose; the other is owned by the City of Omak and is used for municipal purposes.

There are 37 water rights with an annual volume exceeding 1,000 AFY; 15 of these are larger than 3,000 AFY and only three are larger than 10,000 AFY. Sixty percent have an irrigation purpose and 14 percent are municipal water rights. Three of the four largest rights are for non-consumptive purposes (fish propagation and storage).

Figure 3.1-5 summarizes the purposes of WRIA 49 water certificates and permits. The volume of water allocated to these purposes cannot be calculated with certainty from the Ecology database (because some water rights have multiple purposes). As one would expect, the primary purposes given for water use are for irrigation (65 percent of all water rights), domestic use (32 percent), and stockwatering (25 percent). Water claims focus on the same three key uses: 55 percent are for domestic use; 51 percent include stockwatering; and 27 percent have an irrigation purpose.

Commercial water rights are not dominant in WRIA 49. Total pumping under rights with a commercial purpose amounts to 4.5 percent of existing ground water rights, and 3.8 percent of the total annual volume of all existing WRIA 49 water rights. The largest commercial water right is owned by Crown Zellerbach Corporation, in the Joseph Subbasin, granting 5,000 gpm and 8,030 AFY from an unnamed source (1945 priority).

3.1.2 Subbasin Water Rights Assessment

Figures 3.1-5, 3.1-6, and 3.1-7 and Table 3.1-3 present the amounts of surface and ground water appropriated within each WRIA 49 subbasin. Figure 3.1-5 shows instantaneous rights to surface flows (cfs); Figure 3.1-6 shows instantaneous rights to pump ground water in gallons (gpm); and Figure 3.1-7 shows annual surface and groundwater rights (AFY).

Table 3.1-3: Water Rights Subbasin Totals

BASIN	NUMBER	CFS	GPM	AFY			SURFACE SOURCES - CFS BY BASIN
JOSEPH						Joseph	224
Ground Water	163	0	50,953	34,727		Omak	44
Surface Water	160	224	0	43,804		Osoyoos	985
TOTAL	323	224	50,953	78,531		Salmon	279
						Sinlahekin	1,454
OMAK							
Ground Water	25	0	5,507	2,464			Groundwater - GPM by basin
Surface Water	54	44	0	2,003		Joseph	50,953
TOTAL	79	44	5,507	4,468		Omak	5,507
						Osoyoos	51,368
OSOYOOS						Salmon	65,529
Ground Water	273	0	51,368	29,196		Sinlahekin	14,307
Surface Water	359	985	0	86,941			
TOTAL	632	985	51,368	116,137			All sources - AFY by basin
						Joseph	78,531
SALMON						Omak	4,468
Ground Water	443	0	65,529	29,496		Osoyoos	116,137
Surface Water	229	279	0	32,423		Salmon	61,919
TOTAL	672	279	65,529	61,919		Sinlahekin	28,887
SINLAHEKIN							
Ground Water	41	0	14,307	7,159			
Surface Water	120	1,454	350	21,729			
TOTAL	161	1,454	14,657	28,887			
WRIA 49 TOTAL							
Ground Water	945	0	187,663	103,041			
Surface Water	907	2,987	350	186,900			
Reservoir	15	0.00	0	10,880			
TOTAL	1,867	2,987	188,013	289,941			

Figure 3.1-5: WRIA Appropriation by Subbasin (CFS)

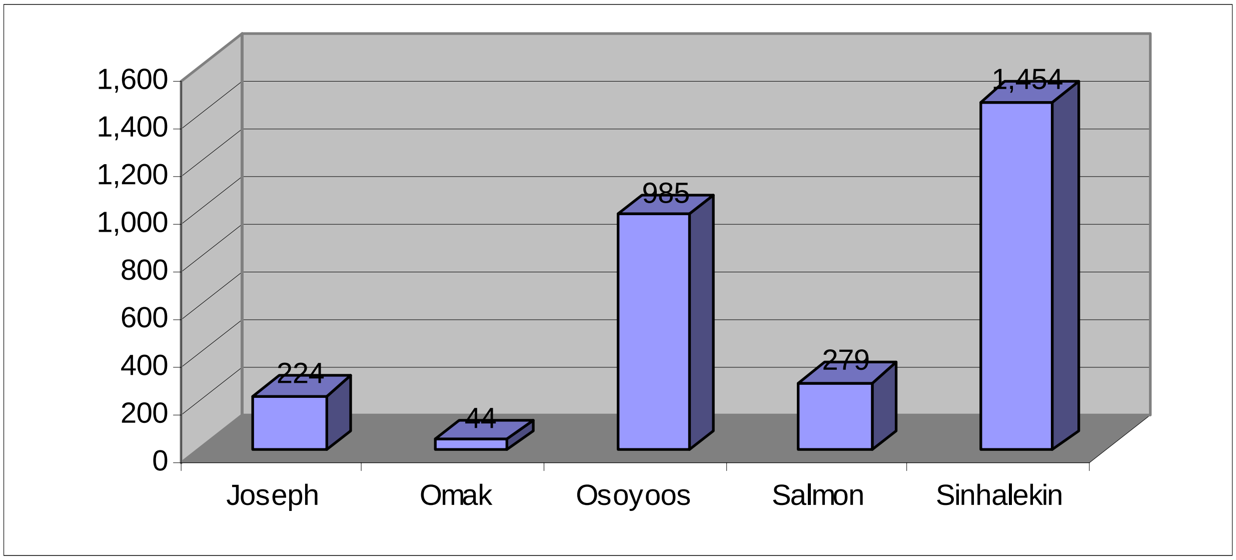


Figure 3.1-6: WRIA Appropriation by Subbasin (GPM)

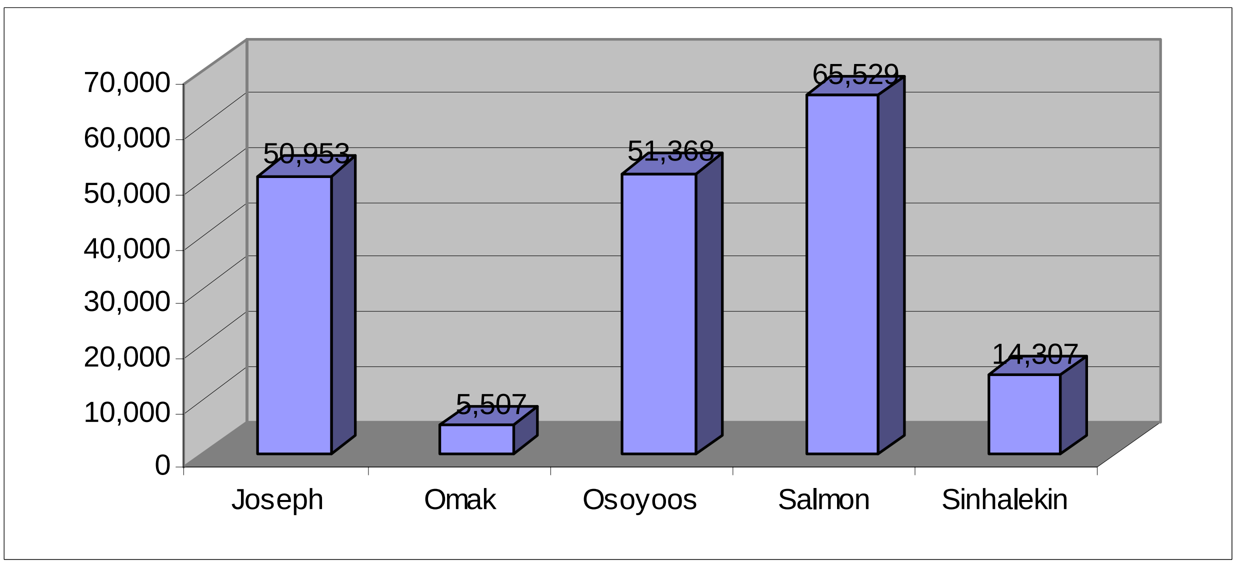
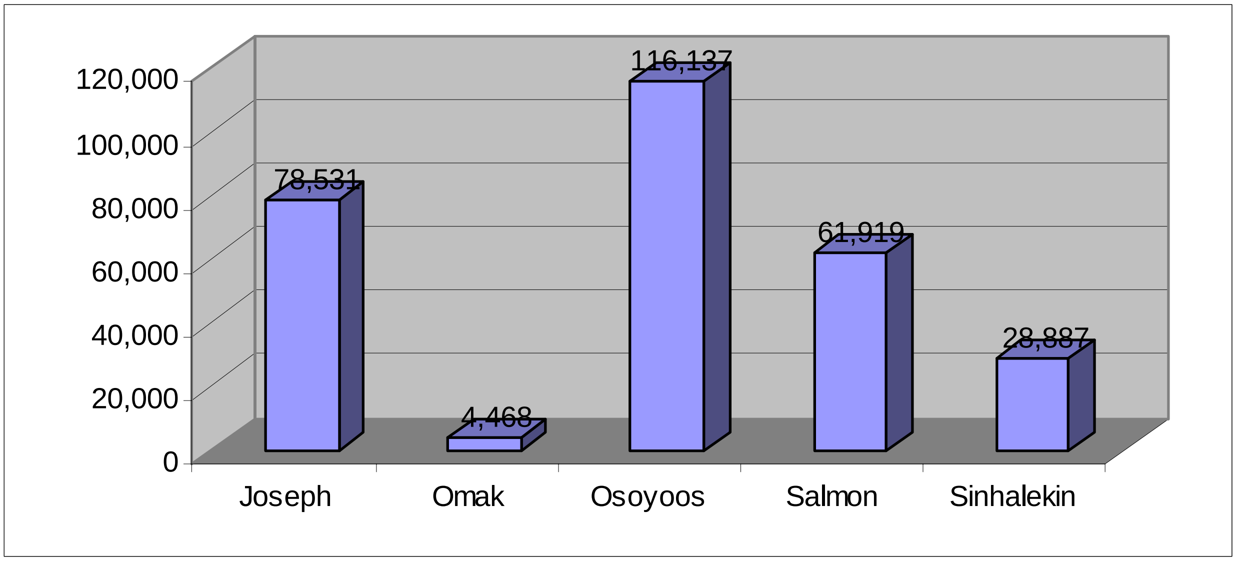


Figure 3.1-7: WRIA Appropriation by Subbasin (AYF)



Relatively little water is appropriated in the **Omak Subbasin** (which contains largely reservation lands). Appropriations from ground water wells and the Okanogan River account for 91 percent of the annual volume of water rights in the Omak Subbasin.

Sinlahekin Subbasin consumptive appropriations are also small. The large appropriation of flow shown in Figure 3.1-5 is dominated by three large non-consumptive water rights: (1) the 1,000 cfs Similkameen non-consumptive water right for run-of-river power generation at Enloe dam); and (2-3) the large 168 cfs water storage rights on Sinlahekin Creek owned by the Sinlahekin Water Users Association. We understand from Planning Unit members that the latter right was never used by placed in this association, which does not actually operate. These three rights comprise 92 percent of the instantaneous surface rights in the subbasin. Otherwise, Sinlahekin Subbasin instantaneous appropriations of ground water and annual appropriations of ground and surface water are relatively modest.

The **Joseph and Salmon subbasins** are roughly comparable in amounts of water appropriated. Each has a modest amount of instantaneous surface flows appropriated, but relatively large instantaneous appropriations of ground water and large annual appropriations of ground and surface water. For the Joseph Subbasin, a total of 209 cfs (93 percent of the total) is appropriated from the large mainstem rivers (Okanogan and Columbia) or lakes (Lake Pateros) it borders. In the Salmon Subbasin, 113 cfs (40 percent of the total) is appropriated from the Okanogan River, and an additional 107 cfs of surface water rights (38 percent) appear to have been converted to ground water sources. There are no other large surface water instantaneous water rights in either subbasin.

Most of the large annual appropriations of water in the Joseph Subbasin are for irrigation, and occur from the Okanogan River or Lake Pateros, including a 12,160 AFY private water right to irrigate 2432 acres from Lake Pateros. Nearly three-quarters (72 percent) of Joseph Subbasin water rights (by annual volume) have an irrigation purpose (although not all this water may be allocated to irrigation, as many of these water rights have multiple purposes). This subbasin also includes a large commercial right to 5,000 gpm and 8,030 AFY nominally owned by Crown Zellerbach Corporation. (The Ecology database does not track changes in ownership; apparently Crown Zellerbach no longer is in operation in the County, but the ownership of the rights is unknown. They may have been relinquished for non-use.).

In the Salmon Subbasin, 94 percent of water rights (by annual volume) have an irrigation purpose (although not all this water may be allocated to irrigation, as many of these water rights have multiple purposes). This subbasin has 4 municipal wells with annual water rights totaling 1,830 AFY, and no other large annual appropriations.

The **Osoyoos Subbasin** has the largest volume of potentially consumptive instantaneous surface flows appropriated, the largest annual volume of water appropriated, and compares with the Joseph and Salmon subbasins in its appropriation of ground water. Osoyoos Subbasin surface flow appropriations are dominated by: (1) the very large 375 cfs private irrigation right on Tonasket Creek and (2) a total of 203 cfs in 95 separate water rights on the Okanogan River and Osoyoos Lake. These together account for about 70 percent of the instantanous surface rights in the subbasin.

The three largest annual water rights (and 5 of the 10 largest rights) in the Osoyoos Subbasin are non-consumptive. These nonconsumptive purposes total 50,615 AFY (44 percent of the total) and are for storage and fish propagation. In the Osoyoos, a greater proportion of water rights annual volume is for domestic and municipal use than in the other subbasins, which is consistent with the development trends discussed in this report. Of the annual water rights in the Osoyoos Subbasin, 48 percent (by volume) have an irrigation purpose and 13 percent have domestic/municipal purposes (some water rights have both purposes and are counted in both totals).

Figure 3.1-8 compares the numbers of water claims registered by WRIA 49 subbasin. Claims tend to be concentrated in the Osoyoos and Salmon subbasins, each of which have more than 1,000 ground water claims and nearly 700 surface water claims. As explained previously, these claims are largely unquantified and many are suspect. Table 3.1-4 summarizes the numbers and types of claims by subbasin.

Figure 3.1-8: WRIA Water Claims by Basin

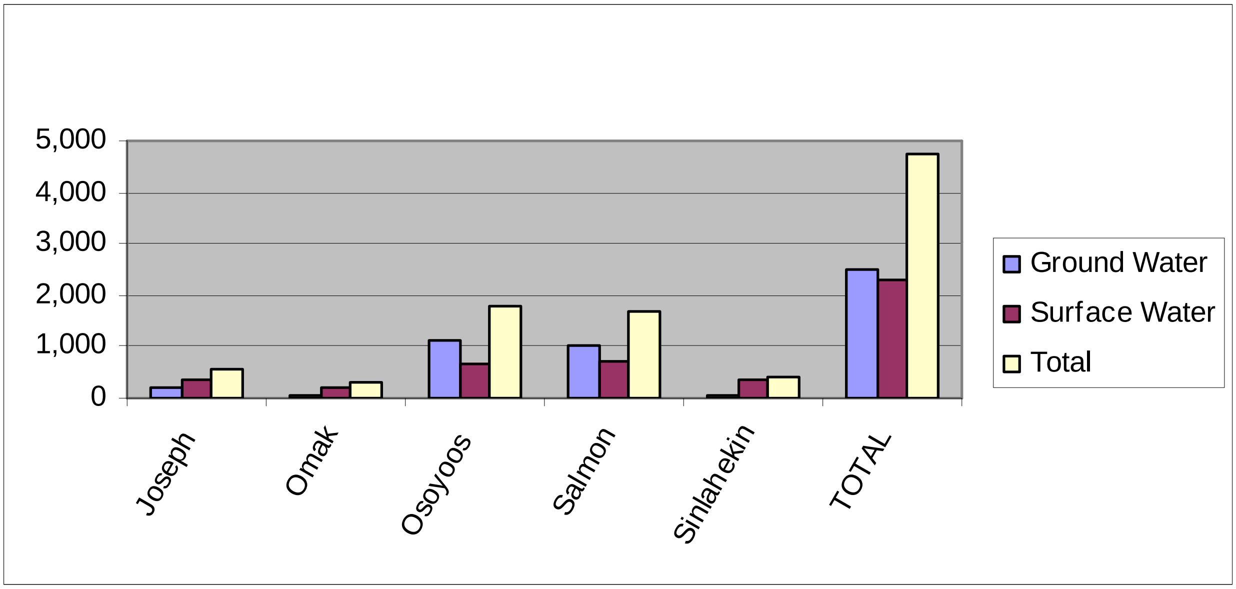


Table 3.1-4: Water Rights Claims Summary by Subbasin

BASIN	GROUND WATER	SURFACE WATER	TOTAL
Joseph	215	355	570
Omak	75	216	291
Osoyoos	1,114	668	1,782
Salmon	1,005	692	1,697
Sinlahekin	70	346	416
TOTAL	2,479	2,277	4,756

3.2 WATER USE

Water use is described in terms of the amount both surface and ground water used. The major uses of water in WRIA 49 are for agricultural and municipal and domestic purposes. Water may be taken for use either from exempt wells (exempt from the requirement to obtain a water right certificate), or from a water right stating the purpose, place of use, and amount of water that may be used (including any seasonal or other restrictions on the timing of use).

3.2.1 Exempt Wells[2]

WRIA 49 water well data were obtained from the Washington Department of Ecology well-log database (Appendix A-2), including the downloaded data from Ecology (Appendix A-2.1) and the filtered data analyzed for the Level 1 Report (Appendix A-2.2).

Locations and relative distributions of WRIA 49 water wells are shown in Attachment 2, Atlas Maps. There are 4,183 well logs recorded in the Ecology well log database for WRIA 49, and 910 water-righted wells identified in the water rights database. This suggests that there may be about 3,300 exempt wells in the WRIA. There are about 3,900 residences in the WRIA that are not connected to public water and about 2,300 unoccupied residences. Since the number of unconnected residences exceeds the number of exempt wells, this suggests that some of the unoccupied residences may not have wells developed (some of these may be in public water system service areas but not yet connected). Alternatively, some residences may share wells with neighbors, but not be reported as Group B water systems.

Wells range in size from 6-inch residential wells to large diameter irrigation, commercial, and municipal water supply wells, and include wells up to 5 to 10 feet in reported diameter, some of which are probably old hand-dug wells and some of which may be Ranney collectors. Figure 3.2-1 and Table 3.2-1 present summaries of water well diameters, including an inferential guess at which of them may be exempt versus non-exempt. More than 80 percent of WRIA 49 wells are 6- to 8-inch diameter, and most of these are probably exempt wells.

Figure 3.2-2 and Table 3.2-2 present summaries of water well depths. A fairly even distribution occurs over the range up to 300 feet in depth, accounting for 78 percent of all wells. A substantial number of wells have been drilled in the 300- to 500-foot depths (12 percent of the total), and even up to 800 feet (4 percent). The deepest wells are at 1510 feet and 2400 feet, and nearly 100 wells are reported to be 20 feet or less in depth.

As is true of many other regions, there has been an increasing trend to drill wells, with the number of new wells per year multiplying by a factor of three through the 1960s and 1970s. In the 1980s and 1990s the numbers of new wells continued to double, flattening off in the 2000-2005 period at 142 new wells per year (Figure 3.2-4 and Table 3.2-3).

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[2] "Exempt well" is shorthand for groundwater withdrawals that are exempt from the water right permitting process through the Washington State Department of Ecology (but not exempt from regulation in the same manner as other water withdrawals – the exemption extends only to the paperwork of permitting). Specific exemptions include:

- withdrawal of groundwater for stock watering,
- irrigation of a lawn or non-commercial garden not exceeding one-half acre in size,
- single or group domestic purposes in amounts less than 5000 gallons per day, or
- industrial purposes in an amount less than 5000 gallons per day
- Exempt wells may serve individual dwellings or Group B systems of up to six connections.

These data may reflect an increase in WRIA 49 land development in more remote areas, far from public water service.

Figure 3.2-1: Diameters of WRIA 49 Water Wells

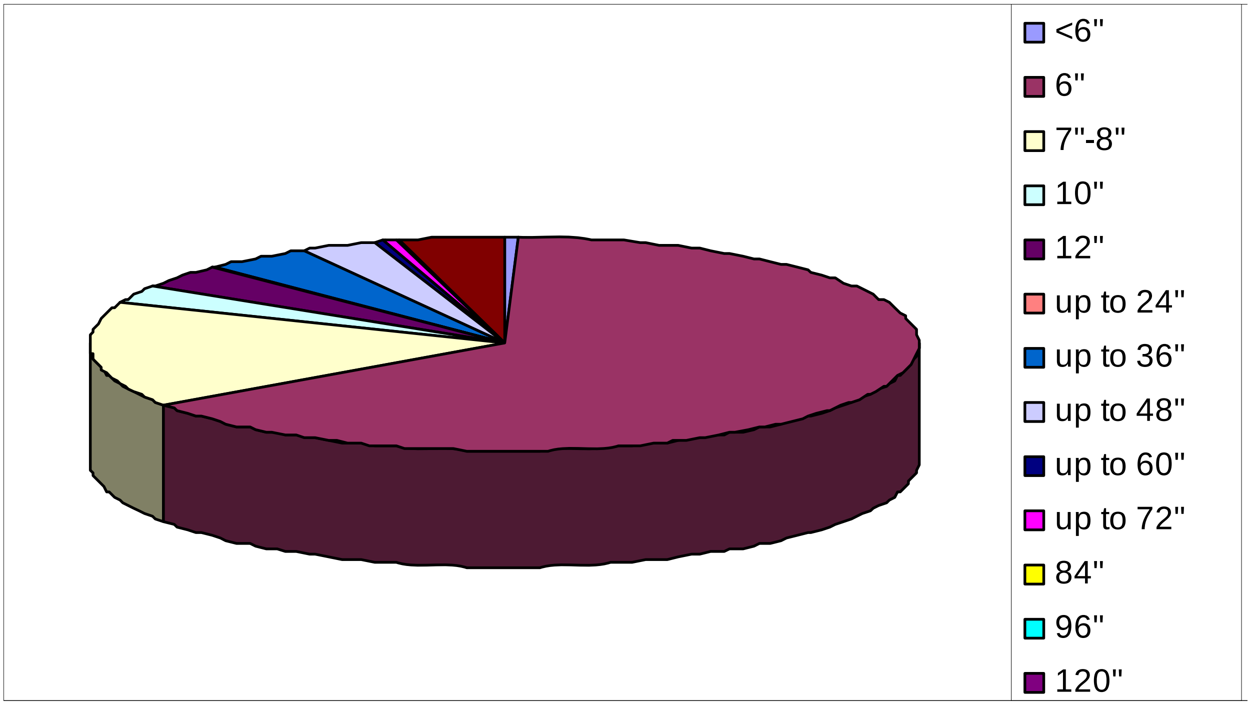


Table 3.2-1 Water Well Depths

	DIAMETER	NUMBER	PERCENT
	<6"	29	0.7%
Exempt	6"	2705	64.7%
Wells	7"-8"	658	15.7%
	10"	116	2.8%
Non-exempt	12"	149	3.6%
(municipal	up to 24"	19	0.5%
& industrial)	up to 36"	171	4.1%
	up to 48"	130	3.1%
	up to 60"	13	0.3%
Hand-dug	up to 72"	13	0.3%
(exempt)	84"	3	0.1%
	96"	4	0.1%
	120"	1	0.0%
	no diameter	172	4.1%
		4183	100.0%

Figure 3.2-2: WRIA 49 Water Well Depths

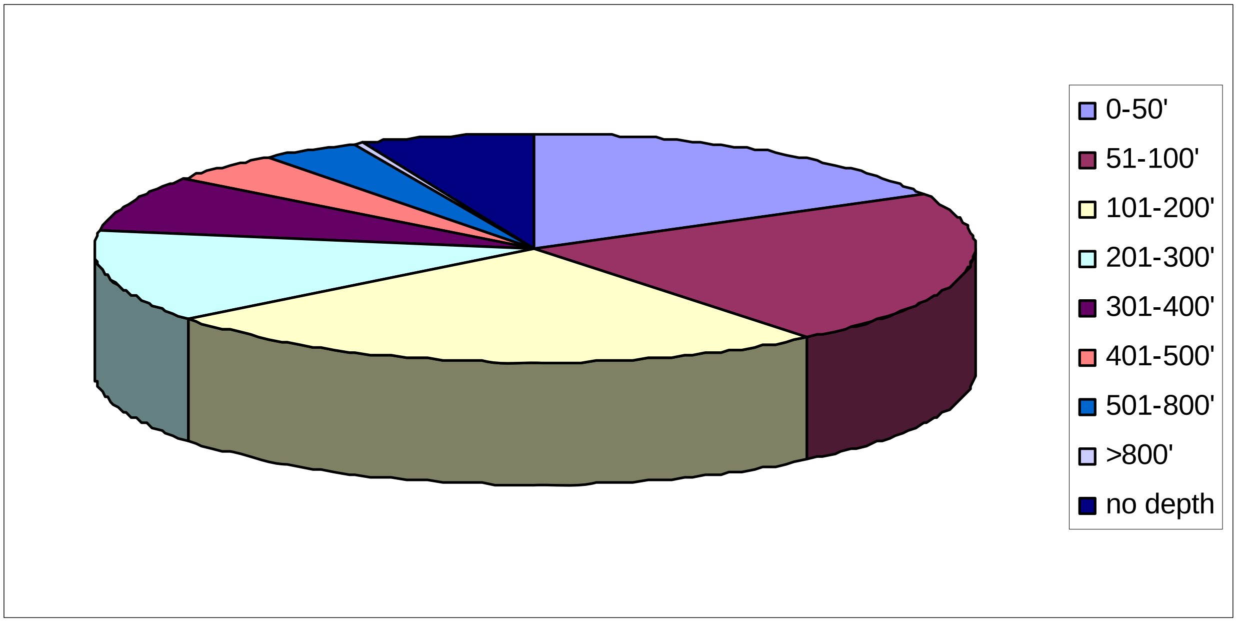


Table 3.2-2: WRIA 49 Water Well Depths

DEPTH	NUMBER	PERCENT
0-50'	722	17.3%
51-100'	923	22.1%
101-200'	1046	25.0%
201-300'	551	13.2%
301-400'	324	7.7%
401-500'	183	4.4%
501-800'	150	3.6%
>800'	15	0.4%
no depth	269	6.4%
	4183	100.0%

Figure 3.2-3: WRIA 49 New Wells by Decade

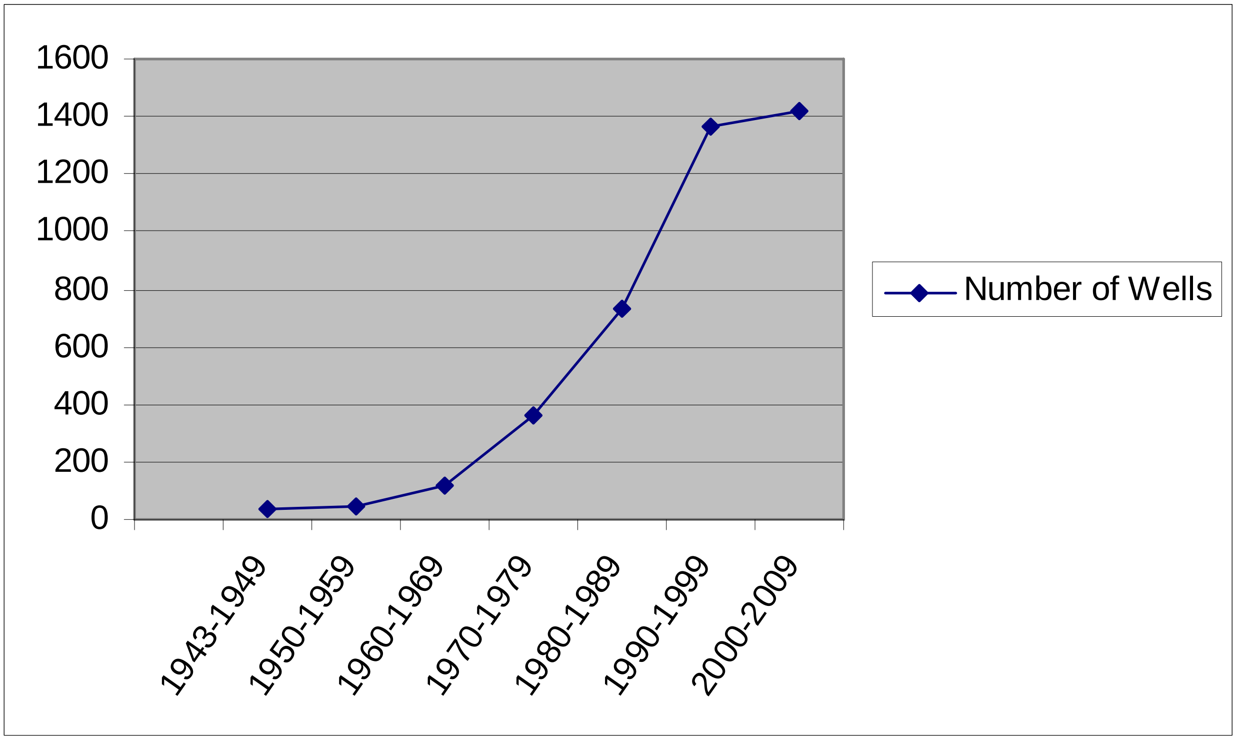


Table 3.2-3: WRIA 49 New Water Wells by Decade

DECADE	NUMBER OF WELLS	NEW WELLS	ROUGH RATE OF INCREASE
1943-1949	35	5	
1950-1959	43	4	1.0
1960-1969	120	12	3.0
1970-1979	358	36	3.0
1980-1989	731	73	2.0
1990-1999	1368	137	2.0
2000-2005	852	142	1.0
2006	8	5	1.0
No date	668	4	3.0
	4183		3.0
	35		

3.2.2 Domestic & Municipal Water Use

Single domestic (residential) use in WRIA 49 is supplied by exempt wells and by water rights with domestic purposes. Multiple domestic use requires service by a Group A or Group B water system. Group B systems serve 2 to 14 connections. Those with 15 or more connections are classed as Group A systems. Table 3.2-4 summarizes the number of Group A and B water systems in the WRIA, the total number of connections they serve, and the population served. The distribution of exempt wells, discussed above, reflects the likely comparative domestic water use by subbasin.

Table 3.2-4: WRIA 49 Group A & B Water Systems

	NUMBER	TOTAL CONNECTIONS	POPULATION SERVED
Group A Systems	59	7,223	15,663
Group B Systems	189	817	1,278
TOTAL	248	8,040	16,941

The larger WRIA 49 Group A water systems (Brewster, Okanogan, Omak, Oroville, Riverside, and Tonasket) file WSCPs with the Department of Health. These are required to be updated every six years. Appendices A-3.1 and A-3.2 contain DOH data for all WRIA 49 Group A and B water systems, and more detailed information from the WSCPs for the six large Group A systems (including current and future water demand). Appendix A-3.3 summarizes water conservation programs and measures described in the WSCPs.

Estimating water use for municipal and domestic purposes depends upon the number of residences and population size. Table 3.2-5 summarizes current WRIA 49 population and housing (based on Census 2000). The census reported a population of 32,588 in the WRIA, an average household size of 2.7 persons, and a total of 14,178 residential units. Of these, some are seasonally occupied and 2,268 are unoccupied (16 percent).

Census 2000 data do not currently reconcile well with Okanogan County Assessor parcel data, which reports a substantially smaller number of residences (6,553). This discrepancy should be considered for Level 2 analysis to provide more confidence in the estimated water use.

There are 8,040 total connections (residential and non-residential) reported to be served by public water systems in WRIA 49, most of which are residential. Above, it was estimated that there may be about 3,300 exempt wells in the WRIA; some exempt wells serve small water systems (connecting several residential units), and some serve individual dwellings. The sum of public water connections and exempt wells (11,340) agrees reasonably well with the 2000 Census report for the number of residential units (11,910). (Detailed data, if it were available, would show that some of the 8,040 connections are not residential, but that some of the exempt wells serve more than one residence; adjusting for both of these factors would likely reconcile with the reported number of residences.)

Table 3.2-6 summarizes the numbers of residences, connections, and source (public water versus exempt well) for WRIA 49.

Table 3.2-5: WRIA 49 Current Population and Housing

LOCATION	POPULATION	TOTAL HOUSING UNITS	HOUSING UNITS	
			Occupied	**Unoccupied**
City of Brewster	2,189	739	662	77
City of Oroville	1,653	794	691	103
City of Tonasket	994	482	420	62
Town of Riverside	348	153	143	10
Town of Conconully	185	192	94	98
City of Omak	4,721	2,016	1,861	155
City of Okanogan	2,484	997	909	88
Total Incorporated	12,574	5,373	4,780	593
Unincorporated	20,014	8,805	7,130	1,675
WRIA 49 Totals	**32,588**	**14,178**	**11,910**	**2,268**

Notes:

Based on Census 2000

Average household size: 2.7

Percent unoccupied: 16%

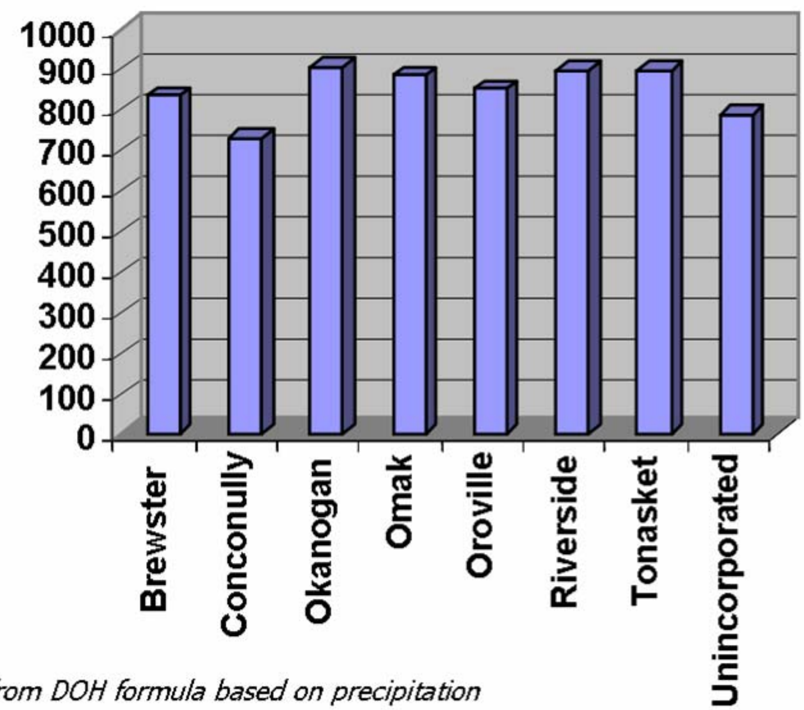
Table 3.2-6: WRIA 49 Residences Served by Wells and Public Water Systems

WRIA 49	
Occupied Residences	11,910
Connections	8,040
Residences not Connected to Public Water	3,870
Wells	4,183
Unoccupied Residences	2,268

Based on a formula provided by the Washington Department of Health (see Chapter 2) which uses local precipitation to calculate water demand, Figure 3.2-5 summarizes average residential water demand for the larger WRIA 49 cities and towns, and for the unincorporated area. Demand is presented in gallons per day (gpd), and is calculated on a standard basis used in the municipal water industry called an “ERU” or Equivalent

Residential Unit[3]. The graph shows that on an average day, standard residential use would range from a low of about 700 gpd in Conconully to a high of about 900 gpd in Okanogan.

Figure 3.2-5 Average Residential Water Dam and gpd/ERU



Calculated from DOH formula based on precipitation

3.2.3 Commercial, Industrial & Institutional Water Use

Some Commercial, industrial, and institutional use may be served by individual wells or stream diversions under water rights owned by the business or institution, or by larger public water systems. Use in these categories is generally not documented in much detail in the WSCPs. There are a total of 25 WRIA 49 water rights with “CI” (Commercial and Industrial) purposes. These are almost entirely served by ground water and have appropriated 8,529 gpm and 11,101 AFY of water. These represent 4.5 percent of instantaneous ground water rights and 10.8 percent of annual water rights in WRIA 49. Water rights recorded in the database as owned by Crown Zellerbach comprise the largest group owned by a single industrial user, with 60 percent of the CI pumping rights (5,025 gpm) and 77 percent of the annual CI water rights (8,529 AFY).

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[3] An equivalent residential unit is simply the amount of water used by an average residence in a water system’s service area. It is used to place different types of connections on a common footing for analysis (such as commercial, institutional, industrial, residential, outdoor watering, etc.

3.2.4 Agricultural Water Use

There are about 80,668 acres of land water-righted for irrigation in WRIA 49, according to the Ecology WRATS/GWIS database. As discussed previously, it is undocumented – and unlikely – that all water rights are fully employed. The County Assessor’s parcel database designates a total of 55,321 acres for an agricultural use of some sort. The 1999 Okanogan LFA identified a total of 101,930 acres of crop land in the Okanogan Basin, of which 50 percent (about 51,000 acres) was estimated to be irrigated. This value would agree reasonably well with the County Assessor’s data.

Agricultural water use is typically calculated by determining the acreages of land planted in different crop types and the crop water requirements (or water duty) of each crop on a seasonal basis for a particular climate. Crop water requirements for WRIA 49 are shown in Table 3.2-7 (source: OCD). Irrigation season water requirements range from 19 inches per acre for grapes to nearly 33 inches for cherries. The LFA estimated that 13 percent of cropland was irrigated hay and 37 percent was orchard (these add to the 50 percent of cropland under irrigation cited above). Given the water requirements shown in Table 3.2-7 for growing alfalfa in the region (about 25” per acre) and for orchard crops (ranging from about 29 inches to 33 inches per acre), a simplifying (and conservative) assumption was made for Level 1 analysis that irrigation averages 30 inches per acre per year (as shown at the bottom of the table).

Table 3.2-7: Seasonal Water Duty by Crop Type

SEASONAL WATER DUTY BY CROP TYPE	
Crop Type	**Seasonal Water Duty**
Alfalfa	25.39"
Pasture	26.90"
Apples	31.65"
Pears	29.53"
Cherries	32.89"
Other minor crops	15" - 30"
Grapes	19.09"
Level 1 Assumption	30"

If all acres designated for agricultural use in the County were irrigated, and assuming an irrigation season water requirement of 30 inches, total agricultural water use would be more than 138,000 AFY. This is surely an over-estimate. National Agricultural Statistics Service (NASS) data, presented in Appendix A-4.1, is available only for Okanogan County as a whole (including WRIAs 48 and 49), and shows 48,416 acres of irrigated land in the entire county in the 2002 Census of Agriculture. NASS also shows a declining trend in irrigated land, dropping from 50,469 acres in 1997 – a decline of about 1 percent per year.

Appendix A-4.2 presents an analysis of County Assessor parcel data, identifying the number of parcels and deeded acres in a series of land use designations, including agriculture. The County Assessor database includes orchard, irrigated alfalfa, vineyards, irrigated pasture, and other irrigated crops (in addition to a number of use categories for dry land agriculture). Often multiple land use codes apply to a single parcel, and the breakout of crop acreage is unknown, making it impossible to use this data source to definitively identify irrigation water use.

The analysis in Appendix A-4.2 shows the breakout of land designated for agricultural use in the eight largest irrigation districts in WRIA 49: Aeneas Lake, Alta Vista, Brewster Flat, Helensdale, Okanogan, Oroville-Tonasket, Riverside Flood, and Whitestone. Together, these irrigation districts comprise 9,123 deeded acres under agricultural designation. The largest of these, OTID, has 6,553 deeded acres in agricultural designation, followed by OID with 1,762 deeded acres. Together these two irrigation districts account for 91 percent of the total agricultural lands in the eight largest districts but only 15 percent of all County Assessor deeded acres with an agricultural designation.

Agricultural water use data were solicited from all the irrigation districts, but only OID and OTID responded with information. A distribution of acreage by crop types is shown in Table 3.2.8. Note that the acreage totals for OID (3,511 acres) and OTID (9,3000) are significantly greater than shown in the County Assessor's parcel database. These discrepancies and the general lack of irrigation data for smaller irrigators are data gaps that could be addressed in Level 2. Appendix A-4.3 presents an example of a detailed irrigation district analysis, conducted for OID as part of the Salmon Creek project. Elements of this analysis may be considered for Level 2 work. It includes:

- Summary of district water rights and claims.
- Characterization of irrigation diversions, losses, flow requirements, end of canal spills, and delivery to farms.
- Calculated district-wide and on-farm efficiencies of water use.
- Crop water use: district acreage by crop, ET rates by crop, district water requirements by crop, and comparison of warm/cool and dry/wet year demand.
- District water balance (pump, delivery, crop water use, spills), including water sources and the percent contribution of each, as well as calculated annual water quantities diverted, used, lost/spilled by source.
- Water source budgets, monthly flows vs. water rights and use for stream sources; annual inflows and outflows for reservoir sources; and recharge and withdrawal for ground water sources.

Table 3.2-8 Distribution of Crop Types by Irrigation District

DISTRIBUTION OF CROP TYPES BY IRRIGATION DISTRICT

	OID		OTID	
Crop Type	**Acres**	**Percent of Land**	**Acres**	**Percent of Land**
Alfalafa	372	11%		
Other hay	101	3%	917	10%
Pasture	870	25%	1,005	11%
Apples	1586	45%	3,217	35%
Pears	436	12%	1,406	15%
Cherries	107	3%	922	10%
Apriots	4	0%		0%
Peaches	5	0%		0%
Other minor crops	30	1%	123	1%
Soft Fruit			408	4%
Grapes			76	1%
Vegetables			80	1%
Ind. (?)			41	0%
Fallow			1,105	12%
	3511	100%	9,300	

Figure 3.2-6 and subbasin atlas maps summarize the distribution of acres designated for agricultural use by the five major WRIA 49 subbasins. Appendices A-4.5 and A-4.6 present agricultural parcel data and water use data by subbasin.

Figure 3.2-6 compares the water-righted acreage with the acres designated by the County Assessor in agricultural categories likely to be irrigated. As one would expect, water-righted acreage is greater than the acreage designated in current use in all subbasins but Omak. The Omak result could be due to tribal land under irrigation outside of Washington water rights.

The Osoyoos Subbasin has the greatest acreage under irrigation, with 44 percent of the total (based on County Assessor data). The Salmon Subbasin has about 21 percent, Omak about 17 percent, and the Joseph subbasin about 12 percent of the total. Sinlahekin has relatively little irrigation, about 6 percent of total County-designated acres.

Assuming an average irrigation season water requirement of 30 inches, Figure 3.2-7 shows the relative water use by subbasin. Since all subbasins have the same average irrigation season crop water requirement under this simplified analysis, the proportions are the same as for agricultural acreage.

Figure 3.2-6: Acres Under Irrigation by Subbasin

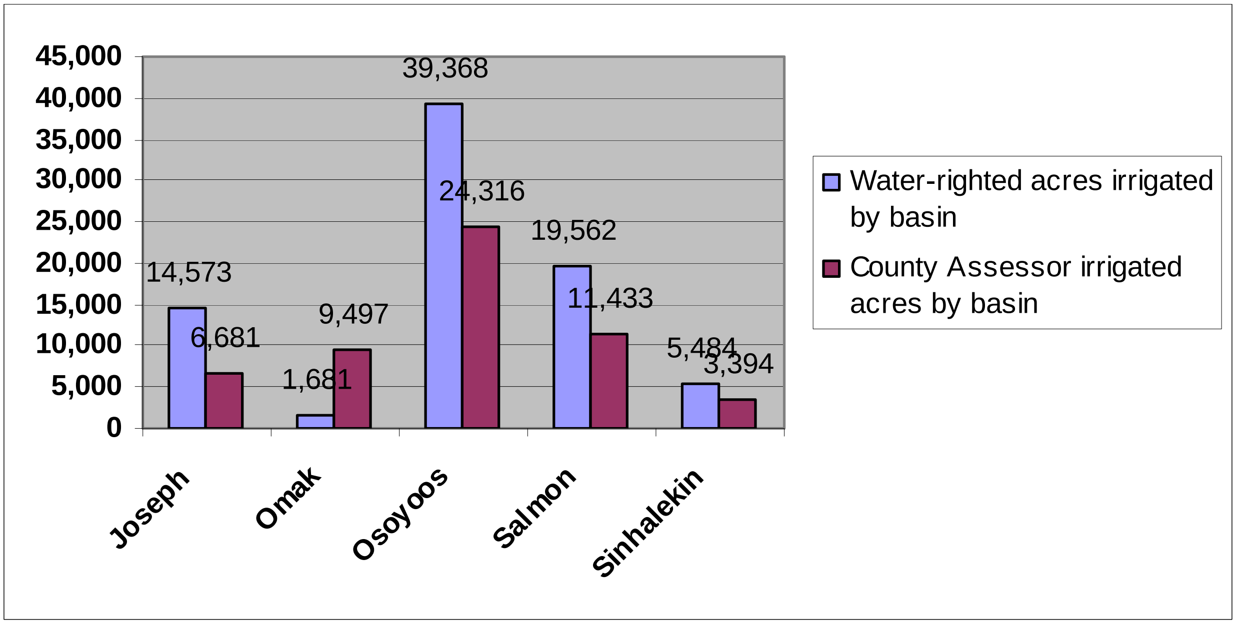
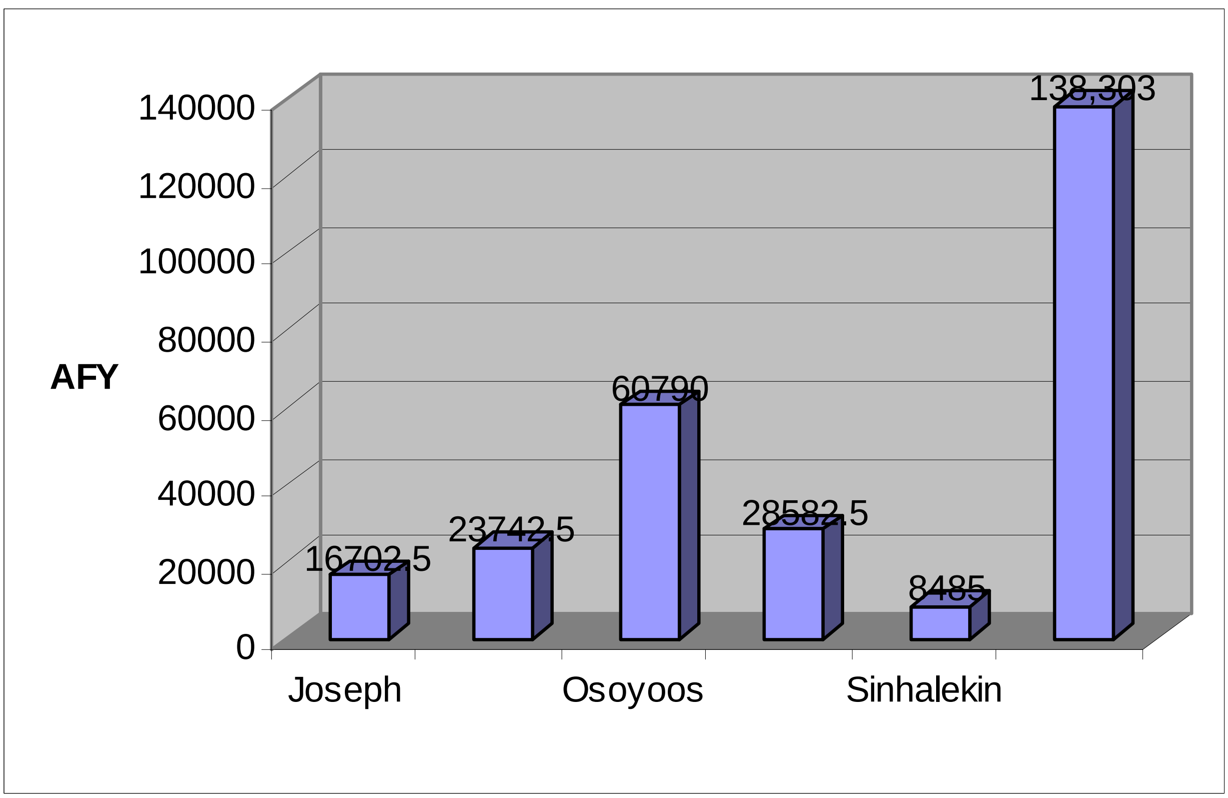


Figure 3.2-7: Agricultural Water Use by Subbasin (30"/acre)



3.3 APPROPRIATIONS FROM STREAMS

Table 3.3-1 lists streams with major diversions, aggregating quantities from all permits and certificates for those named stream sources that total more than one cfs. Appropriations are compared with mean and estimated low flows. Tonasket and Toats Coulee creeks are of concern due to large appropriations, as discussed above.

Anotine and Tunk creeks appear to be overappropriated in terms of low monthly summer flows (however, Level 1 analysis did not look at individual water rights, which may contain seasonal restrictions on diversions). Bonaparte, Loop, Peony, Sinlahekin, Toats Coulee, and Tonasket creeks appear to be overappropriated in terms of both mean annual flows and summer low flows. Johnson Creek also appears overappropriated, but has been adjudicated. Tables 3.3-2 and 3.3-3 summarize the percent of mean annual and summer low flows appropriated from smaller streams in WRIA 49. Table 3.3-4 contrasts flows appropriated from the larger rivers (Similkameen and Okanogan). WRIA 49 water rights appropriate 10 to 13 percent of these rivers' mean annual flows, and 35 to 38 percent of their low summer flows (this does not include non-consumptive appropriation for run-of-river power generation on the Similkameen).

Figure 3.3-1 compares total appropriations of surface waters by subbasin (in terms of total annual water rights expressed as AFY) with net runoff to streams in these subbasins estimated from the Level 1 water balance. These data suggest that surface waters may be overappropriated in the Joseph and Osoyoos subbasins. Moreover, appropriations in these two subbasins include significant amounts from the Okanogan River and Lake Osoyoos, which receive only a small proportion of their flow from net runoff generated in these subbasins (skewing the comparison). However, using the rough estimate generated above that half of WRIA 49 water rights are not in current use, it appears that while there may be overappropriation in some basins, it is doubtful that there is overuse. This may not be true of some individual streams, but more detailed Level 2 analysis would be needed to confirm that.

Table 3.3-1: Major Stream Diversions

STREAM	APPROPRIATED FLOW (CFS)	MEAN ANNUAL FLOW (CFS)	PERCENT APPROPRIATED	LOW MONTHLY SUMMER FLOW	PERCENT APPROPRIATED
ANTOINE CREEK	8.87	no data		0.01	88700.0%
BONAPARTE CREEK	16.475	5	329.5%	0.04	41187.5%
CHILIWIST CREEK	3.596	no data		no data	
CHOPAKA CREEK	6.78	no data		no data	
DUCK LAKE	20.66	no data		no data	
JOHNSON CREEK	23.30	5.00	466.0%	0.8	2912.5%
LAKE OSOYOOS	32.85	no data		no data	
LAKE PATEROS	119.092	no data		no data	
LOOP CREEK	3.13	1.60	195.3%	0.01	31250.0%
MIDDLE CHILIWIST CREEK	2.98	no data		no data	
NORTH FORK SALMON CREEK	1.7381	22.2	7.8%	3.7	47.0%
OKANOGAN RIVER	403.264	3049	13.2%	1154	34.9%
PALMER LAKE	10.795	no data		no data	
PEONY CREEK	2.56	2	128.0%	0.5	512.0%
SARSAPKIN CREEK	1.22	no data		no data	
SIMILKAMEEN RIVER	228.83	2308	9.9%	599	38.2%
SINLAHEKIN CREEK	364.77	53.5	681.8%	12.1	3014.6%
TOATS COULEE CREEK	115.55	45.8	252.3%	9.6	1203.6%
TONASKET CREEK	379	3.22	11770.2%	0.7	54142.9%
TUNK CREEK	1.3	3.1	41.9%	0.1	1300.0%
WHITESTONE CREEK	1.04	2.86	36.4%	1.8	57.8%
WHITESTONE LAKE	11.485	no data		no data	
WHITESTONE LK CR	1.2	no data		no data	

Note: nonconsumptive appropriations not included (e.g., Similkameen PO 1000 cfs) does not include water claims

Table 3.3-2: Percent of Mean Annual Flow Appropriated from Smaller Streams

STREAM	MEAN ANNUAL FLOW (CFS)	PERCENT APPROPRIATED
Bonaparte Creek	5	330%
Johnson Creek	5.00	466%
Loop Creek	1.60	195%
North Fork Salmon Creek	22.2	8%
Peony Creek	2	128%
Sinlahekin Creek	53.5	682%
Toats Coulee Creek	45.8	252%
Tonasket Creek	3.22	11770%
Tunk Creek	3.1	42%
Whitestone Creek	2.86	36%

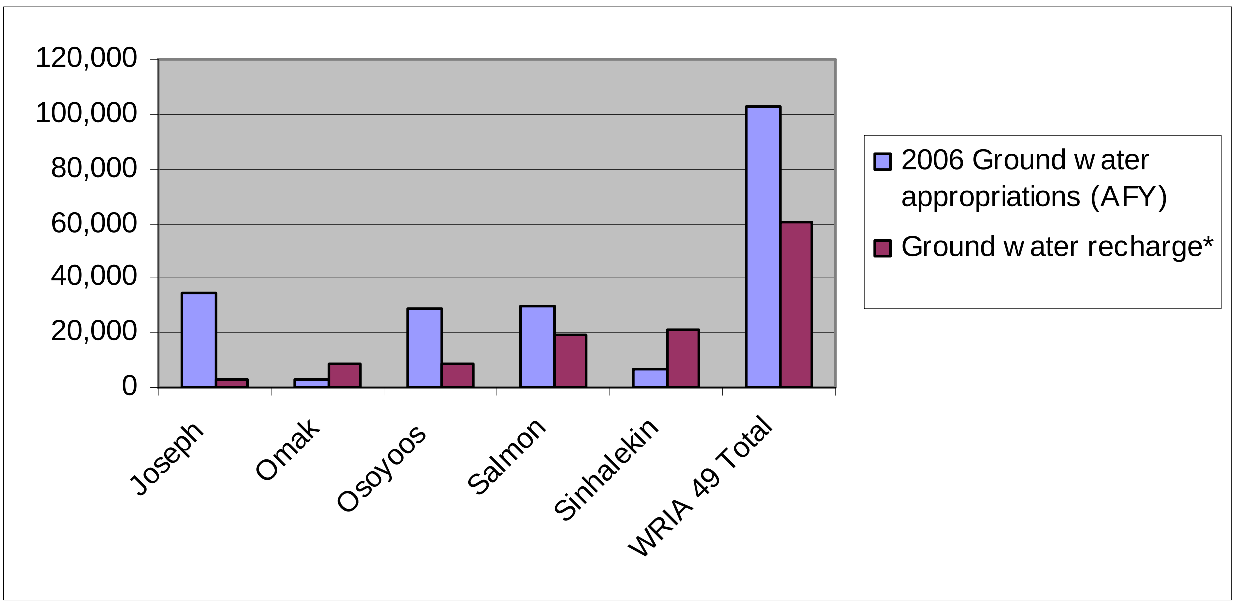
Table 3.3-3: Percent of Low Summer Monthly Flow Appropriated from Smaller Streams

STREAM	LOW MONTHLY SUMMER FLOW	PERCENT APPROPRIATED
Antoine Creek	0.01	88700%
Bonaparte Creek	0.04	41188%
Johnson Creek	0.8	2913%
Loop Creek	0.01	31250%
North Fork Salmon Creek	3.7	47%
Peony Creek	0.5	512%
Sinlahekin Creek	12.1	3015%
Toats Coulee Creek	9.6	1204%
Tonasket Creek	0.7	54143%
Tunk Creek	0.1	1300%
Whitestone Creek	1.8	58%

Table 3.3-4: Percent of Flow Appropriated from Larger Streams

	SIMILKAMEEN RIVER	OKANOGAN RIVER
Appropriated Flow	229	403
Mean Annual Flow (cfs)	2,308	3,049
Percent Appropriated	9.9%	13.2%
Low Monthly Summer Flow	599	1,154
Percent Appropriated	38.2%	34.9%

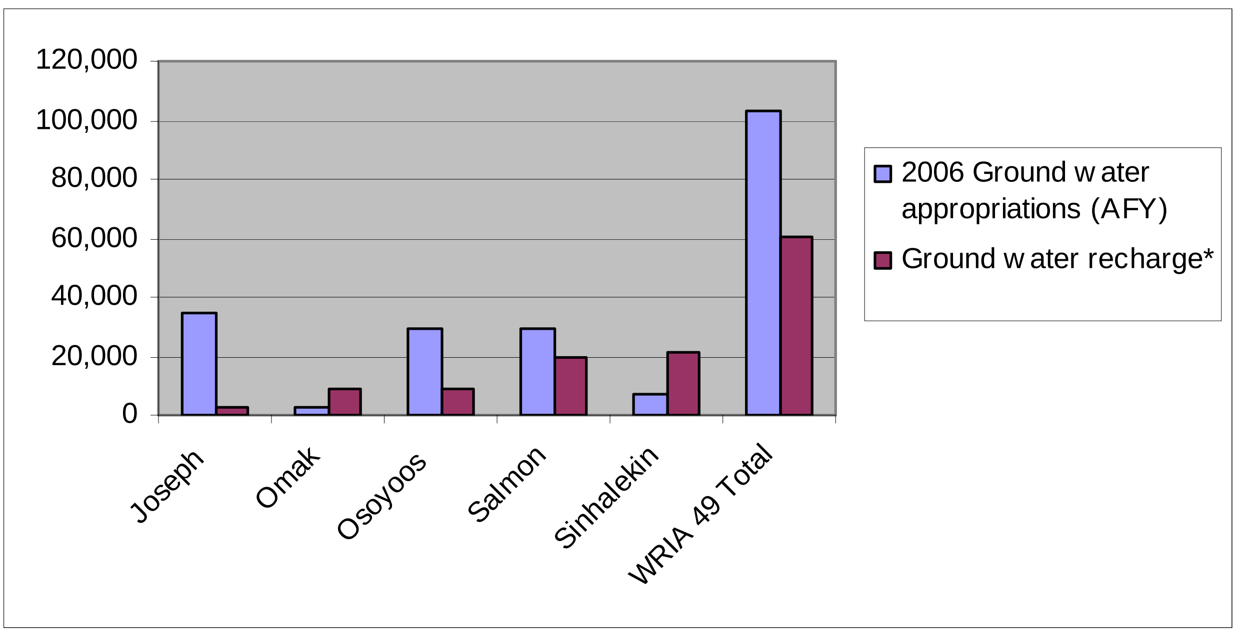
Figure 3.3-1: Current Appropriation of Surface Water (AFY)



3.4 APPROPRIATIONS FROM GROUND WATER

Figure 3.4-1 compares total appropriations of ground waters by subbasin (in terms of total annual water rights expressed as AFY) with ground water recharge in these subbasins estimated from the Level 1 water balance. These data suggest that ground waters may be overappropriated in the Joseph, Osoyoos, and Salmon subbasins. Again, our rough estimate that half of WRIA 49 water rights are not in current use would cast doubt on this conclusion. Further, ground water appropriations in these basins may be in hydraulic continuity with the Okanogan River, which delivers a large additional increment of recharge beyond that which would occur from percolation of surface precipitation within the boundaries of the subbasin. Therefore, it appears that while there may be overappropriation in some basins, it is doubtful that there is overuse. Again, this may not be true of some individual aquifers, particularly small lenses or perched aquifers, but more detailed Level 2 analysis would be needed to confirm that.

Figure 3.4-1: Current Appropriation of Groundwater (AFY)



3.5 FUTURE WATER DEMAND

3.5.1 Overview of Future Water Demand

Level 1 analysis of WRIA 49 future water demand suggests that water in WRIA 49 may be overappropriated, but not overused. To calculated future demand, WRIA 49 growth rates were first projected (Table 3.5-1).

Table 3.5-1: Growth Projections for WRIA 49

DATA SOURCE	AREA/ENTITY	PERIOD	ANNUAL GROWTH RATE	NOTES
U.S. Census	Okanogan County	2000-2005	0.1%	Block level analysis
Washington OFM	Okanogan County	20-yr low 20-yr med 20-yr high	0.1% 2.2%	Projections based on Countywide data.
Water System Comprehensive Plans	City of Brewster (1999)	1980-1997 20 year forecast	2.56% 2.1%	(growth 1337 to 2055 over period) Project growth at 11% over 5 years based on 1995 Comp Plan
	City of Okanogan (2000)	1980-1990 1990-1998 20 year forecast	0.1% 1.9% 1.3%	WSCP range 0.85% (low) to 1.9% (high)
	City of Omak (2004)	1990-2000 20 year forecast	1.38% 1.38%	Projects growth to continue at historical rate
	City of Oroville (2003)	1990-2000 20 year forecast	0.9% 1.7% 1.5% 3% 0.5%	City historical Unincorporated hist. City forecast North End/East Lake Commercial/industrial
	City of Riverside (2000)	1980-1998 20 year forecast	1% 2.8%	Riverside growth rate based on housing units (population forecast is 3.1%)
	City of Tonasket (2004)	1980-2000 20 year forecast	0% 1.77%	No net growth over past 20 years; forecast based on OFM
Okanogan PUD (professional opinion)	PUD Service Area	2000-2005 2005-2010 North End	2% 3% up to 5%	Electrical connections and building permits provide best insight on growth.

Figure 3.5-1 indicates the projected growth rates for the larger cities and towns and for the unincorporated area of WRIA 49. These range from 1.3 percent (Okanogan) to 2.8 percent (Riverside) for the cities. The unincorporated areas of Okanogan County are forecasted to grow at a somewhat greater rate (3 percent). The taller bar to the right of the figure shows the estimated north end growth rate (5 percent).

In summary, until recently historical rates of growth have been very low for unincorporated areas and the County as a whole. The cities of Okanogan and Tonasket have had no net growth for long periods. Recent growth in incorporated areas has been one to two percent per year (according to WSCPs), except in Brewster where higher growth has been experienced (2.6 percent per year). In the past five years, the north end growth rate has increased.

Figure 3.5-2 shows current (2006) and a 20-year forecast (2026) of water demand for the larger cities and towns. The greatest current use; 602 million gallons per year (MGY) and greatest growth (792 MGY) occurs in Omak; at the other end of the range, Conconully has low current use (25 MGY) and little growth (37 MGY) (see Appendix A-3.1 for data).

Figures 3.5-3 and 3.5-4 compare residential and total water demand for 2006 and 2026, looking at the total incorporated demand, demand in unincorporated areas, and total WRIA 49 demand. These figures demonstrate that: (1) most demand growth is driven by growth in residential demand, and (2) most of that demand growth occurs in unincorporated areas.

This analysis does not include the agricultural water use sector, because NASS data – as well as information from Planning Unit members – indicates that farmland conversion is occurring and less land is irrigated now than in the past. This trend is expected to continue, and would offset the growth in domestic and municipal water demand in the WRIA. However, the data do not currently exist to quantify these trends in agricultural water use.

In round numbers, the projected growth in WRIA 49 water demand by 2026 (not including offsetting reduction in agricultural water use) is roughly 2,000 MGY. This is equivalent to approximately 6,500 AFY, or continuous pumping of 4,000 gpm, or continuous diversion of 9 cfs. This is not a great deal of water, particularly framed as an increase in demand over 20 years.

Existing appropriations (water rights, discussed above) would appear to fully use or overuse the available from of some surface waters and the recharge capacity of some ground waters in the WRIAs, *if the water rights were fully used*.

Because the volumes of water used for agriculture appears to be much greater than domestic and municipal use in WRIA 49 (approximately 138,000 AFY versus approximately 4,000 AFY), and because the basis of calculation for agricultural water use is so rough and inexact, it is not possible to state with confidence what proportion of water rights are used in the WRIA. However, if these values were roughly correct, about 142,000 AFY of water are put to use, representing a little less than half of all existing WRIA 49 annual water rights.

Figure 3.5-1: WRIA 49 Projected Growth Rates

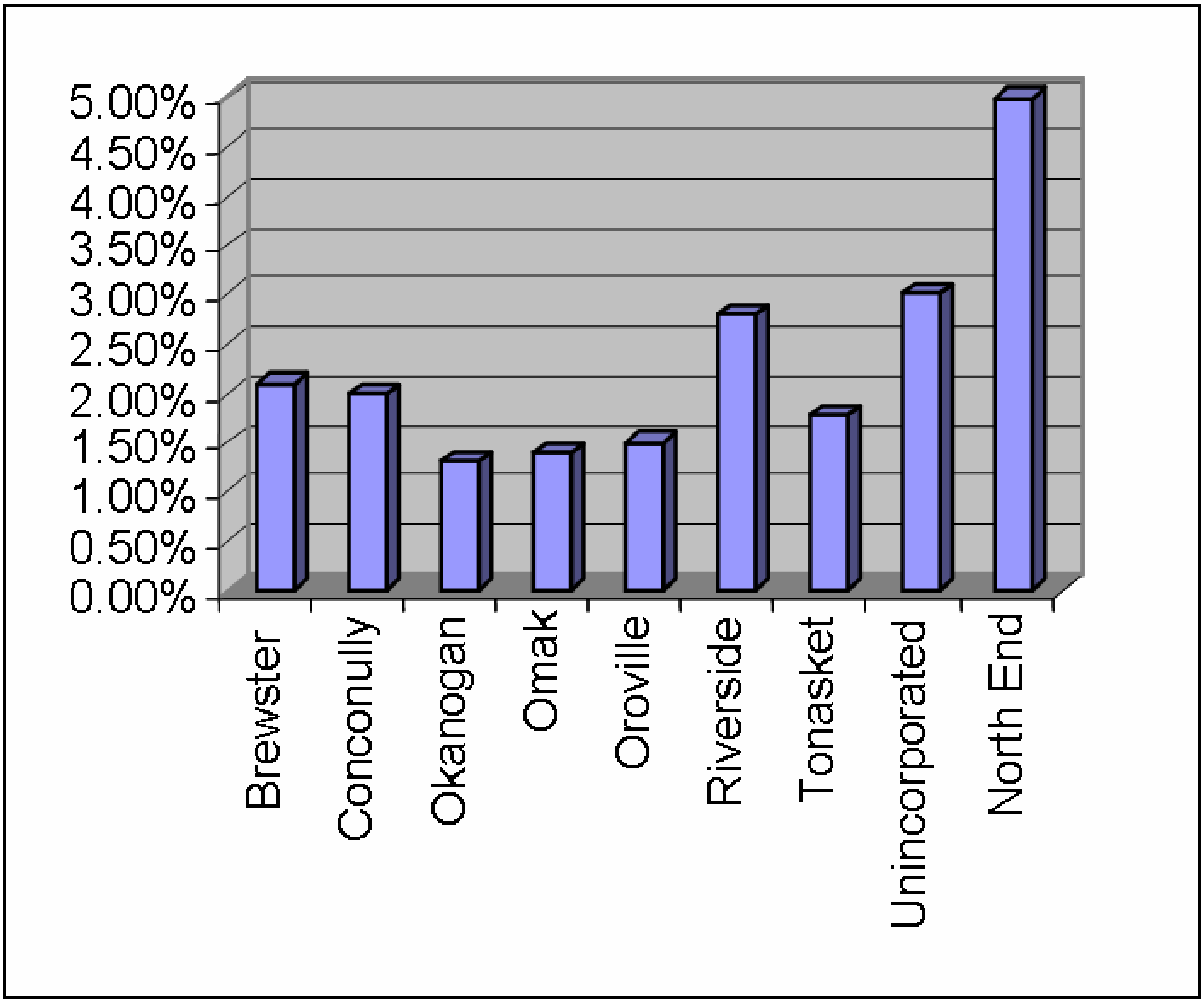


Figure 3.5-2: 2006 and 2026 Residential Water Demand – Incorporated Areas

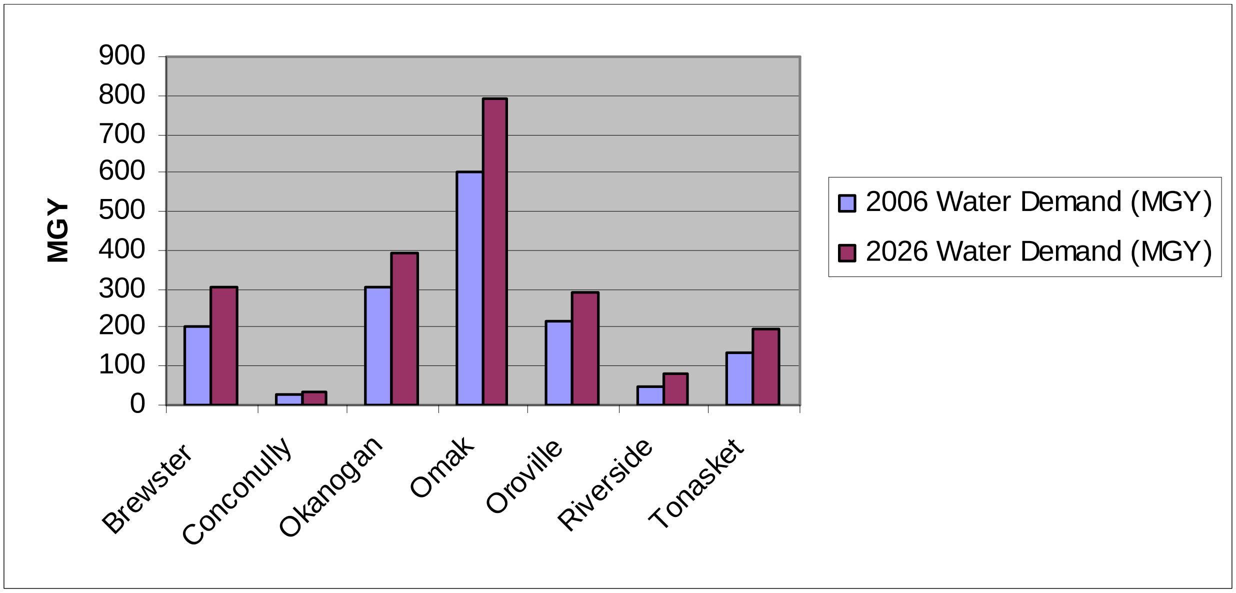


Figure 3.5-3 WRIA 49 2006 and 2026 Residential Water Demand Combined

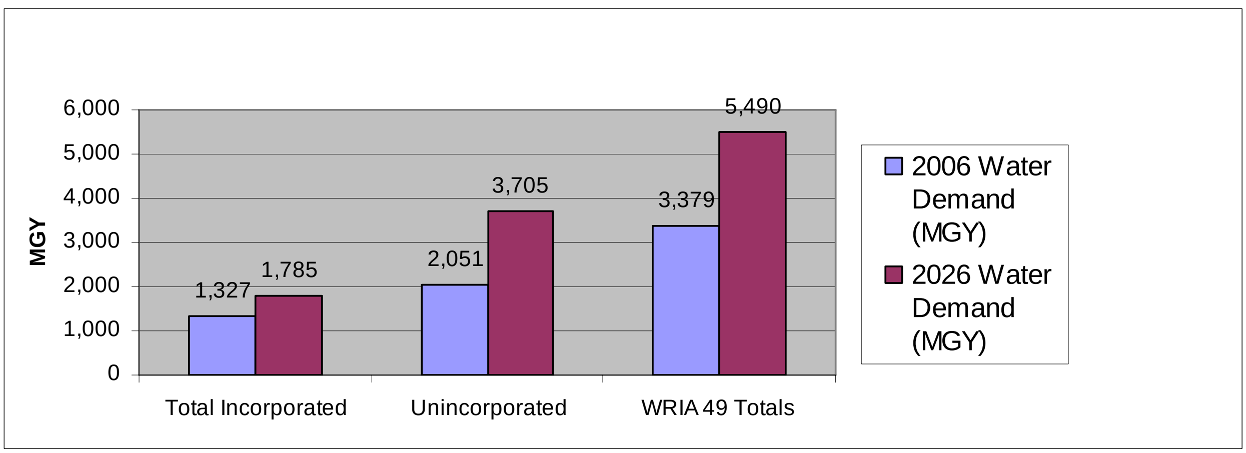


Figure 3.5-4 WRIA 49 2006 and 2026 Total Water Demand

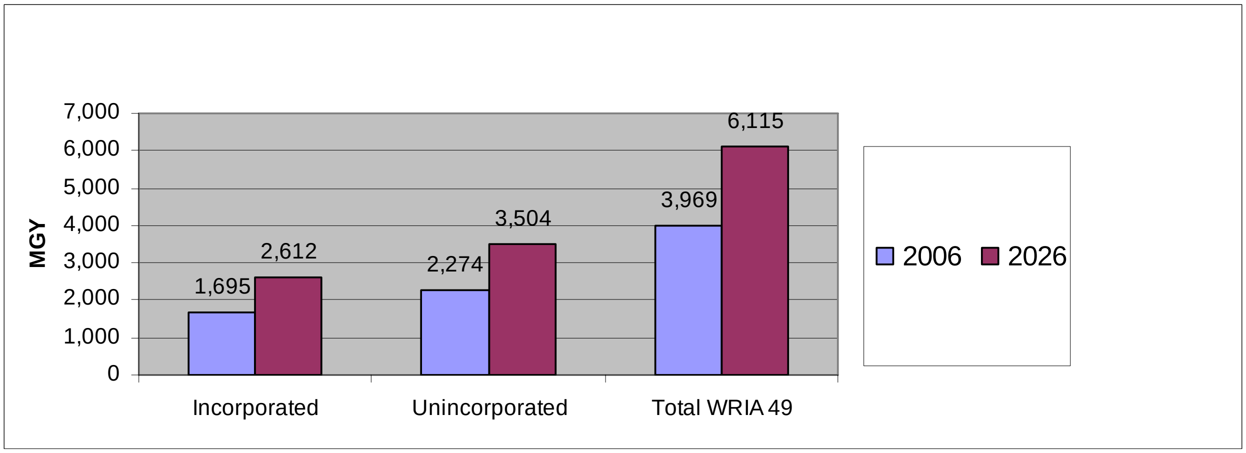


Figure 3.5-5 shows existing (2006) and 2026 demand for water for the six largest Group A water systems in the WRIA. Both peak demand (maximum demand day, MDD) expressed in gallons (gpm) and annual demand (MGY) are shown (see Appendix A-3.2 for data). Based on these existing and projected levels of demand, and the information presented in these water systems' WSCPs, a comparison was made to the adequacy of their existing water rights, water sources, and pumping capacity to supply that demand (Figures 3.5-6, 3.5-7, 3.5-8, and 3.5-9).

Figure 3.5-5: WRIA Purposes of Water Rights

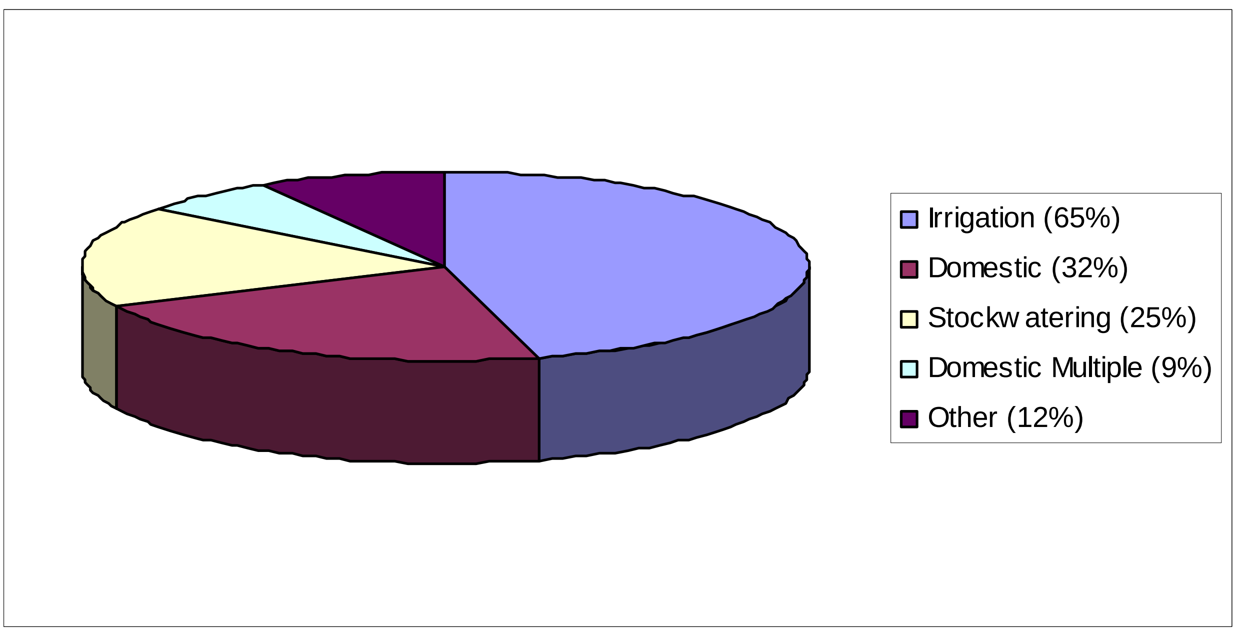


Figure 3.5-6: Source Pumping Surplus/Deficit (2006)

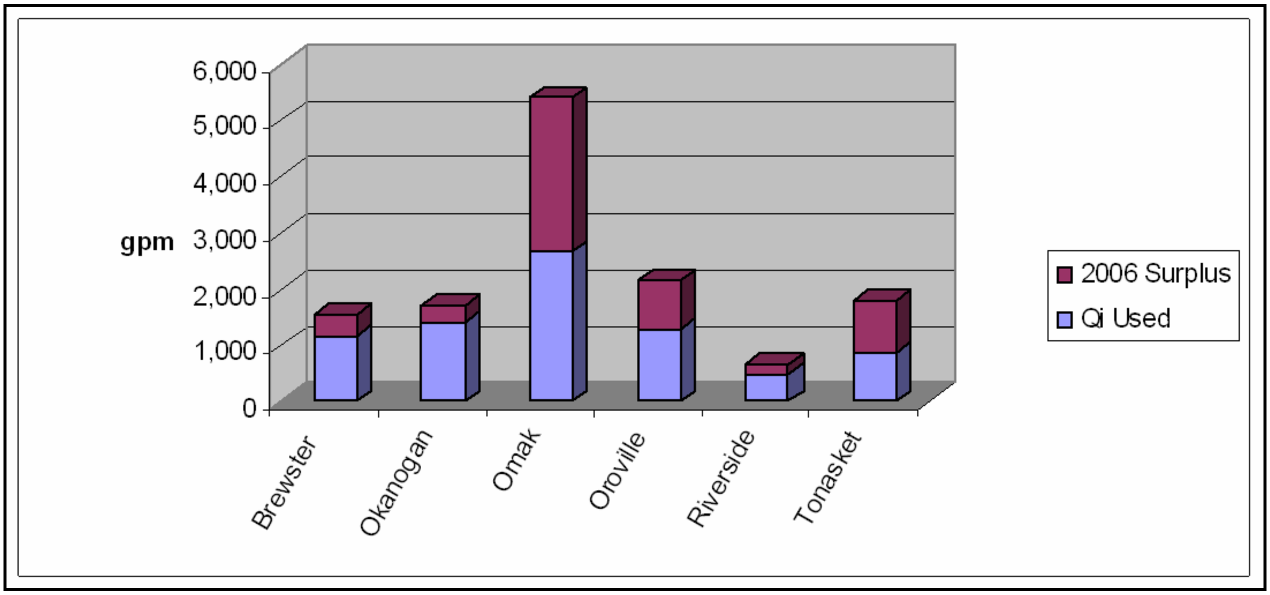


Figure 3.5-7: Source Capacity Annual Surplus/Deficit (2006)

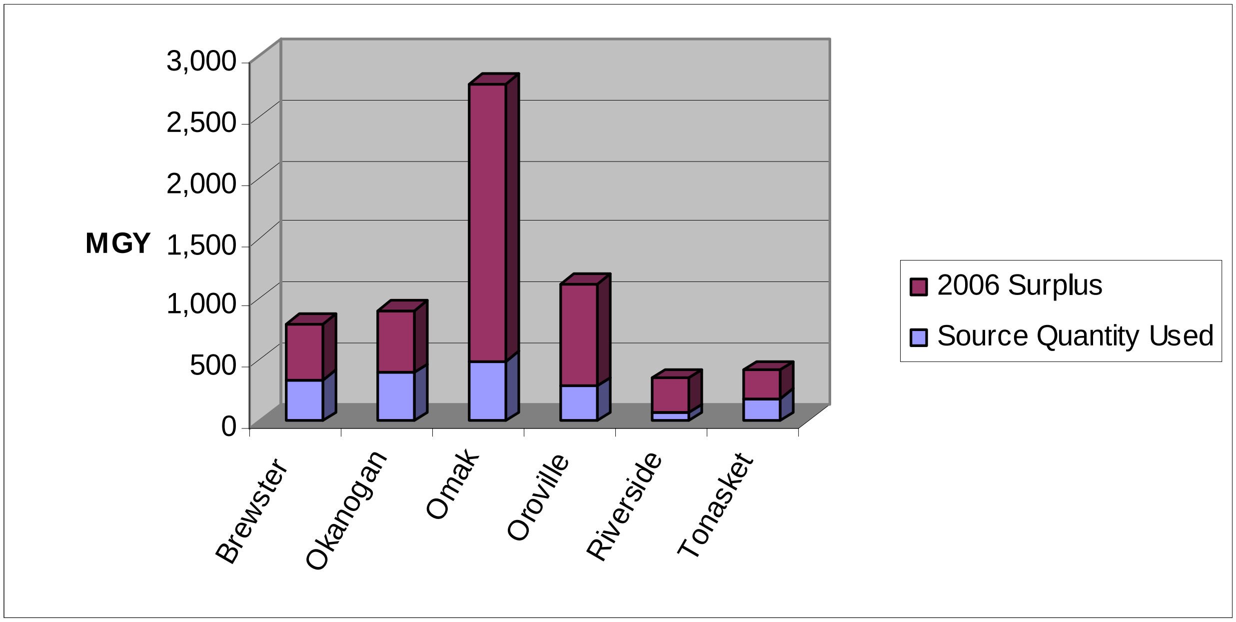


Figure 3.5-8: Instantaneous Water Rights Surplus/Deficit

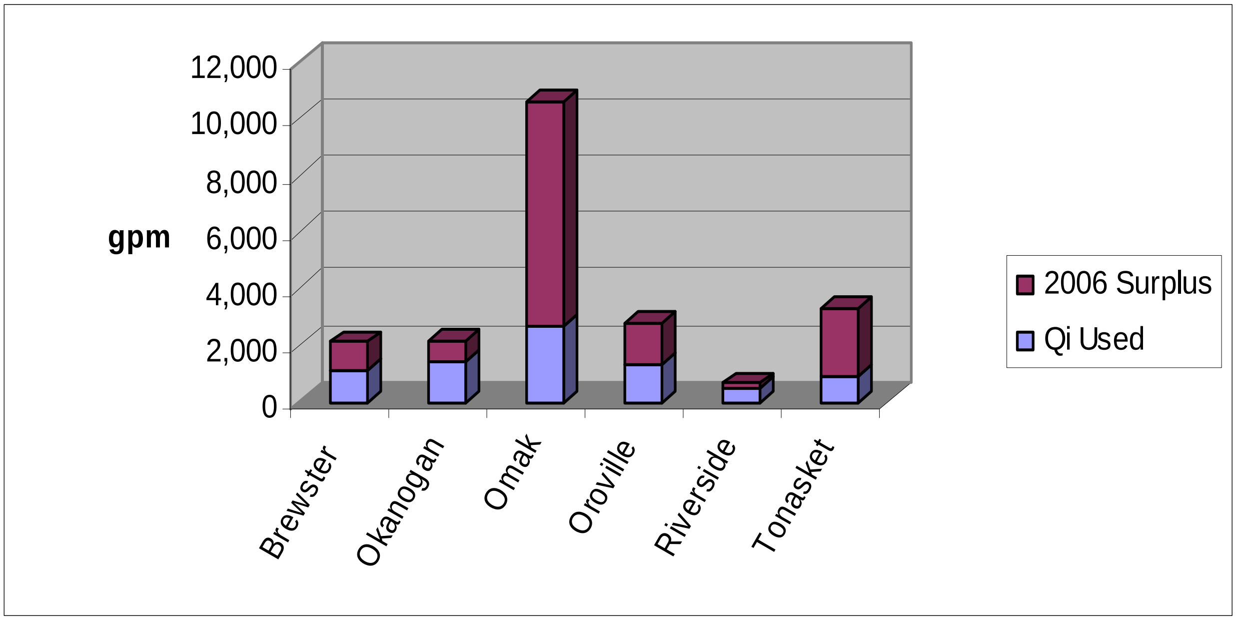
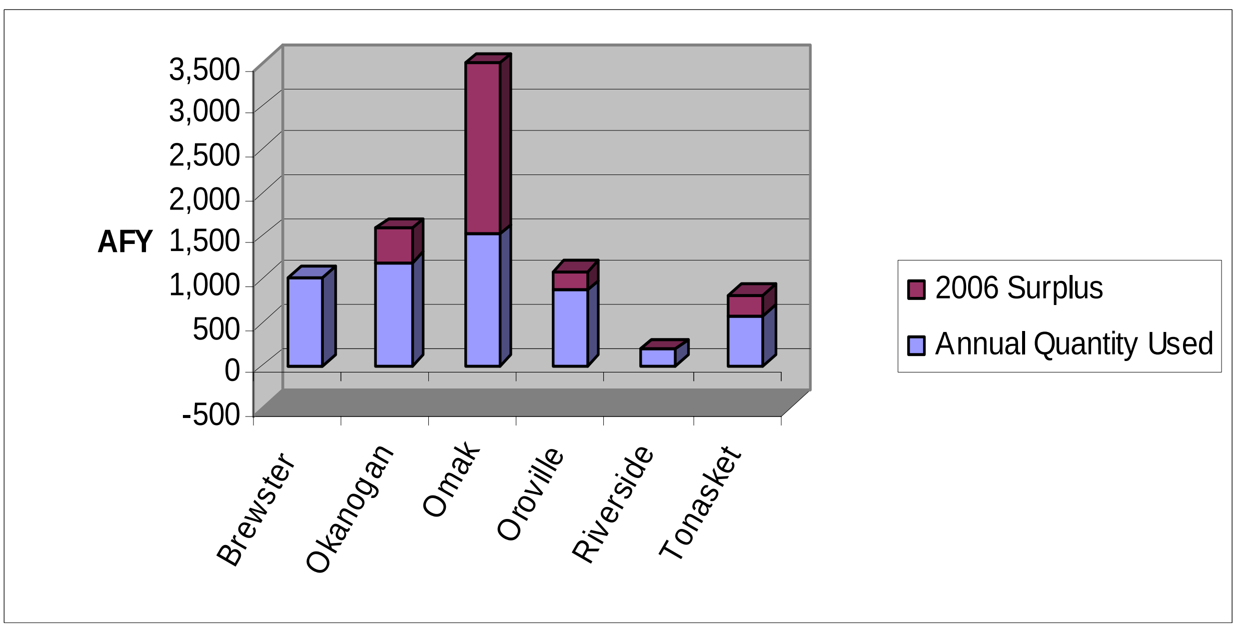


Figure 3.5-9: Annual Water Rights Surplus/Deficit



Figures 3.5-10, 3.5-11, 3.5-12, and 3.5-13 show the adequacy of the six larger water systems water rights, water sources, and pumping capacity to supply demand with growth trends extended to 2026. Only the Omak and Tonasket have sufficient current pumping capacity to meet the 20-year forecasted demand; Brewster (615 gpm deficit), Riverside (413 gpm), Okanogan (295 gpm), and Oroville (50 gpm) would need to add

capacity. All the systems, however, have sufficient source capacity to meet growing demand over the next 20 years.

Figure 3.5-10: Source Capacity Pumping Surplus/Deficit (2026)

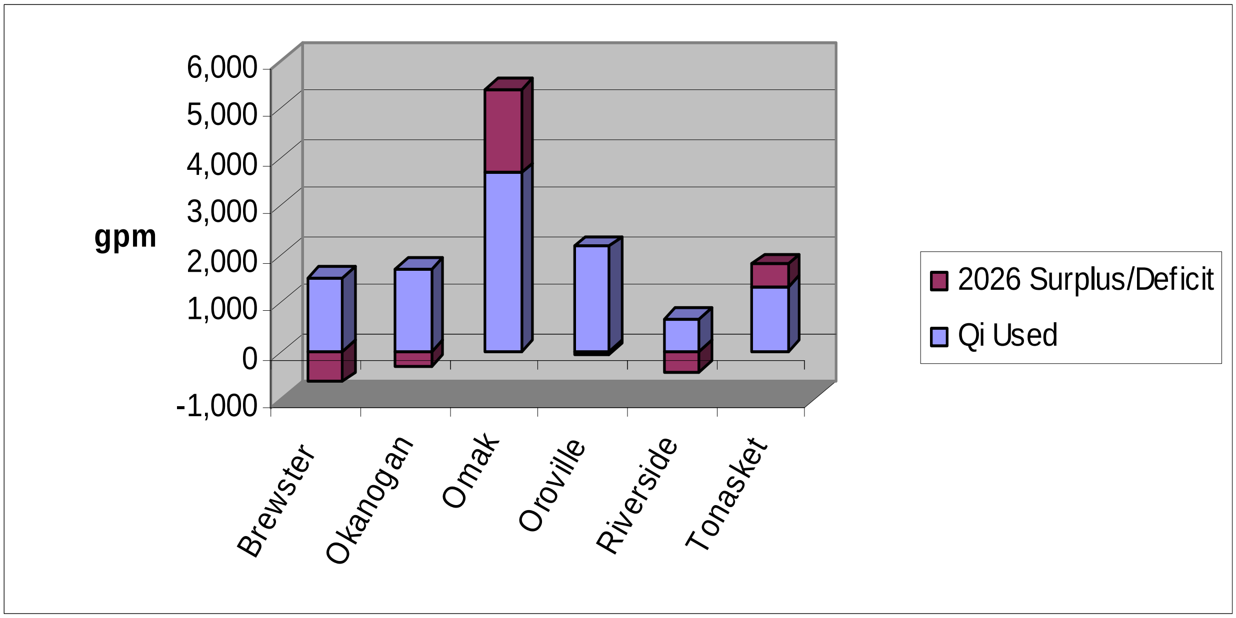


Figure 3.5-11: Source Quantity Annual Surplus/Deficit (2026)

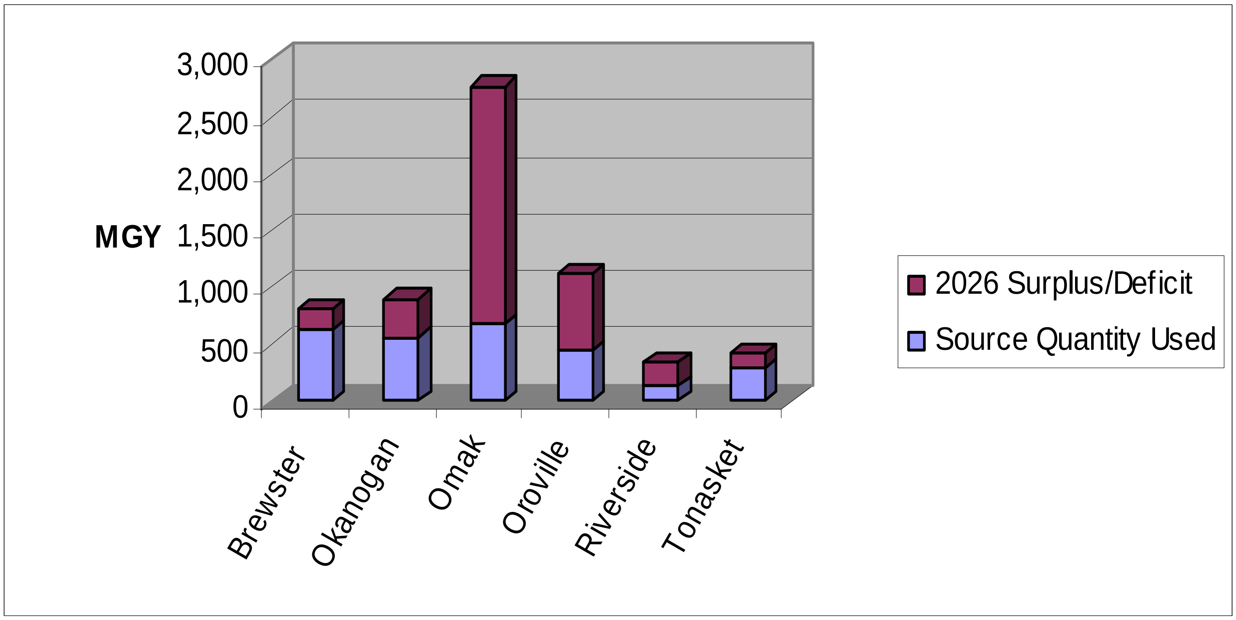


Figure 3.5-12: Instantaneous Water Rights Surplus/Deficit (2026)

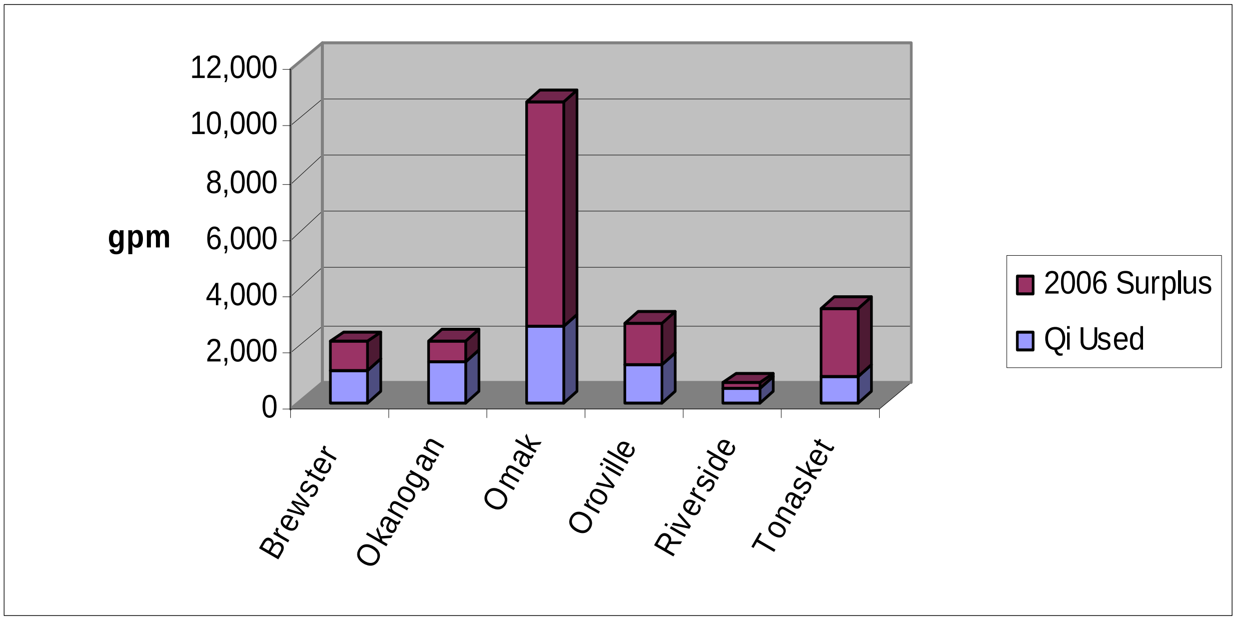
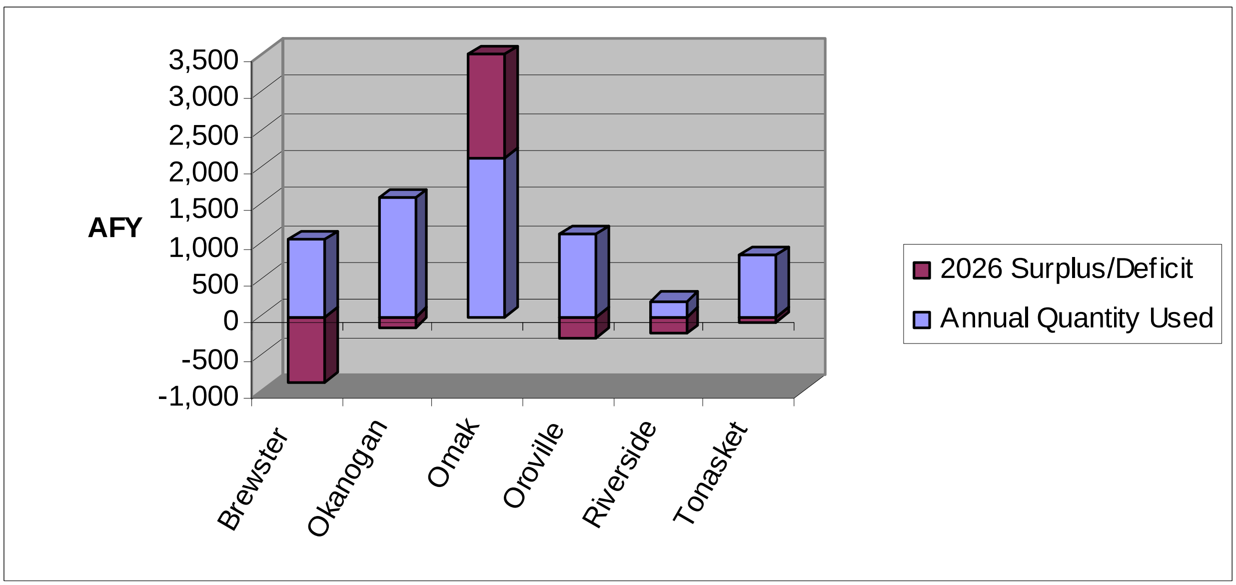


Figure 3.5-13: Annual Water Rights Surplus/Deficit (2026)



These figures show that all six water systems currently have surplus pumping capacity and surplus source capacity to meet existing demand. Existing instantaneous water rights are also more than sufficient to meet current demand, but not all of the water systems may have sufficient water rights to meet water demand on an annual basis. Both Brewster and Riverside appear to be fully using their existing water rights to meet current needs, and appear to have no margin left to serve new growth.

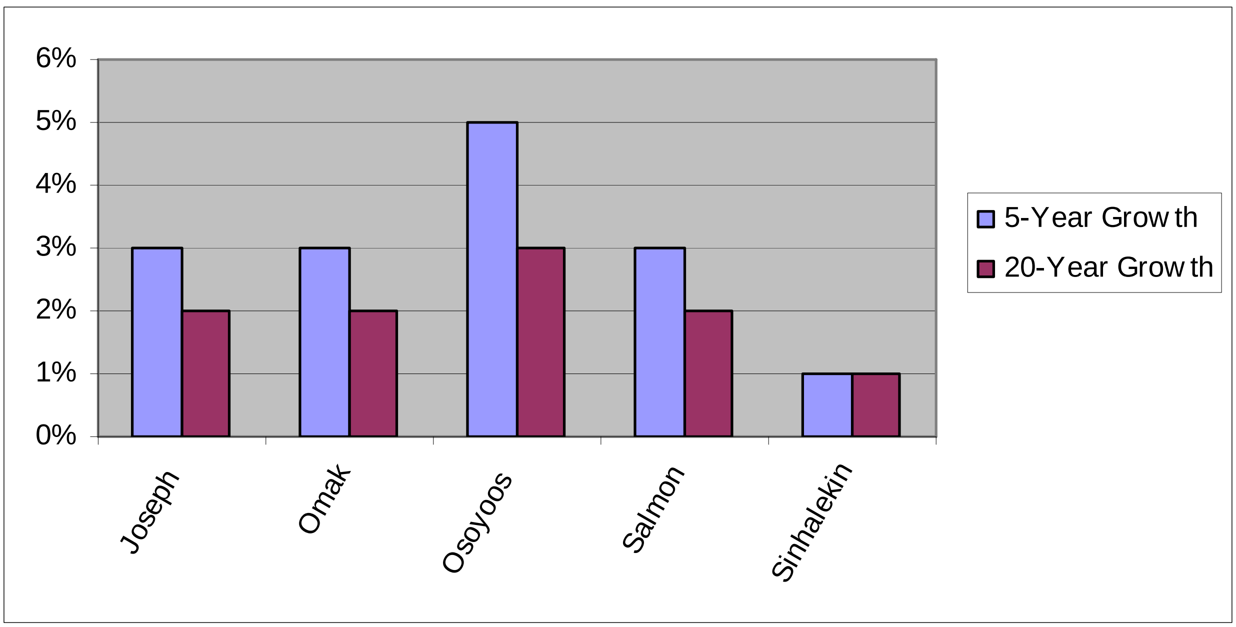
Turning to instantaneous water rights with growth projected to 2026, again both Omak and Tonasket have a large surplus; Oroville's water rights are more than adequate; and Okanogan has a slim margin. Riverside (433 gpm) and Brewster (45 gpm) would require additonal water rights to serve growth.

On an annual basis, all the water systems except Omak would need additional water rights by 2026. Deficits range from 78 AFY (Tonasket) to 887 AFY (Brewster). Detailed data for all the water systems, including these projections, is contained in Appendix A-3.2.

3.5.2 Subbasin Future Water Demand Assessment

Figure 3.5-14 presents estimated growth rates by subbasin. These include 5-year and 20-year horizons, based on an expectation that near-term growth would be somewhat higher but could not be reasonably projected to continue at that rate for as long as 20 years.

Figure 3.5-14: WRIA Subbasin Growth Rates



For the near-term, the Osoyoos Subbasin is projected to experience a significantly higher growth rate, 5 percent per year, due to development in the north end in the vicinity of Lake Osoyoos. The rate is projected to drop to 3 percent per year for the 20 year forecast.

The Joseph, Omak, and Salmon subbasins are all forecasted to grow at an annual rate of 3 percent for the next five years, dropping to 2 percent per year for the 20 year forecast. The Sinlahekin Subbasin is considered a low growth area, holding at a 1 percent per year growth rate over the entire 20 year forecast period.

Figures 3.5-15 and 3.5-16 compare ground water recharge and net runoff to streams for the five major WRIA 49 subbasins with the projected water appropriations in 2026. It is evident that the same three basins (Joseph, Osoyoos, and Salmon) continue to be of concern. Again, the role of Okanogan River in delivering water from outside the subbasin boundaries that is appropriated within the subbasin skews the comparison.

Figure 3.5-15: 2026 Appropriation of Groundwater

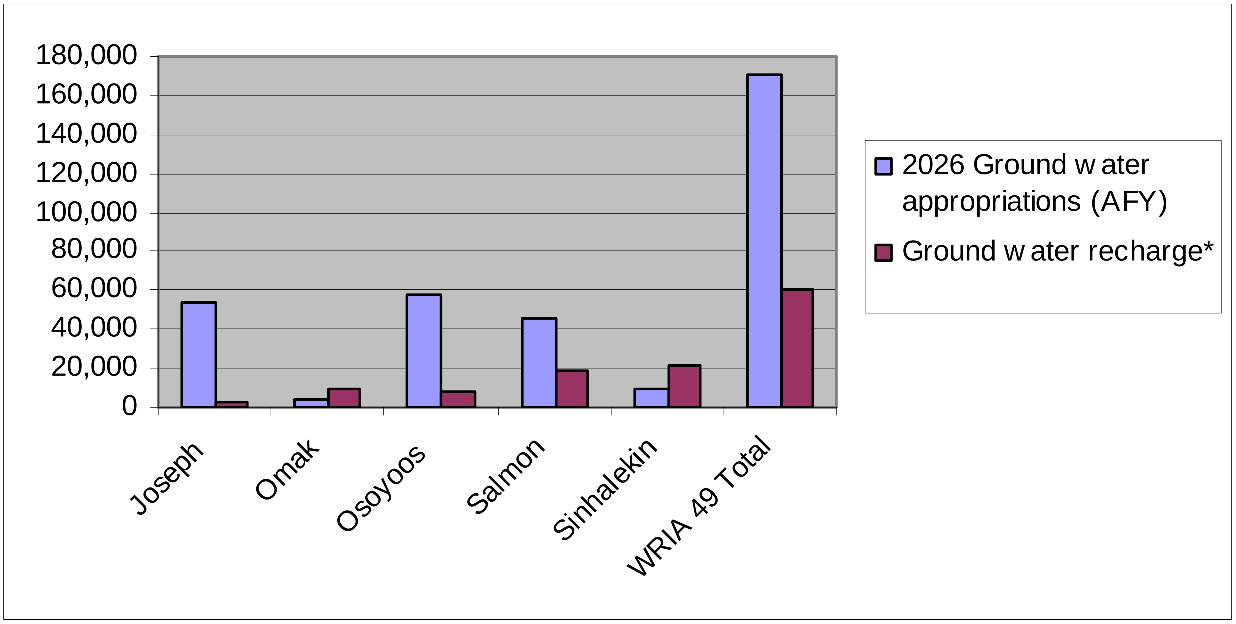
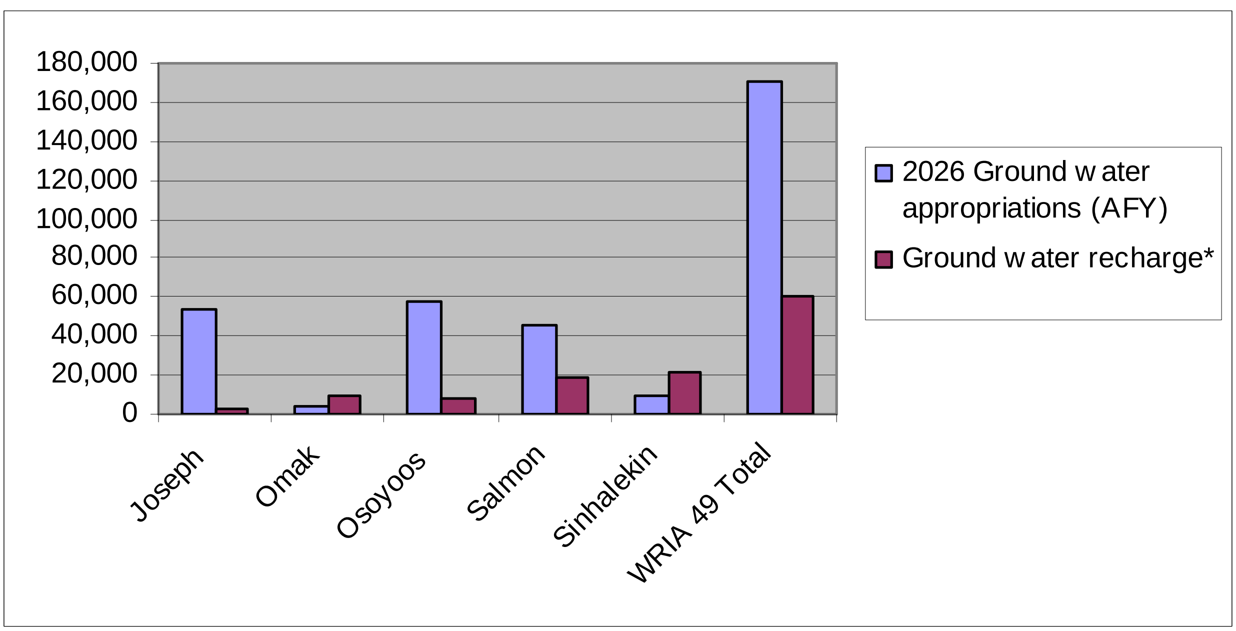


Figure 3.5-16: 2026 Appropriation of Surface Water (AYF)



Since we have data on the relative proportions of surface and ground water that is appropriated but we do not have data on the relative proportions of surface and ground water actually used, appropriations are used as a surrogate for projecting future growth even though it is not at all likely that Ecology would continue issuing new permits and certificates at a rate that matches growth. However, using the rough approximation of 50 percent of water rights put to use, and considering the role of the Okanogan River, it appears that overuse may not be of concern in the next 20 years for the larger subbasins. Again, individual streams and aquifers may be overused. Level 2 work which could address these might include:

- identifying “unnamed streams” in the water rights database
- refining net runoff and ground water recharge estimates
- better delineating aquifers
- obtaining flow measurements for streams of concern
- investigating actual use of some large water rights on small streams
- checking individual water rights on small streams for seasonal limitations
- determining actual water use for specific streams and aquifers of concern

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Chapter 4.0: Water Storage Assessment

This section summarizes existing information regarding water storage opportunities in the Okanogan Basin. Existing documents (see bibliography in Appendix F) were searched for information characterizing any known water storage opportunities and the larger Group A water systems and irrigation districts were contacted to ascertain any plans, studies, or anecdotal information regarding water storage in the WRIA.

Existing information on WRIA 49 water storage potential is available from the Salmon Creek Phase I Study and from studies of projects on the Similkameen River by the Okanogan PUD. These provide good sources of information for surface water storage potential on the Salmon Creek and Similkameen River drainages, and a fair evaluation of ground water storage potential in the Salmon Subbasin. No storage information was found for the Omak, Osoyoos, or Joseph basins.

Additional information on water storage opportunities has been requested through the offices of Senator Morton, who has been a leading figure in the Legislature following up on the State water storage program, and from irrigation districts that may have investigated individual storage sites. This information has not been received in time for the Level 1 Report.

4.1 SALMON CREEK BASIN

Figure 4.1-1 indicates the location of several potential surface and ground water storage sites investigated for the Salmon Creek Phase I Study. Data collected for these sites is provided in Appendix C-1. Table 4-1 (taken from the Salmon Creek Phase I Study, Table ES-2), provides a summary of the storage opportunities, timing and amount of water potentially available, cost and timeframe of development, engineering feasibility, regulatory requirements, and environmental impacts and benefits. This summary provided a “fatal flaw” level screening, and could be considered as a prototype or template for Level 2 work on other potential storage opportunities in WRIA 49.

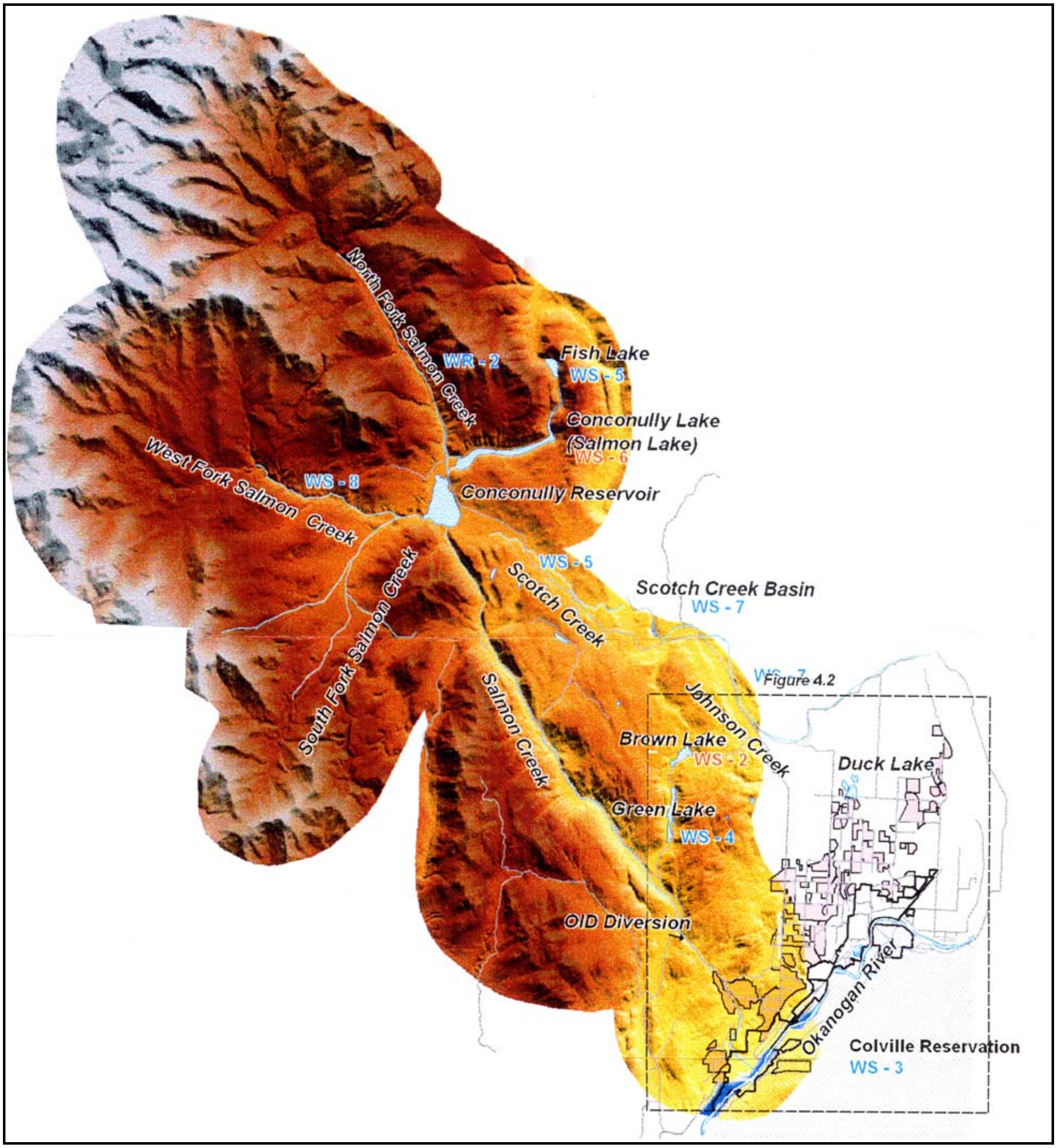
Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) in the Salmon Basin was considered capable of providing approximately 5,100 acre-feet (AF) of storage with a firm yield of 800 acre-feet per year (AFY). In 1999, ASR was roughly estimated to cost $2.5 M to develop and $40,000 per year to operate.

Brown Lake

At Brown Lake, about 10,000 AF was available, with a firm yield of 1,300 AFY at a cost if $8 M. A high dam at Salmon Lake was considered capable of providing up to 990 AF, with a firm yield of 200 AFY, at a cost of $2.1 M.

Figure 4.1-1: Potential Surface and Groundwater Storage Sites Investigated for the Salmon Creek Phase I Study



Infeasible Water Storage Sites

Storage at Green Lake was investigated, but the 5,000 AF site considered infeasible due to impacts. No storage sites were identified in the West Fork of Salmon Creek, and no water was available to serve storage at Scotch Creek, Johnson Creek, or Fish Lake.

Scotch Basin offered an attractive 10,000 AF storage site, but was considered infeasible under the constraints used by the Joint Committee (Colville Tribes and OID), due to its impacts. In addition, the Joint Committee ruled out the site in consideration of the fact the area is owned by WDFW and is designated for wildlife and other environmental purposes.

Irrigation Reregulating Reservoir

The Okanogan Irrigation District also considered a small (100 AF) reregulating reservoir as part of the Salmon Creek Project, but it was ultimately considered infeasible due to cost.

4.2 SIMILKAMEEN RIVER

Enloe Dam

A grant application to investigate flashboard storage at Enloe Dam was submitted to the Washington Department of Ecology in December 2005, and was endorsed for study by the WRIA 49 Planning Unit. The flashboards would have provided 280 to 350 AF firm yield (cost unquantified) and would have supplied water to the City of Oroville. The application was not funded by Ecology; the reason given was that the Planning Unit had not completed its Watershed Plan.

Palmer Lake

OTID conducted a study of potential storage at Palmer Lake in 1990 under the Small Reclamation Projects Act (CH2M Hill 1990) (Appendix C-2.1).[4] Palmer Lake is a natural water body located approximately two miles south of the confluence of Palmer Creek and the Similkameen River. The lake floods during spring runoff, raising the level of the lake an average of 12 feet to an elevation of 1156 feet. During the severe flood of 1972, the lake reached an elevation of 1165 feet. Average late summer minimum pool elevation is 1144 feet. A 1955 Plan of Development issued by the International Columbia River Engineering Board considered a low earth-fill dam raising the level of the lake by 15 feet and providing 30,000 AF of storage (Appendix C-2.2). A 1972 evaluation by Ecology concluded that the same amount of storage could be obtained by raising the lake 12 feet, using an 18-foot dike. Ecology found that a 30-foot dike would have protected against the 46,500 cfs floodstage reached in 1972 on the Similkameen (Appendix C-2.2).

[4] CH2M Hill. 1990. Palmer Lake Environmental Assessment. Prepared for Oroville-Tonasket Irrigation District under Small Relcamation Projects Act (Public Law 84-984).

OTID's predecessor, West Okanogan Valley Irrigation District, obtained in 1919 the right to store up to 10,500 AF of flood water in Palmer Lake. OTID proposed to construct a concrete control structure adjacent to Chopaka Road bridge over Palmer Creek, about one mile north of the lake. The control structure would have consisted of two 15-foot wide steel gates between two earthfill embankments. The gates would maintain the lake at an elevation of 1149 feet to achieve 10,500 AF of water storage. The project would have been operated to release flows from July through October for irrigation purposes. Storage would expand the lake surface by 180 acres (from 2,020 to 2,200 acres). Natural flooding normally inundates up to 530 peripheral acres around the lake, including the acreage that would be dedicated to water storage under this project. CH2M Hill (1990) reported that the project would have very little impact. No costs were included in the CH2M Hill report.

Shanker's Bend

A large volume of storage is potentially available upstream of Enloe on the Similkameen River, at Shanker's Bend. Excerpts from detailed studies and announcements regarding potential projects at this site are provided in Appendix C-2.2. Storage at this site was first studied 1948,[5] in a study of major storage and hydro projects on the Columbia River and its tributaries issued by the U.S. Army Corps of Engineers. This Similkameen River site is the last of the large feasible storage projects that remains unrealized; the others have all been constructed.

The 1948 Corps design would have backed water about 10 miles into Canada, almost to Cawston. The design featured either an earth-fill or a rock-fill dam with a top elevation of 1304 feet and a pool elevation of 1289 feet. As designed, the dam was 260 feet high and had a top length of 1200 feet. The existing railroad tunnel (on the west bank, now abandoned and considered for a Nighthawk to Oroville recreational trail), would have been employed as a power tunnel (conveying water to the powerhouse located at the PUD's then-active Enloe generating station). Further details are given in Appendix C-2.2. Costs estimates by the Corps at the time ($37 million) are obsolete and would need to be redone.

The project was designed to provide both flood control and hydroelectric generation. With 245 feet of head and 1.3 M acre-feet of usable storage capacity for power generation, the project was capable of producing up to 84 MW of power.

The project's flood control storage would be somewhat larger, with 1.6 M acre-feet of usable storage available. The Corps estimated in 1972 that about 367,000 AF of storage would be needed to control a 100 year flood on the Okanogan; Appendix C-2.2. Washington Department of Ecology published an Okanogan Basin Initial Statement in 1972 which reviewed the Shanker's Bend high dam option and concluded that it would have been capable of controlling the severe 1972 flood to well below the non-damage level of 17,000 cfs at Tonasket. Ecology also found that the project "would provide

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5 U.S. Army Corps of Engineers. 1948. Review Report on the Columbia River and Tributaries. H.D. 531-81-2 Vol. III.

ample water (minimum flow of 1,000 cfs) to mitigate thermal blocks for anadrmous fish in the lower Okanogan, to dilute effluent from sewage treatment plants, and to cover spawning areas).

In 1955, the same project was included in a Plan of Development issued by the International Columbia River Engineering Board. The Plan of Development also included a low dam at Shanker's Bend, with a pool elevation of 1175 feet, usable storage of 162,000 AF, and a generating capacity of 11 MW. This would have required a 160-foot high dam with a crest length of 800 feet, and would not have backed water into Canada. It would have provided a smaller flood hazard management benefit, not capable of controlling the 1972 flood.

The 1955 Plan of Development also included brief descriptions of projects at Nighthawk, and in Canada at many other locations in the Similkameen Basin. Preliminary information for the Nighthawk site suggested a dam ranging in height from 30 to 45 feet (elevation ranging from 1155 to 1170 feet), with associated storage of 31,900 to 106,000 AF. This design would not have backed water into Canada and would not generate power.

In 1972, the Corps published a brochure depicting the high and low Shanker's Bend storage alternatives with substantially the same design information as was developed in 1948. In 1975, Governor Evans wrote to Secretary of State Kissinger to request the assistance of the International Joint Commission in resolving water resource management problems of the Okanogan-Similkameen river basins. The letter cited the Corps and others studies of basin potential and addressed the need for international cooperation to determine the best solution and recommend implementation. Evans addressed two major areas: (1) Osoyoos Lake levels and inflows, and (2) potential multiple use projects on the Similkameen River, including the proposed high and low dams at Shanker's Bend. Evans noted that aspects of both project were (at that time) unacceptable to one or both parties, and proposed terms of reference to the International Joint Commission to include benefits on both sides of the water of: flood control, irrigation, power generation, fisheries, and water based recreation. In today's environment, water supply benefits would have to be added to that list. Evans noted that there would need to be allocation of flow interests in and to the waters of the basin; clear recommendations on the sharing of the costs and benefits of storage; and clear disposition of the inundated lands.

The Okanogan PUD is currently considering applying for funding recently allocated by the Washington State Legislature to perform water storage feasibility studies. The scope would be to reevaluate all previously considered projects and new alternatives to determine the optimal size of a water storage project. The PUD obtained a Preliminary Permit in 1983 for a 90' dam at Shanker's Bend that would have backed water to the confluence of the Similkameen River and Palmer Creek. It would not have flooded Nighthawk, but the shoreline would have been quite close.

Impacts of a high dam at Shanker's Bend identified by the Corps included relocation of 16 miles of road; the location of a mine adit (a horizontal mine entry) at Nighthawk that would be below the proposed pool level; and inundation of 18,000 acres of agricultural lands, rural homesites (including properties around Palmer Lake and at Nighthawk), and tribal lands. Inundation effects would be felt on both sides of the border.

The benefits of a large storage project at Shanker's Bend could be regional. As described in the Summary of Concerns section opening this report, the Okanagan region of southern B.C. is one of the Province's most densely populated regions and has one of the fastest population growth rates in Canada. Growth is leading to concerns on both sides of the border about the future availability of water and the situation appears to be ripe for collaborative development of future water supplies. To the south, inquiries regarding the availability of Okanogan water have been made by representatives from Washington's Tri-Cities.

In addition to its potential water supply benefits, a large storage project on the Similkameen upstream of Enloe Dam also could provide regional fisheries and water quality benefits by providing flows that cool the Okanogan River and benefit anadromous fish well downstream, and potentially by diverting smaller flows to local streams that could provide or improve resident and anadromous fish spawning and rearing habitat (pers. comm. Perry Harvester, WDFW, January 6, 2006).

Potential agricultural benefits cited by the Corps in 1948 included the potential rehabilitation of irrigation projects undertaken by Whitestone Reclamation District that had been adandoned due to insufficient water supply from Sinlahekin and Toats Coulee Creeks.

As noted, the project would be large enough to provide flood control benefits, capable of controlling the 100 year flood on the Okanogan and reducing floods to below damage levels, particularly to the City of Oroville and downstream to Tonasket.

Finally, potential hydroelectric generation at Shanker's Bend could provide substantial regional economic benefits to local ratepayers and potential development partners. These economic benefits were estimated to be so large as to be capable of more than offsetting the costs and compensation related to inundation of lands by the reservoir.

Chapter 5.0: Water Quality Assessment

In this section we summarize water quality conditions observed in the mainstem Okanogan River and its tributaries based on a review of the available water quality data obtained from the CCT, the OCD ,and the Washington State Department of Ecology (Ecology). The summary provided here is truncated from Appendix B-1, where the data are explored in greater depth and discussed relative to objectives outlined in the Data collected by the OCD were in response to recommendations first identified in the Okanogan County Water Quality Management Plan (OCD 1999, *revised* 2005). The initial plan itself does not present data, but an outline for data needs. Figure 5-1-1 identifies the water quality and flow monitoring stations throughout the Okanogan watershed where data have been collected, and the approximate periods of record covered by each monitoring program. Some of the stations identified are historic only. The Excel data files from each of the sources are provided in Appendix B. Specifically, Appendix B-2 contains the data files from the CCT, B-3 contains the data files from the OCD and B-4 the files from Ecoogy. A full listing of all the appended data files the data files found within Appendix B is provided in the Table of Contents.

A screening level analysis was conducted to evaluate water quality conditions relative to existing Class A and Class AA water quality numeric criteria recognized in the State of Washington (Tables 5-1 and 5-2, see also Appendix B-1). Class A criteria apply throughout the Okanogan watershed, including the mainstem and tributaries. As demonstrated in Tables 5-1 and 5-2, Class AA criteria are slightly more stringent for some water quality parameters, but are not legally applicable to the Okanogan watershed. Notwithstanding, for this report monitoring results were compared to both of these standards, as it was thought equally important to identify when water quality conditions met the highest AA standards recognized by the state, as well as those waters that regularly or periodically failed to meet Class A standards. A more detailed description of the methods used to evaluate water quality in the Okanogan basin is provided electronically in Appendix B-1 of this report. Appendix B-1 also describes the relevancy of each parameter monitored, the specific monitoring programs overseen by the CCT, OCD, and Ecology, and detailed results and graphics by parameter. However, for many of these programs, flow was also a parameter measured, and summary tables of the flow data sources are found in Chapter 2 (Attachment 3, printed with this main report provides a brief condensed tabulated description of some of the water quality parameters, their relevancy, and what has been considered “properly functioning conditions” of the parameters for salmonid fishes).

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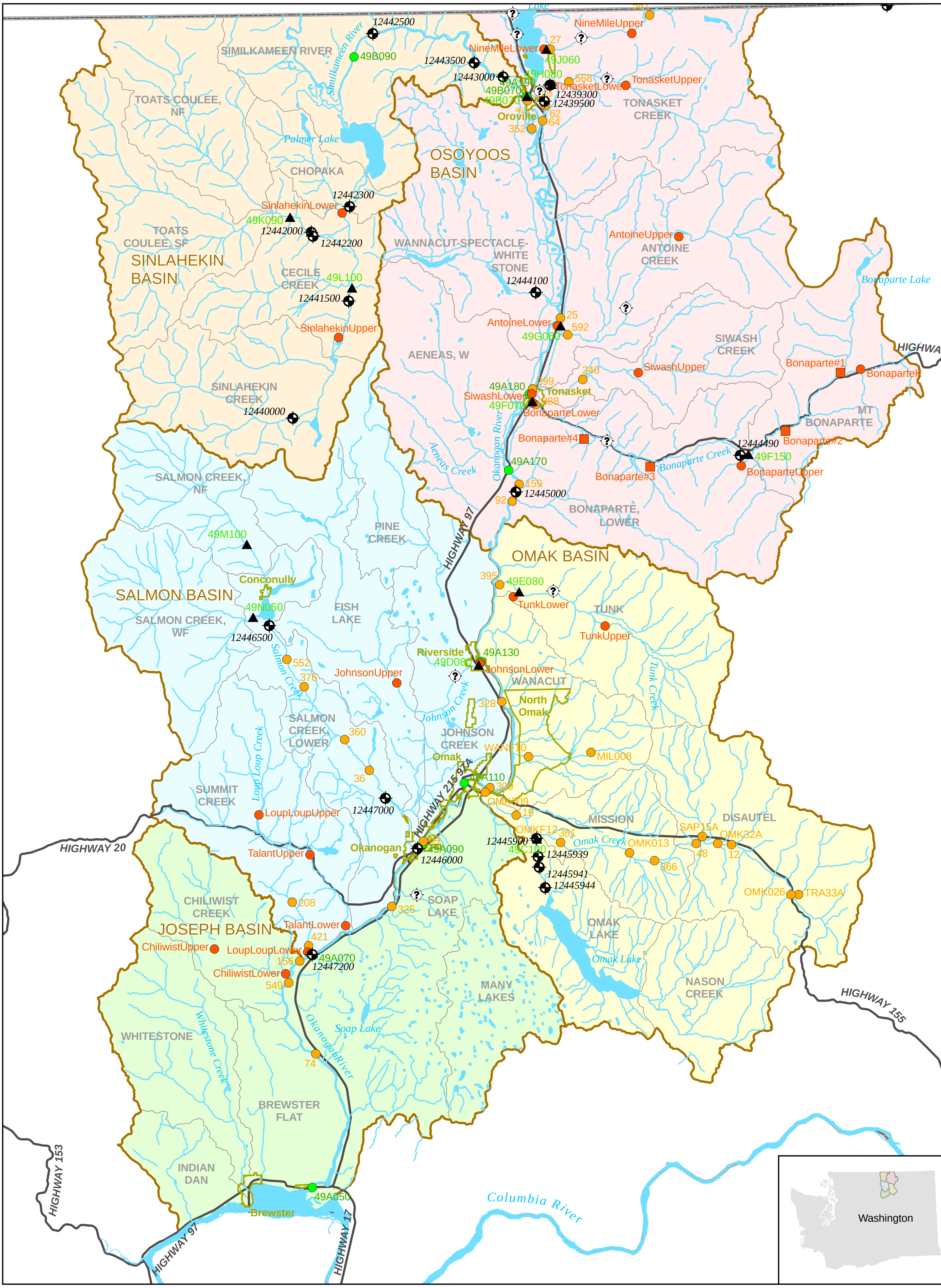
WRIA 49 Stream Monitoring Locations



Okanogan County	
City Boundary	
Stream	
Lake/Reservoir	
Highway	
Basin Boundary	
WAU Boundary	

Monitoring Stations

- Fecal (Okanogan Conservation District)
- Water Quality (Okanogan Conservation District)
- Water Quality (Colville Tribe)
- Water Quality (WA DOE)

Stream Flow Gages

- Stream Flow (WA DOE)
- USGS Stream Gage
- Stream Flow Gage (Location uncertain)

2 1 0 2 4 Miles

Stateplane 4601 NAD27 Feet

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Table 5.1-1: Washington State Water Quality Standards for Conventional Parameters

PARAMETER	AA STANDARD	A STANDARD
Temperature	Must not exceed 16.0 C[1]	Must not exceed 18.0 C[1]
Turbidity	Not to exceed 5 NTU over background, or 10% over background of 50 NTU or more	Not to exceed 5 NTU over background, or 10% over background of 50 NTU or more
Dissolved Oxygen	Must exceed 9.5 mg/L	Must exceed 8.0 mg/L
pH	Within 6.5 – 8.5[2]	Within 6.5 – 8.5[2]
Ammonia-N	Varies with pH and temperature: Acute = 0.26 mg/L (@ 20 ^{o}C, 8.0 $\leq$ pH $\leq$ 9.0) Chronic = 0.04 (@ 15 ^{o}C, 7.7 $\leq$ pH $\leq$ 9.0)	Varies with pH and temperature
Fecal Coliform	Not to exceed geometric mean of 50 col./100 ml, less than 10% of all samples exceeding 100 col./100 ml	Not to exceed geometric mean of 100 col./100 ml, less than 10% of all samples exceeding 200 col./100 ml

[1] Human activities shall not result in more than a 3.0oC increase when water temperatures naturally exceed this maximum criterion. Incremental temperature increase resulting from point source activities shall not exceed t=28/(T=7) where T=background temperature; maximum incremental increase for nonpoint sources is 2.8 C.

[2] Human caused variation must be + / – 0.2 pH units (Class AA) and +/- 0.5 (Class A).

[3] Does not apply when stream flow exceeds the 7-day, ten-year frequency flood.

Table 5.1-2: Washington State Water Quality Standards for Metals (micrograms/L)

PARAMETER	ACUTE	CHRONIC
Arsenic	360.0	190.0
Cadmium[1]	3.5	0.311
Chromium (hexavalent)	15	11
Copper[1]	17.0	11.4
Lead[1]	64.6	2.5
Mercury	2.1	0.012
Selenium	20.0	5.0
Silver[1]	3.45	NA
Zinc[1]	100.4	93.0

[1]. Numeric standards listed are based on an assumed hardness of 100 mg/L as calcium carbonate. Section 3 metals analysis used site specific hardness concentrations in determination of compliance with water quality standards as presented in WAC 173-201A-04[0.]

The following text summarizes the principal findings, relative to existing criteria, for conventional water quality parameters (e.g., temperature, dissolved oxygen, pH, turbidity), metals, and organic pollutants (e.g., DDT, PCBs). More sophisticated modeling would be required to characterize how changes in land use practices might yield measurable changes to these water quality parameters in the surface waters of the Okanogan Basin, and how parameter results may vary[6] (e.g., relationship between dissolved oxygen and temperature). Modeling using such tools as AquaTox® or multivariate regression can be used to better understand how the watershed would respond to the implementation of management actions. Such applications could be considered by the Planning Unit for the Level 2 watershed assessment.

Table 5.1-3: Washington State Water Quality Standards for Organic Pollutants Identified as Chemicals of Concern in the Okanogan Watershed

PARAMETER	ACUTE	CHRONIC
DDT1 (ug/l)	1.1a	0.001b
Polychlorinated Biphenyls (PCBs)1 (ug/L)	2.0 b	0.014 b
(108) 4,4'-DDT2 (ug/l)	0.00059	0.00059
(109) 4,4'-DDE2 (ug/l)	0.00059	0.00059
(110) 4,4'-DDD2 (ug/l)	0.00083	0.00083

[1]. Numeric criteria from WAC 173-201A-040.

[2]. Human health criteria from 40CFR131.36 (July 1, 2000), for the consumption of organisms and water.

[a] Instantaneous concentration not to be exceeded at any time.

[b] A 24-hour average not to be exceeded.

Tables 5.2-1 to 5.2-7 summarize the results of the water quality screening against existing surface water quality criteria for the Okanogan mainstem, and for the tributaries where monitoring has been conducted. The values *are not* (emphasis added) a reflection of measured concentrations — these are provided graphically in the full water quality report provided electronically as Appendix B-1, and/or in data files used to prepare that appendix (*see* appendices B-2, B-3 and B-4). Rather, they are a reflection of the percentage of samples collected that did not meet water quality standards. The inset box describes how to read and interpret these tables. The text following the inset box highlights some of the more significant findings of the parameters monitored.

5.1 TEMPERATURE

Monitoring data from all the sources reviewed (i.e., OCD. WDOE, CCT) has shown that Class A criteria are exceeded regularly in the Okanogan River mainstem and in many of the WRIA 49 streams where temperature has been monitored. Tributary contributions of cooler water appear to reduce mainstem temperatures slightly downstream of Lake Osoyoos. This is demonstrated by a lower percentage of temperature exceedances

[6] Covariance in this context refers to how a change in one water quality parameter can affect the measurement of another parameter. For example, the maximum amount of oxygen dissolved in water reduces with increasing water temperature.

recorded at Mallot. However, temperature measurements still exceed the Class A standards to a degree that concern may be warranted for sensitive aquatic life. Anecdotal information on salmonid migrations through the Okanogan suggests that salmonids are negatively impacted by the high temperatures seen in the mainstem at some times of the year (C. Fisher personal communication, CCT, 2006). For example, sockeye salmon that migrate through the U.S. portion of the Okanogan mainstem to spawn in Canadian waters, regularly stage below the Okanogan confluence when extended periods of high temperature occur in the mainstem.

Numerous tributary exceedances of Class A temperature standards were identified in multiple monitoring stations in Omak, Tunk, Salmon Creek, and Wannacut creeks, and in the lower Sinlahekin, Bonaparte, Antoine, and middle Tonasket creek monitoring stations. There are some stations and creeks, however, where temperature is not regularly noted as a problem. These tributaries currently include Chiliwist, Tallant, Johnson, Siwash and Loup Loup creeks. Some of these systems (e.g., Loup Loup) probably experience cooler temperatures due to the heavily forested nature of the watersheds. For others, more work is needed to ascertain the role of riparian shading for buffering stream temperatures. Where the proportion of warmer surface runoff to cooler ground water is low, temperatures may be reduced. Ground waters often represent the most significant contribution to baseflows during the time of year when temperatures often exceed criteria.

At some stations, the number of temperature exceedances that occurred over the monitoring period may have been underestimated. The OCD, as a condition of their approved quality assurance plan (QUAP) was required to monitor during the same period for their grab samples. Since the grab samples (i.e., not the continuous monitoring stations) were collected in the morning hours, before peak daily temperatures would occur, higher temperatures may have occurred that were not recorded.

5.2 DISSOLVED OXYGEN

Monitoring by the OCD and detected possible problems in dissolved oxygen (DO), based on the failure to meet Class A criteria on more than 10 percent of the monitoring dates, at the following stations: lower Tunk Creek, Salmon Creek, Johnson Creek, Bonaparte Creek, Antoine Creek, Tonasket Creek, and Ninemile Creek. Tables 5.-2 through 5.-7 demonstrate the relationship between systems that failed to meet the DO standards outlined in Table 5.1-1 and the recurrence of temperature exceedances for some systems. Such findings are not surprising, as water holds less dissolved oxygen saturation with increasing temperature and altitude (Fisher 2000). However, this finding cannot be assumed to be the cause for all the tributary systems that repeatedly failed to meet Class A DO standards. For example, Bonaparte and Salmon Creeks exhibited extreme deficits in DO (Table 5.2-6), but these deficits were not always associated with temperature problems (at least, not at every station). In Bonaparte Creek, it is possible that the DO problems identified (e.g., at the uppermost station K1) are at least partially contributed by high biological oxygen demand (BOD), as evidenced from the high fecal coliform counts measured in that system. At other stations (middle Siwash), further research is needed. Considering that 65 percent of the records fail to meet DO criteria (Table 5.2-6), BOD may be contributing to oxygen deficits where monitoring results have not indicated there is a problem with temperature exceedances. In still other cases, fecal coliform is recorded as a regular problem, yet DO criteria are generally met (e.g., Sinlahekin Creek).

Regardless of the cause, the extensive number of tributary systems that fail to meet Class A DO criteria could be problematic for aquatic life and the restoration of salmonid populations in some tributaries, as outlined in other planning documents (ENTRIX and Golder 2001, NWPPC 2004). Of all the conventional parameters monitored, deficits in oxygen will have the most severely limiting effect on the functionality of aquatic systems to support aquatic life.

5.3 pH

The pH of the Okanogan basin’s tributaries appears almost uniformly high (well above neutral readings of 7), and slightly elevated in the mainstem. Clearly, the alkaline pH recorded throughout the basin is primarily reflective of natural conditions, but in some systems the alkaline pH readings are particularly high (e.g., Tunk Creek monitoring stations, lower Tallant monitoring station). Data reviewed suggest a fairly consistent increase in pH lower in the tributary subbasins (i.e., where multiple monitoring stations allow for such comparisons). In the mainstem, pH criteria were exceeded in no more than 10 percent of the samples collected, suggesting that some of the alkalinity is quenched by the higher water flows and/or organic matter in the mainstem – as compared to the tributary systems.

The relationship between pH and water allocations and use requires further exploration. Although the pH values are generally alkaline throughout the basin, the pH of the basin’s waters do not exceed physiological limitations for most fish species (Fisher 2000). A longer period of record is required to tell if there has been a progressive increase in pH in the Okanogan’s tributary systems that may suggest causes related to land use or other climatic factors. It is possible that repeated land disturbance that increases sediment run-off, coupled with an increase in dewatering and/or evaporation rates, could potentially increase salt and/or carbonate concentrations in the remaining surface waters, but such explanations are inherently speculative at this point. The biological significance of such increases, should they be occurring, cannot be deduced from the existing data.

5.4 TURBIDITY

Generally, turbidity increases with total suspended solid (TSS) loads and is an optical measure of light penetration or light refraction, depending on the method of measurement. Factors that contribute to TSS include suspended sediment, suspended organic matter, and dissolved organic matter (e.g., tannic acids from decaying leaves). The precise relationship between turbidity and TSS is generally basin specific, and depends on the source geology and organic matter in a system. Turbidity is generally measured as a measure of light reflection (nephelometric turbidity units), or light penetration (jackson turbidity units — JTUs). In the Okanogan basin, turbidity regularly exceeds 50 nephelometric turbidity units (NTUs) in the mainstem and in a variety of tributaries. As an inverse measure of light penetration (i.e., the NTU number increases with decreasing light penetration/increasing light reflection), NTU's generally increase with an increase in sedimentation in a system. The relevancy of the parameter is explained in Appendix B-1, but in brief, a 50 NTU measurement might be of the color of a cup coffee with cream.

Because turbidity can be caused by both inorganic and organic particles suspended in the water column, and because it varies with basin geology, a direct reflection of the relevancy of the parameter to factors such as aquatic life tend to be basin specific. In general, the impact of turbidity on aquatic life generally depends on the duration and frequency of events where it is measurable above background levels. However, no basin-wide background turbidity has been established in the Okanogan river, so the exceedance rate summaries identified in Tables 5.-1 to 5.-7 should be considered qualitative and preliminary. Notwithstanding, Omak Creek and Tunk Creek appear to have excessive sediment recruitment to cause turbidity. This finding was previously thought likely due to high road density within these watersheds and/or improper maintenance of them (ENTRIX and Golder 2001). Without a site-specific analysis of turbidity effects on biological resources in the basin, identifying additional systems that may be affected is speculative. Establishing the relationship between TSS and turbidity for a "model system" within the watershed (e.g., Omak or Bonaparte Creek) could provide data to develop a relationship further that could be applied to many other tributaries in the Okanogan basin with similar geology. This could yield a powerful tool by which to predict sedimentation loads entering the mainstem Okanogan from simple turbidity measurements.

5.5 NUTRIENTS AND FECAL COLIFORM

Excessive contributions of nutrients – ammonia, nitrite nitrate, soluble reactive phosphorous and total phosphorous – ha the potential to degrade baseline water quality. Ammonia is a nitrogen-based waste product from humans and animals, and is often contained in high concentrations in fertilizers. It can be highly toxic to aquatic life at low parts per million concentrations. Ammonia is oxidized (broken down) to nitrite, and subsequently to nitrate by bacterial populations naturally present in all water bodies. Ammonia chemistry and toxicity is explained further in Appendix B-1.

Both nitrates and phosphates are readily used by plants, and when present in excess can lead to unwanted blooms of algae and/or other aquatic plant life. Such "eutrophication" processes may reduce the ability of waters to support the beneficial uses that are recognized (as narrative standards) in Washington's water quality criteria.

An example of such a "narrative standard" would be "salmonid spawning and rearing". Nutrient loading may reflect human and/or animal waste input into a system. This can be measured by fecal coliform counts, as explained in detail in Attachment 5. The principal findings from monitoring of both of these water quality elements are discussed in this section.

5.5.1 Okanogan Mainstem

In the Okanogan mainstem, ammonia-nitrogen concentrations were detected at all three mainstem sampling stations (Figure 5.1-1), but were lower than the detection limit in more than half of the samples. The range of observed values for this parameter was relatively similar at all stations, although the Oroville and Malott stations were observed to have slightly higher concentrations than the Similkameen station. The median nitrate-nitrite-nitrogen concentration at Malott was 0.21 mg/L while median values at the other stations were recorded at the detection limit. The maximum concentration observed at the Oroville station equaled 2.5 mg/L and was an order of magnitude higher than the maximum concentration observed at the Similkameen station (0.149 mg/L) and the Malott station (0.23 mg/L).

Median soluble reactive phosphorous concentrations at the Similkameen River station (0.0034 mg/L) were slightly above the detection limit while concentrations at the Malott station (0.00465 mg/L) were higher yet. Further, the range of soluble reactive phosphorous concentrations at the Malott station, in comparison to the other stations, were higher. For samples collected at the Oroville station, more than 50 percent contained concentrations of soluble reactive phosphorous lower than the detection limit. One possible explanation for these noticeably lower concentrations is that soluble reactive phosphorous becomes "fixed" by primary production in Lake Osoyoos.

In contrast to the results for soluble reactive phosphorous measured in the mainstem, the range of total phosphorous values at the Oroville station were similar to those observed at the Similkameen station and, in fact, median values were higher suggesting that phosphorous is present in the system, but perhaps, not biologically available. Median total phosphorous concentrations at the Malott station were double those observed at the Similkameen station.

Fecal coliform samples rarely exceeded numeric criteria at the Similkameen River (AA = 8, A = 3, n = 322) and Okanogan River at Oroville (AA = 3, A = 1, n = 306) stations. Exceedances at the Malott station were of a greater magnitude and were more frequent than at the other mainstem monitoring stations (AA = 56 percent, A = 18 percent, n = 290). Patterns of abundance are further detailed in the box plot charts provided in Appendix B-1, with counts at the Malott station greatly exceeding those observed at the other stations regardless of season (see Appendix B-1, Figure 5.1-7). All of the stations exhibited seasonal trends, with counts generally higher between May and October and lower between November and February. However, some comparatively high values were observed at the Malott station in February, although the median values were consistent with prevailing seasonal patterns. The seasonal pattern of fecal coliform identified in the mainstem may reflect greater direct contact with the water by livestock and wildlife during the late spring to early fall months.

5.5.2 Tributary Findings

Nutrient data of adequate quality for interpretation were identified only from Tunk, Sinlahekin, and Bonaparte creeks. Sampling conducted in Omak creek for ammonia following two spills of fire retardant in 2002 and 2003 was not relevant to the baseline data collected from these other systems and was not reviewed for watershed assessment purposes. The principal findings from these sampling events, detailed completely in Appendix B-1, are as follows:

- Fecal coliform was sampled twice in Omak Creek at stations OMK009 and OMK013 and three times at OMKF12 and OMK32A in 2005. None of these samples exceeded numeric water quality criteria. Further sampling is ongoing by the CCT.
- Fecal coliform samples collected at lower and upper Tunk Creek locations exceeded Class AA numeric criteria on 20 occasions and Class A criteria on thirteen occasions. These exceedances correlate with exceedances of ammonia detected in this tributary at both the upper (n = 5) and lower (n = 4) sampling stations.
- A persistent and significant problem with fecal coliform is present in Bonaparte Creek (Table 5.2-6). For example, between 2000 and 2003, 50 percent and 33 percent of 36 samples from lower Bonaparte Creek exceeded Class AA and A criteria, respectively. At the Upper Bonaparte station, Class AA numeric criteria were exceeded in sixteen samples and Class A criteria in eight samples (n = 33). Additional samples were collected at station numbers one through five between 2002 and 2003. The proportion of samples that exceeded criteria generally (not always) increased downstream. At station #5 12 of 13 samples exceeded Class AA criteria and 8 of those samples exceeded Class A criteria.
- As might be expected from the frequent fecal criteria exceedances, the nutrient contributions in Bonaparte Creek also exceeded water quality criteria. Observed ammonia-nitrogen concentrations at the Upper Bonaparte K sampling location exceeded acute (n = 4) and chronic criteria (n =18). Fewer exceedances were observed at the Upper Bonaparte station with two classified as acute and eight as chronic. Only the chronic criteria were exceeded at the Lower Bonaparte station (n = 6).
- As demonstrated in Table 5.2-7, fecal coliform samples collected at the lower Sinlahekin Creek monitoring station exceeded Class AA numeric criteria on 78 percent, and 56 percent of the sampling events, respectively (i.e., n = 28, n = 20). Fewer exceedences were observed in samples collected in the upper reach, but the rates of exceedance were still significant; Class AA criteria were violated seven times (19 percent) and Class A criteria four times (11

percent). Similar to Bonaparte Creek, there appears to be a correlation between the high rates of fecal coliform exceedance, and nutrient contributions. Observed ammonia-nitrogen concentrations in lower Sinlahekin Creek exceeded acute and chronic toxicity standards on two and 14 occasions, respectively.

Information regarding nutrient contributions throughout the basin is localized to a few select basins. Results from these basins each demonstrate potentially significant problems with fecal coliform and/or nutrient contributions that may or may not be related. Given that problems have been identified in each basin where these parameters have been investigated, an expansion of nutrient analysis should be considered in other basins.

5.6 METALS

5.6.1 Mainstem and Similkameen Findings

Ecology surveyed metals concentrations in the Similkameen River at four locations in August 1995 and April 1996. Sampled constituents included iron, aluminum, and manganese (Johnson 1997). Key findings from this study include:

- Metals concentrations were highest during spring floods;
- "All metals concentrations were within EPA criteria for protection of aquatic life criteria and within state drinking water standards;"
- "Copper (0.51 – 2.6 ug/L), arsenic (2.0 – 7.0 ug/L), and mercury (<0.001 – 0.006 ug/L) were the predominant metals of interest in the water column;"
- EPA human health National Toxics Rule criteria for arsenic (consumption of fish = 0.14 ug/L; consumption of fish and water 0.018 ug/L) were exceeded; and
- Previous USGS studies analyzed samples for chlorinated pesticides and PCBs but did not detect significant concentrations.

Ecology conducted a field study to determine if small-scale gold dredging operations in the Similkameen River increase ambient concentrations of arsenic, copper, lead, zinc, turbidity, and total suspended solids (TSS) (Johnson and Peterschmidt 2005). Dredge effluent was analyzed at 14 locations between Nighthawk and Oroville and discharge plumes were sampled immediately below three dredges. Key findings from this study include:

- Arsenic, copper, zinc and lead concentrations in dredge effluents were higher than ambient river concentrations;
- Turbidity, total suspended solids, zinc, and arsenic concentrations were highest in within 10 feet of dredging operations and declined to levels approaching those measured outside the immediate influence of dredging (i.e., background).

- Copper concentrations in the dredge effluent occasionally exceeded acute and chronic water quality standards and lead concentrations occasionally exceeded chronic criteria. Arsenic and zinc concentrations in the effluent did not exceed either acute or chronic criteria; and
- Plume concentrations were below acute and chronic standards.

Ecology recently analyzed metals concentrations in the Okanogan River at the Malott monitoring station six times between October 4, 2004 and August 1, 2005. Their findings can be summarized as follows:

- None of the observed concentrations, for any parameter, exceeded water quality standards.
- Silver concentrations were always below the detection limit and cadmium, mercury, and lead were detected infrequently and at concentrations only slightly greater than the detection limit.
- Arsenic, chromium, copper, and zinc were generally present at measurable concentrations, but were still substantially lower than Class A or AA surface water quality criteria.

5.6.2 Recent Findings from Tributary Sampling Conducted by the OCD

The Okanogan Conservation District collected grab samples from four systems between 2000 and 2003. With the exception of Tunk Creek, where copper and lead were detected above metals criteria, there were no other exceedances of metals criteria in the tributaries monitored by the OCD. Table 5.2-1 summarizes the nominal metals values (the dissolved metals concentrations) recorded from the OCD's efforts between 2000 and 2003. Table 5.2-4 reflects the percent exceedances found in Tunk Creek. However, it is recognized that the database for analysis is limited — only three tributaries and the mainstem Okanogan River were monitored for metals. Indeed, in the monitoring conducted (Table 5.2-1), only one other system monitored had detectable dissolved metals (Bonaparte Creek). Arsenic, technically a "metalloid", was repeatedly detected in Sinlahekin Creek, near the detection limit of the analytical method; it was not detected in the mainstem in the OCD monitoring program.

Collectively, the results of the metals sampling conducted by Ecology and the OCD do not suggest there are basin-wide issues with metal contamination. Issues may exist within some tributary basins from localized land use practices (e.g., dredge mining, etc.) that could be addressed through changes in management practices, but these do not, with the present information available, appear to be significant at the watershed scale. The alkaline conditions of the waters within the basin help to buffer the potential toxicity of metals, but given that in the systems monitored there have been few detections, this buffering capacity is essentially moot. The source of copper and lead contributions to Tunk Creek may be natural, or have anthropogenic causes. The data base evaluated does not provide adequate information to identify source contributions for this Level 1 analysis. Nor are the data comprehensive enough to characterize metals contributions throughout the basin. The biological significance of localized actions that may mobilize metals to concentrations above water quality criteria remains a data gap.

5.7 ORGANIC POLLUTANTS

DDT and related compounds (DDE, DDD, etc.,) and PCBs appear to persist in low but detectable levels in some isolated areas, but current evidence does not suggest these persistent organic pollutants, for which TMDL studies have been conducted, are a problem basin-wide. The following discussion highlights the principal findings of authors that have overseen the most recent studies of organic pollution within the Okanogan Basin.

5.7.1 Mainstem and Similkameen Findings

Previous USGS studies analyzed samples for chlorinated pesticides and PCBs but did not detect significant concentrations. More recent information on the presence of persistent bioaccumulative toxins in the Okanogan Basin was recently presented in Serdar (2003) and Peterschmidt (2004). Specifically, DDT and PCB concentrations were examined in the Okanogan River and tributaries, in Osoyoos Lake, and in sewage treatment plant effluent and sludge, sediment in cores of bottom sediment, and in fish tissues were examined between 2001 and 2002. Key findings from the mainstem and Similkamen sampling include:

- 4,4'-DDE, 4,4'-DDD, and t-DDT were detected at sampling stations near Zosel Dam, at Riverside, and Malott. Observed concentrations were lower than lower than those specified for human health and aquatic life and therefore these waterbodies complied with applicable standards.
- 4,4'-DDT and PCBs were not detected in the water column in May, 2002. The PCB detection limit (0.64-0.66 ng/L) was lower than the NTR threshold.
- None of the DDT compounds were detected in the Similkameen River during May, 2002 sampling event.
- 4,4'-DDE, 4,4'-DDT, and t-DDT were detected in the Oroville STP effluent. Constituents detected in the Okanogan STP effluent included 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, t-DDT, and PCBs. A small number of samples at both plants exceeded human health standards. None of the DDT or PCB derivatives were detected in the Omak STP effluent. Overall, the transfer of these pollutants to the environment from the STPs (loading) was low. These pollutants were detected in the wastewater treatment sludge at all three STPs.
- Loading from the source tributaries and Osoyoos Lake are "low".
- In general, DDT concentrations in fish tissue appear to be declining from 1980s and 1990s. However, concentrations of 4,4-DDE in fish tissue samples exceeded human health advisory criteria in 23 of 24 samples. PCB concentrations appear similar to previous studies, suggesting little attenuation is occuring.

- The primary source of the pollutants in fish tissue is believed to be from bottom sediments in the Okanogan River.

5.7.2 Tributary Findings

In April and/or May of 2001 Ecology sampled for the persistent bioaccumulative toxicants DDT (and its related compounds) and PCBs at one station each in Loup, Loup, Tonasket, Nine Mile, Antoine, Whitestone, Elgin, Mosquito, Siwash, Salmon, Bonaparte, Aeneas, Johnson, Chewiliken, Wanacut, and Tunk creeks (Serdar 2003). Principal findings from these tributaries are summarized as follows:

- Detected pollutants 4,4'-DDE, 4,4'-DDD, 4,4'-DDT and t-DDT exceeded human health standards (based on the consumption of organisms and water) and/or the chronic aquatic life criteria for total-DDTs (i.e., 1 part per trillion) in Elgin, Whitestone (4,4' DDE only), Tonasket, Nine Mile, Antoine, Mosquito, and Loup-Loup creeks.
- Detectable DDT forms or "moieties" (e.g., 4,4'-DDE and t-DDT) were measured in Bonaparte, Salmon, Siwash, and Aeneas creeks, but health standards were not exceeded.
- DDT and its metabolites were not measurable in Tunk, Wannucut, Chewiliken and Johnson Creeks
- Tallant Creek, which was placed on the 303(d) list because of 1995 samples that contained levels of DDT and/or its metabolites above chronic toxicity criteria (Johnson et al. 1997), was not sampled due to lack of flow.

INTERPRETING TABLES 5.2-1 TO 5.2-7

Tables 5.2-1 to 5.2-7 summarize the proportion of surface water samples that failed to meet the Washington State Class A or AA water quality criteria outlined above in Tables 5.1-1 to 5.1-3. The values represented in Tables 5.2-1 to 5.2-7 represent the percent of samples of the total number analyzed that exceeded (i.e., did not meet) the numeric water quality standard for that parameter. Tables 5.2-1 to 5.2-7 are separated by sub-basin and table cells are shaded lightly if between 10 and 20 percent of the samples collected did not meet the applicable water quality standard for that parameter, darkly if greater than 20 percent of the samples did not meet the standard, or not at all if less than 10 and greater than zero percent of the samples exceeded the standard. If no samples exceeded a standard, then the cell in the table would reflect that as a 0.0. If no data were collected for a specific parameter, no percentage could be calculated, and the cell was left blank. For example, Table 5.2-1 shows that 30 percent of the water samples collected from the Okanogan mainstem at Mallott failed to meet the dissolved oxygen standard for Class AA waters, but only 6 percent did not meet the legally applicable Class A standard at this station.

Table 5.2-1 Proportion of Samples Exceeding Numeric Water Quality Criteria in the Mainstem Okanogan and Similkameen Rivers*

Stream	Temperature Continuous (AA	Temperature Continuous (A)	Temperature Grab (AA)	Temperature Grab (A)	Turbidity	Dissolved Oxygen (AA)	Dissolved Oxygen (A)	pH	Fecal Coliform (AA)	Fecal Coliform (A)	Arsenic - Acute	Arsenic - Chronic	Cadmium - Acute	Cadmium - Chronic	Chromium - Acute	Chromium - Chronic	Copper - Acute	Copper - Chronic	Lead - Acute	Lead - Chronic	Mercury - Acute	Mercury - Chronic	Selenium - Acute	Selenium - Chronic	Silver - Acute	Zinc - Acute	Zinc - Chronic
Similkameen River			0.18	0.12	0.01	0.14	0.00	0.05	0.02	0.01																	
Okanogan River at Oroville			0.33	0.27	0.00	0.30	0.06	0.10	0.01	0.00																	
Okanogan River at Malott			0.26	0.19	0.02	0.28	0.05	0.04	0.19	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00

x > 0.20
0.10 > x > 0.20
x < 0.10

1 Okanogan Conservation District
2 Colville Tribe
D Detection Limit Higher Than Water Quality Standard

* Black shading indicates that greater than 20 percent of the samples exceeded numeric criteria while gray shading indicates between 10 and 20 percent of the samples exceeded criteria. Calculated proportions are listed in the table.

Table 5.2-3: Proportion of Samples Exceeding Numeric Water Quality Criteria in the Joseph Subbasin*

Stream	Temperature Continuous (A	Temperature Continuous (A)	Temperature Grab (AA)	Temperature Grab (A)	Turbidity	Dissolved Oxygen (AA)	Dissolved Oxygen (A)	pH	Fecal Coliform (AA)	Fecal Coliform (A)	Arsenic - Acute	Arsenic - Chronic	Cadmium - Acute	Cadmium - Chronic	Chromium - Acute	Chromium - Chronic	Copper - Acute	Copper - Chronic	Lead - Acute	Lead - Chronic	Mercury - Acute	Mercury - Chronic	Selenium - Acute	Selenium - Chronic	Silver - Acute	Zinc - Acute	Zinc - Chronic
Upper Chiliwist Creek			0.00	0.00	0.00	0.08	0.00																				
Lower Chiliwist Creek	0.18	0.07	0.00	0.00	0.03	0.03	0.00																				

x > 0.20
0.10 > x > 0.20
x < 0.10

1 Okanogan Conservation District
2 Colville Tribe
D Detection Limit Higher Than Water Quality Standard

* Black shading indicates that greater than 20 percent of the samples exceeded numeric criteria while gray shading indicates between 10 and 20 percent of the samples exceeded criteria. Calculated proportions are listed in the table.

Table 5.2-4: Proportion of Samples Exceeding Numeric Water Quality Criteria in the Omak Subbasin*

Stream	Temperature Continuous (A	Temperature Continuous (A)	Temperature Grab (AA)	Temperature Grab (A)	Turbidity	Dissolved Oxygen (AA)	Dissolved Oxygen (A)	pH	Fecal Coliform (AA)	Fecal Coliform (A)	Arsenic - Acute	Arsenic - Chronic	Cadmium - Acute	Cadmium - Chronic	Chromium - Acute	Chromium - Chronic	Copper - Acute	Copper - Chronic	Lead - Acute	Lead - Chronic	Mercury - Acute	Mercury - Chronic	Selenium - Acute	Selenium - Chronic	Silver - Acute	Zinc - Acute	Zinc - Chronic
Trail Creek TRA33A			0.01	0.00	0.03	0.10	0.00	0.04																			
Omak Creek OMK026			0.02	0.00	0.07	0.33	0.05	0.03																			
Omak Creek OMK32A			0.08	0.02	0.03	0.33	0.05	0.00	0.00																		
Stapaloop Creek SAP15A			0.06	0.02	0.01	0.16	0.04	0.03																			
Omak Creek OMK013			0.12	0.05	0.08	0.29	0.00	0.00	0.00																		
Omak Creek OMKF12			0.14	0.08	0.12	0.25	0.01	0.01	0.00																		
Omak Creek OMK009			0.28	0.18	0.12	0.29	0.03	0.02	0.00																		
Mill Creek MIL008			0.15	0.07	0.03	0.15	0.07	0.00																			
Wanacut Creek WANF10			0.25	0.18	0.06	0.21	0.04	0.05																			
Upper Tunk Creek1	0.32	0.19	0.06	0.00	0.00	0.14	0.03	0.31	0.56	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.14	0.00	0.00	0.00	0.00	D	0.00	0.00
Lower Tunk Creek1	0.24	0.07	0.00	0.00	0.00	0.17	0.03	0.25	0.56	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	D	0.00	0.00
Lower Tunk Creek (395)2			0.37	0.11	0.11	0.58	0.42	0.16																			

x > 0.20
0.10 > x > 0.20
x < 0.10

1 Okanogan Conservation District
2 Colville Tribe
D Detection Limit Higher Than Water Quality Standard

* Black shading indicates that greater than 20 percent of the samples exceeded numeric criteria while gray shading indicates between 10 and 20 percent of the samples exceeded criteria. Calculated proportions are listed in the table.

Table 5.2-5 Proportion of Samples Exceeding Numeric Water Quality Criteria in the Salmon Subbasin*

Stream	Temperature Continuous (AA	Temperature Continuous (A)	Temperature Grab (AA)	Temperature Grab (A)	Turbidity	Dissolved Oxygen (AA)	Dissolved Oxygen (A)	pH	Fecal Coliform (AA)	Fecal Coliform (A)	Arsenic - Acute	Arsenic - Chronic	Cadmium - Acute	Cadmium - Chronic	Chromium - Acute	Chromium - Chronic	Copper - Acute	Copper - Chronic	Lead - Acute	Lead - Chronic	Mercury - Acute	Mercury - Chronic	Selenium - Acute	Selenium - Chronic	Silver - Acute	Zinc - Acute	Zinc - Chrnic
Upper Loup Loup Creek1	0.01	0.00	0.00	0.00	0.00	0.17	0.03	0.00																			
Middle Loup Loup Creek (208)2			0.00	0.00	0.25	0.67	0.58	0.00																			
Lower Loup Loup Creek1			0.00	0.00	0.00	0.00	0.00	0.25																			
Upper Tallant Creek1	0.41	0.28	0.19	0.08	0.00	0.18	0.00	0.29																			
Lower Tallant Creek1	0.35	0.14	0.20	0.00	0.00	0.20	0.00	0.80																			
Upper Salmon Creek (552)2			0.73	0.45	0.00	0.91	0.91	0.36																			
Upper-Middle Salmon Creek (376)2			0.57	0.29	0.00	1.00	1.00	0.29																			
Lower-Middle Salmon Creek (360)2			0.30	0.20	0.00	1.00	1.00	0.10																			
Lower Salmon Creek (36)2			0.50	0.13	0.00	1.00	0.88	0.13																			
Upper Johnson Creek	0.50	0.26	0.06	0.00	0.00	0.06	0.00	0.14																			
Lower Johnson Creek			0.11	0.07	0.00	0.15	0.04	0.41																			

x > 0.20
0.10 > x > 0.20
x < 0.10

1 Okanogan Conservation District
2 Colville Tribe
D Detection Limit Higher Than Water Quality Standard

* Black shading indicates that greater than 20 percent of the samples exceeded numeric criteria while gray shading indicates between 10 and 20 percent of the samples exceeded criteria. Calculated proportions are listed in the table.

Table 5.2-6: Proportion of Samples Exceeding Numeric Water Quality Criteria in the Osooyos Subbasin*

Stream	Temperature Continuous (A	Temperature Continuous (A)	Temperature Grab (AA)	Temperature Grab (A)	Turbidity	Dissolved Oxygen (AA)	Dissolved Oxygen (A)	pH	Fecal Coliform (AA)	Fecal Coliform (A)	Arsenic - Acute	Arsenic - Chronic	Cadmium - Acute	Cadmium - Chronic	Chromium - Acute	Chromium - Chronic	Copper - Acute	Copper - Chronic	Lead - Acute	Lead - Chronic	Mercury - Acute	Mercury - Chronic	Selenium - Acute	Selenium - Chronic	Silver - Acute	Zinc - Acute	Zinc - Chronic
Bonaparte Creek Upper K1	0.13	0.05	0.00	0.00	0.07	0.07	0.22	0.07	0.62	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	D	0.00	0.00	0.00
Bonaparte Creek #1									0.38	0.15																	
Bonaparte Creek #2									0.38	0.31																	
Bonaparte Creek Upper Reach1	0.28	0.19	0.00	0.00	0.00	0.00	0.06	0.30	0.48	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	D	0.00	0.00	0.00
Bonaparte Creek #3									0.69	0.62																	
Bonaparte Creek #4									0.85	0.62																	
Bonaparte Creek #5									0.92	0.62																	
Bonaparte Creek Lower Reach2			0.37	0.16	0.16	0.74	0.58	0.79																			
Bonaparte Creek Lower Reach1	0.49	0.34	0.11	0.08	0.06	0.14	0.03	0.43	0.50	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	D	0.00	0.00	0.00
Upper Siwash Creek1	0.07	0.01	0.00	0.00	0.00	0.09	0.03	0.17																			
Middle Siwash Creek2			0.12	0.00	0.12	0.94	0.65	0.16																			
Lower Siwash Creek1			0.00	0.00	0.00	0.00	0.00	0.60																			
Upper Antoine Creek1			0.50	0.25	0.00	0.75	0.25	0.25																			
Lower Antoine Creek2			0.47	0.13	0.20	0.87	0.60	0.13																			
Lower Antoine Creek1	0.41	0.20	0.03	0.00	0.03	0.19	0.00	0.42																			
Upper Tonasket Creek1			0.10	0.00	0.07	0.17	0.13	0.27																			
Middle Tonasket Creek2			0.62	0.54	0.15	0.85	0.69	0.54																			
Lower Tonasket Creek2			0.83	0.50	0.00	0.50	0.33	1.00																			
Lower Tonasket Creek1			0.09	0.00	0.17	0.13	0.04	0.35																			
Upper Ninemile Creek1	0.20	0.12	0.00	0.00	0.04	0.29	0.00	0.36																			
Upper Ninemile Creek2			0.14	0.00	0.07	0.71	0.57	0.29																			
Lower Ninemile Creek1	0.22	0.07	0.00	0.00	0.00	0.17	0.03	0.34																			
Lower Ninemile Creek2			0.24	0.00	0.12	0.82	0.71	0.12																			

x > 0.20
0.10 > x > 0.20
x < 0.10

1 Okanogan Conservation District
2 Colville Tribe
D Detection Limit Higher Than Water Quality Standard

* Black shading indicates that greater than 20 percent of the samples exceeded numeric criteria while gray shading indicates between 10 and 20 percent of the samples exceeded criteria. Calculated proportions are listed in the table.

Table 5.2-7: Proportion of Samples Exceeding Numeric Water Quality Criteria in the Sinlahekin Subbasin*

Stream	Temperature Continuous (A	Temperature Continuous (A)	Temperature Grab (AA)	Temperature Grab (A)	Turbidity	Dissolved Oxygen (AA)	Dissolved Oxygen (A)	pH	Fecal Coliform (AA)	Fecal Coliform (A)	Arsenic - Acute	Arsenic - Chronic	Cadmium - Acute	Cadmium - Chronic	Chromium - Acute	Chromium - Chronic	Copper - Acute	Copper - Chronic	Lead - Acute	Lead - Chronic	Mercury - Acute	Mercury - Chronic	Selenium - Acute	Selenium - Chronic	Silver - Acute	Zinc - Acute	Zinc - Chronic
Upper Sinlahekin Creek	0.58	0.53	0.08	0.00	0.00	0.33	0.03	0.00	0.19	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	D	0.00	0.00
Lower Sinlahekin Creek	0.48	0.41	0.19	0.17	0.00	0.33	0.06	0.03	0.78	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	D	0.00	0.00

x > 0.20
0.10 > x > 0.20
x < 0.10

1 Okanogan Conservation District
2 Colville Tribe
D Detection Limit Higher Than Water Quality Standard

* Black shading indicates that greater than 20 percent of the samples exceeded numeric criteria while gray shading indicates between 10 and 20 percent of the samples exceeded criteria. Calculated proportions are listed in the table.

Chapter 6.0: Aquatic Habitat Assessment

Habitat may be generally defined as the place occupied by an organism, population, or community. It is the *niche*, the physical part of the community structure in which an organism finds its home, and includes the sum total of all the environmental conditions present in the specific place occupied by an organism. Habitat is the physical template upon which communities express themselves. The distribution of species and biological communities across the landscape is a direct response to the distribution of habitat types.

Previous efforts to assess aquatic habitat in the Okanogan basin, notably ((e.g., ENTRIX and Golder 2001, NWPPC 2004), relied largely on site specific knowledge and expert opinion to describe habitat quality. However, quantitative data characterizing habitat types, using standardized repeatable methods, exist for only a limited number of sites. In recent years, great progress has been made in characterizing certain elements of habitat (i.e., water quantity, water quality) and these data are described in greater detail in other sections of this document. Other important elements of habitat such as stream bed configuration, substrate characteristics, bank characteristics, hydraulic properties, channel geometry, etc. remain uncharacterized throughout the basin. The first objective of the Aquatic Habitat Assessment provided in this section was to provide a comprehensive representation of the type, proportion, and distribution of channel types, and thus habitats, in the Okanogan basin. The structure and variability of stream channel habitat is predominantly a function of channel slope (gradient), which is largely determined by topography (Montgomery 1999). Therefore, it was possible to broadly classify the types of stream habitat that might occur at a given location using maps of the stream channel location and widely available elevation models that portray basin topography. These methods are described in greater detail in Appendix E.

A second objective of the Aquatic Habitat Assessment was to summarize newly acquired information on site specific locations and provide an assessment of the relative quality of the habitat. In the summer of 2004, the CCT began collecting information on physical habitat conditions in the mainstem Okanogan River, the Similkameen River, and various subbasin tributaries as part of a long term status and trend monitoring program known as Okanogan Baseline Monitoring and Evaluation Program (OBMEP). Figure 6.1-1 reflects these habitat sampling locations. The objective of this program is to collect the required information necessary to adaptively manage aquatic resources in the Okanogan Basin and this program is based on the EPA Environmental Monitoring and Assessment Program (EMAP). Information collected by the Colville Tribe includes data characterizing channel dimensions (e.g., wetted width, bankful width, etc.), habitat type (e.g., glides, riffles, pools, etc.), substrate (e.g., bedrock, boulder, cobble, gravel, etc.), riparian vegetation, and wood loading.

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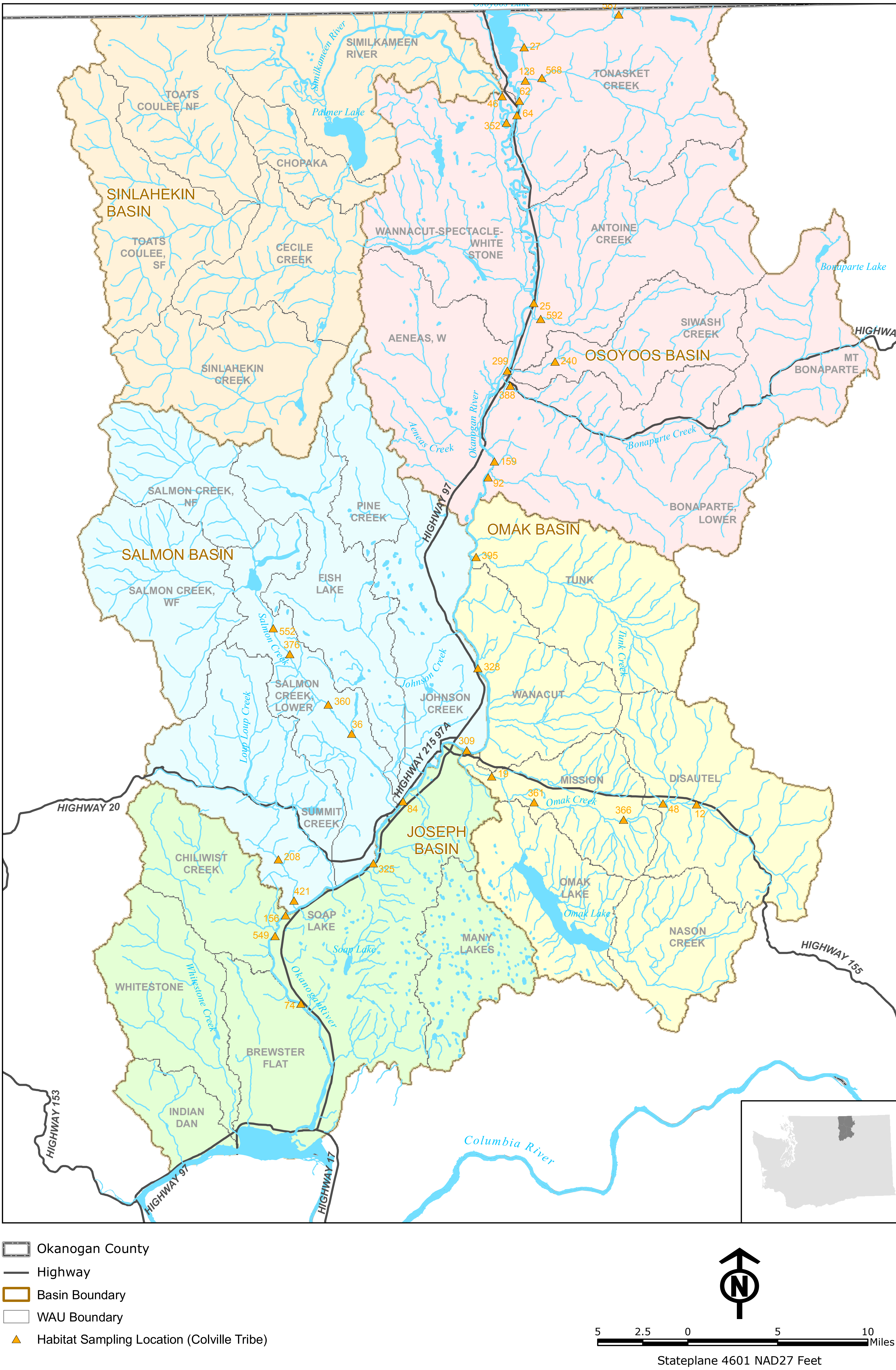
WRIA 49 - Habitat Sampling Location



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While these data were not collected for use in this Level 1 assessment, and were therefore not in a form readily interpretable through habitat criteria such as those provided in Attachment 3, it was possible to use some of the information collected by the Colville Tribe to develop a rudimentary understanding of the quality of stream and riparian habitat conditions at specific locations within the Okanogan basin. That information is reflected in the following text, and in the maps Further analysis of these data, unavailable until late in the Level 1 assessment process, is recommended under Level 2.

6.1 MAINSTEM STREAM CHANNEL ASSESSMENT

Approximately 99 percent of the mainstem Okanogan and Similkameen River can be classified as low-gradient valley or pool-riffle reaches (Table 6.1-1, see also Attachment 2 — Map Atlas, Gradient and Channel Characteristics). These gently sloping stream channels are punctuated at intervals by relatively high gradient reaches. Cascades were the next most abundant reach type. More than half of the pool riffle reaches are located in the Similkameen River (eleven miles). The mainstem Okanogan and Similkameen Rivers, within the United States, are heavily utilized by steelhead trout for spawning. Roughly 75 percent of the observed redds (gravel “nests” where salmon deposit their eggs during spawning) have been recorded in one of these two waterbodies (Arterburn et al. 2005). Of the spawning that occurs in the mainsteam rivers, redd densities are highest near the confluence of the Similkameen and Okanogan Rivers. While spawning occurs throughout the mainstem Okanogan, redds appear to be concentrated in areas immediately downstream of mainstem-tributary confluences (e.g., Omak Creek, Tunk Creek, and Bonaparte Creek). The role that tributaries may play in maintaining mainstem spawning habitat, either through transport and deposition of sediment or altered hydraulic properties is as topic that merits further investigation.

Table 6.1-1: Proportion of Stream Length Classified by Reach Type, Mainstem Okanogan and Similkameen Rivers

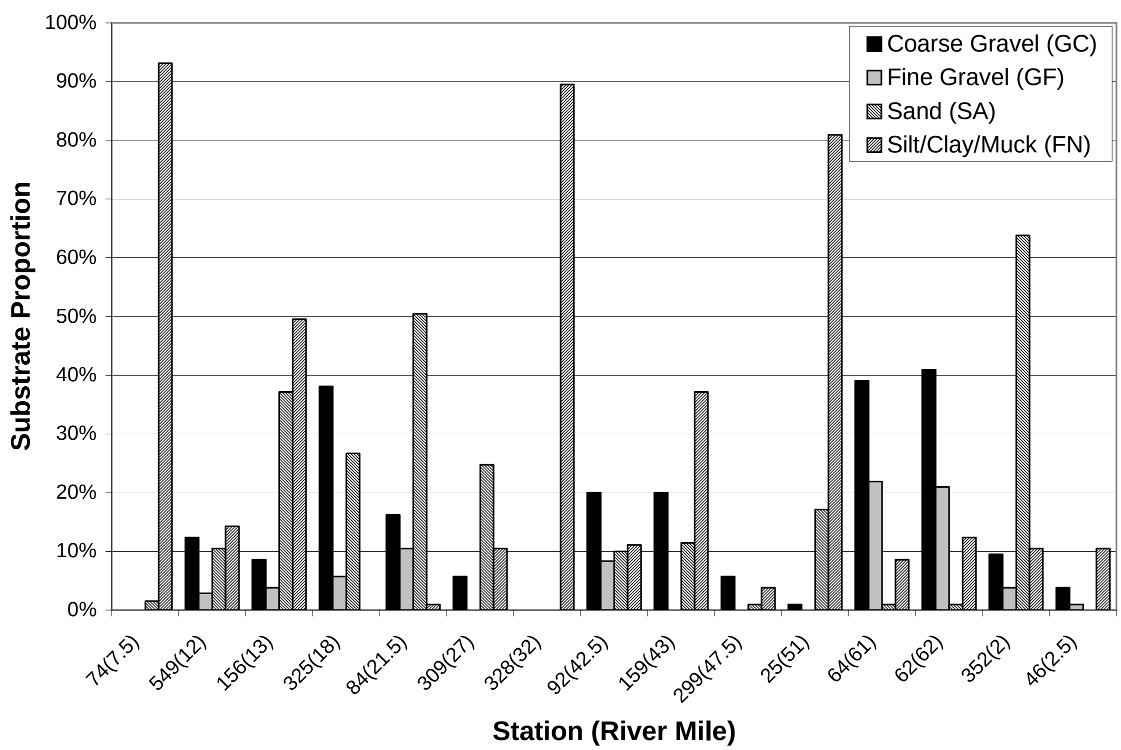
SUBBASIN NAME	REACH TYPE	LENGTH (MILES)	PERCENT OF TOTAL
Mainstem	Low-gradient valley	88.45	81%
Mainstem	Pool-riffle	20.02	18%
Mainstem	Plane_bed	0.31	0%
Mainstem	Step_pool	0.35	0%
Mainstem	Cascade	0.64	1%
	Total	109.77	

6.2 SITE SPECIFIC HABITAT ASSESSMENT– MAINSTEM

As depicted earlier in Figure 6.1-1, the Colville Tribe sampled site specific habitat conditions at thirteen locations on the Okanogan River (Stations 74, 549, 156, 325, 84, 309, 328, 92, 159, 299, 25, 64, and 62) and two locations on the Similkameen River

(Stations 46 and 352) (please refer to Attachment 2 — Map Atlas Gradient and Channel Characteristics). Fine sediments comprised a relatively large proportion of the substrate types at all of the mainstem study locations (Figure 6.2-1). This is typical of large low-gradient rivers. In all but four of the sites (299, 64, 62 and 46), fine sediments comprised more than 20 percent of the substrate. In five of the survey reaches, fine sediments comprised more than 70 percent of the total substrate (74, 156, 328, 25, and 352). Fine and coarse gravel were relatively abundant and comprise more than 40 percent of the total substrate at stations 325, 64, and 62. Between 20 and 30 percent of the substrate was comprised of gravel at stations 159, 92, and 84. Stations 64 and 62 appear to be heavily utilized by steelhead trout for spawning (Colville Tribe 2005) while stations 84, 325, 159, and 92 are used less intensively. Although gravel comprised only five percent of the total substrate at station 46 on the Similkameen River, this reach is intensively used for steelhead trout spawning.

Figure 6.2-1: Proportion of Substrates Smaller than 65 mm at Sample Locations in the Mainstem Okanogan and Similkameen Rivers



Wood loading was ranked as poor for all mainstem study reaches (Table 6.2-1). However, it should be noted that while the evaluation criteria used in this assessment have been applied to Eastern Washington streams, as originally used in the Okanogan LFA (ENTRIX and Golder 2001) they were originally developed for small streams (<15 m in width) in western Washington. However, the evaluation criteria do not consider ecoregional differences in riparian stand density or in potential tree size, both of which are important factors in determining whether wood pieces delivered to the stream influence channel morphology. As such, the criteria may be overly conservative and suggest that "poor" conditions exist in circumstances where wood loading is appropriate. The structure of eastside riparian forests under natural conditions have not been systematically characterized in the same manner as riparian forests in western Washington (Collins and Montgomery 2002, Collins et. al. 2003) and is an information gap that could be addressed in future studies. Another information gap for eastern Washington streams in the role of wood in larger low-gradient streams. Contrary to conventional wisdom, large wood pieces can, and do, affect channel morphology through the formation of floodplain islands, wood jams and rafts, and channel avulsion (Fetherston 1995, Abbe and Montgomery 2003) and thus play a critical role in structuring aquatic habitats.

Table 6.2-1 Large Woody Debris Loading at Sample Locations in the Mainstem Okanogan and Similkameen Rivers

SUBBASIN	STREAM	STATION ID (RM)	TOTAL REACH LENGTH (M)	LWD COUNT	LWD PIECES / METER	RATING
Mainstem	Okanogan River	74 (7.5)	630	92.0	0.1	Poor
Mainstem	Okanogan River	549 (12)	500	161.0	0.3	Poor
Mainstem	Okanogan River	156 (13)	500	39.0	0.1	Poor
Mainstem	Okanogan River	325 (18)	500	136.0	0.3	Poor
Mainstem	Okanogan River	84 (21.5)	500	114.0	0.2	Poor
Mainstem	Okanogan River	309 (27)	500	53.0	0.1	Poor
Mainstem	Okanogan River	328 (32)	500	54.0	0.1	Poor
Mainstem	Okanogan River	92 (42.5)	860	64.0	0.1	Poor
Mainstem	Okanogan River	159 (43)	500	55.0	0.1	Poor
Mainstem	Okanogan River	299 (47.5)	500	29.0	0.1	Poor
Mainstem	Okanogan River	25 (51)	500	165.0	0.3	Poor
Mainstem	Okanogan River	64 (61)	500	41.0	0.1	Poor
Mainstem	Okanogan River	62 (62)	500	81.0	0.2	Poor
Mainstem	Similkameen River	352 (2)	500	76.0	0.2	Poor
Mainstem	Similkameen River	46 (2.5)	500	36.0	0.1	Poor

The percentage of surface area comprised of pool habitat at the mainstem study reaches sampled ranged between 42 and 100 percent (Table 6.2-2). One of the sites ranked as "fair" is intensively used for spawning by steelhead trout (Colville Tribe 2005). Seven of the study reaches lacked riffles altogether.

Table 6.2-2 Pool Characteristics at Sample Stations in the Omak Creek Subbasin

SUBBASIN	STREAM	STATION ID (RM)	POOL SURFACE AREA RATING	TOTAL POOLS	TOTAL RIFFLES	WETTED WIDTH AVERAGE (M)	POOL RIFFLE RATIO
Mainstem	Okanogan River	74 (7.5)	Good	100%	0%	100	NR
Mainstem	Okanogan River	549 (12)	Good	100%	0%	81	NR
Mainstem	Okanogan River	156 (13)	Good	100%	0%	102	NR
Mainstem	Okanogan River	325 (18)	Good	70%	29%	68	2.4
Mainstem	Okanogan River	84 (21.5)	Good	100%	0%	83	NR
Mainstem	Okanogan River	309 (27)	Fair	49%	51%	93	0.9
Mainstem	Okanogan River	328 (32)	Good	93%	7%	89	13.4
Mainstem	Okanogan River	92 (42.5)	Fair	42%	63%	66	0.7
Mainstem	Okanogan River	159(43)	Good	85%	15%	55	5.7
Mainstem	Okanogan River	299 (47.5)	Good	56%	44%	55	1.3
Mainstem	Okanogan River	25 (51)	Good	100%	0%	79	NR
Mainstem	Okanogan River	64 (61)	Good	75%	25%	36	3.0
Mainstem	Okanogan River	62 (62)	Fair	49%	48%	49	1.0
Mainstem	Similkameen River	352 (2)	Good	100%	0%	70	NR
Mainstem	Similkameen River	46 (2.5)	Good	100%	0%	55	NR

NR = not reported

6.2.1 Joseph Subbasin Habitat

SUBBASIN WIDE STREAM CHANNEL ASSESSMENT

Stream channel habitat in the Joseph Subbasin totaled approximately 220 miles in length (Table 6.2-3). Many of the streams drain to terminal basins and do not connect to the mainstem Okanogan River (See Attachment 2, Map Atlas — Joseph Basin). The composition of habitat types was dominated by reaches with gradients greater than two percent.

Table 6.2-3: Proportion of Stream Length Classified by Reach Type, Joseph Subbasin

SUBBASIN NAME	REACH TYPE	LENGTH (MILES)	PERCENT OF TOTAL
JOSEPH	Low-gradient valley	8.36	4%
JOSEPH	Pool-riffle	40.72	19%
JOSEPH	Plane_bed	54.00	25%
JOSEPH	Step_pool	65.73	30%
JOSEPH	Cascade	50.69	23%
		219.50	

SITE SPECIFIC HABITAT ASSESSMENTS

Very little is known about stream habitat in this subbasin and no systematic survey of aquatic habitat has been conducted. However, water quality was sampled in Chiliwist Creek by the Okanogan Conservation District and numeric water quality exceedances were infrequent at both stations although flow was often absent at the upper sampling site. Steelhead smolts have been observed in the lower reach (ENTRIX and Golder 2001) and further investigation of habitat conditions is warranted to determine the relative value of this creek for fisheries resources.

6.2.2 Omak Subbasin

SUBBASIN WIDE STREAM CHANNEL ASSESSMENT

The Omak Subbasin contains the most stream miles of the five subbasins in the Okanogan watershed. As depicted in Table 6.2-4, more than 70 percent of the total stream length in the Omak Creek subbasin was classified as step-pool or cascade (see also Attachment 2 — Map Atlas Gradient and Channel Characteristics). Omak Creek is the largest catchment in the Omak Subbasin and the mainstem Omak is predominately classified as a pool-riffle reach although higher gradient sections occur sporadically along its length. The reach of Tunk Creek downstream of McAllister Falls (approximately three quarters to one mile from the Okanogan confluence) is apparently used by steelhead trout but chinook and sockeye salmon are not known to occur in this waterbody (ENTRIX and Golder 2001).

Most reaches in Tunk Creek upstream of the falls, were classified as plane-bed although some sections had slopes (gradients) characteristic of pool-riffle reaches. The lower portion of Wannacut Creek has slopes that generally yield characteristic of pool-riffle reaches that have been found to be accessible to anadromous salmonids in other systems. Culverts are present in some reaches of Wannacut Creek (ENTRIX 2001) but it isn’t clear where they occur in relation to this reach. Brook trout, an introduced species, are the only fish species recorded in Wannacut Creek, both currently and historically (CCT 1997) although rainbow trout may occur in the upper reaches. The stream is not currently stocked, but the presence of brook trout suggests that it was stocked in the past.

Table 6.2-4: Proportion of Stream Length Classified by Reach Type, Omak Subbasin

SUBBASIN NAME	REACH TYPE	LENGTH (MILES)	PERCENT OF TOTAL
OMAK	Low-gradient valley	11.77	3%
OMAK	Pool-riffle	42.51	9%
OMAK	Plane_bed	76.40	17%
OMAK	Step_pool	135.83	30%
OMAK	Cascade	190.21	42%
		456.71	

SITE SPECIFIC HABITAT ASSESSMENTS

The Colville Tribe sampled site specific habitat conditions at five locations on Omak Creek (Stations 19, 361, 366, 48, and 12) and one location on Tunk Creek (Station 395) (please refer to Attachment 2 — Map Atlas Gradient and Channel Characteristics). Substrates at stations in the lower portion of Omak Creek (19, 36, and 366) were comprised primarily of coarse substrates greater than 65 mm in diameter (Figure 6.2-2). The absence of small diameter substrates at station 19 is somewhat surprising given the lower position in the drainage basin and the fact that this portion of the channel was classified as a pool-riffle reach type. Stations 361 and 366 both appear to be to be in higher gradient (higher energy) reaches. Gravel was relatively scarce and fine sediments comprised no more than 34 percent of the total substrate. For the uppermost stations, fine sediments comprised between 71 and 81 percent of the total substrate while gravel comprised between seven and eleven percent. Thus substrates larger than 65 mm were virtually absent at these sites. The Tunk Creek station is located near the confluence with the Okanogan River and approximately 64 percent of the substrates were comprised of particles less than 65 mm in diameter with 33 percent comprised of fine sediments. Coarse gravel (12-65 mm) accounted for approximately 31 percent of the substrate area and fine gravel was absent.

Large woody debris was rated as “poor” (< 0.4 pieces/meter) at stations 19, 361, and 12 on Omak Creek and station 395 on Tunk Creek while stations 366 and 48 on Omak Creek were rated as “good” (Table 6.2-5). Despite the relative abundance of wood pieces at station 366 and the increased channel roughness (resistance to flow and sediment movement such that pools may form) that wood pieces would provide, fine sediments were not abundant.

Figure 6.2-2: Proportion of Substrates smaller than 65 mm at Sample locations in Omak Creek

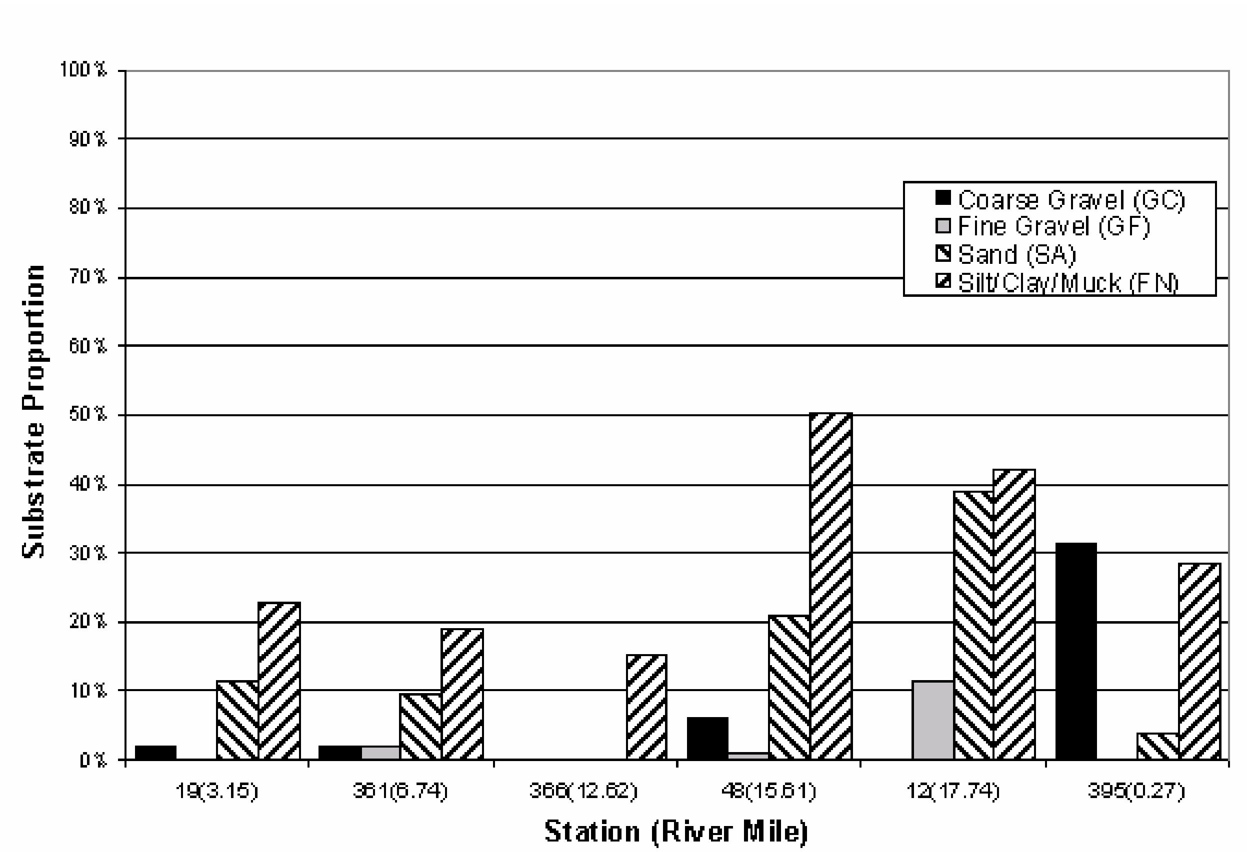


Table 6.2-5: Large Woody Debris Loading at Sample Stations in the Omak Creek Subbasin

SUBBASIN	STREAM	STATION ID (RM)	TOTAL REACH LENGTH (M)	LWD COUNT	LWD PIECES / METER	RATING
Omak	Omak Creek	19 (3.15)	150	36.0	0.2	Poor
Omak	Omak Creek	361 (6.74)	208	48.0	0.2	Poor
Omak	Omak Creek	366 (12.62)	170	97.0	0.6	Good
Omak	Omak Creek	48 (15.61)	160	166.0	1.0	Good
Omak	Omak Creek	12 (17.74)	150	14.0	0.1	Poor
Omak	Tunk Creek	395 (0.27)	90	18.0	0.2	Poor

Table 6.2-6: Pool Characteristics at Sample Stations in the Omak Creek Subbasin

SUBBASIN	STREAM	STATION ID (RM)	POOL SURFACE AREA RATING	TOTAL POOLS	TOTAL RIFFLES	WETTED WIDTH AVERAGE (M)	POOL RIFFLE RATIO
Omak	Omak Creek	19 (3.15)	Poor	20%	79%	5	0.3
Omak	Omak Creek	361 (6.74)	Poor	0%	100%	7	0.0
Omak	Omak Creek	366 (12.62)	Poor	11%	89%	5	0.1
Omak	Omak Creek	48 (15.61)	Good	66%	34%	6	1.9
Omak	Omak Creek	12 (17.74)	Poor	2%	98%	4	0.0
Omak	Tunk Creek	395 (0.27)	Poor	12%	0%	0	NR

NR = not reported

6.2.3 Salmon Subbasin

SUBBASIN-WIDE STREAM CHANNEL ASSESSMENT

The Salmon Creek Subbasin includes one large catchment (Salmon Creek), a number of smaller catchments (e.g., Tallant, Loup Loup, and Johnson Creeks) and terminal basins that do not drain to the mainstem Okanogan River. This subbasin is characterized by fairly steep stream channels, as indicated by the fact that 39 percent of the total channel length has slopes exceeding eight percent (Table 6.2-7). Salmon Creek, Johnson Creek, and Talant Creek all rise steeply away from the confluence with the Okanogan River (please refer to Attachment 2 — Map Atlas Gradient and Channel Characteristics). Salmon Creek and Johnson Creek transition to lower gradient pool-riffle reaches and these mainstem segments account for the majority of the pool-riffle reach type that occurs in the subbasin. Channels in Tallant Creek are greater than 4 percent through most of the basin. The Loup Loup Creek stream channel near the confluence exhibits a gradient characteristic of a pool-riffle channel.

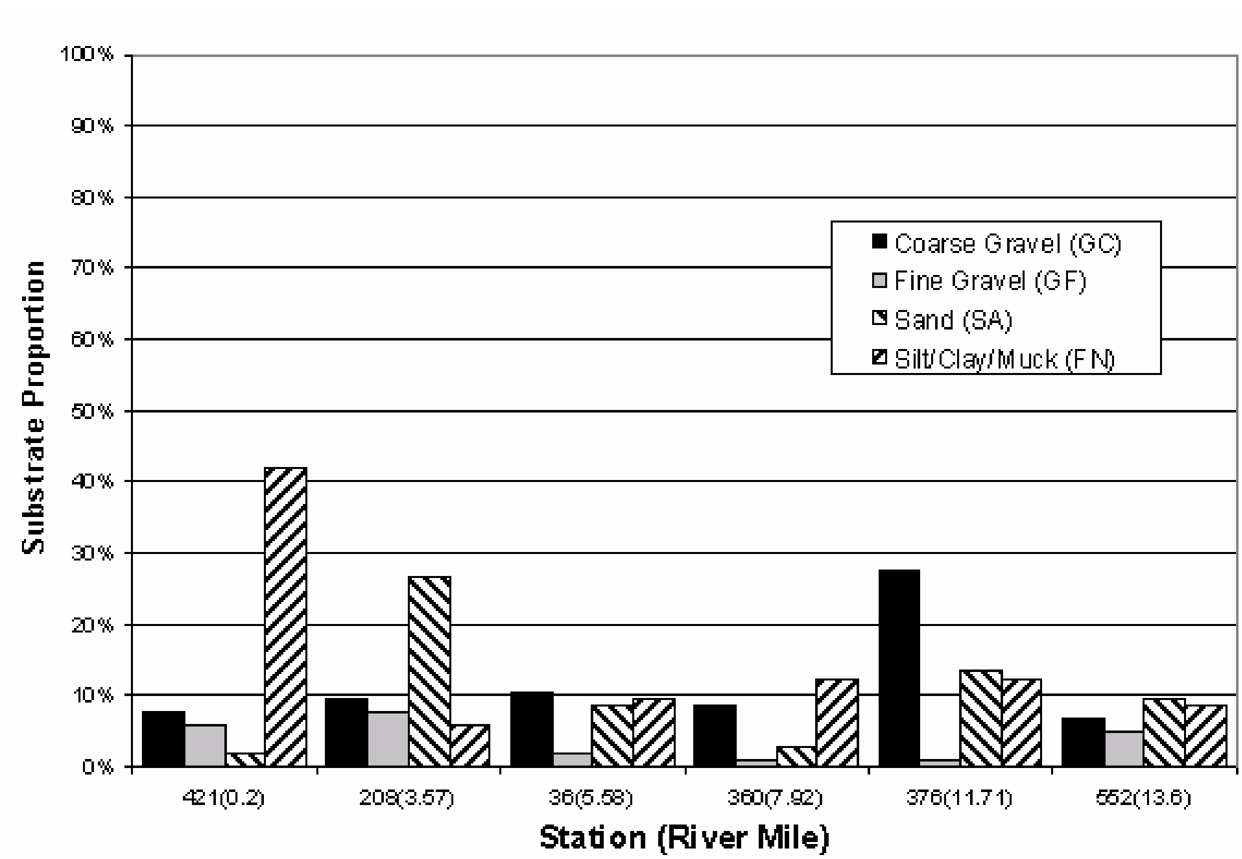
Table 6.2-7: Proportion of Stream Length Classified by Reach Type, Salmon Subbasin

SUBBASIN NAME	REACH TYPE	LENGTH (MILES)	PERCENT OF TOTAL
SALMON	Low-gradient valley	9.24	3%
SALMON	Pool-riffle	61.06	18%
SALMON	Plane_bed	51.84	15%
SALMON	Step_pool	84.58	25%
SALMON	Cascade	132.83	39%
		339.55	

SITE SPECIFIC HABITAT ASSESSMENT

The Colville Tribe characterized habitat conditions at two locations on Loup Loup Creek (Stations 421 and 208), and four locations in Salmon Creek (Stations 36, 360, 376, and 552). At the Loup Loup Creek sites, fine sediments comprised between 33 and 42 percent of the total substrate while gravel comprised less than 20 percent of the substrate (Figure 6.2-3). Sediment particles less than 65 mm in diameter at the Salmon Creek locations comprised between 25 and 54 percent of the total substrate with fine sediments accounting for between 15 and 25 percent of the total. Station 376 contained nearly three times more coarse gravel than any of the other Salmon Creek stations.

Figure 6.2-3: Proportion of Substrates Smaller than 65 mm at Sample Locations in Salmon Creek



Between 12 and 122 pieces of wood were observed in Loup Loup Creek and Salmon Creek and the number of pieces per meter ranged between 0.1 and 0.8 (Table 6.2-8). One station in Loup Loup Creek (208) and one station in Salmon Creek (36) exhibited wood loading considered “good”. The remaining study reaches had fewer than 0.4 pieces per meter and were considered “poor”. Pool surface area at station 360 comprised approximately 75 percent of the total surface area and habitat conditions for this indicator were ranked as “good” (Table 6.2-9). Two stations, were ranked as “fair” (36 and 376) and the remainder were categorized as “poor”.

Table 6.2-8: Large Woody Debris Loading at Sample Stations in the Salmon Creek Subbasin

SUBBASIN	STREAM	STATION ID (RM)	TOTAL REACH LENGTH (M)	LWD COUNT	LWD PIECES / METER	RATING
SALMON	Loup Loup Creek	421 (0.2)	150	23.0	0.2	Poor
SALMON	Loup Loup Creek	208 (3.57)	150	63.0	0.4	Good
SALMON	Salmon Creek	36 (5.58)	150	122.0	0.8	Good
SALMON	Salmon Creek	360 (7.92)	218	75.0	0.3	Poor
SALMON	Salmon Creek	376 (11.71)	220	12.0	0.1	Poor
SALMON	Salmon Creek	552 (13.6)	208	44.0	0.2	Poor

Table 6.2-9: Pool Characteristics at Sample Stations in the Salmon Creek Subbasin

SUBBASIN	STREAM	STATION ID (RM)	POOL SURFACE AREA RATING	TOTAL POOLS	TOTAL RIFFLES	WETTED WIDTH AVERAGE (M)	POOL RIFFLE RATIO
SALMON	Loup Loup Creek	421 (0.2)	Poor	0%	0%	0	NR
SALMON	Loup Loup Creek	208 (3.57)	Poor	22%	78%	2	0.3
SALMON	Salmon Creek	36 (5.58)	Fair	52%	48%	5	1.1
SALMON	Salmon Creek	360 (7.92)	Good	75%	30%	7	2.5
SALMON	Salmon Creek	376 (11.71)	Fair	49%	51%	4	0.9
SALMON	Salmon Creek	552 (13.6)	Poor	40%	55%	4	0.7

6.2.4 Osoyoos Subbasin

SUBBASIN-WIDE STREAM CHANNEL ASSESSMENT

Streams in the Osoyoos Subbasin total approximately 450 miles in length (Table 6.2-10). Channels with slopes less than 0.1 percent are very rare (please refer to Attachment 2 — Map Atlas Gradient and Channel Characteristics). Stream channels with gradients characteristic of streams with pool-riffle and plane bed habitat account for approximately 41 percent of the total length. Step-pool and cascade reaches combine for 56 percent of the total length. In general, the lower gradient reaches occur along the mainstem of the major tributaries (e.g., Bonaparte Creek and Antoine Creek). However, Bonaparte Creek has more pool-riffle channels (20 miles) than any other single tributary and accounts for 21 percent of the total length. With the exception of Mosquito Creek and Tonasket Creek, all of the tributaries have slopes greater than four percent near the confluence with the Okanogan River. The relatively steep slopes of tributaries near their confluence with the mainstem are a natural feature of many of the Okanogan tributaries. Recent surveys (Arterburn 2005) indicate Bonaparte Creek and Nine Mile Creek are intensively used by steelhead trout for spawning but less is known about use in the other tributaries.

Table 6.2-10: Proportion of Stream Length Classified by Reach Type, Osoyoos Subbasin

SUBBASIN NAME	REACH TYPE	LENGTH (MILES)	PERCENT OF TOTAL
OSOYOOS	Low-gradient valley	9.74	2%
OSOYOOS	Pool riffle	90.97	2%
OSOYOOS	Plane bed	97.09	21%
OSOYOOS	Step pool	124.40	27%
OSOYOOS	Cascade	132.38	29%
		454.58	

SITE SPECIFIC HABITAT ASSESSMENT

The Colville Tribe characterized habitat conditions in Bonaparte Creek (Station 388), Siwash Creek (Station 240), Antoine Creek (Station 592), Tonasket Creek (Station 128 and 568), and Nine Mile Creek (Station 27 and 587). Fine sediments comprised 57 percent of the total substrate at the Siwash Creek station and 64 percent at the lower of the two Nine Mile Creek stations (Figure 6.2-4). Gravel was most abundant at Antoine Creek and the two Tonasket Creek stations comprising between 25 and 30 percent of the total substrate.

Large woody debris loading was ranked as “poor” for all of the reaches surveyed (Table 6.2-11). The number of pieces per meter ranged between 0.1 and 0.3. Siwash Creek was the only tributary in the Osoyoos Subbasin to receive a “good” ranking for pool surface area. Pool surface area for the remaining tributaries ranged between eleven and 30 percent, well below the 40 percent threshold for a “fair” ranking (Table 6.2-12).

Figure 6.2-4 Proportion of Substrates Smaller than 65 mm at Sample Locations in Osoyoos Subbasin

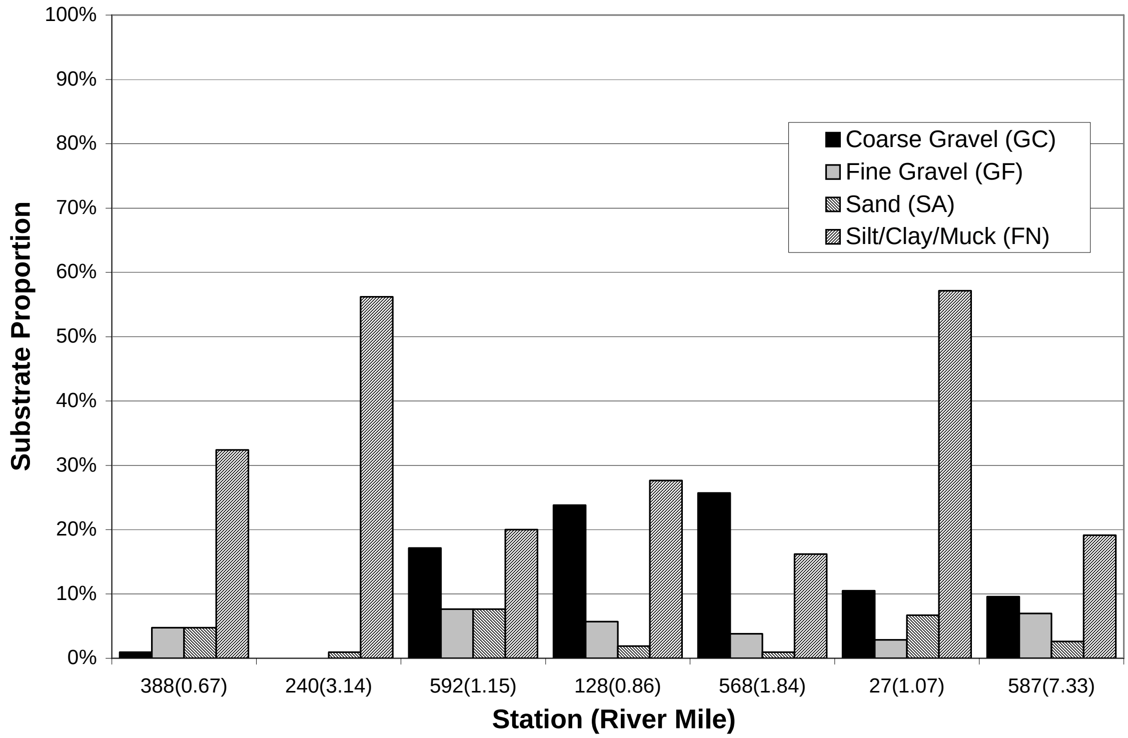


Table 6.2-11 Large Woody Debris Loading at Sample Stations in the Osoyoos Subbasin

SUBBASIN	STREAM	STATION ID (RM)	TOTAL REACH LENGTH (M)	LWD COUNT	LWD PIECES / METER	RATING
OSOYOOS	Bonaparte Creek	388 (0.67)	150	14.0	0.1	Poor
OSOYOOS	Siwash Creek	240 (3.14)	150	15.0	0.1	Poor
OSOYOOS	Antoine Creek	592 (1.15)	150	29.0	0.2	Poor
OSOYOOS	Tonasket Creek	128 (0.86)	150	38.0	0.3	Poor
OSOYOOS	Tonasket Creek	568 (1.84)	150	22.0	0.1	Poor
OSOYOOS	Nine Mile Creek	27 (1.07)	150	42.0	0.3	Poor
OSOYOOS	Nine Mile Creek	587 (7.33)	150	52.0	0.3	Poor

Table 6.2-12: Pool Characteristics at Sample Stations in the Osoyoos Subbasin

SUBBASIN	STREAM	STATION ID (RM)	POOL SURFACE AREA RATING	TOTAL POOLS	TOTAL RIFFLES	WETTED WIDTH AVERAGE (M)	POOL RIFFLE RATIO
OSOYOOS	Bonaparte Creek	388 (0.67)	Poor	22%	76%	2	0.3
OSOYOOS	Siwash Creek	240 (3.14)	Good	84%	16%	2	5.3
OSOYOOS	Antoine Creek	592 (1.15)	Poor	11%	89%	2	0.1
OSOYOOS	Tonasket Creek	128 (0.86)	Poor	25%	2%	0	12.5
OSOYOOS	Tonasket Creek	568 (1.84)	Poor	15%	85%	2	0.2
OSOYOOS	Nine Mile Creek	27 (1.07)	Poor	15%	83%	2	0.2
OSOYOOS	Nine Mile Creek	587 (7.33)	Poor	30%	69%	0	0.4

6.2.5 Sinlahekin Subbasin

SUBBASIN-WIDE STREAM CHANNEL ASSESSMENT

The Sinlahekin Subbasin contains approximately 330 miles of stream habitat. With the exception of the mainstem Sinlahekin Creek, very little of the total stream length has slopes characteristic of low-gradient valley, pool-riffle, or plane bed channels (Table 6.2-13; Attachment 2 — Map Atlas Gradient and Channel Characteristics]). Channels with slopes in excess of 8 percent account for over half of the total length in the subbasin and channels with slopes greater than 4 percent account for 78 percent of the total length (Table 6.2-13).

Table 6.2-13: Proportion of Stream Length Classified by Reach Type, Sinlahekin Subbasin

SUBBASIN NAME	REACH TYPE	LENGTH (MILES)	PERCENT OF TOTAL
SINLAHEKIN	Low-gradient valley	11.01	3%
SINLAHEKIN	Pool-riffle	33.16	10%
SINLAHEKIN	Plane_bed	29.12	9%
SINLAHEKIN	Step_pool	89.99	27%
SINLAHEKIN	Cascade	170.34	51%
		333.61	

SITE SPECIFIC HABITAT ASSESSMENT

Streams in this subbasin were not explicitly covered in earlier reviews of habitat conditions (e.g., ENTRIX and Golder 2001) because the upper limit of anadromy is many miles downstream at the falls below Enloe Dam. A review of available information produced no new systematic studies of aquatic habitat in this Subbasin.

Chapter 7.0: Data Gaps and Recommendations

This section presents data gaps and recommendations for water quantity, water storage, water quality, aquatic habitat, and GIS/mapping. The gaps and recommendations are intended to provide a beginning point for Planning Unit consideration as possible options for Level 2 work and as possible foci for watershed planning. They are not listed in any order of priority.

7.1 WATER QUANTITY

7.1.1 Water Availability Potential Areas for Consideration

1. Improve estimates of stream flows and diversions during low flow seasons for over-appropriated streams.
2. Refine groundwater recharge estimates for subbasins of concern (Joseph, Osoyoos, Salmon).

7.1.2 Water Quantity Potential Areas for Consideration

1. Develop a factor to account for unknown amounts of appropriation under water claims in assessing subbasins of concern.
2. Define amount of water conserved in current agricultural and municipal/domestic use (data gap).

7.1.3 Water Rights Potential Areas for Consideration

1. Investigate use of large water rights diverting from over-appropriated streams.
2. Use GIS to identify sources for large surface water rights on unnamed streams.
3. Refine estimates of appropriations to account for inflows (e.g., Okanogan River) for subbasins of concern (Joseph, Osoyoos, Salmon).
4. Further work to quantify water claims to clean up database.
5. Further work to quantify water rights.

7.1.4 Water Wells Potential Areas for Consideration

1. Filter wells database for water-righted wells and errors.
2. Improve exempt well withdrawal estimate.
3. Plot and analyze well withdrawals by depth, static water level, and volume of withdrawal.

7.1.5 Agricultural Water Use Potential Areas for Consideration

1. Consider more in-depth analyses of WRIA 49 irrigation districts' water balances, similar to that available for Okanogan Irrigation District.
2. Define acreage by crop type (and possibly by subbasin) to improve water use estimate.
3. Reconcile disparity in Omak subbasin water-righted acres v. County Assessor records.
4. Estimate the rate at which farmland conversion is occurring, taking land out of production and reducing the overall future water demand for agriculture.
5. Identify uses to which farmland is being converted and estimate water demand for lands converted from farmland to other use.

7.1.6 Municipal Water Use Potential Areas for Consideration

1. Reconcile US Census data, County Assessor parcel data, Group A and B water system connections, and exempt well data sets to improve estimate of municipal/domestic water use.
2. Improve estimate of seasonal residences for municipal/domestic water use.
3. Develop buildout analysis by subbasin for municipal and domestic water use and farmland conversion.
4. Define commercial, industrial, and institutional water use from WSCP's for large Group A water systems and by contacting owners of large water rights with these purposes.

7.1.7 Potential Future Water Supply Strategies for Consideration

1. Develop sector-specific future water supply strategies (FWSS) for WRIA 49.
2. Develop FWSS targeted to specific subbasins and incorporated areas of concern (over-appropriated or high growth areas).

7.2 WATER STORAGE

1. Prepare a primer explaining different storage concepts – how they work, contraints to development.
2. Better quantify surface water storage potential by subbasin.
3. Identify potential for small off-stream storage projects (amount and locations of potential storage).
4. Explore examples or case studies of small storage project development elsewhere in Eastern Washington (e.g., Rosa-Sunnyside), including funding approaches used.
5. Estimate aquifer storage potential for WRIA 49 aquifers.

7.2.1 Precipitation

1. Estimate the accuracy of the NRCS maps and the effect of data uncertainty on water balance calculations.

Rationale: Water balance calculations rely on the NRCS precipitation contour map, which was apparently developed from station data and a model to fill in areas with no station data. The station location distribution is preferential to valley bottoms and towns, so there is very little data for high elevations and non/low-populated areas, where the majority of rain and snow occur.

2. Confirm the locations of all precipitation stations and determine the most appropriate time period for statistical calculations.

Rationale: Although, the precipitation data were readily available from three different data sources, there may be other sources that have not reported their data to the National Climate Data Center. Further, statistics such as mean annual precipitation is generally not comparable among stations because they may reflect different periods of record.

7.2.2 Evapotranspiration (ET)

1. Check the calculations for ET using equations based on independent means.

Rationale: Water balance calculations assumed ET as an unknown, and ET data are not readily available.

7.2.3 Groundwater

1. Research and analyze existing groundwater database to assess short and long-term water well production by area

Rationale: The water well database provides a significant amount of data about a well when it was first drilled but there are no follow-up data.

2. Establish a groundwater-monitoring network in areas of concern to provide data that could be used to determine if any trends are apparent.

Rationale: Water balance calculations assume that the long-term change in groundwater storage is zero but no long term groundwater level records were identified for use in Level 1 so this assumption cannot be validated.

1. Conduct a systematic survey of existing well owners to help clarify the usefulness of the WRATS database for estimating water withdrawals.

Rationale: Using only the WRATS database probably overestimates total withdrawals.

2. ndependently check water balance assumptions by using various process models that consider, for example, soil/rock type, infiltration potential, moisture availability, or performing groundwater budget analyses for smaller or local zones or areas or aquifers where more data exist, and then extrapolating the results to larger areas.

Rationale: Water balance calculations assumed that recharge could be calculated as a percentage of precipitation ranging from 1 percent to 5 percent depending on the subbasin. However, there are no recharge data available to validate this assumption. Further, water balance calculations assumed that groundwater discharge was equal to groundwater recharge, but there are no data to support this assumption.

7.2.4 Streamflow

1. Validate the estimates of mean annual flow for those basins with little or no data.

2. Conduct additional research with county and irrigation district records to evaluate and estimate annual and monthly irrigation withdrawals from streams in areas of concern.

3. In drainage basins of concern, conduct field studies and water budgets to identify gaining and losing stream reaches (level of hydraulic continuity), and the locations of discharge from groundwater and springs into streams. Further, inventory and quantify the effect of reservoir and lake storage on streamflow budgets.

4. Examine flows in systems where never measured to establish, at a minimum, base, peak and mean annual flows (e.g., Chopaka, Sarsapkin, Cecile, Chewiliken, Mosquito, Aeneas Creeks, Swamp, Whitestone).

5. Expand measurements in systems where only point measurements have been made to provide for estimates of flow under multiple stage conditions (e.g., Antoine, Siwash, Loup Loup, Tallant, Tunk, Omak and Chiliwist Creeks).

6. Where streamflow measurements were only conducted downstream of a diversion, expand the monitoring such that the natural flows upstream of the diversion are also measured.

7. Expand monitoring in systems where only short periods of record are available to ensure that a baseline of the annual hydrograph of the tributary can be established (e.g., Ninemile Creek).

8. Install pressure transducers and develop stage discharge relationships at water quality monitoring where continuous temperature monitoring devices are in use.

Rationale: This information can be used to examine the relationship between streamflow and temperature in a more rigorous fashion than is currently possible.

7.3 WATER QUALITY

1. Sample tributary temperatures to capture afternoon “worst case” condition for temperature.

Rationale: Much of the temperature sampling conducted by the OCD to date is biased in that sampling was nearly always done before noon, for consistency – per Ecology guidance). Alternatively, explore expanded use of continuous monitoring devices.

2. Sample for metals and organic pollutants in tributary systems where baseline data are lacking to enable better characterization of source(s) where problems with water quality exceedances have been identified (particularly in the mainstem).

3. Examine whether silver exceeds the water quality criteria in the mainstem by measuring silver in water with analytical limits of detection appropriate to the water quality criteria.

4. Establish baseline data for conventional parameters in tributaries where few or no data have been collected (e.g., Chewiliken, Wannacut, Whitestone, Aenias).

5. Sample mainstem upstream of Mallot, between the next upstream sampling station, to better understand trend in decreasing water quality and potential sources of parameters exceeding water quality criteria (e.g., fecals).

6. Establish water quality sample stations across tributary basins such that they are stationed at positions that capture roughly equivalent surface area for drainage upstream.

Rationale: This approach would allow for better cross basin comparisons of the parameters analyzed.

7. Clarify the relationship between streamflow and water quality exceedances (where identified) and investigate potential remedies, as available.

8. Continue all monitoring programs established in recent years with the objective of transitioning from baseline data collection to effectiveness monitoring program.

7.4 AQUATIC HABITAT ASSESSMENT, INSTREAM FLOW AND FISHERIES

1. Establish aerial photographic coverage of mainstem and tributaries at a scale that allows for a broad scale assessment of riparian coverage.

Rationale: Existing aerial photographic coverage is out of date, incomplete, and/or at a scale that is not essentially useful.

2. Refine analysis of CCT habitat data for more accurate characterization of the tributary systems that were sampled under the EMAP program.

Rationale: Raw data were received from CCT too late to fully consider, and many analytical interpretations are beyond Level 1.

3. Refine assessment of what would constitute "properly functioning conditions" for fish habitat specific to the Okanogan basin's range of altitude, climate, gradients, and historical riparian conditions.

Rationale: Such a system would greatly improve the value of habitat data interpretations.

4. Characterize relationship between instream flow and usable habitat area in tributary streams supporting salmonids; with one exception, this has not been done throughout the basin.

Rationale: Given overallocation of surface waters, it is useful to understand where only minor increases in flow could have substantial increases in habitat benefit.

5. Collect physical habitat data from the tributaries draining the western portion of the watershed, where habitat data are almost completely lacking.

Rationale: Data collection by the CCT under the EMAP program has focused only on Salmon Creek, Loup Loup Creek, and tributaries draining the eastern basin.

6. Analyze site-specific habitat data collected near and around areas where mainstem steelhead spawning occurs to improve understanding of conditions that may be unique to the Okanogan basin.

Rationale: Steelhead spawning surveys in 2005 document noteworthy concentrations of redds [nests] short distances downstream of the more significant tributary confluences.

7. Consult with the CCT to ensure that any additional habitat data collection and/or analysis conducted through watershed planning represents value added, and not replication of effort.

8. Refine analysis of stream channel slope data to include channel confinement, sinuosity, etc. as a means to identify those reaches most likely to exhibit a response to anthropogenic impacts and to identify areas that may be responsive to habitat improvements such as wood placement.

7.5 GIS AND MAPS

1. Correct erroneous information that is retained in existing maps. E.g., irrigation flumes and canals that have not been in existence for more than 30 years, connection between Whitestone and Spectacle Lake, etc.
2. Map potential fish habitat, especially in upper tributaries.

3. Some maps show anadromous fish habitat in non-connecting streams. Correlate barrier survey with fish habitat mapping, including potential fish habitat.

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