Okanogan Watershed Water Quality Management Plan

A PLAN TO ADDRESS NONPOINT AND POINT SOURCE POLLUTION AND IDENTIFY IMPLEMENTATION STRATEGIES.

Final

May 2000

Developed by the Okanogan Watershed Stakeholder's Advisory Committee
&
Technical Advisory Committee
with support from:
Okanogan Conservation District
Okanogan County

Funded in part by Centennial Clean Water Fund grants administered through the Washington Department of Ecology.

Dedication of Document
The Okanogan Watershed Water Quality Plan

The members of the Okanogan Watershed Committee (Okanogan County Board of Commissioners and me Okanogan Conservation District Board of Supervisors) dedicate this document, the Okanogan Watershed Water Quality Plan, to the members of the project Stakeholders' Advisory Committee (SAC) in recognition of their commitment and voluntary service on behalf of the citizens and the invaluable water resources of Okanogan County.

Furthermore, the Watershed Committee members wish to make a matter of record: 1) their commitment to the objectives set forth in the plan and; 2.) the achievement of significant improvements in water quality for all its beneficial uses and residents of the Okanogan River Basin.

Lastly and very importantly, the Watershed Committee recognizes the wealth of knowledge on water quality issues attained by members of the Stakeholders' Advisory Committee through their three-plus years of meetings, technical and issue paper reviews, discussions, and on-site field trip evaluations. This knowledge and the level of communication and trust developed between them as representatives of various constituencies is an invaluable resource for the people of Okanogan County. In light of the above, the Watershed Committee commits to honor the request of the Stakeholders Advisory Committee members that they be provided every possible opportunity for continued involvement both in regard to the implementation of the Okanogan Watershed Water Quality Plan, to which they have contributed so greatly, and to all additional efforts and activities directed towards the enhancement of water quality in Okanogan County.

<u>Further acknowledgement to the public agency Stakeholders' Advisory Committee participants:</u> The Watershed Committee wishes to express their special thanks to the public agency representatives, both state and federal, who have served faithfully and contributed their considerable knowledge and expertise to the deliberation of the Stakeholders' Advisory Committee. This required attending innumerable after-hours meetings throughout the three-year plan development process and m many cases was done without consideration or lessening of their normal full-time workload responsibilities.

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Key to Acronyms

BLM	Bureau of Land Management (USDI)
BMP	Best Management Practice
CCT	Colville Confederated Tribes
CRM	Coordinated Resource Management
DNR	Department of Natural Resources (Washington State)
DOE	Department of Ecology (Washington)
DOT	Department of Transportation (Washington)
FSA	Farm Service Agency (USDA)
GIS	Geographic Information System
NMFS	National Marine Fisheries Service (NOAA)
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service (USDA)
OCD	Okanogan County Conservation District
OCHD	Okanogan County Health District
OID	Okanogan Irrigation District
OTID	Oroville-Tonasket Irrigation District
PUD	Public Utility District (may either be Okanogan or Douglas Counties)
SAC	Stakeholder's Advisory Committee (Okanogan Watershed)
TAC	Technical Advisory Committee (Okanogan Watershed)
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USF&WS	United States Fish & Wildlife Service (USDI)
USFS	United States Forest Service (USDA)
USGS	United States Geologic Survey (USDI)
WDFW	Washington Department of Fish & Wildlife
WSUCE	Washington State University Cooperative Extension

1 Introduction

This document is known as the Okanogan Watershed Water Quality Management Plan. It was developed to characterize the environments of the Okanogan River Watershed and recommend action items necessary to protect or improve water quality conditions. This document will not in any way address water rights.

Watershed Management Plan

In 1995, the Okanogan Conservation District and Okanogan County each sought grant funding from the Washington Department of Ecology to characterize pollution in the Okanogan River Watershed. The Department of Ecology was interested in completing both non-point and point source water quality characterization at the same time. Therefore, they contacted both the County and Conservation District in the summer of 1995 asking them to work together and complete a joint project. In this project, the County would characterize non-agriculture related pollution and the Conservation District would focus on agriculture related pollution.

The County and Conservation District consented to this format and thus the long journey began. Approximately one year later the scope of the project was determined and each party had a contract that detailed what activities would be accomplished during this project.

The Conservation District was tasked with convening a local citizen based committee, which would advise the County Commissioners and Conservation District Supervisors on recommendations to improve and protect water quality. On December 16, 1996 the first Stakeholder's Advisory Committee meeting was held in Okanogan. To supplement the knowledge of the Stakeholder's Advisory Committee, a Technical Advisory Committee was formed that would provide technical knowledge and resources to the project.

Since the first meetings the two committees have been meeting on a regular schedule to accomplish the tasks required to meet the needs of the grant contracts. The Stakeholder's Advisory Committee (SAC) met regularly twice per month while the Technical Advisory Committee met once per month for the majority of the project and nearing completion was meeting twice per month. The Stakeholder's Advisory Committee met a total of 51 times, while the Technical Advisory Committee met a total of 30 times.

During these meetings, information was gathered shared and disseminated. It was not always a fun process, however after many months of meetings and information gathering the two committees have come up with a list of identified problems and concerns. In addition, the committees have established action items to be completed.

Desired Future Conditions

Desired future conditions are statements of a goal to be reached in which the purpose of work is achieved. Usually there is a timeline given such as twenty or thirty years. In the case of this document, it is a statement of what the water quality conditions are hoped to be at various points along a twenty (20) year timeline. Below is the statement of desired future conditions for the Okanogan Watershed Water Quality Management Plan:

"It is the goal (intention) of the SAC to achieve:
In five years (2005), significant progress in addressing the most serious water quality problems identified in the plan.
In ten years (2010), resolution of the most serious problems and significant progress on all problems and concerns identified.
In twenty years (2020), water in the Okanogan River will be of good quality for all beneficial uses as identified now and in the future.

Sources of pollution presently identified will have been addressed and local residents will be working together to identify and address additional sources of pollution, as they occur to maintain water quality at a high level continuously into the future.

The Okanogan Watershed Water Quality Management Plan Watershed Committee (Okanogan Conservation District and the Okanogan County Commissioners) are committed to the above timeline objectives with regard to projected activities for which each ahs been identified as the lead entity contingent on the availability of technical assistance and funding."

What Are the Pollution Sources in the Okanogan

There are many types and sources of pollution in the Okanogan. By definition, pollution is any substance that causes something such as air or water to be unsuitable for use. For example, high amounts of chemicals such as arsenic in water can be harmful to humans. Thus, knowing as much as we can about how water is polluted and how to prevent pollution can have a direct impact on humans. Pollution is generally divided into two types, point source and non-point source pollution.

Point source pollution is pollution that originates from one source and with proper testing can be tracked back to the point of input. This type of pollution is most commonly found originating from industrial areas or city sewage treatment plants. Point source pollution can be found elsewhere, such as in agriculture with an accidental spill of a pesticide.

Non-point source pollution is pollution that originates over a broad area such as pesticide runoff from orchards, or sediment from roads and streambanks that are unstable due to human causes. This type of pollution is most commonly found originating in rural areas. However, one distinct form of non-point source pollution found in cities is run-off from city streets. Most cities now have at lease rudimentary storm sewers and although they discharge to one point, they are considered a form of non-point source pollution because they discharge material and debris from a large broad area.

Another distinction about point source pollution that needs to be made is that many times one source of pollution is of such a nature to degrade water quality beyond acceptable limits all by itself. Whereas, one source of non-point pollution such as run-off from a small hay field will usually not cause severe effects to water quality.

Committees

Three committees worked together to develop this plan. Each committee had a distinct purpose and role in this project. The three committees included the Watershed Committee, Stakeholder's Advisory Committee (SAC), and the Technical Advisory Committee (TAC).

The Watershed Committee is comprised of the Okanogan County Commissioners and the Okanogan Conservation District Supervisors. This committee has complete oversight over the project as the responsible parties to the residents of the watershed and to the Department of Ecology for the grant funds they received. Their role was to first identify the necessary stakeholder's for the SAC, and second to assist project participants in any way they can. Their final role will be to review this document and amend it as necessary and/or forward it to the Department of Ecology for approval.

The Stakeholder's Advisory Committee was developed to provide the necessary local input into the project. The members of the Watershed Committee wanted this project to have strong local support. They decided the best way to do that would be to have representatives of local stakeholder groups come together to review data, develop the plan, and make recommendations they felt they could live with. The SAC is comprised of representatives of 10 resource groups such as the Okanogan County Cattlemen, Horticulture Association, and environmental groups. Also sitting on the SAC are representatives of local, state, federal, and tribal agencies that manage lands and water in the watershed.

The Technical Advisory Committee was developed to assist the SAC in identifying data, characterizing the watershed, and identify problems and solutions. This committee was made up almost exclusively of local, state, federal, and tribal agency representatives.

Public Involvement

Public input into this document is essential. Throughout the duration of this project, meetings were open to the public and meeting times and locations were announced in local newspapers and radio stations. All efforts were taken to receive public comment during the development of this document. Additionally, opportunities were provided for interested persons to submit verbal and written comment on draft versions of the plan. This was accomplished through a public comment period and a series of public hearings on the plan that were held throughout the watershed.

Concurrence

Meetings will be held with those groups identified to take the lead in the action items. These meetings will be to gain agreement that they will implement the action items to the best of their ability and as funding allows. When such a time as statements of concurrence can be obtained, they will be included with this document as a sign of the commitment that exists in the watershed to preserve, enhance, or improve our water quality.

2 Watershed Overview

Watersheds are the lands that water flows across or under on its way to a stream, river, lake, or ocean. This plan focuses on the watershed lying within the boundaries of Water Resources Inventory Area 49 (WRIA 49). The Pasayten and Ashnola Rivers in northwestern Okanogan County drain approximately 300 square miles into the Okanogan River Watershed, however these drainages are not included in WRIA 49. Despite the fact that these drainages are not within the WRIA boundary, they will be covered by this plan. A significant portion of the geographic watershed lies within British Columbia, Canada. However, this area (approximately 6,300 square miles) will only be covered minimally within this plan due to the fact they are outside of the jurisdiction of our planning efforts. Additionally, the area identified as the East WRIA area has been included in this plan.

Description of the Watershed

The Okanogan River Watershed is a sub-watershed of the Columbia River Watershed. The Okanogan River Watershed is located in north central Washington State and encompasses approximately 2,600 square miles or more than 1.65 million acres (see Map 1). The Okanogan River is considered the northernmost geologic dividing line between the Cascade and Rocky Mountain Ranges. Within the Okanogan River Watershed, there are numerous sub-watersheds. These sub-watersheds are listed with approximate size in Table 2.3 and referenced to Map 1.

The Okanogan River runs primarily north to south through a mountainous region that has elevations ranging from the 8,242-foot summit of Tiffany Mountain to the level of Lake Pateros (reservoir behind Wells Dam on the Columbia River) at 779 feet (average elevation) above sea level. The eastern and western portions of the watershed are dominated by forested ridgelines that are steep and rugged. From these ridgelines smaller lateral ridges extend toward the Okanogan River forming the numerous smaller sub-watersheds. These sub-watersheds have streams that are fed by rain and snowmelt, then empty into the Okanogan River.

The floodplain of the Okanogan River averages approximately one mile in width. The elevation of the valley floor ranges from the water level of Lake Osoyoos at 915 feet (average elevation) to the level of the Lake Pateros at 779 feet (average elevation). There are many natural terraces created mostly of glacially deposited gravel and sands. These terraces rise as much as 500 feet above the flood plain and intersect many of the lateral ridgelines [Washington State Department of Ecology (DOE), 1995).

> "The bedrock geology of the basin is composed primarily of granitic, andesitic, metamorphosed sedimentary and basaltic rocks. These rocks form a complex arrangement of geologic terrains which are, in places, highly fractured, folded and faulted. During the last large-scale glaciation, more than 10,000 years ago, the entire Okanogan drainage was overridden by the Okanogan Lobe of the Cordilleran ice sheet. As the glacier melted it deposited sequences of silt, sand, gravel, and cobbles. These sequences of unconsolidated materials are generally present as valley fill and along valley

walls as terraces. More recently modern rivers have scoured the bedrock and glacial deposits and redeposited them as additional sand and gravel terraces and plains. A review of well logs, and previous reports indicates that the valley fill and terrace deposits may be more than 500 feet thick in areas" (DOE, 1995).

The soils of the watershed have been placed into three major groups:

"Soils of Steep and Very Steep Mountainous Lands. Soils are slightly acid to extremely acid, sandy loam to silt loam soils formed in volcanic ash, glacial materials, and weathered granite, schist, limestone, shale and gneiss. These soils are dominantly forested.

Soils of the nearly level to strongly sloping valleys, terraces, plateaus, and till plains. These soils are moderately deep and deep loam, silt loam, and sandy loam formed in glacial outwash, alluvium, ash, and pumice. Some bottom land soils are sandy loam formed in glacial outwash, alluvium and lake sediments. Also included in this group are moderately deep and deep loam soils formed in glacial till with some wind-laid silts, ash, and pumice overlay. These soils are mainly used for forage and crop production; some areas also have shrub and forest cover.

Soils of gently sloping to steep uplands. These are deep, silt loam and loam soils formed in volcanic ash and glacial till and underlain by granite, basalt, andesite and limestone. They are primarily in grassland cover" (Pacific Northwest River Basins Commission, 1977).

Cool winter precipitation and dry hot summer conditions characterize the climate of the Okanogan River Watershed. The climate is influenced considerably by the barrier to marine air that the Cascade Mountain Range provides. Other factors that influence the climate of the region are the mountain and valley formations of the region. Precipitation in the watershed ranges from more than 40 inches in the western mountain region to approximately 8 inches at the confluence of the Okanogan and Columbia Rivers. Precipitation in the main river valley ranges from approximately 12 inches annually near Oroville to 13 inches near Omak [National Oceanic and Atmospheric Administration (NOAA), 1994].

Mean annual temperature for the Okanogan Watershed is 49°F. The average temperature for January is 21°F. and the July average is 73°F. Wind velocities throughout the region are calm to moderate and generally originate from the north or south. Thunderstorms occur occasionally in the watershed during late spring and early summer. Summer months see approximately five cloudy days per month compared to winter months, which average approximately 20 cloudy days per month. On average, there are 150 frost-free days each year in the main Okanogan River Valley. The number of frost-free days reaches only about 75 days in the surrounding hills and uplands (NOAA, 1994).

The hydrology of the Okanogan River Watershed is characterized by high springtime run-off due to spring rains and melting snowpack, with low summer and early fall flows due to nearly absent precipitation and diminishing snowpack. Irrigation practices may have subsequently reduced summer flows further. The United States Geological Survey (USGS) has been recording flows in the Okanogan River Watershed continuously since 1911. Table 2.1 identifies the USGS station number and various flows at each station since each started recording. All flow data are taken from records beginning the year the station started, to water year 1996.

Table 2.1
USGS Recording Stations Flow Records
Okanogan River Recording Stations

Station #	Location	Year Started	Average Flow	Highest Flow	Lowest Flow
12438700	Oliver, B.C.	1944	639 ft^3/s	3,740 ft^3/s	55.9 ft^3/s
12439500	Oroville	1942	676 ft^3/s	3,730 ft^3/s	-2,270 ft^3/s
12445000	Tonasket	1929	2,940 ft^3/s	44,700 ft^3/s	126 ft^3/s
12447200	Malott	1958	3,063 ft^3/s	45,600 ft^3/s	288 ft^3/s*

** This record was observed and not recorded.*

Similkameen River Recording Station

12442500	Nighthawk	1911	2,289 ft^3/s	45,800 ft^3/s	65 ft^3/s

Source: United States Geological Survey Water Resources Data Washington Water Year 1995, pages 314-319.

The Oroville gauging station on the main stem Okanogan River located approximately one mile upstream of the confluence with the Similkameen River records reverse flows during high spring runoffs. The floodplain is nearly level and as such during high spring flows water flows up channel in the Okanogan River to the gauging station causing a reverse flow reading.

The population of Okanogan County in 1998 was approximately 38,400 [Washington State Office of Financial Management (OFM), 1999]. Population figures have never been collected specifically for the Okanogan River Watershed. According to figures collected in 1998 by OFM, the unincorporated population of Okanogan County was 22,964 or 60 percent of the total county population. The unincorporated area shows an increase of 3,670 people since the 1990 census when the unincorporated population was 19,294. This accounts for a growth rate in the unincorporated areas of 19%. In Table 2.2 below the incorporated areas are listed with their respective populations in 1990 and 1998 and the associated percent increase over that time period.

The first human residents of the project area were Indians. “It has been established that humans have been living in Okanogan County for at least 7,000 years and perhaps longer” (Wilson, 1990). The structure of their communities was one of, “. . . small autonomous bands or villages” (Honey, 1979). “Most of the Indians of eastern Washington, northern Idaho, northwestern Montana and lower British Columbia spoke related languages referred to as ’interior Salishan’” (Wilson, 1990). “But even among interior Salish of the greater Okanogan County area seven languages were spoken: Shuswap and Lillooet; Thompson; Okanogan; Columbia; Kalispel; and Coeur d’ Alene” (Wilson, 1990).

Table 2.2
City Populations

City	1990	1998	% Increase
Brewster	1,633	2,050	25.5%
Conconully	174	205	1.8%
Okanogan	2,370	2,415	1.8%
Omak	4,117	4,435	7.7%
Oroville	1,505	1,595	5.9%
Pateros	570	595	4.3%
Riverside	223	365	63.7%
Tonasket	900	995	10.6%

Source: Washington Office of Financial Management. April 1 Population of Cities, Towns, and Counties Used for the Allocation of Designated State Revenues, 1999.

These first inhabitants were hunters and gatherers who depended primarily upon salmon, roots, and berries. These small bands would move from location to location in a yearly cycle based on what run of fish were migrating, and the availability of other food sources such as berries and roots. As Bruce Wilson states in Late Frontier A History of Okanogan County, Washington, "When the whites came into the Okanogan county area in the early 1800's, they found here a semi-nomadic native people living in harmony with a benign environment, the yearly cycles of their existence molded by the changing seasons". The yearly cycle included spring hunts for bear that were just coming out of hibernation, fishing the early runs of salmon, sockeye, and Chinook, and gathering edible roots. As the season changed to summer they focused primarily on ripening berries, roots and most importantly the sockeye and Chinook fish runs. During the fall months they focused primarily on deer hunting and gathering late season berries.

William D. Honey states in his A Survey and Evaluation of Cultural Resources Phase I of the Oroville-Tonasket Unit Extension that:

> "At the time of Euroamerican contact in the early eighteenth century, eight aboriginal groups occupied or utilized the Okanogan Valley and its associated resources. These groups came to be known as the Southern Okanogan, Okanogan, Wenatchi, Columbia, Lakes, Ne Palem, Colville and Sanpoil".

Honey goes on to state:

> ". . . names given to various groups arose out of both historical and theoretical circumstances. Early settlers, traders, missionaries and government officials entering the region carried with them from the east the idea that all Indians were organized along tribal lines".

The Okanogan River Watershed was first inhabited by whites in the early to mid 1800's. The white settlement of the area is much the same as the rest of the western United States. First, trappers and traders moved into the area relying on the diverse wildlife of the area. These trappers would trade their goods at Fort Okanogan, which was located in the southern part of the watershed. Next came the farmers and ranchers to the valley. Hiram "Okanogan" Smith planted the first apple orchard in the watershed near Lake Osoyoos in 1857. This would become the mainstay of the local economy in years to come, however it was slow to evolve due to the lack of transportation for the harvest and the lack of developed irrigation systems. “A federal census of 1870 enumerated John Utz, 45, saloon keeper, Hiram F. Smith, 40, retail merchant, three farm laborers, two white gold miners, and 27 Chinese, presumably placer mining on the Similkameen, as non-Indian residents of the northern Okanogan” (Wilson, 1990).

18,000 miners and associated followers moved to the Fraser River area of British Columbia in 1858 searching for gold. This influx of people to the north of the Okanogan Basin had a profound effect on the local area because it spurred large cattle drives up the Okanogan River Valley. Bruce Wilson states in his Late Frontier A History of Okanogan County, Washington:

> “The British customs station at Osoyoos during its first 2 ½ years, from early 1862 to mid-1864, collected duty (usually $1 a head for livestock) on 7,720 cattle, 5,378 horses, 1,317 sheep, and 948 mules. From 1859 to 1870, duty was collected on 22,256 head of beef cattle. In all likelihood, as many cattle or more escaped the collector’s attention. During the peak years, from 1862 to 1866, the demand for fresh beef in the northern mining camps was insatiable. Nearly all that arrived came by way of the Cariboo Trail”.

The discovery of gold brought about major migrations of people to the watershed in the late 1800’s. This influx of residents caused “boom towns” to spring up in many areas of the watershed. The most famous town was Ruby, which became the first county seat of Okanogan County in 1888. The county seat was moved eleven months later to Salmon City (now named Conconully). Soon afterwards the gold diminished, the miners moved away and the boom towns declined in size and distinction.

The mining economy was replaced by dryland farmers and ranchers. During high spring flows, riverboats (paddle wheelers) would move up the Okanogan River to the town of Riverside and offload goods and more settlers. In 1914, the Great Northern Railroad came to the basin virtually replacing the paddle wheelers. Following on the footsteps of the railroad was the extensive expansion of irrigation systems throughout the valley. With the relatively fast and reliable railroad service to the area, farmers were able to convert more and more ground into agriculture commodities (most notably was fruit orchards). With this stabilization in transportation and the development in the economic base, communities became more settled and permanent.

Land within the Okanogan River Basin is split almost evenly between public, private and Tribal ownership. The lands of the Colville Indian Reservation that fall within the boundary of the study area were not split between public and private because there are actually four classes of ownership. These ownership classes are: Fee, Allotment, Tribal Trust, and Tribal. Fee land is land within the reservation boundary that is owned by any individual, and who pays property taxes to the County for that land. Allotted land is land that was given to a member of the tribe when the reservation was formed and typically has been divided up among succeeding generations. Tribal Trust is land that was Allotted land at one time, but the management of the land has been given to the Tribe. Tribal land is all other land within the reservation and is managed for Tribal member use.

Land ownership is broken down in Table 2.4. There are many land uses within the Okanogan Watershed. These land uses and cover types are included in Table 2.5.

Table 2.3
Okanogan River Sub-watersheds

Reference letter	Name	Area (acres)	Tributary to:
A	Okanogan River – Interfluve	204,398	Columbia River
B	Nine Mile Creek	13,516	Okanogan River Interfluve
C	Tonasket Creek	37,874	Okanogan River Interfluve
D	Mosquito Creek	6,093	Okanogan River Interfluve
E	Antoine Creek	46,690	Okanogan River Interfluve
F	Siwash Creek	31,032	Okanogan River Interfluve
G	Bonaparte Creek	97,877	Okanogan River Interfluve
H	Chewilken Creek	17,125	Okanogan River Interfluve
I	Tunk Creek	45,586	Okanogan River Interfluve
J	Wanacut Creek	12,595	Okanogan River Interfluve
K	Omak Creek	90,691	Okanogan River Interfluve
L	Chiliwist Creek	27,841	Okanogan River Interfluve
M	Loup Loup Creek	40,868	Okanogan River Interfluve
N	Tallant Creek	9,832	Okanogan River Interfluve
O	Salmon Creek	98,625	Okanogan River Interfluve
P	Brown Lake/Johnson Creek	28,694	Okanogan River Interfluve
Q	Sinlahekin Creek	189,521	Similkameen River
R	Aeneas Creek	6,890	Okanogan River Interfluve
S	Spectacle Lake/Whitestone Lake	27,333	Okanogan River Interfluve
T	Similkameen River	228,536	Okanogan River Interfluve
X1	Omak Lake	68,685	Self Contained Basin
X2	Duley Lakes/Joseph Flats Area	51,319	Self Contained Basin
X3	Fish Lake Basin Area	23,124	Self Contained Basin
X4	North Fork Pine Creek	23,841	Self Contained Basin
X5	Aeneas Lake	21,246	Self Contained Basin
X6	Wanacut Lake	13,853	Self Contained Basin
X7	Swamp Creek	64,158	Columbia River
X8	Columbia River Interfluve - East WRIA Area	139,955	Columbia River
	Total	***1,667,798***	

Source: USDA Natural Resources Conservation Service GIS data, unpublished.

Table 2.4
Land Ownership

Land Owners	**Approximate Acres**
Department of Agriculture – Forest Service	357,000
Department of the Interior	
Bureau of Land Management	48,000
Fish and Wildlife Service	2,750
Department of Defense	375
Federal Subtotal	*408,125*
Washington State	
Department of Natural Resources	245,000
Department of Fish & Wildlife	29,873
Department of Parks & Recreation	600
State Subtotal	*275,473*
County	300
Municipal	2,900
Total Public (federal, state, & local)	**686,798**
Tribal	**422,000**
Total Private	**559,000**
Total Land Area	***1,667,798***

Source: USDA Natural Resources Conservation Service GIS data, unpublished.

Table 2.5
Cover & Land Use

Land use	**Approximate Acres**
Forest	787,070
Range	754,996
Cropland	101,930
Urban	5,737
Other	18,065
Total Land Area	***1,667,798***

Source: USDA Natural Resources Conservation Service GIS data, unpublished.

3 Watershed Characterization

Introduction

This chapter is intended to be a characterization of the watershed based upon available data and the knowledge of all the people that have worked on this project. Each section was authored by a member of the Technical Advisory Committee. When each section was drafted, it was reviewed by the Technical and Stakeholder's Advisory Committees numerous times to ensure that the sections best represented local conditions. The following individuals either authored or co-authored one or more sections of the characterization.

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Due to the overwhelming size of the watershed and general scope of the project, this chapter covers the watershed in a general fashion. Where it was thought pertinent and supportive, specific items were drawn upon to highlight the author's point. One result of this is the creation of many tables that have been included in the section titled Appendix C.

The environment of the Okanogan River Watershed can be impacted both positively and negatively by human landuse activities and naturally occurring events. Seemingly, irrelevant activities can have impacts, direct and indirect, on water quality. For example, forest regeneration can alter species composition, stand densities, and subsequent water infiltration to ground and/or surface waters. Another example is that different agricultural crops and rotations impact water quality by changing types of pesticides used, altering application rates of fertilizer, and changing potential runoff rates due to vegetative or residue cover.

Forest

Extent

Forest land comprises approximately 47% of the Okanogan River basin. Forests can be classified into series, identified by climax tree species. Conceptually, climax species would dominate plant communities, which have stabilized after relatively long disturbance-free periods. In the Okanogan, five series exist; ponderosa pine, Douglas fir, subalpine fir, whitebark pine, and subalpine larch (Lillybridge et al., 1995). Series do not occur in uniform bands across the landscape, but lay more in a mosaic, which can also include non-forested areas of shrub-steppe. Individual site characteristics such as soil type, elevation, precipitation, and aspect contribute to the variation. Major tree species include ponderosa pine, Douglas fir, lodgepole pine, Englemann spruce, western larch, subalpine fir, and aspen. Whitebark pine and subalpine larch occupy alpine settings. Black cottonwood, water birch, and white and thinleaf alder are found in riparian groves though these can also contain any of the tree species (Arno, 1977).

Four general ownership categories exist for forest land: federal, state, tribal trust, and private. Federal lands are managed primarily by the United States Department of Agriculture, Forest Service (USFS). The Bureau of Land Management manages a small portion of federal lands. A general goal in management is to allow multiple use while maintaining forest and resource health. Management of National Forest lands is based on requirements of the Organic Act, Multiple Use-Sustained Yield Act, National Environmental Policy Act, Forest and Rangeland Renewable Resources Planning Act, National Forest Management Act, Wilderness Act, and Endangered Species Act. The Okanogan National Forest Land and Resource Management Plan also guides management of the National Forest lands. Management emphasis varies from timber and range forage to wilderness on National Forest lands.

State lands include those managed by the Washington Department of Natural Resources (DNR) or Washington State Department of Fish and Wildlife (WDFW). DNR manages to support a set of trusts such as the State Common School Construction Fund. This management is governed by legal trust doctrine and the forest management is guided by a Forest Resource Plan (1992). The large block of trust land located north of Conconully has an individual landscape plan, The Loomis State Forest Plan (1996). Non-trust lands also managed by DNR include aquatic lands, Natural Resource Conservation Areas and Natural Area Preserves. On WDFW lands, management emphasizes maintenance of wildlife habitat.

Tribal lands may be considered to include lands owned in common by the Colville Confederated Tribes (CCT) and allotments owned by individual tribal members. They are managed cooperatively by CCT and the federal Bureau of Indian Affairs (BIA). The BIA management is based on trust doctrine. The CCT is developing an Integrated Resources Management Plan (Phase I, 1997 and Phase II, 1998) to guide natural resource management on lands within the reservation.

Private lands are managed by their owners who may retain the services of professional forestry consultants. Conservation and stewardship advice is available from agencies such as DNR, WDFW, Natural Resources Conservation Service (NRCS), and USFS. Open Space or Timber Tax status for parcels of land may be obtained through the county assessor. A landowner qualifies by submitting an application with a professionally prepared resource management plan to the assessor.

Land within the various ownership categories lies in scattered distribution across the basin. There are large blocks of federal, tribal and state managed land. Interspersed within these blocks are parcels managed by other agencies or are privately owned. Throughout the rest of the basin, ownership is varied with smaller ownership sizes controlled by individual owners. One trend evident within the watershed is the division of larger private ownerships into smaller parcels, generally 20 acre lots. During a four-year period (1994-1997), approximately 11,000 acres of forestland were segregated into lots (Bob Clark, personal communication, 1997). As these parcels are sold, characteristics of land ownership and use are changing.

Forest land provides a variety of resources for its owners, managers, or users. These resources include timber and other forest products, range forage, homes, recreation settings, and scenic beauty. Often several may be derived in combination from the same parcel of forestland. Individual owners can have different objectives for their forests. Accordingly, forest management may emphasize production of any of the individual resources or a combination.

Forests also provide resources in which the public, as a whole, has a stake. These include water, fish, wildlife, and clean air. The protection of these resources is achieved through compliance with laws such as the Forest Practices Act. The act requires that provisions for water quality and fish and wildlife habitat protection be followed during forest management activities.

Timber and vegetation management is the means typically used in managing forest resources. Wood and other products are grown and harvested. Range forage is grazed (see the Grazing section). Fuels can be managed to reduce wildfire risk. Plantings, specifically designed harvest, and placement of debris or habitat structures may enhance habitat value. Safety of recreational or residential users in developed forest settings is improved by removal of hazard trees.

Each owner needs access to their property to fulfill management objectives. Accordingly, the system of roads which provide access to forest lands is extensive. Although roads typically provide physical access to a parcel, legal easement is not often obtained or granted. Road use and responsibility for maintenance are often an issue in these situations.

Timber management practices may be grouped by function into four groups; forest regeneration, stand maintenance, road construction and maintenance, and harvest.

Forest regeneration activities include preparation of a site for tree planting or natural regeneration, and the actual planting of seedlings. In the Okanogan, site preparation methods used include broadcast burning, piling and burning, or simply scattering slash. The different methods will be appropriate on specific sites based on considerations such as nutrient cycling, fire, erosion, silvicultural considerations, and wildlife habitat. Generally, the disturbance to vegetation and soil from logging creates conditions suitable for tree seedlings to reestablish.

Natural regeneration is most commonly used. Seed comes from mature trees standing within or adjacent to regeneration sites or from seed existing on the ground from previous years' seed production. Species composition of the reproduction can be influenced by leave tree selection. However, species composition can be variable with this approach and may not be the most desirable for a manager or owner. Planting of nursery-grown forest seedlings can give the manager more assurance of desired species and stocking levels. Planting may also be necessary to meet legal requirements for reforestation. Summer drought, competing vegetation, and animal damage are three challenges to successful survival of young trees on many Okanogan sites.

Stand maintenance activities are those which contribute to sustained growth and health of forest stands. Pre-commercial thinning, and to a minor extent, fertilization and pesticide application are used for stand maintenance. Most young forest stands start out with more trees per acre than can be sustained over time. Growth is limited by availability of light, water, nutrients, and carbon dioxide (Smith, 1986). Natural thinning occurs over time in most cases, but tree growth and vigor may be less than desired. Trees become more susceptible to damage or mortality caused by insect or disease. In pre-commercial thinning, tree numbers are reduced to give those remaining adequate growing space. Pre-commercial thinning is performed at an age before the trees become merchantable. Due to the high reproduction of Okanogan forests, pre-commercial thinning is often desirable in the management of stands.

Fertilization and pesticide applications of forest lands are rarely conducted. Aerial or ground applications are possible. Weed control is practiced on forest land as on other lands. Cutting or mowing, pulling, chemical, and biological treatments may be applied. On DNR lands, the lessee/land manager (if one exists) or DNR performs weed control. Noxious weeds and their control are covered in the Grazing section.

Timber harvest can be characterized in two ways; silvicultural cutting method and method of yarding.

Harvest practices are varied in the Okanogan watershed, influenced by ownership objectives, forest zones, and vegetation types. They include commercial thinning, selection, seed tree, shelterwood, clearcutting, and salvage. Thinning and light selection harvests retain full stocking on a site, removing defective or high value trees and providing the remaining trees good growing conditions. Heavier selection or partial cuts target a majority of the merchantable volume on site when an appropriate stocking of smaller trees exists prior to harvest. Seed tree and shelterwood harvests leave mature trees distributed across the site to reseed openings and to shelter the reproduction. Clearcutting removes most or all of the trees from a site prior to regeneration. Salvage removes dead or dying trees.

Several yarding methods are used in harvests; ground skidding, line yarding, and helicopter yarding.

Ground skidding is most often used. Horses, rubber-tired skidders, tracked dozers and rubber-tired or tracked forwarders are different methods of ground skidding. Ground skidding is usually the least expensive yarding method. It provides flexibility in skidtrail location, but may cause significant disturbance to soils and vegetation. Soil disturbance impacts can be reduced through a combination of operator skill and plans which indicate where and when skidding should occur. Operations which minimize both skidtrail area and trail locations, particularly on wet soils and steep terrain, tend to minimize impacts. Restricting operations to periods when soils are frozen, snow-covered, or dry can also reduce impacts. Finally, trails may be treated prior to skidding with a slash layer and afterwards by waterbarring, scattering slash, and seeding with grass. Such treatments reduce erosion potential and the spread of noxious weeds.

Line yarding is used less often, primarily to log deep canyons and steep mountainous terrain, or where limited soil disturbance is needed. Logging towers, which provide lift for log suspension, or manually pulling line from the winch of a dozer or skidder are both used. Line yarding is more expensive than ground skidding. Given favorable topography and landing location, logs may be lifted fully over streams and riparian areas. Disturbance to soil and vegetation is highest along line corridors where complete suspension is not achieved. Use of line yarding can often be limited by topographic features such as slope breaks and convex slopes or by lack of adequate tail-holds.

Helicopter yarding is used infrequently in the Okanogan Basin. It can be the only option where road access is impractical or expensive, or long yarding distance and concerns regarding soil disturbance exist. Disturbance to soil and other vegetation is minimized. Flexibility in tree selection is greatest. It is the most expensive yarding method. Costs tend to limit removal of lower valued timber.

Forest road construction, maintenance, and timber haul are forest practices. These are covered in the Transportation section.

Timber harvest levels on the various ownership categories have fluctuated over time. Some reasons for this include changing societal and market values, fire salvage, implementation of management plans, and listing of threatened or endangered species. Harvests removing most of a site's merchantable volume are often associated with private land ownership changes.

Historical conditions

Forests have been used and managed throughout history around the globe. Multiple use management has been practiced for centuries in European countries to produce amenities and forest products. Native Americans also managed the forests prior to Euro-American settlement, harvesting wood and other forest products and conducting burning to maintain desirable seral plant communities.

Throughout the United States, more trees and timber volume exist within forests today than at the turn of the century. Concurrent changes throughout the interior west include a greater share of shade tolerant trees and forests which are more susceptible to damage or mortality from insects, disease, and fire. During this century timber harvest and wildfire suppression have resulted in greater numbers of trees per acre, species composition changes on given sites, and greater fire intensities (Agee, 1993).

Current conditions

Forests naturally undergo continual change. This change is called succession. Changes occur both gradually and sometimes abruptly. Different growth rates of individual trees or species on a given site, destructive agents such as insects or disease which may affect individuals, groups, or species in a stand, or disturbance events such as wildfire, wind, or snow all combine to effect such change. The various forest series have their own pattern of succession due to a natural regime of environmental conditions, disturbances, and other factors.

Nature provides a complex set of checks and balances in stabilizing the existence of forests over time. Forest health or integrity is the term used to describe a forest's resilience to destructive agents and disturbances.

A characterization of forests in Salmon Creek follows:

> “Past timber harvest and mining activities have been concentrated at the lower elevations. The higher elevation forests are relatively untouched by harvest and activities. In general, the past harvesting has created a deficit of late old structure (LOS) stands at the lower elevations and a surplus of early seral stands. Fire suppression has also affected the LOS stands at lower elevations by allowing the parklike ponderosa pine stands to convert to multi-canopied Douglas fir and mixed-conifer stands. In addition, fire suppression has created larger patch sizes and a more continuous forest at the lower elevations. At the higher elevations, fire suppression has allowed development of stands to proceed without stand replacement disturbances. This has resulted in a deficit of early structure stands at the higher elevations and stands that are more susceptible to insect and disease. In addition, this has caused a shift in structure from large patches of varying age and structure to larger patches with homogenous age and structure.
>
> In addition, past harvest activities and the associated road construction at the lower elevations have decreased wildlife security, decreased snag habitat, increased potential for noxious weed spread, and increased sediment to streams" (USFS, Salmon Watershed Assessment, 1997).
>
> Forest conditions within the Omak Creek drainage are described as follows:
>
> “Historic logging practices and fire suppression have changed the forest species composition, structure, and density. These changes have led to unhealthy forest stands over extensive areas of the watershed. Insects and diseases are at epidemic levels. The continuing accumulation of fuels in the forest has the potential to support catastrophic fire events" (USDA, Natural Resources Conservation Service, Omak Creek Watershed Plan/Environmental Assessment).

These conditions prevail generally throughout the Okanogan basin at lower to moderate elevations.

A recent region-wide effort evaluating forest health is the Interior Columbia Basin Ecosystem Management Project (ICBEMP), conducted by USFS and United States Department of Interior Bureau of Land Management. In this project, the Okanogan drainage is divided into two subbasins, the Okanogan and Similkameen. Forest integrity was rated poor within the main Okanogan subbasin, and high within the Similkameen subbasin. High forest integrity is defined as “A mosaic of plant and animal communities; well-connected, high-quality habitat; diverse assemblages of native and desired non-native species" (USDA, PNW-GTR-404, 1997). Ratings of forest integrity were based on forest vegetation characteristics, road density and distribution, and changes in fire severity and frequency.

Composite ecological integrity considers the combined integrities of forest land, rangeland, and forest and range hydrologic and aquatic systems. Composite ecological integrity of the Okanogan subbasin is rated low. It is grouped within Forest Cluster 6, described as “in relatively poor condition from both a forest and an aquatic perspective, with especially fragmented aquatic systems and the lowest hydrologic integrity of any forest cluster.” Composite ecological integrity of the Similkameen subbasin is rated high. The subbasin is grouped within Forest Cluster 1, "most intact ecologically, with the least loss of integrity in both forest and aquatic ecosystems" (USDA, PNW-GTR-385, 1996). These ratings were developed through broad level analysis of information from across the Columbia River basin, hence they will have specific appropriate applications.

In summary, at mid and lower elevations, an extensive road system has provided good access for management. Commonly, fire suppression, harvest practices, and lack of young stand management have created many stands to be highly susceptible to damage from fire, insects, disease, and water stress. This condition in turn creates increased potential for erosion, and hydrologic and water quality changes (Swanston, 1991). Roads themselves directly affect forest hydrology, riparian conditions, and water quality (see the Transportation section). Forested riparian sites have been impacted by timber harvest activity, grazing, and conversion to other land uses. Recreational use and firewood cutting along road corridors also contribute to some of the problems mentioned above.

Trend

Our understanding of forests grows through continuing efforts in research, monitoring, and societal discussions. Watershed research continues in areas such as water movement and storage within timber canopy and soils, effects of harvest on snow pack, melt, and runoff, and water quality effects due to roads, harvest, fire and fire suppression, grazing, and recreation, and watershed processes such as erosion, hydrology, and riparian function.

Two trends are occurring in forest management. First, a more broad and balanced consideration of all forest resources and their interrelationships is generally occurring. Secondly, the scale at which management activities are analyzed and planned has expanded from focus only on individual treatment units to analysis areas as large as ecoregions.

Ecosystem components of the existing forest are surveyed to evaluate its health on most public forest land and some private ownership. Forest planning often is conducted on the basin or landscape scale. Watershed analysis helps determine what ecosystem processes are occurring in a watershed, how they have been influenced by past activities, and what trends are occurring.

A large planning effort is currently underway by the USFS and BLM for federal lands within the interior Columbia River basin (the ICBEMP). Habitat conservation plans (HCP) are developed by landowners or project proponents and the US Fish and Wildlife Service or National Marine Fisheries Service to protect federally threatened or endangered species.

The USFS conducts watershed analyses to study watershed conditions prior to planning management activities. They have prepared five analyses within the Okanogan drainage; North Fork

Toats Coulee, Salmon Creek, Tonasket Creek, Bonaparte Creek, and Antoine-Siwash Creeks. The CCT in partnership with the NRCS has produced a watershed plan for Omak Creek (CCT). The DNR or a private landowner (owning 10% or more of a subdrainage or Watershed Administrative Unit) may also conduct a Watershed Analysis as allowed in the Forest Practice regulations. This type of analysis, studies watershed conditions within the subdrainage and can result in revision of forest practice rules keyed to specific water problem sites in the study area.

Laws such as the state Forest Practices Act, Hydraulics Act, Shoreline Management Act, State Environmental Policy Act, and Federal Endangered Species Act require certain operational constraints for resource protection. Forest management operations on private lands must be carried out in ways that protect water quality, fish habitat, archaeological and cultural resources, and retain some elements of wildlife habitat across the landscape. Cumulative impacts caused by individual operations may be assessed and treated by applying the Forest Practice Act Watershed Analysis process.

Relationship to water quality concerns

Forest management practices affect the environment. The possibility exists to have either a positive or negative effect, or combination. The type and intensity of effect varies, depending on both the kind of operation, site characteristics, and location on which it is conducted. Potential effects to water, riparian and wetland resources are discussed below.

Sediment inputs to streams can increase due to either mass wasting or surface erosion (Megahan, 1981)(Sidle, 1980). Accelerated surface erosion can occur following timber harvests due to decreased ground cover or concentrated water flow over soil exposed by roads, skidtrails, or cable yarding corridors. Mass wasting activity, or landslides, can occur following harvest and road or skidtrail construction where soils are unstable. Soil failure may be triggered by loss of root strength, hydrologic changes at the site, or by soil disturbance and surface drainage changes associated with road construction and use of skidtrails. Accelerated surface erosion may occur after wildfire or prescribed burning due to the loss of the soil organic layer and exposure of mineral soil.

Soils vary in erodibility and stability. Soil surveys provide relative ratings of these characteristics, though these should be used in combination with operational experience and site-specific evaluations (US Department of Agriculture Soil Conservation Service, 1980). Some soil may be displaced without reaching waterways. Surface erosion and mass wasting are natural processes, which also occurs to some extent in undisturbed watersheds.

Hydrology may be altered, increasing peak flows and changing overall water yield and timing of runoff. Timber harvest and roads contribute to these changes (Washington Forest Practices Board, 1997). Operations can cause more dramatic changes in certain portions of a drainage, such as in small headwater subbasins with southerly aspects than in other areas. Increases in water yield may provide benefits to water users. Increasing frequency or severity of peak flows can cause fish habitat degradation and increase stream channel instability.

Water temperatures and water chemistry can change as a result of forest management activities (Platts, 1981). Water temperature will rise as shade to a watercourse is reduced.

Dissolved oxygen and pH may be affected by accumulations of slash or other organic debris. Timber harvest or road location, which removes vegetation or deposits slash and debris, can affect water chemistry, though water temperature is most often affected (Washington Forest Practices Board, 1997).

Woody debris recruitment to streams may be reduced when timber harvest or road and skidtrail locations occur within riparian areas. Large woody debris is an important component of stream channel structure, fish habitat, and instream nutrient processes (Washington Forest Practices Board, 1997).

Impacts on riparian/wetlands, and channel hydrology

Several watershed analyses have been performed by the USFS within the Okanogan watershed. The DNR has examined water and soil resources and related issues during its planning process for the Loomis State Forest, located in the northeast portion of the basin (DNR, 1993). The CCT in conjunction with the NRCS has published a watershed plan and environmental analysis for the Omak Creek drainage. The USFS and BLM have assessed ecosystem conditions within the watershed as a part of the ICBEMP, mentioned previously.

Surface erosion related to forest management activities does generate sediment, which enters waters of the Okanogan River watershed. This sediment generation and delivery is widespread and primarily road-related. Since they are often used for a variety of purposes besides logging, forest roads and related problems such as sedimentation are described in the Transportation section. Sediment related to skidding or other yarding enters streams less frequently than from roads. Skidding down the bottoms of confined draws compacts and ruts the soil, sometimes creating surface flow and erosion.

Mass wasting, landslide activity, within the basin is more localized. It occurs naturally as well as being triggered by harvest and roads on certain sites. Landslides have been noted on steep glacial outwash terrace escarpments and silty glacial lake deposits in some of the forest basins in the western portion of the basin. Twenty-three mass wasting events documented during the Toats Coulee analysis were attributed to natural causes. Follow up analysis of a slide which occurred in the Cecile Creek drainage in May 1995 points both to localized natural soil instability and loss of root strength following harvest as contributing factors.

The USFS and the DNR have created maps which indicate levels of soil erosion and mass wasting potential for the Loomis State Forest and within watershed analysis areas studied by USFS (Loomis Plan, Toats Coulee analysis respectively). Additional site-specific evaluations are conducted during Forest Practice program review of proposed management activities on sites with potential soil instability. Problems related to hydrologic changes due to forest management have not been documented on a drainage or subbasin scale within the Okanogan River basin. Runoff effects due to timber canopy changes have not been identified here, but have been documented in barometer watersheds elsewhere in the west. Site scale effects do occur, generally where roads and skidtrails intercept and concentrate subsurface water flow leading to increased peak flows and surface erosion.

Skidding down confined draw bottoms draws out subsurface flow and accelerates runoff from a site. A stream channel conditions assessment conducted on major streams in the Loomis Forest showed little to moderate peak flow-related damage, and generally low or moderate potential for future damage due to channel banks with high rock content and deep rooting (DNR, 1993).

Studies have not indicated water temperature problems in forested portions of the Okanogan River watershed. Data collected on the Loomis State Forest indicates cool temperatures ranging from 7 to 11°C (DNR, 1993). Other water chemistry concerns related to forest management activities have not been evaluated.

Riparian conditions have been affected within the basin by timber management. A 1994 survey of 80.5 miles of streams and associated riparian areas in the Toats Coulee watershed by USFS and DNR found nearly all channel segments rated good or excellent with regard to mass wasting, entrenchment, and sedimentation. It was noted that fire suppression and absence of beaver activity were contributing to a change in riparian vegetation. This change involves the encroachment of conifer into riparian areas and subsequent loss of shrubs and other herbaceous plants. Livestock, roads, and recreational use are also noted as influencing riparian condition.

In the upper Salmon Creek watershed, stream surveys performed by the USFS have found conditions within certain drainages deficient in number of pools and large woody debris (USFS Salmon Creek Watershed Assessment, 1997). The reduction in pools and debris is attributed to logging in riparian areas.

Roads and skidtrails, often created prior to current requirements for water and riparian protection, have been located within many riparian areas. Continued use, particularly of roads in these locations, reduces shade and woody debris recruitment potential. Sediment entry to streams is chronic in many cases. Timber harvest and grazing together can have a cumulative effect on bank, channel, and riparian conditions where not managed carefully.

Past timber management and fire suppression, especially on ponderosa pine and Douglas fir series sites, has created increased potential for fires of greater intensity and size with resultant hillslope erosion, hydrologic and stream channel changes.

In summary, two primary watershed problems are associated with forest management in the Okanogan River basin. First, surface erosion related to forest roads and disturbed soils from skidding down confined draw bottoms delivers large levels of fine sediment to the stream system. Second, riparian conditions have been degraded due to timber harvest, the presence of roads, skidtrails, other forest uses such as poorly-managed grazing, and recreational or homesite development within riparian zones. Potential for additional undesirable watershed impacts exists due to the risk of large, intense fires.

Forest Hydrology

Okanogan County's forestlands encompass 48% of the county and receive approximately 75% of the annual precipitation (Gullidge, 1977). This characterization is an attempt to provide an overview of present forest conditions in Okanogan County that may be affecting watershed functions. Its purpose is to bring to stakeholders attention hydrologic principles and research that indicate modification of some forest management practices could increase quantity and quality of water passing through the county. This work is neither a scientific study nor an exhaustive literature search. It is a review of basic forest hydrologic principles and relevant research applied to conditions that exist in the local forests. It may provide some focus points for further study and research.

Forest hydrology, in the US, became an issue in the early 1800's. In 1811, the commissioners of the Erie Canal complained of forest practices that diminished the supply of water for canals (Rafter, 1905). European countries had also been dealing with forest management during this period. By 1868, the French had reforested 190,000 acres of the French Alps and re-turfed 7,000 acres (Marsh, 1907). U.S. Congress commissioned Dr. Franklin B. Hough to prepare a report on forestry in 1876. His report stated, "… our streams diminish as our woodlands are cleared away, so as to materially injure the manufacturing interests depending on hydraulic power, and to require new sources of supply for our state canals and for the use of cities and large towns"(Hough, 1878). That same year the first national forest bill was introduced by Congress. Its purpose was to preserve forestlands at the sources and tributaries to rivers to prevent them from becoming scant of water. A major impetus for passage of the first national forest law, of 1891, was the concept of forest preservation for watershed protection. The relationship of forest conditions to stream flows was based on observation and expert opinion rather than hard scientific research. Scientific research that could quantify the relationship between forest condition and hydrologic function was begun, in the first decade of the Twentieth Century, by the establishment of several forest experiment stations (Cameron, 1928). These were located primarily in the west where water issues were already controversial.

In the ensuing 90 years, much has been learned about forest hydrology. General principles and specific processes that affect the water cycle are understood. Utilizing this knowledge to institute management practices that maximize retention and the quantity, quality, and timing of water release from Okanogan uplands could be beneficial to all water users.

Forest conditions have a significant impact on watersheds. Density and species mix affect the amount of potential water available to recharge upland aquifers while soil conditions influence the amount and timing of water that actually reach them. In the Okanogan watershed, management, over the last 100 years, has modified the condition of the forest and resulted in altered streamflows. With numerous variables that effect these flows it is difficult, if not impossible, to quantify the exact amount of alteration. By accessing current knowledge on natural processes, it is possible to identify forest conditions that have negative impacts and modify forest practices to remedy the situation.

The major changes that have occurred in Okanogan forests are found in forest structure, species and age class mix, soil conditions, and road densities. All of these changes have had an effect on the function of the watershed.

The amount of precipitation that reaches the ground is affected by the structure of the forest. Intercept losses are moisture caught by vegetation that reenters the atmosphere through sublimation or evaporation. Wet humid forests lose relatively little precipitation to intercept, while in arid forests 100% of the moisture from light summer showers can be lost to the surface. Studies in British Columbia have determined that these losses can be 20-30% of the annual precipitation (Spittlehouse, personal communication, 1998). These figures are consistent with previous research. Isaac, while studying fog intercept, found that 7km inland the interception loss was 33% (Isaac, 1946). Mature Ponderosa forest interception losses have been measured at 22% in Idaho and 40% in Arizona (Kittredge, 1948).

In the Okanogan, most precipitation is in the form of snow. Closed canopy forests have the maximum amount of snow intercept while open forests, consisting of a mosaic of differing densities with numerous openings, contribute to snow pack accumulations. Snow deposition is increased by disruption of air currents creating turbulence and eddies. The trees act much like snow fences. Protection from wind and direct sun provided by trees also delay snow melt in the spring depending on the size of canopy breaks (Golding & Swanson, 1978).

The significance of interception loss in the Okanogan becomes apparent when changes of forest density, over the last 100 years, are taken into consideration. Prior to European settlement, frequent fire regimes in the mid elevations, 2000-4500 ft, resulted in open stands of predominantly mature, fire resistant Ponderosa pine (PP) with a smaller larch (L) component in the 3,000+ elevations. Unpublished preliminary data of forest reconstruction plots in North Central Washington are showing 12-20% canopy closure at these elevations. Forest density, age class, and species mix have changed from open, late seral, PP, and L forest to dense, suppressed, early to mid seral stands of Douglas fir or PP (Tratnik, personal communication, 1995).

Formerly, Douglas fir was confined to wet areas or areas where topography limited exposure to fire. Frequent low intensity fires favored survival of mature PP and L while increasing mortality rates for seedlings, younger trees and Douglas fir. In the absence of these fires, seedling survival increased dramatically resulting in thick stands of trees with 100% canopy closure. Shade tolerant, fire sensitive Douglas fir became favored over fire tolerant, but shade intolerant PP and L. This condition over a large portion of the Okanogan forest maximizes interception loss to the watershed.

Throughfall is precipitation that flows down trunks of trees (stem flow), drips from the canopy or reaches the watershed surface directly. Infiltration is the movement of moisture through the watershed surface. It occurs if the surface is permeable. The rate of infiltration is dependent on factors such as soil type, surface, and sub-surface conditions. Particle size (clay, silt, sand, gravel, cobble, and boulders) and organic component are variables of soil composition that grossly affect infiltration rates. Overall, larger particles facilitate infiltration. All things being equal, sandy loam will have a higher infiltration rate than clay loam. Variables that can alter this are compaction, presence or absence of a duff layer, temperature, soil structure, soil moisture levels, etc. Undisturbed forest soils generally have high surface porosity resulting from the duff layer that protects the mineral surface while it maintains nutrient and moisture levels that support a diverse biological soil community.

Compaction occurs when mechanical energy is applied to a soil surface and results in an increase of bulk density. Energy applied to soil has differing rates of compaction under various conditions. Moist soil allows individual soil particles to slide into extremely compact configurations. Saturated soils are more resistant as compressive energy has to overcome hydraulic pressure while dry soils, lacking the lubricating effect of moisture, require more energy input to overcome friction. Soil moisture content and temperature become much more significant below freezing levels. Frozen surfaces, depending on porosity, are significantly resistant to compaction. Vegetation and duff layers protect most of the soil surface from this impact. Removal of these protective layers result in surface compaction.

The largest contributor, of mechanical energy to soil, is rain and hail impact followed by snow pack accumulations (Satterlund, 1972). Management practices that can result in compaction are logging, grazing and recreation. Road building, which permanently compacts surface area while providing an artificial channel in the form of a ditch, tractor skidding equipment and heavy grazing that removes most vegetative cover are major contributing factors to lowered infiltration rates. ATV's, dirt bikes, hiking trails and campgrounds contribute to the percentage of watershed surface impacted.

Compacted soil recovers over time through biological activity and freeze thaw cycles. Soil macro and micro flora and fauna form a biotic community that is important to maintenance of soil structure and nutrient levels. The biotic community, along with physical and chemical factors, result in aggregation of mineral soil particles to form peds. Structure is the variable that can make clayey soils more porous than soils with larger individual particles. On a macro scale badgers, gophers, moles, earthworms, and insects tunnel through the soil surface creating channels that facilitate water infiltration and movement of organic material. The same thing occurs on a micro level through activity of bacteria, fungi, microbes, and plant roots. Soil biological activity correlates to nutrient and moisture levels that are directly linked to the plant community, which soil supports. Degree of compaction slows this biological process primarily by inhibiting moisture infiltration (Kimmins, 1996).

Surface flows occur when moisture input exceeds infiltration rate of a watershed surface. Surface flows pass water through the watershed much more rapidly than water that enters the soil. It also influences stream characteristics. Carrying capacity of water is a function of volume and velocity. High volume at high velocity equal high carrying capacity. Increased carrying capacity results in soil loss on the site of surface flow and deposition in areas of lower volume or velocity.

Timing and intensity of moisture inputs directly effect surface flows. Rate of input from a gentle rain can result in more infiltration than a cloudburst. A heavy snow pack coupled with warm spring rain increase the amount of moisture leaving the forest as surface water, whereas the same snow pack subjected to alternate freeze thaw cycles will result in higher infiltration rates and less surface flows.

Water infiltrating the soil surface becomes ground water and passes through the soil, or percolates, by capillary action. This rate of flow is affected by particle size, structure, hydraulic pressure, surface vegetation and substrate. Water travels downward only when surface layers are at field capacity (saturated). This subsurface flow will travel slowly in comparison to surface flow. Subsurface flow is the primary source of water for all springs, streams and lakes in late summer. Recharge rates for these flows can be affected by transpiration losses (Kimmins, 1997).

Species and age class of trees has an impact on the evapotranspiration loss to the watershed. Leaf biomass is a major determinant of transpiration loss along with light, temperature, humidity, soil moisture, wind, health, etc. (Ibid). Older PP trees and L have less leaf mass than younger PP, L or Douglas fir. In addition, the PP has drought adaptations that minimize moisture loss during hot and dry conditions as well as during periods of darkness.

The area of leaf has a direct correlation to the amount of water transpired. Transpiration, of conifers, begins to increase with light levels and warmer air temperature while other vegetation remains dormant or is growing leaf area. Early spring photosynthetic activity can occur when temperatures are below freezing as conifer leaf surface temperatures may be as much as 15 degrees higher than the surrounding air (Parker, 1953). Rates and timing differ by species. PP stomates will open 2.5 hours after exposure to sunlight at 0 degrees C. and shut down completely in darkness. Douglas Fir stomates remain open even in darkness transpiring 26-42% of the daytime rates (Drew, Drew, & Fritts, 1972). Another factor influencing transpiration rates, of conifers in the Okanogan, is that mistletoe brooms transpire at a higher rate both day and night (Fisher, 1983).

The Ponderosa to shrub-steppe ecotone transpiration rates have also changed over the last 100 years. Frank Matsura photos, at the Okanogan County Historical Society Museum, and verbal descriptions of pioneers describe a grass-dominated understory in the low elevation forests as well as in rangeland (Tratnik, personal communication, 1995). Fire suppression and grazing practices have altered these conditions. Woody shrubs, without frequent fires and competition from grass have had a competitive advantage. Today much of this area is dominated by sage/bitterbrush. The effective rooting depth of woody shrubs is 8-10 feet while grasses are only 2-3 feet (Satterlund, 1972).

The deeper rooting depths of these woody shrubs utilize subsurface flows at a much higher rate than shallow rooted grasses and forbs (Biswell, 1989). Timing and depth of this depletion may be a factor in groundwater recharge rates. Field capacity of the upper layers of soil must be achieved before gravity can overcome the matric potential, or molecular attraction of soil particles, to allow water to move through the soil (Kimmins, 1997). Early depletion of soil moisture could lessen the ability of spring rains to contribute to subsurface aquifer recharge.

Open forests of older trees minimize intercept while they disrupt wind and provided scattered shade, which slows atmospheric loss from the snowpack. Older trees also have lower transpiration rates. The closed canopy of a dense forest maximizes intercept while, in stands of vigorous younger trees, evapotranspiration is increased (Bassman, 1987). The cumulative effect of this transformation over thousands of acres of a watershed may have a significant impact on streamflows.

Other variables also effect the amount of water recharging aquifers supplying headwater streams. Aspect, slope, soil, wind patterns, etc. are variables that increase the difficulty of quantifying impacts.

RANGE

Extent

The native plant communities of the open shrub steppe lands in the Okanogan Watershed have been described by the Natural Resources Conservation Service (NRCS) into ecological sites. An ecological site is a distinctive kind of rangeland that differs from other kinds of rangeland in its ability to produce a distinctive kind and amount of vegetation. It is capable of supporting a plant community typified by an association of species that differs from that of other ecological sites in the kind (warm season vs. cool season, grassland vs. shrub-grass), proportion of species, or in amount (total production) (NRCS National Range & Pasture Handbook, 1997).

An ecological site is typified by a characteristic hydrology, particularly infiltration and runoff, that has developed over time. The development of the hydrology is influenced by the development of the soil and plant community.

Range condition (excellent, good, fair, and poor) is determined by comparing (through vegetation transects of modal soils and plant communities) existing plant communities with the presumed climax community for a specific ecological site regardless of the value of individual plants or the plant community for specific uses. Departures from climax, which can result from many causes, can enhance or depreciate the value of the resultant plant community for various uses.

The primary purpose of determining range condition is to provide a basis for predicting the extent and direction of changes that can result in the plant community because at specific treatment or management. The invasion of plants not native to the site indicates a decline in ecological range condition (such as knapweed, or cheatgrass plants invading native bluebunch wheatgrass sites).

Range Condition Classes

Range Condition Class	Percentage of Community That is Climax for the Ecological Site
Excellent	76-100%
Good	51-75%
Fair	26-50%
Poor	0-25%

Ecological Site descriptions are referenced and can be found in the NRCS Okanogan Field Office. Ecological Sites include the following information:

- Physiographic Features
- Climatic Features
- Soil Description
- Potential Native Vegetation
    - Species Composition
    - Total Annual Production (Air Dry Weight)
    - Ground Cover

Wildlife Habitat
Effects of Grazing
Effects of Fire
Threatened and Endangered Species
Management Practices

The Okanogan River Corridor and the Spectacle Lake areas receive about nine to 12 inches of annual precipitation. Ecological sites include Loamy, Shallow, Stony Loam, and Sandy Loam.

Bonaparte Creek and Omak Creek areas are typified by the Northern Rocky Mountain forested lands. Lower elevation areas receive 12 to 15 inches of annual precipitation. Ecological sites include Loamy and Stony Loam sites. Areas above 15 inches of precipitation are timbered.

Joseph area annually receives 9 to 12 inches of annual precipitation. Ecological sites include Loamy, Shallow, Stony Loam, and Sandy Loam. Some of the area is internally drained so that salt tends to accumulate as evidences by salt tolerant species like salt grass. These type of sites include Calcareous Loam, Saline Semi-Wet Meadow, and Saline Terrace.

Swamp Creek, Loup Loup Creek, Salmon Creek, and Similkameen River areas are on the eastern slopes of the Cascade that are mostly forested with south slopes generally open not timbered. In the lower elevations, 1500 to 3000 feet, annual precipitation is 12 to 15 inches. In the upper elevations, 5000 to 6500 feet, south slopes are not timbered with about 25 to 35 inches of precipitation annually.

In the Pasayten area, precipitation varies from 40 to 80 inches.

The best description of the native plant communities in the timbered areas is the Forested Plant Associations of the Wenatchee National Forest, published in October 1995. The United States Forest Service (USFS) Okanogan National Forest and the Washington Department of Natural Resources (DNR) uses this guide to identify:

Environment
Vegetation Summary
- Tree overstory layer
- Tree understory layer
- Shrubs
- Herbs

Distribution and Environment
Vegetation
Productivity and Management
Relationships to other Classifications

Upland Grazing Resources

The forage resources are listed by ownership. Forage quantity is summarized by Animal Units Months (AUM). Table 3.1 in Appendix C lists nine areas in the Okanogan Watershed along with the ownerships, AUMs, and acres of each.

DNR lands have been divided into two categories, permitted land and lease land. All of the DNR permit land was inventoried between 1989 and 1996. Few of the DNR lease parcels have had recent range inventories.

Where the private land has had a range inventory in the past ten years, that information is listed. Where the private land has not been inventoried, the AUMs are listed as unknown. Those areas of rangeland that are not grazed are included into the category of private not inventoried.

The Okanogan River Corridor has only limited grazing in the Ellisforde area (less than 2000 acres). There are some small confined horse pastures located up and down the corridor. The predominant land uses in this area are orchards, irrigated hay fields, town sites and homes, and transportation.

History

The earliest evidence of human occupation for North Central Washington is known from the East Wenatchee Richey Clovis site dated to 11,500 years before present. Another significant site from this time period was the Lind Coulee bison-kill site near Warden dated between 8,600 and 11,000 years ago. Silisham Mesa and the associated spring site north of Coulee City, shows evidence of utilization as long ago as 4,000 to 5,000 years. At the spring site, the existence of grinding stones and plant foods indicates use there may have occurred back as far as 2,300 years ago. Whether there are sites which sustained continuous use is unknown as the archaeological record is lacking, but there was most likely utilization of root digging in this part of Washington somewhere (Galm, 1998). According to Nat Washington, an Ephrata historian, native Americans undoubtedly utilized camas and lomatium in a few pothole depressions over thousands of years (Washington, 1998). Paleo-Indian and more recent prehistoric sites have been uncovered in the vicinity and indicate these early peoples most likely followed subsistence patterns similar to those used during ethnographic times. Sites with identified cultural materials have been dated from several thousand years old to within the last 150 years.

The project area lies within a geographic region where numerous aboriginal boundaries overlapped. Ethnographic information shows that many village sites occurred in close proximity to the areas major river systems which also doubled as places for food procurement and processing. All of the Native American inhabitants of the Columbia Plateau pursued a semi-nomadic subsistence type of lifestyle. Typical subsistence patterns consisted of occupying semi-permanent winter villages around major rivers or water courses and seasonally traveling to upland camps to collect plant foods and hunt game (Galm, Harmann, Masten, Stephenson, 1981). Other important opportunities for food exploitation were with the various salmon runs, other fish, large and small mammals, water fowl, and numerous vegetable resources including root crops (Chalfant, 1974).

At the time of white settlement in the Okanogan watershed by the early 1800's, there were at least four groups of indigenous people in the Okanogan watershed; the South Okanogan, the Sanpoil, the Wenatchee, and the Okanogan. The later were mostly located in what is today Canada. Tribal organization as far as a central authority over several villages did not exist; each village had their own chief and was autonomous. Land was not a possession, there were no hard and fast boundaries, simply areas where yearly activities took place (Ray, 1933).

In the spring time, villages broke up into small groups of perhaps four or five families each and journeyed to their favorite root gathering area. The Sanpoils journeyed south of the Columbia, the South Okanogans likely had their favorite digging grounds in the area southwest of Omak Lake. This area in the watershed study is referred to as the Joseph Area. A whole year's supply of roots were dug and then preserved by drying (Ray, 1933).

The summer fishing season began in early May. The largest traps were located at the mouth of the Sanpoil River, the Spokane River, and at Kettle Falls. These places drew native people from near and far. Other fishing areas include the Okanogan River. An early photographer, Frank S. Matsura, photographed an Indian fish trap on the Okanogan River around 1910.

Winter villages were reoccupied by about the middle of October. Dried salmon and dried roots were the principal foods. Deer hunting took place in the fall and winter.

Tribes did not use the same residence year round. Three different types of residences were used which included the winter mat house, the semi-subterranean lodge, and the summer mat house. These houses were supplemented by a mat hut employed when travelling, a menstrual lodge, and a sweat lodge. All residences were occupied seasonally. Natives speak of the semi-subterranean lodges being the older type and in the last 100 years few being occupied (Ray, 1933). When the winter mat houses were rebuilt in the fall, toward the middle of October, a particular group seldom rebuilt on the site previously occupied. Sites were chosen with an eye to warmth, a minimum of wind, and proximity to water. Rye grass was used for the floor. Tules woven into mats up to 20 feet long were used for the winter mat houses and for the movable summer mat houses (Ray, 1933).

Horses did not greatly influence the trading activities or manner of life for the Sanpoils and perhaps the other bands. Horses did make possible a greater amount of travel, but this was still confined, for the most part, within the old accustomed boundaries. Horses were never possessed in very great numbers, especially as compared with peoples to the south, and were received relatively late, perhaps around 1840. Verne Ray interviewed John Tom, a Sanpoil, in the early 1900's who remembered his mother's stories of when she saw her first horse. John Tom's mother was still a young woman at the time. She died about 1900 at the age of 85 or 90. The first horses presumably were obtained from the Nez Perce, perhaps by way of the Columbia (Ray, 1933).

The population declined with the coming of the European contact. We may be able to understand the trends in population by looking at the Sanpoil and Nespelem tribes. The smallpox epidemic of 1782-83 destroyed from one-third to one-half of the population. It was followed by epidemics of the same disease in 1846 and 1852-53, introduced in both cases by the white people (Mooney, pages 13-14). Measles and influenza caused considerable losses as well. Mooney calculated that in 1780 the Sanpoil and Nespelems numbered 800. Verne F. Ray in his 1933 book, "The Sanpoil and Nespelem: Salishan Peoples of Northeastern Washington" interviewed John Tom, an elder at the time, to determine the population around 1860. They cataloged 31 winter villages including the native names of the villages, the number of houses, and approximate population. Ray thought Mooney's 1780 population estimate was low and thought 1600 was a better figure. By 1910 the U.S. Bureau of the Census, Indian Population section recorded the Nespelem and Sanpoil population at 234. Between 1860 and 1890 the death rate was unquestionably very high. This was due, perhaps, to the introduction of diseases by the white traders and settlers, coupled with the refusal of the natives to receive medical assistance from the agency doctor (Ray, 1933).

The impacts to the Okanogan watershed that the various tribes had were minimal. The winter housing sites which were located on south exposures close to water likely received heavy use as did the summer housing sites at the fishing rounds. These areas were not occupied year round and were likely quite small. Spring root gathering camps were dispersed with small family groups moving to various favorite areas (Ray, 1933). Due to the dispersed activity with a relative low population, root gathering had little to no effect on water quality issues in the watershed. Root gathering areas within the watershed included the southwest corner of the reservation referred to in this watershed management plan as the East WRIA (Water Resources Inventory Area) subwatershed (Emerson, 1997).

Information about the use or frequency of fires set by the aboriginal peoples of the Okanogan watershed to manipulate the rangeland vegetation was not found.

European Settlement

The fur trade impacted the Okanogan watershed from the number of beaver harvested, but more important as a major transportation corridor. Beaver pelts, out of the interior of what is today Canada, were pressed into 85 pound bales in Fort St. James and sent down the Fraser River to Fort Alexandria. In early May, there began an overland packhorse journey of ten to fourteen days to Kamloops, where furs from the Thompson River district were added. The brigade came down the west side of Okanogan Lake and Lake Osoyoos and following the eastern shoreline of the Okanogan River. It took about ten days with 200 to 300 horses to transport the goods to Fort Okanogan. Light draft, double ended boats 30 to 40 feet long and about five feet wide, called bateaux, transported the goods to Fort Vancouver, which in 1828 took eleven days. The horses grazed around Fort Okanogan until august when goods brought back up the Columbia River were packed back to Kamloops and points north (Wilson, 1990). Based on the reports of the number of stock, the seasonal nature, and the large area cover, these activities likely had little effect on the watershed other than in the vicinity of Fort Okanogan. The grazing of 200 to 300 horses around this area may have caused areas of overgrazing, but with the vast acreage and gentle topography, the effects on water quality were probably small.

With the discovery of gold in Canada came the large cattle drives up the Cariboo Trail. The British customs station at Osoyoos from 1859 to 1870 collected duty on 22,256 head of beef cattle. In all likelihood, as many cattle or more escaped the collector's attention (Wilson, 1990). This activity suggests over-grazing occurred along the river's flood plains (Wissmar, Smith, MacIntosh, Li, Reeves, Sedell, 1994).

From the 1860's to about mid 1870, only four small cattle operations were in Okanogan County. In the 1870's, Phelps and Wadleigh were the largest cattle operation in the Washington Territory. One of their cowboys, John Rinehart, said Phelps and Wadleigh branded 1,800 calves at Loomis in 1878. The winter of 1880-81 shattered the notion that livestock could graze there year round when the partnership lost 8,500 head with only 2,000 surviving (Wilson, 1990).

The winter of 1889-90 also produced a terrible blizzard in January followed by a thaw and then a freeze producing a crust no livestock could paw through. No one can say how many head of livestock were actually lost in Okanogan County. However, one of the early school teachers in the area, Virginia Grainger, guessed 10,000 livestock perished. By other estimates, 90% had perished (Wilson, 1990).

A grazing allotment system was begun by the Federal government in the early 1900's in response to complaints about the grazing and burning of the forests. The formation in 1897 of the Washington Forest Reserve, covering most of today's Okanogan, Wenatchee, and Mt. Baker-Snoqualmie National Forests, facilitated the implementation of the allotment system. Eligible ranchers were granted permits to graze on federal lands at specific times of the year at a fee for each animal per month. In the Toats Coulee area, now DNR and US Forest Service (USFS), between 1906 and 1925 1,096 cattle grazed the area from June 1st to November 15th each year. In 1925 the lower portion of the watershed was transferred to the DNR leaving the Okanogan National Forest with it's current boundary (USFS, 1995).

The 1905 Agricultural survey by the state of Washington showed the following trend:

	1890	**1900**	**1901**	**1904**
Horses and Mules	2,328	4,930	5,731	7,000
Cattle	4,744	9,157	10,997	21,058
Sheep	None	2,098	6,078	31,757

One of the largest early ranch operations was located on the reservation around Kartar Valley on the south half of the reservation, which is in the Joseph area as designated by the 1998 Okanogan Watershed Management Plan. Coxit George, a Wenatchee, settled in this area in the late 1880's and developed one of the largest horse and cattle ranches in Okanogan County. He hired up to 25 cowboys to drive cows to the railhead in Almira and in later years to Okanogan. Coxit George died in 1922. The earliest major white cattleman on the south half of the reservation was Matt Duley. Ed Schrock came after Matt Duley and began running thousands of cows. He paid a grazing fee of 25 cents per head annually. In later years, after the homesteaders settled the area, he curtailed his South Half cattle operations and grew wheat. The largest single landowner in Okanogan County was Victor Lesamiz. A sheepman turned cattle rancher, Lesamiz came to own an estimated 60,000 acres in the Spectacle Lake area and leased perhaps another 60,000 acres of state and federal lands in the Similkameen area (Wilson, 1990).

Current Condition

Range condition ratings do not apply to the forested portions of the Okanogan Watershed simply by definition. The effects of range condition on water quality are such that excellent, good, and high fair condition range land will all provide adequate ground cover of grass, shrubs and forbs in the right proportion to protect the soil resource. Depending on the species remaining when rangeland falls into low fair condition and poor condition, the remaining plants generally are less suited to protect the soil resource and may be subject to accelerated erosion. Accelerated erosion will likely degrade water quality.

Similkameen and Sinlahekin sub-watersheds

In the forest, the south slopes are open parks and can be considered rangeland. These rangelands are a small portion of the 135,392 acres of DNR land that has been inventoried. These rangelands are predominantly in good to excellent range condition with some fair condition range in the lower elevations. No poor condition range was recorded in the 1989 to 1994 range inventory. The USFS lands that are grazed fall in the following categories:

12% of the acres are verified as meeting the Forest Plan Objectives,
48% of the acres are estimated as meeting the Forest Plan Objectives,
5% of the acres are verified as moving toward the Forest Plan Objectives,
34% of the acres are estimated as moving toward the Forest Plan Objectives,
1% of the acres are in an undetermined status.

No data is available from the Washington State Department of Fish & Wildlife (WDFW) at this time on their acreages.

All of the 31,654 acres of Bureau of Land Management (BLM) land are lower in elevation than the DNR and USFS lands and are mostly range lands. The BLM conducted a range condition inventory in 1982. Of the area classified during the inventory, 49% of the area is in good to excellent range condition, 19% of the area is in fair condition, and 32% is in poor condition. Thirty-seven percent of the total area inventoried is unclassified. The unclassified area includes rock outcrop, and areas unsuitable for grazing due to steep slopes.

Spectacle Lake, Wannacut Lake, Aeneas Lakes, Aeneas Creek sub-watersheds

In the Spectacle Lake area, 19,068 acres were inventoried in Horse Spring Coulee in 1994. Approximately 30% of the flatter ground had been plowed in the original homestead days or in preparation for the irrigation water to be diverted out of Blue Lake in about this same era. Of the area remaining, approximately 65% to 75%, is in poor to fair condition similar to the BLM land in the Similkameen area. Re-claiming the previously plowed fields and seeding to native perennial grass has been done on about half of these fields.

Bonaparte Creek, Siwash, Antoine, Mosquito, Tonasket, Nine Mile Creek sub-watersheds

Of the 10,689 acres of private ground inventoried, 7,687 acres are considered rangeland. 70% of the acres are in good to excellent condition, 29% are in fair condition, and 1% of the acres are in poor condition.

Omak Creek, Wanacut Creek, Tunk Creek, Chewiliken Creek sub-watersheds

In the Tunk Creek and Chewiliken Creek area there is 8,410 acres of Washington State Department of Natural Resources permit land that is considered grazable woodland. Total approximate acreage for the Tunk and Chewiliken Creek sub-watersheds is 25,000 acres of grazable woodland and 37,000 acres of rangeland. Of the remaining rangeland in these two sub-watersheds, about 50% is in good to excellent condition with the rest in fair range condition.

On the Colville Indian Reservation (Omak and Wanacut Creek sub-watersheds) 72,000 acres are grazable woodland with another approximately 87,000 acres being rangeland.

In the above listed four sub-watersheds, range condition close to old home sites is in poor condition. Most of the upper areas close to the timber and over a half mile from water are in good to excellent range condition.

Of the remaining area, about 75% is in good to excellent range condition with the remainder in fair range condition. On the Colville Indian reservation, 75% of the 72,000 acres are timbered. Range condition close to old home sites is in poor condition. Most of the upper areas close to the timber and over a half mile from water are in good to excellent range condition. The remaining 19,178 acres of range has yet to be inventoried.

Omak Lake, Joseph flats, Bridgeport Point sub-watersheds

From a Soil Conservation Service (now NRCS) inventory of the rangeland conducted from 1982 to 1985, 4% of the rangeland is in excellent condition, 14% is in good condition, 15% is in fair condition, and 67% is in poor condition.

Swamp Creek sub-watershed

In the Swamp Creek area most of the land is private. Of the 12,676 acres inventoried, about 75% are timbered. The remaining land that was inventoried showed 85% in good to excellent range condition, 10% in fair condition, and the remainder in poor range condition.

Loup Loup Creek, Chiliwist, Tallant Creek sub-watersheds

Loup Loup Creek area is predominantly DNR forested land with some private land. The DNR area was inventoried in 1993, recording about 10 to 15% in fair range condition with the remaining in good to excellent range condition.

Salmon Creek, North Fork Pine Creek, Brown Lake, Fish Lake sub-watershed

Most of the lower Salmon Creek area is private. The private ground has had very little land inventoried in the last ten years. A range inventory of the 14,205 acres was done on private and DNR lease land and recorded about half the area in fair to poor range condition. The remaining acres were in good to excellent range condition.

Okanogan River Interfluve sub-watershed

Little rangeland exists in the Okanogan River Corridor area. Due to the proximity to water, most of the land next to the river consists of intensive irrigated agriculture or home sites.

Pasayten Area

No information is available at this time.

Noxious Weeds

Noxious weeds are a serious threat to water quality in the Okanogan River Basin. Once noxious weeds become established, they crowd out native vegetation, and in severe cases, are the only plants left growing. Downy brome and spotted knapweed have displaced native grasses throughout the Intermountain West. Noxious weeds may invade habitats occupied by rare and endangered plant species and modify such habitats so that these species can no longer survive. Soil stability and water quality suffer when native plants that have fibrous root systems are replaced by noxious weeds with deep tap roots (Yenish, 1998).

The state of Washington has three categories on the state noxious weed list. Noxious weeds that are new invaders are classified as Class A. More common, yet not extensive noxious weeds are Class B. Class C noxious weeds are extensive in acreage.

The Noxious Weed Control Board of Okanogan County has estimated the acres of the various noxious weeds by area as listed in Table 3.2.

Data Gaps

The Noxious Weed Control Board of Okanogan County Field Supervisor, Mary Lou Peterson, reported that the data gaps for noxious weed control in Okanogan County is the lack of accurate location mapping and extent of each noxious weed species found in the county. The Noxious Weed Control Office has begun mapping weeds with a Geographic Positioning System and then enters this data into a Geographic Information System. Peterson estimated it would take three full time workers two years (six staff years) to map the presence and extent of all the noxious weeds in Okanogan County.

Keith Rowland, USFS Supervisors Office, reported the data gaps on USFS lands is the lack of base line data monitoring of water quality for riparian and stream systems. This type of information would include but is not limited to stream temperature, turbidity, photo plots and so on.

Richard Fleenor, Colville Confederated Tribes (CCT) Range Department, reported that stream inventory data is lacking on Coyote Creek, Kartar Creek, Nathan Creek, Smith/Condon Creek, and Wanacut Creek and its tributaries.

Ray Pease, DNR, reports that about sixteen miles of streams listed as high priority remain to be inventoried in the South Okanogan District of the DNR. Those streams that remain to be inventoried include Chiliwist Creek, Sulivan Creek, South Fork Salmon Creek, and Conger Creek. These streams will be done by 2002.

Private lands have been inventoried by the NRCS at the private land owners request. There are considerable private range and grazeable woodland acres that have not been inventoried and several streams that have not been inventoried.

Relationship to Water Quality Concerns

Livestock grazing management requires being aware of the potential impacts that can happen to streams. When livestock cross or drink from streams, the mechanical action of their hoofs can break off sod or soil, referred to as hoof shear, causing unstable streambanks. The sediment eroded from these unstable streambanks during high water events results in a deterioration of water quality.

Livestock grazing on native rangelands and/or grazeable woodlands balance their nutritional requirements by selectively grazing forages. Forages from native range in Okanogan County meet the nutritional needs of livestock in the spring and early summer until the native bunchgrass begins to cure out and set seed. At this point, the protein content of the native bunchgrass does not meet the needs of a cow with a suckling calf. Cows will sample various forages including forbs and brush species to find forage that meet their biological needs. Brush species such as rose, willow, alder, dogwood, or bitterbrush are readily consumed by livestock and can make up the protein deficit in the late summer and fall. Alder, dogwood, rose, and willows are needed on most stream types to stabilize streambanks against high seasonal flows. Grazing the woody brush species can result in the reduction of vigor and the density of these species. On some stream types, the removal of woody species can result in bank failures, which may lead to an increase in the width to depth ratio, in other words a broad shallow stream. This can lead to increased water temperature, a decrease in the ability of the stream to store water in the associated shallow aquifers during high water events, and increases unstable streambanks. On lower gradient streams, woody species, sedges, and forbs on the flood plain slow flood water and filter out sediments. Vegetation helps to moderate diurnal temperature fluctuations. Depending on flow and elevation shade can make a difference on maintaining cool stream temperatures needed by salmonids.

The USFS uses their own methodology to judge the condition of the riparian zones. The standards used are the riparian vegetation objective contained in the Okanogan Forest Plan. On a forest wide basis, 24% of the acres were monitored in 1997. There are about 268 acres of riparian vegetation in this area along the perennial streams. The figures below are forest wide averages:

9%	acres verified meeting Forest Plan Objectives,
49%	acres estimated meeting Forest Plan Objectives,
4%	acres verified moving toward Forest Plan Objectives,
36%	acres estimated moving toward Forest Plan Objectives,
2%	acres of undetermined status.

Similkameen and Sinlahekin sub-watersheds

The DNR inventoried streams using the Rosgen stream types and streambank stability on 55.8 miles of stream from 1994 to 1997. Streams that were not inventoried were those streams that were not accessible to livestock. The assumptions about these streams were ground truthed and then not inventoried. The 55.8 miles of streams that livestock had access to were inventoried. Counting both sides of these streams, 111.6 miles of streambank were assessed for streambank stability. Almost 3% of these streambanks were unstable from livestock.

The BLM used the Proper Functioning Condition methodology to determine the condition of their riparian areas. Below is the summary of the 11.8 miles of streams inventoried on BLM land (BLM, unpublished):

Proper Functioning Condition	25%
Functional at Risk - Upward Trend	35%
Functional at Risk - Static Trend	27%
Functional at Risk - Downward Trend	13%
Not Functional	1%

Spectacle Lake, Wannacut Lake, Aeneas Lake, Aeneas Creek sub-watersheds

Almost all of the streams in this area are on private land. No information is available.

Bonaparte, Siwash, Antoine, Mosquito, Tonasket, and Nine Mile Creek sub-watersheds

In 1987, the Okanogan Conservation District (OCD) received a Centennial Clean Water Grant to inventory a number of streams and rivers in Okanogan County. In the fall of 1988 27 miles of Bonaparte Creek was inventoried, which started at the confluence with the Okanogan River to the headwaters at Bonaparte Lake. A Riparian Vegetation Rating System was developed by Ivan Lines Soil Conservation Service State Biologist. Linear measurements of riparian habitat were rated on a scale of zero to ten, zero represented no woody vegetation, heavy grazing or other removal, grassy vegetation only and or bare banks. A rating of ten meant a good diverse mixture of trees, shrubs, and herbaceous with large trees present, very little if any human or livestock disturbance, with a dense understory. Table 3.3 is a summary of their findings.

Table 3.3
Bonaparte Creek Riparian Vegetation Ratings

Condition of Riparian Habitat	Miles of Stream	Percent of Stream
Slightly impacted	12.3	46%
Moderately impacted	12.0	44%
Severely impacted	2.7	10%
Total	27	100%

From the OCD assessment, 5.4 miles of the 27 miles of Bonaparte Creek were adversely impacted from livestock. The livestock uses of Bonaparte Creek include stream running through portions of corrals, wintering grounds, and spring or fall pasture. One of the major erosional areas along the stream involved 1.2 miles of bare eroding streambank where the stream has laterally downcut. At the upstream end of this area is an active headcut.

Omak Creek, Wanacut Creek, Tunk, Chewiliken Creek sub-watersheds

Chewiliken Creek and Tunk Creek are almost completely on private ground; thus, no information is available. Wanacut Creek on the CCT reservation also has no information about streambanks or riparian conditions.

At the headwaters of Swipkin Creek on DNR land, there are no adverse impacts to the stream from livestock. Prior to 1997, 800 feet of perennial stream was adversely impacted by livestock. The local Coordinated Resource Management planning group developed a plan for this area and funding for the project was through the OCD.

The NRCS inventoried Omak Creek, which is on the CCT land, in 1991 and 1992. Thirty-two miles of Omak Creek and Stapaloop Creek were inventoried; livestock had adversely impacted 81% of streams. Either streambank erosion has been accelerated by livestock hoof shear or streambank vegetation has suffered in these areas from season long grazing by livestock.

Joseph Flats, Omak Lake, Bridgeport Point sub-watersheds

This low elevation plateau of shrub steppe vegetation has no perennial streams that flow into the Okanogan River. Livestock grazing in this area has little impact on the intermittent streams.

Swamp Creek sub-watershed

Two perennial streams, Swamp Creek and Hooker Creek fall within this area and both are predominantly on private land. No data is available from either although as part of the South Summit Coordinated Resource Management plan, 1.6 miles of Swamp Creek will be assessed in 1998 by OCD crews and NRCS staff.

Loup Loup Creek, Chiliwist, Tallant Creek sub-watersheds

Little Loup Loup Creek is on private land and no data is available. The upper portion of Chiliwist Creek is a perennial stream and is inhabited by salmonids. This upper portion is on DNR land, but no information is available. The lower portion of the perennial stream is on private or WDFW and for the most part is ungrazed. The upper reaches of Loup Loup Creek and its tributaries are on DNR land. There has been 1.2 miles of Loup Loup Creek inventoried using the Rosgen stream class and streambank stability classification. There was 16% or 1055 feet, of this 1.2 mile reach that was unstable from livestock in 1997. At a long-term stream monitoring point, one mile upstream from this reach, 175 feet of a 400 foot sample was unstable from livestock in 1997. This was an unusual case as 25 pair were missed on the initial move out of this riparian pasture and stayed on the creek until they ran out of forage in the uplands and grazed heavily on the sedges and alder. This is likely the heaviest impacted stream in the Loup Loup Area.

Salmon Creek, North Fork Pine Creek, Brown Lake, Fish Lake sub-watersheds

The South Fork, North Fork, and West Fork of Salmon Creek are predominantly on USFS land. The USFS uses the Forest Plan Riparian Vegetation Objectives as the standards for proper riparian management.

The land ownership from Conconully Reservoir to the confluence with the Okanogan River is predominantly private with some BLM ownership. There was 6.2 miles of stream on BLM lands inventoried and rated under the proper functioning condition methodology developed by the USFS and BLM. Below are results of the 1994 to 1995 inventory (BLM, unpublished):

Proper Functioning Condition	82%
Functional at Risk - Upward Trend	7%

Functional at Risk - Static Trend	11%
Functional at Risk - Downward Trend	0%

The BLM did not collect streambank stability information during this assessment. No data is available on the private land.

Okanogan Interfluve

Most of the land in this area is private; thus, no information is available.

Management Alternatives, Tools for Management

Grazing management for upland grass species is keyed to the needs of the plants and how those plants respond to herbivory. For grazing management it is useful to categorize grass species into native bunchgrass types such as blue bunch wheatgrass, introduced bunchgrass like intermediate wheatgrass, and sod forming grasses such as Kentucky bluegrass or pinegrass.

Managers have control over the intensity and timing of grazing. Grazing intensities where 50% of the photosynthetic plant material is removed appears to have little effect while the three grass types are in a vegetative stage and have adequate soil moisture. Heavier grazing intensities reduce or stop root formation. The timing of grazing is important as the different types of grass respond differently in re-allocating carbohydrates after defoliation.

Native bunchgrass is the most susceptible to damage due to the elevation of the growing points for seed formation. Native bunchgrass continues to send carbohydrates to root growth instead of replacing photosynthetic material after grazing. Proper management means allowing the plants to set seed without grazing one out of every three years and only grazing during the critical period one out of three years. The critical period for native bunchgrass is from seed head formation in the boot stage to just before seeds ripen in mid summer.

Introduced bunchgrass species are less susceptible to grazing damage due to their ability to reallocate carbohydrate reserves to regrow leaves after grazing. Proper management means allowing the plant to set seed by not grazing every third year and only grazing during the critical period two out of the three years.

Sod forming grasses are the most resilient to grazing. Growing points are located at the base of the plant. Due to the mechanical process of livestock grazing, the growing points are out of reach of livestock. Grazing has little effect if adequate leaf surface area is maintained and there is adequate soil moisture for regrowth. Carbohydrates are reallocated to regrowing photosynthetic plant material. Proper management allows season long grazing if adequate leaf surface area is maintained.

Adverse grazing influences on streams comes from the physical impacts of hoof shear on streambank stability and the effect of herbivory on woody species in the flood plain.

Please refer to the Loomis Monitoring Plan, Riparian Inventory and Streambank Stability. Below is a number of grazing management strategies for riparian areas.

For animal trails round glaciated river rock is used to armor a 6 to 1 (16%) sloped trail to the water edge. Livestock pick the easiest route to access or cross streams so use is concentrated on the armored animal trails. These animal trails work on deep narrow streams parallel to the slope for access where livestock are looking for the easiest places to cross.

Woody species are the most susceptible to grazing in the fall when carbohydrates are being stored in the roots. Grazing early in the growing season allows herbaceous and woody species to regrow before the following year's spring runoff event. Maximum growth on the flood plains allows vegetation to slow high water flows and filter sediments. Management strategies may include fencing to graze pastures at different times.

Innovative strategies include highlift water pumping systems or, where available, developing springs for livestock watering to draw livestock out of stream bottoms.

In some areas, the most practical measure for riparian management is to exclude livestock. This is intensive management as the fence maintenance requirements are higher and the exclusion area needs to be checked regularly, as livestock tend to wander into these areas and become trapped.

Noxious weed management deals with noxious weed seed sources, the methods of seed dispersion, and the reduction of values from infestations.

Resource Needs

The water quality issues raised for the uplands and riparian area involve the capture, storage, and release of seasonal precipitation. Grazing management of livestock on rangeland and grazeable woodlands involves manipulating the timing and intensity of grazing. In addition, physical impacts to streambanks from livestock hoof shear needs to be recognized and addressed. In order to manage native rangelands, landowners and managers will need to rotate grazing use to meet the needs of the plants and maintain enough vegetation to protect the site against soil erosion. This frequently requires site specific facilitating practices such as additional livestock watering sites and fencing.

Livestock tend to congregate in valley bottoms and graze the succulent green sod forming grasses along streams. Distribution of livestock needs to be addressed.

In grazeable woodlands, forest roads increase livestock access to streams. Livestock use roads to trail to streams for water. The upstream side of culverts generally exhibits livestock impacts. The sites that have concentrated livestock use, should have animal trails constructed to armor the sites and structures so animals can not trail up the stream.

Developing springs for livestock water in the uplands away from streams holds a tremendous opportunity to reduce the impact of livestock on streams. There are only a limited number of springs and these need to be developed where practical.

In the various sagebrush dominated sites where basin big sagebrush or mountain big sagebrush is the dominant brush species, management measures such as burning may need to be implemented. These plant communities evolved with fire resulting in bunchgrass dominated plant communities with perhaps 10 to 15% sagebrush canopies. To maintain this balance, these shrub/grasslands require periodic burning to maintain a balance between the grass species and sagebrush.

Soil stability, water quantity, and water quality suffer when native plants with fibrous root systems are replaced by noxious weeds with deep tap roots. The Noxious Weed Control Board of Okanogan County has categorize weeds into management requirements based on their current acreage's and rate of spread.

Class A weeds consist of those noxious weeds not native to the state that are of limited distribution or are unrecorded in the state and pose a serious threat to the state.

Control Class B Designate. Control is defined as the prevention of all seed production within a single program year; with the eventual aim being a reduction of the total acreage of the plant to a point where eradication is deemed possible.

New Invader Classification, Class A, B, C Weeds. Are those noxious weeds that have not been recognized by the state weed board as being a Class A Weed, that are new and/or established, which pose a very serious threat.

Reduction Class B and C Weeds. Weeds listed in this category are too widespread to be immediately controlled or eradicated Countywide. Currently diffuse knapweed is classified as a reduction species in Okanogan County. Landowners with one or more of these species present on their property should concentrate their initial reduction efforts in high priority areas such as roads, driveways, parking lots, and property boundaries. Reduction efforts should follow elsewhere on their property.

Suppression Class B and C Weeds. Weeds listed in this category are so widely disseminated that prevention of seed production within a single season is not practical. None the less, the species in the category are noxious weeds, and landowners are encouraged to control them.

There will be no harvesting of St. Johnswort in Okanogan County without an adequate plan accepted and approved by the Okanogan County Noxious Weed Control Board. The plan needs to address the prevention of off-site infestations as well as containment and clean up. A permit will be required.

Aquatic and /or Riparian Species. Because species in this category are found in or near water, a number of special considerations need to be taken to assure that impact to sensitive areas is eliminated or minimal in scope.

To keep the US Forest Service (USFS) Okanogan National Forest Pasayten Wilderness free of weeds, the trailheads where vehicles park will be kept free of weeds. The USFS does not allow hay into the wilderness and recommends only weed free pellets be packed in. The USFS Wilderness guards pull what few noxious weed plants that show up on the trails in the wilderness.

Herbicides have been found most successful in reclaiming infested rangeland and riparian sites. On severely infested sites, selective herbicide use has controlled and restored native grass stands. If left untreated, the surface water runoff and soil erosion can increase, resulting in damage to the soil resource resulting in reduced water quality. Selective herbicides kill targeted plant species while allowing grass recovery, without disturbing the seedbed or increasing the erosion potential.

Mechanical control methods can suppress noxious weeds but they can also create other problems such as soil erosion. Higher cost are involved in mechanical control, it is more time consuming, and may increase the infestations by creating more disturbed ground for the weeds seeds to take over. Mechanical control methods have not been widely adopted.

Management practices that restore desirable vegetation, such as those described above, are essential to improve the condition of ecosystems that have been damaged by changes in the composition or density of native plants or through the introduction of invasive, non-native plants. A challenge remains for land managers to use the most appropriate methods to remove or reduce problem vegetation and help create a healthy ecosystem and environment.

The Okanogan Conservation District strongly endorses the voluntary Coordinated Resource Management Planning process to landowners and land managers for managing natural resources. In the Okanogan Watershed Management Planning area there are 15 active Coordinated Resource Management planning groups with another eight more planning groups starting up in the next 5 years in the Omak Creek Watershed. These local planning groups operate within a framework of existing laws and regulations. They can assist and work with, but not over-ride, the decision-making authority of those responsible for public and private lands and resource management. The process provides for a voluntary coordination of activities toward common objectives and solves management problems through plan implementation.

CROPLAND

Extent

Cropland is defined as that land that is suited to or used for crops. Land devoted to row crops, close grown field crops, orchards, rotation hay and pasture, improved hayland, and summer fallow [NRCS (Natural Resource Conservation Service) Field Office Technical Guide, National Agronomy Manual].

Using the crop categories as provided in each annual issue of the Washington Agricultural Statistics booklet, the types and estimated acreage of crops grown in the county and in the watershed are listed below in Table 3.4:

Table 3.4
Crops and Associated Acreages

Field Crops	Watershed Acreage*

Non-irrigated Small Grains	29,911
Non-irrigated Hay	20,936
Field Crops	**Watershed Acreage***
Irrigated Hay	13,281
Vegetables	Not Available
Berries	Not Available
Fruits (all orchard land)	37,340
Nuts	Not Available

** Watershed Acreage is based on information from delineations by land use compiled and digitized by the NRCS and the Okanogan Conservation District, Okanogan, WA 1998.*

Refer to maps A through X8 and maps 3 through 6 in Appendix B for a visual interpretation of the various landuses in the watershed.

Wheat is the primary cereal grain grown in Okanogan County as well as in the Okanogan River basin (Washington Agricultural Statistics, 1998). Soft white winter wheat is grown more than any other class of wheat. Winter wheat and other cereal grains are grown primarily in two areas within the basin. The Molson and Pine Creek areas grow wheat and oats as part of a rotation that includes grass and legumes. The Duley Lake area (south part of the basin) grows wheat and other cereal grains as the primary crop. Total acreage used for cereal grain production for the basin is 29,911 acres.

Other cereal grains may include spring wheat (variety: Penewawa), spring barley (beardless varieties), and spring oats (Monida or Magnum). These grains are usually minor, in extent, but may be seeded due to certain crop rotations, weather conditions, grain markets and, to some extent, requirements of certain government programs.

Non-irrigated grass hay or grass/legume hay is found in areas that have a high water table, usually located along small creeks in the upland areas and mountain meadows. Most of these sites are harvested once each year (one cutting) or even less frequently. The decision to hay these fields is based on favorable moisture and growing conditions. Total acreage used for non-irrigated hay production in the basin is 20,936. The majority of the hay is raised by livestock operators who use the hay for their own livestock feed. If surplus hay is available, it is sold as a cash crop. Many farmers, who raise hay as part of their rotation, sell to livestock operators. During some years, the hay crop is insufficient to feed the basin's herd and Columbia basin hay is then brought into the Okanogan River basin to meet livestock needs.

Some truck crops (vegetables and fruit) are grown on a limited basis. These types of crops are usually grown in areas of the Okanogan River valley where there is deep soil, ample water available through irrigation and warm evenings providing the needed "degree days" to raise vegetables. Tomatoes, hot peppers, and sweet corn are examples of these types of vegetables.

History

Subsistence farming began and was centered on the developing mining industry. In the 1880's, more Euro-American settlement began with more "homesteading and general farming" type of agriculture. Many crops and different types of livestock were raised by homestead families for their own use with the surplus being sold to miners or mining companies. The turn of the century brought tremendous growth and changes to the agricultural community in the basin. The transportation system was being developed that would link communities, farmers and markets together. Fruit processing plants were being constructed, irrigation districts were being formed, and farmer marketing co-ops were developed. Technology was integrated into the fruit processing plants, making them more efficient, and allowing the fruit industry to become competitive at the national level. Railroad shipping connected the entire United States to producers in the watershed. Irrigation systems were extensively developed by 1916 with approximately 12,000 acres of irrigated orchards in the county.

The first type of agriculture was “dryland farming” and was used on most homesteads. Forage crops were grown to feed livestock. Homesteaders seeded dryland hay and utilized the hay for winter feed for dairy and beef livestock. Late summer and fall grazing was available on these fields in most years. Typical grass and grass/legume mixes were alfalfa and wheatgrasses. The most successful homesteads had fields that contained silt loam and sandy loam soil. These sites had enough depth to hold moisture through the growing season. This needed depth also allowed for an effective rooting depth and provided the available nutrients to meet the plant’s needs. Other less successful homesteads, located on shallow soils, were either sold to other neighboring farms or the county took the deed to the land if the taxes were in arrears. These former “farms” were eventually bought by other more successful farms or ranches and the ground was seeded to range grasses. Dryland fruits and vegetables were grown with limited success. As the valleys and terraces were developed into irrigated crops, dryland cereal grain production was concentrated in areas that were not suited to irrigation development. Cereal grains (mostly winter wheat) were grown in the Molson/Pine Creek area and the Duley Lake area on the Colville Indian Reservation. Grain production has not significantly expanded, during this century, because of the inability to compete with grain farmers in central Washington and the Palouse region.

The first irrigator in Okanogan County was Hiram F. “Okanogan” Smith who settled on land bordering the east end of Osoyoos Lake near Oroville in the 1850's (Wilson, 1990). In 1857 he planted 1200 tree sprouts obtained from a man named Phillip Ritz in the small settlement of Walla Walla, WA (Hilderbrand, 1991). His original orchard consisted of 24 acres of apples, 8 acres of peaches and pears, and 3 acres of grapes (Mierendorf et al., 1981). Irrigation water was supplied by a diversion ditch coming from Nine Mile Creek.

In 1887, about thirty years after Hiram Smith planted his orchard, Dr. J.I. Pogue and his brother John Pogue established homesteads near the base of Pogue Mountain, adjacent to Salmon Creek. Dr. Pogue planted the first orchard in 1888 and constructed a three and one-half mile irrigation ditch from Salmon Creek to his orchard land (Wilson, 1990 & Mierendorf et al., 1981). The first actual irrigation ditch was constructed in 1887 by H.C. Richardson. This ditch was routed from Salmon Creek to the top of the Okanogan Grade. Along with Victor Ruffenach, these gentleman combined their efforts to improve and develop three or four miles of ditch to deliver water to the three ranches (Wilson, 1990).

By 1906, fifteen private ditches were located between Conconully Dam and the Okanogan River diverting water from Salmon Creek. These ditches delivered water to 1,423 acres and had a capacity of approximately 57 cubic feet per second (Mierendorf et al., 1981).

The federal Reclamation Act (Newlands Act) of 1902 created the USDI Bureau of Reclamation (BOR). Initially concluding the Pogue Flat project, otherwise known as the Okanogan Irrigation District, (OID) was too small, too expensive, and too far from markets, the BOR felt it should not be considered. However, political pressure was brought to bear on the Secretary of Interior, E.A. Hitchcock to have the BOR reassess the project (Wilson 1990; Simmons 1984). In December 1905 the Okanogan project was approved thus becoming the first federal reclamation project in Washington State.

The OID began delivering water to about 2,052 acres in 1909 and added the second unit of 6,085 acres in 1910 (Wilson, 1990). However, there was not enough water for a 10,099-acre project nor did the sandy soils allow for efficient transportation of water. The most acres ever irrigated in this project was 7,850 acres (Wilson, 1990). The primary apple varieties grown were Winesaps and Jonathans with the balance being Spitzenbergs, Rome Beauties and Newton Pippins. The OID project contributed to the major population influx into the area.

The Oroville-Tonasket Irrigation Project (O-T) was completed in 1916 when it began irrigating about 3,000 acres. The Great Northern Railway promoted and financed the O-T in order to increase its freight volume. In 1927, the O-T annexed the irrigated land on the west side of the river, formally known as the West Okanogan Valley District. The O-T now served growers from the Canadian line south to Janis, WA. The delivery system was comprised of open ditches and wooden flumes. The BOR became involved in the early 1960's when rehabilitation work began. From 1983 to 1986, it was completely reconstructed to a pressurized system. This was to support the changes in technology and methods used in irrigation having changed from the old rill type originally used.

The Whitestone Irrigation and Power Company was formed in 1910 to serve the area from Loomis toward the Okanogan River. The water would be diverted from Toats Coulee Creek and transported to storage in Spectacle and Whitestone Lakes. The company gave way in 1919 to the Whitestone Reclamation district. Originally planned as a 10,000 acre project, it never expanded beyond 3,000 acres (Wilson, 1990).

The Pleasant Valley irrigation project diverts water from Loup Loup Creek and stores it in Leader Lake. About 80% of the water is supplied to Johnny Appleseed Orchards (formerly the Boston and Okanogan [B & O]). In the late 1920's with the Loup Loup Creek watershed drying up due to drought, the B & O Orchard began pumping out of the Okanogan River to augment the water from Leader Lake. There are presently a total of 1,800 acres being irrigated from this project (Wilson, 1990).

The Helensdale Irrigation District sells its water from Loup Loup Creek to the Pleasant Valley District but pumps from the Okanogan River to irrigate about 225 acres of orchard, alfalfa fields and lawns around Malott.

The Brewster Flat Irrigation Project was made possible by the construction of Chief Joseph Dam in 1950 - 1955. It delivers water to approximately 2,832 acres of mostly orchard land.

Current Condition

Dry Cropland

Most of the fields used for non-irrigated pasture and hay are in a long-term rotation, many are in a 10-15 year rotation. Some fields have been in permanent pastures for over 30 years with no planned rotation. The majority of the hay fields are in an alfalfa/grass stand for seven to nine years and a spring grain crop, such as oats, is seeded for one or two years. The one or two years of grain, in the rotation, allows the opportunity for field "clean up". Clean up refers to the opportunity to kill grasses and broadleaf weeds through both cultivation and herbicide applications. While the fields are being prepared for a grain crop, tillage will eliminate sod bound vegetation, and will smooth the field. A typical seed mix, for hay, is 7 pounds of alfalfa and 2-3 pounds of pubescent wheatgrass or smooth bromegrass seeded per acre. Hay seedings are mostly performed in the spring.

Alfalfa hay fields receive fertilizer every other year. A typical fertilizer program is to apply 25 pounds of phosphorus, 18 pounds of sulfur and 1 pound of boron per acre.

Normally, dryland hay fields will yield 1-2 tons per acre. Usually, one cutting is taken each year. On wet years, (averaging 1 in 10 years), two cuttings may be obtained with the second cutting only yielding 1/2 ton per acre. The second cutting is usually limited to the draws and low-lying areas where the moisture is present allowing for additional plant growth.

Pocket gophers are considered pests when they inhabit agricultural fields. They are treated by using strychnine coated oats or milo. The bait is applied by machine or by hand. This type of application is performed by licensed private or commercial applicators. The treated bait is placed underground away from domestic animals and non-target wildlife.

Weed control can be accomplished through cultivation during the stand establishment year or with herbicides in subsequent years.

The Okanogan County weed board administers State law (RCW 17.10), county weed laws, and local ordinances. The laws have listed and classified noxious weeds that are to be controlled or eradicated in the county. The laws have identified procedures, policy and control requirements, with time frames, that landowners need to adhere to.

The Molson/Pine Creek area has an annual precipitation range of 12” to 15”. The Duley Lake area has an annual precipitation range of 9” to 12”. During intensive conservation planning between the Okanogan Conservation District and the dryland farmers, in the late 1980’s, five typical crop rotations were identified with their corresponding tillage program. There were different amounts of over-winter surface residue requirements that were agreed to through Highly Erodible Land (HEL) provision of the 1985 Food Security Act (1985 Farm Bill) in order to achieve protection from excessive sheet and rill erosion. Tables 3.5 and 3.6 outline the rotations, the required residue amounts, and the typical tillage program by precipitation zone.

Table 3.5 outlines the rotations and typical tillage programs (when not in permanent vegetation) for each rotation in each precipitation zone.

Table 3.5
Crop Rotation and Required Residue to Reduce Potential Erosion

9-12 inch precipitation	Crop Rotation	12-15 inch precipitation
300 lbs. residue	WW - SF	400 lbs. Residue
N/A	10 years WW - SF (5 years in wheat, 5 years summer fallow)	350 lbs. Residue
N/A	WW - SG – SF	300 lbs. Residue
N/A	Continuous SG	1400 lbs. residue
N/A	9 years Continuous SG (straw is baled) - 5 years Grass	500 lbs. Residue

WW: Winter wheat, SF: Summer-Fallow, SG: Spring Grain (barley, wheat, oats, rye)

The average yields for non-irrigated grains and forage crops in the Okanogan Watershed are:

The Molson/Pine Creek area produces the following average yields:

Winter wheat	45 bushels/acre
Spring wheat	25 bushels/acre
Spring barley	1.0 ton/acre
Oats	2.0 ton/acre
Grass hay	1.5 tons/acre
Grass/legume hay	1.8 tons/acre

The Duley Lake area produces the following average yields:

Winter wheat	35 bushels/acre
Spring wheat	20 bushels/acre
Spring barley	1 tons/acre
Oats	1 tons/acre

Weeds and other competing vegetation have always presented a challenge to the commercial farmer. Weeds compete for moisture and nutrients from the growing crop and adversely affects yield potential. Weed control can be accomplished either biologically, chemically, mechanically or a combination of these. Mechanical weed control leaves the ground open and susceptible to erosion and chemical weed control increases the leaching potential of certain chemical compounds that may affect water quality in the basin.

The following table shows the most common weeds and typical herbicides used for weed control in the associated crops.

Table 3.7
Common Non-irrigated Crop Weeds and Controls

Non Irrigated Crop	**Target Pest**	**Pesticide**	**Trade name** **(Example only, not an endorsement)**
Grass hay	Broadleaf weeds	MCPA amine	2 4D
	wild oats	Diclofop methyl	Hoelon
		Triallate	Fargo
	aphids	Disulfoton	Disyston
		Dimethoate	Dimethoate
Grain	broadleaf weeds	Chlorsulfuron	Sulfinated urea
		Glyphosate	Round Up
		MCPA amine	2 4D
		Dicamba	Banvel
	grassy weeds	Glyphosate	Round Up

Fertilizers are materials, which supply one or more of the essential plant-food elements. Historically, many natural organic materials have been used as fertilizer, such as fish products, animal products and even human waste. Today, commercial fertilizers are used. Commercial fertilizers have several advantages when compared to natural materials.

1. Commercial fertilizers are more concentrated than most natural materials. Less weight and volume are needed to provide equivalent nutrients.
2. The plant food content of commercial fertilizers is known and is uniform throughout.
3. Commercial fertilizers can be tailor-made to suit a particular requirement.
4. Commercial fertilizers reduce impact on beneficial organisms that are susceptible to many pesticides.

Nutrient management includes the safe application of commercial fertilizer and organic fertilizer to a growing crop. The application rates vary and are based on the crop's needs, soil types and a soil test showing the elemental deficiencies for a planned crop. These deficiencies can be made up with the application of commercial fertilizer or natural materials.

Table 3.8 shows typical commercial fertilizer application rates for each major non-irrigated crop grown in the basin.

Table 3.8
Typical Annual rates of fertilizer inputs for small grain/hay (Lbs./Acre) in the Okanogan Basin

Element	Winter wheat	Spring Wheat/Barley	Grass Hay	Grass/Legume Hay
Nitrogen	50	40	40	30
Phosphorus	20	12	12	30
Potassium	0	0	30	30
Sulfur	10	10	20	25
Boron	0	0	0	1

Irrigated Cropland

There are nine irrigation districts, reclamation districts or canal companies operating in the Okanogan Watershed (Table 3.9). These nine irrigation water providers comprise the bulk of irrigation water delivery from surface water sources to approximately 24,710 acres (Okanogan Conservation District, 1989). The Washington State Department of Ecology's (DOE) 1995 Initial Watershed Assessment, Water Resources Inventory Area 49, Okanogan River Watershed notes that 98 percent of the surface water rights issued in the Okanogan Watershed are for irrigation use. There are 470 surface "paper" water right permit holders for 105,414 acre feet per year, over an area of 67,443 acres. For specific information see table 3.9 in Appendix C.

Groundwater rights issued for irrigation use represents 56 percent of the total quantity of groundwater rights. There are 307 water right permit holders with "paper" water rights for 39,344 acre feet per year of groundwater (DOE, 1995). This is to irrigate 10,437 acres.

The DOE assessment shows a total of surface and groundwater water rights permits and certificates in the Okanogan River Watershed for 77,880 acres. NRCS data estimates there is presently only about 51,083 acres of irrigated cropland in the Okanogan Watershed (Maps 3-6 in Appendix B). Of this, approximately 13,281 acres are irrigated hayland. Most of this is alfalfa that is grown for about seven years then the fields are rotated to small grain for two years of cleanup, and are then planted back to alfalfa. Small grain clean up crops are typically spring wheat, spring barley, rye and oats grown for forage hay. There are several hundred acres of irrigated corn grown for silage. Other irrigated forages grown in the watershed are Sudan grass and triticale. The average yields for irrigated grains and forages are as follows:

Table 3.10
Average Yields for Irrigated Grains

Grain	Yield	Unit of Measure
Winter Wheat	125	bushel/acre
Spring Wheat	125	bushel/acre
Spring Barley	2	tons/acre
Oats	1.5 to 2	tons/acre
Rye	1.5 to 2	tons/acre

Grain	Yield	Unit of Measure
Alfalfa	3 (cuttings) or 5	tons/acre
Alfalfa/Grass	3 (cuttings) or 5	tons/acre
Triticale	Multiple cuttings or 3-4	tons/acre
Sudan Grass	2 to 3	tons/acre

There are a number of noxious and other weeds more typically associated with irrigated grains and forage crops than other settings. These are kochia, Russian thistle, dodder, field bindweed, pigweeds, lambs quarter, various mustards, ragweed, quackgrass and foxtail grass.

Control for these weeds is either accomplished while the rotation is in small grains and a combination of herbicides and tillage operations is used, or with herbicides that are specific to grasses. The herbicides most widely used to control the various grasses in alfalfa stands are velpar, kerb, or sencor (see table 3.11). A young seeding of alfalfa may be treated with 2,4D-B and buctryl.

Weeds as defined, by the county weed board, have been and will continue to be part of agriculture. Plant populations will vary and will respond to herbicides for a period of time. Many "new" weeds become introduced via animals, birds or on machinery and vehicles.

Efforts to biologically control weeds in cropland, rangeland, and forestland have been ongoing for many decades. Some successful examples are using beetles to control St. Johnswort (goatweed). British Columbia and American agricultural scientists have been exploring biological means to control the different types of knapweeds in the northwest US, British Columbia, and Alberta. These experiments have been ongoing for many decades.

The nutrients used in the Okanogan Watershed on irrigated small grains are similar to what was described under the non-irrigated small grain cropland (Table 3.8).

Fruits - Plantings are generally done by hand during the spring. Although an increasing number of acres are being planted mechanically, especially in the high density blocks.

Depending upon apple variety and the growers objectives, the spacing between rows and within rows can vary considerably. The standard spacing between rows is 20' but varies from 14' to 25'. The standard spacing within rows is 18' to 20' but varies from 5' to 20'. With the many varieties and types of dwarf or semi-dwarf rootstocks available many growers are opting for higher density plantings of up to 1500 to even 2000 trees per acre. New trees generally take 2 to 5 years before producing.

Table 3.11
Irrigated Crop pests and pesticides most commonly used in the Okanogan Watershed

Irrigated Crop	Target Pest	Pesticide
Alfalfa	> Quackgrass, volunteer cereals, annual grasses in new and established stands.	pronoamide (kerb)
	> Winter annual grasses and broadleaf weeds in established stands.	hexazinone (velpar) metribuzin (sencor)
	> Dodder and other weeds in established stands.	dischlobenil (casoron)
	> Annual grass and broadleaf weeds in establishing new seedings	bromoxynil (buctril + 2,4-DB)
	> Aphids, grasshoppers	disulfoton (Disyston)
	> Grasshoppers, cutworms, alfalfa loopers, aphids, alfalfa weevil.	chlorpyrifos (lorsban) (Penncap-M)
Grains	> Annual broadleaf weeds.	dicamba (banvel) 2,4-D chlorsulfuron (glean) glyphosate (roundup)
Grass Hay	> Broadleaf weeds.	picloram (tordon) dicamba (banvel) 2,4-D
	> Annual grasses.	glyphosate (roundup)

Standard cherry row spacing is 20' to 22' for sweet cherry varieties and usually 18' to 20' for sour cherry varieties. The standard spacing within rows is 20' to 22' for sweet cherry varieties and 16' to 18' for sour cherry varieties. Average yields are 7 tons per acre.

The standard row spacing for pears is usually 18' to 22'. The standard spacing within rows is 10' to 20'. Average yields are 600 to 1000 boxes per acre.

Water management is accomplished using a particular type of irrigation system and irrigation water management. The most common irrigation system is an under the tree permanent solid set sprinkler using micro sprinklers or conventional impact sprinklers. Overhead permanent sprinkler systems are selectively used. Some irrigation systems may be used for spring frost control efforts and for summer temperature modification. The technological knowledge base for irrigation systems and irrigation water management has improved dramatically over the last 20 years. Irrigation methods have changed from rills and clean cultivation to grass cover crops with sprinklers to micro-sprinkler systems. Advances in soil moisture monitoring technology have accompanied these advances in irrigation methods though not all growers are taking advantage of them. These advances have increased the over-all efficient application of water.

Fertilization is necessary to produce the quality and quantity of fruit to make orchard enterprises economically successful. The major soil type found in orchard producing areas are course textured. These porous soils allow for easier root development compared to soils such as silt loams. Additionally, these soils allow for more rapid water infiltration, which increases the risk of leaching nutrients into ground and surface waters. Use of fertilizers, both in agriculture and urban areas, has a major influence on nitrogen and phosphorus in the environment. Commercial nitrogen fertilizers are applied as either ammonia or nitrate, but ammonia is rapidly converted to nitrate in the soil. Excess nitrate, not taken up by plants, can enter streams or seep down into ground water (Mueller & Helsel, 1996).

Phosphorus fertilizer is applied as a compound of phosphate. Phosphate is not very mobile in soil; it tends to remain attached to solid particles rather than dissolving in water. However, soil erosion can carry a considerable amount of particulate phosphate into streams (Mueller & Helsel, 1996).

Generally, young trees may require about 1/10 pound of actual Nitrogen (N) per year of age up to one pound actual N per tree. Mature trees can use about 80 pounds of actual N per acre per year. These general levels should be adjusted up or down depending upon cultural practices, pruning, fruit color, fruit quality and maturity, and soils. Applications may be made at any time after the trees have become dormant in the fall until growth begins in the spring. Soil applications are most effective if made preceding rains or sprinkler irrigation (Tukey et al. 1984). Application of N through trickle irrigation systems (fertigation) is an effective and efficient method for providing N to fruit trees. It generally requires less N (up to one-half less) than might be required in soil surface applications (Peterson & Stevens. 1994). The potential for loss of nitrogen by leaching is greater with nitrates than with ammonium forms of nitrogen. This problem is accentuated when nitrates are applied to coarse-textured soils (Peterson & Stevens. 1994). Nitrogen source, rate of application, and application timing interact with soil properties to play an important role in how a nitrogen management program must be implemented to minimize the potential for pollution of surface or ground waters.

No fruit trees in Washington have been found to respond to Phosphorus (P) regardless of soil or tissue test levels. Availability of P is strongly influenced by soil pH. Maximum availability of phosphorus is usually observed when soil pH is maintained between 6.0 and 7.0. Applications of phosphoric fertilizers to the soil surface in established orchards are relatively ineffective and are more likely to result in contamination of surface water supplies through surface soil erosion than in significant crop responses (Peterson & Stevens. 1994).

Potassium is relatively non-mobile in soils. The potassium supplying ability of individual soils differs widely depending largely upon the parent material from which they are derived. Soils with coarse textures do not restrict root growth, as may finer textured soils, which will allow the potassium to become available (Peterson & Stevens. 1994). However, coarser textured soils tend to be droughtier. Irrigation management, that minimizes moisture stress, will favor potassium uptake.

The acidity or alkalinity of a soil is measured in terms of "pH". Fruit trees can be found growing well at pH values ranging from as low as pH 5.0 to as high as pH 8.0. A soil pH of 6.0 to 7.5 is desirable. Acid to alkaline, should be adjusted soil pH to about 6.5.

Magnesium (Mg) is one of the nutrients often found deficient in fruit trees. Foliar applications of Mg nitrate are effective. Mg is relatively immobile in most soils and maintenance of a healthy root system is important for Mg uptake. Under field conditions, the rate of uptake of Mg is influenced by the amounts of Calcium, potassium, and ammonium ions in the soil solution at the root surface (Peterson and Stevens 1994).

Boron (B) is a nutrient often found low or deficient in Washington orchards. Most well drained soils are low in B (Peterson and Stevens 1994). The majority of typical cropland soils in the Okanogan River watershed are well drained. Deficiencies can be corrected or prevented by soil applications of B, by broadcasting over the entire soil surface (1998 Crop Protection Guide for Fruit Trees in Washington).

Deficiencies of sulfur (S) are most frequently observed on coarse textured soils that have low organic matter content, shallow soils, or soils in which the topsoil has been removed by erosion or land leveling operations. When in the sulfate form, S is readily leached through and from the coarser textured soils (Peterson and Stevens 1994). Various fertilizer materials and sulfur-based fungicides provide S. In addition to maintaining organic matter content of the soils, use of these types of materials in fertilization or pest management programs usually provides adequate amounts of S to meet the requirements of deciduous orchards (Peterson and Stevens 1994). Sulfur, when used, is generally used as a soil amendment/fertilizer to help lower pH so as to enhance the availability of other nutrients such as phosphorus.

Zinc deficiencies are common in the Okanogan Watershed. Maintenance applications of two pounds of actual zinc per acre per year is generally used. With a zinc deficiency, a rate of about 14 pounds actual zinc per acre is applied in the early spring. Spray applications are made with zinc sulfate, zinc nitrate, or one of the zinc chelate materials. Soil applications are either zinc sulfate, one of the zinc chelates or as one of the zinc organic complex materials (Tukey et al., 1984). To be effective, zinc applications need to be made annually and are accomplished via foliar applications.

Pesticides are routinely used in most agricultural applications in the Okanogan Watershed. Herbicides are used for control of weeds and ground cover crops. Insecticides and fungicides are used to keep the crops pest free, healthy, and able to produce a good volume of quality products. New pesticides being used now are “soft chemicals” that are friendlier to the environment. They are very species specific and breakdown or biodegrade quickly. The emphasis now is to control insect populations rather than attempt to eradicate undesirable insect populations. Additionally, mating disruption technology has evolved to where it is a very viable tool and will continue to increase in application.

Integrated Pest Management (IPM) tries to lower pest populations below levels that cause economic damage by using a compatible balance of biological, cultural, chemical, genetic, or other control methods (Extension Services, 1990). The advantages of IPM over routine pesticide applications are:

1. Reduces resistance development in many pests.
2. If IPM leads to reduced pesticide use, growers may benefit from lower production costs.
3. Reduces dependency on fossil fuels, as most pesticides are petroleum based.
4. Many pesticides are toxic to a variety of beneficial organisms that contribute to pleasure in this environment and/or that help control pests.

A typical IPM program for this area is presented in table 3.12.

IPM involves using a combination of chemical, cultural and biological means for control. This type of program reduces the amount of chemicals applied, moves towards a natural balance, and slows the natural progression for pests to build resistance to the pesticide.

Trend

Small Grain Crops

Grain production has been ongoing for almost 100 years in the Okanogan River basin. Excessive sheet, wind, and rill erosion has been the primary problem associated with grain production [US Department of Agriculture (USDA), 1979]. Off-site impacts such as sedimentation to county road ditches, streams and loss of fish habitat have also occurred. Modern machinery, newer herbicides and the use of conservation tillage have been effective in reducing long-term average annual erosion rates in the basin.

Conventional tillage is that series of tillage operations and types of tillage equipment that result in very minimal residue during the critical erosion period. Reduced tillage is that combination of tillage equipment and series of tillage operations which results in more surface residues (which equates to more soil surface protection) during the critical erosion period. The 1985 Farm Bill, titled the Food Security Act, required farmers of agricultural commodity crops who had Highly Erodible Land determined on their fields and participated in USDA programs to have a conservation compliance plan. In this area this generally required maintaining a certain level of residue following seeding. Though controversial at the time, the Food Security Act helped guide farmers to increase the amount of reduced tillage/ residue management with no loss in overall production.

The general rotation of 8 years grass/alfalfa and 2 years annual grain using conventional tillage, during the years when grain is being grown, has an average erosion rate of less than 4 tons per acre per year [Tom Rice, personal communication and Revised Universal Soil Loss Equation (RUSLE) calculations]. If the farmer is using reduced tillage techniques and using a high level of residue management, the average is 3 tons per acre per year. With a crop rotation of continuous annual spring grain, using conventional tillage, the erosion rates average 7 tons per acre and only 4 tons per acre when using reduced tillage. This is calculated using the NRCS's RUSLE with the typical cropland soil (Molson silt loam at 8 - 15 percent slopes) in this area.

In the Duley Lake area, (12 inches of annual precipitation), the typical crop rotation of winter wheat/ summer fallow, (Timentwa loam, 0 - 8 percent slopes) under conventional tillage, will have an average erosion rate of 4 tons per acre per year. Using reduced tillage techniques the average is 2 tons per acre per year. A three-year crop rotation is sometimes used by some of the growers with winter wheat/ spring barley/ summer fallow. This reduces the operating costs and improves the average return over a 5 year period (Tom Poole, personal communication, 1997). If using conventional tillage the average erosion rate on the Timentwa loam, 0 - 8 percent slopes, is 3 tons per acre annually. With reduced tillage, the average erosion rate on this same soil is 2 tons per acre annually.

The amount of farmed acres has been decreasing during the last several decades. Many factors have contributed to the decline. Some factors include: continuous suppressed grain prices in the last 25 years which puts the Okanogan County farmers in a less than competitive position to the central Washington and Palouse area farmers. Yields are typically lower than most areas in the inland northwest. Many fields are small and irregularly shaped. When these fields are farmed with modern equipment, the efficiency decreases and raises the cost of production. The economics of raising grain in Okanogan County do not allow for many full time farmers. It takes approximately 4,000 acres to support a family. The infrastructure associated to grain production is not in Okanogan County. Today, the majority of the dryland cropland is leased to farmers from Douglas County. The dry cropland area near Molson is farmed by local farmers; however, grain production is usually a part of a diversified farm operation, which may also include raising hay, cattle, and forest products.

The amount of fertilizer that is necessary to raise a crop is anticipated to remain at the current level. The additional amounts can only be justified if market conditions improve. By using state of the art fertilizer spreaders, the rates or overall amounts may decrease. This type of application is based on intensive soil testing, and split or multi split applications. In some cases, foliar feeding may be used.

In many cases, terraces above the Okanogan River have been developed into orchards during the last 20 years. This conversion is warranted if irrigation water is available, the soil type is suited for fruit tree production and there is the absence of frost pockets. In some cases these terraces, or older established orchards along the river, have been converted to residential housing or subdivided into small rural farms. The Okanogan County planning commission has guidelines to which subdivisions must adhere.

An aspect of older orchard land conversion to developments is the concern of lead arsenate in the soils.

Lead arsenate was heavily used as a pest control for apple codling moth for more than 40 years (approximately 1908 to 1947) throughout central Washington. The pesticides main components, lead and arsenic, are known to cause serious health effects when chronically introduced into the body in pure form. They do not decompose or breakdown and can remain near the surface of the soil for hundreds of years. The present information is inconclusive as to whether this is a serious health concern on these orchard land conversions. People, in particular children, are known to ingest soil in many ways. Nevertheless, just because soil is ingested, it doesn't always follow that arsenic and lead is adsorbed by the body. Studies suggest that the two substances are not absorbed as well when bound to soil. One longtime study of farmers who had applied lead arsenate and who had been repeatedly exposed to the active ingredients found no conclusive health effects. The cost of digging out contaminated soil to a depth of about 3 feet and replacing it with clean soil is about $20,000 per acre (Wenatchee World, July 1996).

Lead arsenate was not widely used in Okanogan County during the timeframe noted above. The reason it was not used very much was that the codling moth was not nearly so much of a problem in this northern area back then as it was in the central and southern parts of the state (Noble Law, personal communication, 1998).

Important Farmland

The USDA has defined important farmland as part of the USDA Statement on Land Use Policy, Departmental Regulation 9500-3.

Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. It has the soil quality, growing season, and moisture supply needed to produce, economically, sustained high yields of crops when treated and managed, including water management, according to acceptable farming methods. There are specific criteria as defined in Soil Taxonomy, Agriculture Handbook 436, which soils must meet to be considered prime farmland. There are approximately 33,600 acres of non-irrigated prime farmland in Okanogan County and 102,314 acres of Irrigated prime farmland (Okanogan [1980] and Colville Reservation Soil Surveys (unpublished). Note that if the land is considered non-irrigated prime farmland, then it is also considered prime when irrigated. See Table 3.15, which shows the characteristic cropland soils and important farmland classification in the Okanogan Watershed.

Unique Farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops.

Farmland of Statewide Importance is land in addition to prime and unique farmlands, that is of statewide importance for the production of food, feed, fiber, forage, and oilseed crops. Criteria for defining and delineating this land are determined by the appropriate state agency.

Characteristic soils for orchard and irrigated hayland in the Okanogan Valley are as follows. Representative soils are the Pogue-Cashmont-Cashmere Association. These are deep, somewhat excessively drained and excessively drained soils formed in glacial outwash. They are fine sandy loams to sandy loams. These predominantly occur on terraces, terrace breaks, till plains and alluvial fans at elevations of 700 to 1500 feet. Permeability is moderately rapid. The available water capacity is moderate. Runoff is very slow to medium. Hazard of erosion is slight to moderate depending upon the slope. Roots penetrate to 60 inches or more. Predominant slope classes are 0 to 15 percent. The slope class of 15 to 25 percent has been developed where irrigation is available.

Additional soils on which a fair amount of cropland irrigation occurs are: Tonasket silt loams, Okanogan loams and Nighthawk loams. The Tonasket silt loams consists of deep, well drained soils formed in glacial lake deposits at elevations of 700 to 1500 feet. Permeability is moderately slow. The available water capacity is high. Roots penetrate to 60 inches or more. Runoff is slow to very slow and hazard of erosion is none to slight.

The Okanogan loams are deep, well drained soils formed in alluvium. These nearly level soils are on bottom land and broad alluvial fans at elevations of 700 to 1500 feet. Permeability is moderate. The available water capacity is moderately high or high. Roots penetrate to 60 inches or more. Runoff is very slow, and the hazard of erosion is none to slight.

Nighthawk loams are deep well drained soils formed in glacial till over shale. These gently sloping to very steep soils are on uplands at elevations of 700 to 2500 feet. Permeability is moderate. The available water capacity is moderately high. Roots penetrate to 60 inches or more. Runoff is slow to medium (depending on slope) with hazard of erosion slight to medium (depending on slope).

Characteristic dryland soils for field crops in the north end of the Okanogan Valley are Molson, Koepke, Havillah, and Hunters silt loams. These are deep, well drained soils formed in a mantle of volcanic ash and the underlying glacial till, or in the case of the Hunters soil, in glacial lake deposits. These occur mostly on uplands and terraces at elevations from 1900 to 5000 feet. Permeability is moderately slow to moderate. The available water capacity is high. Roots penetrate to 60 inches or more. Runoff is slow to medium. Hazard of erosion is slight to moderate.

Characteristic dryland soils for field crops in the south end of the Okanogan Valley are Timentwa loam and Duley Lake loam. These are deep, well drained soils formed in glacial outwash. The available water capacity is high. Roots penetrate to 60 inches or more. Runoff is slow to medium. Hazard of erosion is slight to moderate.

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are so used, and the way they respond to treatment.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. See Table 3.13 for capability classes of characteristic cropland soils in the Okanogan watershed.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, **e**, **w**, or **s** to the class numeral, for example, IIe. The letter **e** shows that the main limitation is risk of erosion; **w** shows that water in or on the soil interferes with plant growth or cultivation; **s** shows that the soil is limited mainly because it is shallow, droughty, or stony.

Orchard crops are placed into seven groups in the Okanogan Watershed. Focusing on the characteristic soils for the Okanogan watershed, only two orchard groups are relevant. See Table 3.14 for orchard group classification of characteristic soils of cropland in the Okanogan watershed. The soils in each group require similar management. Following is a brief description of the soils in

Table 3.13
Soil Capability Classes

Class I	soils have few limitations that restrict their use
Class II	soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices
Class III	soils have severe limitations that reduce the choice of plants, require special conservation practices, or both
Class IV	soils have very severe limitations that reduce the choice of plants, require very careful management, or both
Class V	soils are not likely to erode, but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife
Class VI	soils have severe limitations that make them generally unsuitable for cultivation and limit their use largely to pasture, range, woodland, or wildlife
Class VII	soils have very severe limitations that make them unsuitable for cultivation and that restrict their use largely to pasture or range, woodland, or wildlife

Class VIII	soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes

each orchard group and the associated management.

Orchard group 1 - well drained, medium textured and moderately coarse textured soils of the Cashmere, Cashmont, Nighthawk, Okanogan, and Tonasket series. Soil depth is greater than 40 inches. Slopes range from 0 to 25 percent, but most are less than 15 percent. Elevations are 700 to 2500 feet. The available water capacity is moderately high, and permeability is moderately slow to moderately rapid. Runoff is very slow to medium, and the hazard of erosion is slight to moderate. On mature orchards, 5 to 8.5 inches of water should be applied every 2 to 3 weeks during the growing season.

Orchard group 2 - well drained, moderately coarse textured soils of the Aeneas and Pogue series. Depth to coarse textures is 20 to 40 inches. Slopes range from 0 to 25%, but most are less than 15 percent. Elevations are 700 to 1800 feet. The available water capacity is moderate to moderately high, and permeability is moderately rapid. Runoff is very slow to medium, and the hazard of erosion is slight to moderate. On mature orchards, 3 to 4 inches of water should be applied every 5 to 8 days during the growing season.

Hydrologic Soil Groups are used to estimate runoff from precipitation. Soils not protected by vegetation are placed in one of four groups based on the intake of water after the soils have been wetted and have received precipitation from long-duration storms. Group A soils have high infiltration rates and low runoff potential. Group B soils have moderate infiltration and moderate runoff. Group C soils have slow infiltration and rapid runoff. Group D soils have very slow infiltration and very rapid runoff potential. For hydrologic soil group classification of characteristic cropland soils in the Okanogan watershed, see Table 3.14.

The predominate soils used for cropland activities in the Okanogan watershed are in the Hydrologic Soil Group B. These soils have moderate infiltration and moderate runoff rates.

Relationship to Water Quality

Siltation

The 1992 Environmental Protection Agency 305(b) report stated siltation is the leading cause of water quality impairment in rivers (Table 3.15).

Table 3.15
Leading Causes of Water Quality Impairment

Rank	Rivers	Lakes	Estuaries
1	Siltatation	Metals	Nutrients

2	Nutrients	Nutrients	Pathogens
3	Pathogens	Organic enrichment	Organic enrichment
4	Pesticides	Siltation	Siltation

Source: EPA 1992 305(b) Report

Mechanical soil disturbing activities invariably result in an increased opportunity for soil erosion to occur. Soil erosion is the movement of soil from its native location. While soil erosion is a natural process, it is often accelerated by human activities. Soil erosion is not only detrimental to crop production; it also results in considerable off-farm damage. There are two types of erosion, wind and water. Water erosion is the major type of erosion affecting the Okanogan Watershed (USDA, Okanogan County Area Soil Survey, 1980).

Eroded sediments and associated nutrients and pesticides from cropland can be introduced in roadside ditches and reservoirs, impede navigational channels, adversely affect aquatic plant and animal life, reduce recreational opportunities, increase costs of municipal water supplies, and can endanger human health.

Water Erosion

Water erosion can be separated into different forms based on how water is moving over the surface. At first, water will move a short distance as a thin film over the soil surface. Loss of soil in this thin film of water is known as sheet erosion. As the process continues, water begins to concentrate in small channels or rills. Soil erosion during this phase is termed rill erosion. The resulting sediment from sheet and rill erosion will be finer textured and will contain higher proportions of nutrients, and other adsorbed pollutants than sediment from other erosion processes (Watson, 1994).

Water concentrated into rills will form larger and more persistent channels. These channels are known as ephemeral gullies and soil erosion from these channels is termed ephemeral gully erosion. Tillage generally removes these channels and they do not become permanent. Eventually, runoff water reaches permanent, natural watercourses, such as drainage ways and draws. These features typically run water only during peak runoff periods. Excessive soil erosion from these features causes gullies and this type of erosion is known as gully erosion. Gullies generally cannot be removed by tillage or crossed with equipment. Runoff water ultimately enters intermittent or perennial streams. Undercutting or other forms of erosion from the water's edge causes stream bank erosion. Gully and stream bank erosion can remove larger soil particles, and often contains a much lower proportion of nutrients and adsorbed pollutants than sediment from sheet and rill erosion.

All forms of erosion can be serious. Although gully or rill erosion is readily visible, sheet erosion may be responsible for greater soil loss.

Water erosion is a combination of three processes: (1) detachment, (2) transport, and (3) deposition. Soil is detached by raindrop impact or the force of flowing water. Once detached, soil particles are transported by flowing water. Deposition occurs when water velocity slows and suspended particles drop out.

Water erosion is affected by precipitation patterns, soil properties, vegetative cover, slope, and management practices. Factors such as organic matter content, crop residue cover, and soil surface roughness interact to determine how a soil resists the erosive force of water.

Please refer back to the Trends section for information of soil erosion rates as calculated by the RUSLE.

Cropping Practices

In the Okanogan watershed, the combination of fall disking and chiseling is the most common type of primary tillage performed in the fall following winter wheat. Fall tillage is used to promote infiltration and to control weeds. Secondary tillage involves field cultivators and rod weeders. The use of non-selective herbicides has helped to delay initial tillage operations in both fall-tillage operations and spring-tillage operations. Fall seeded wheat is usually seeded with a deep furrow drill and is seeded in late August. Late August and early September is considered as "early seeding" and allows for the wheat plants to grow quite significantly before winter dormancy (December-March). This fall growth generally provides ample ground cover for erosion control in most years.

With effective herbicides and using a conservation tillage program, erosion has decreased significantly the last 20 years (Natural Resources Inventory, 1985-1995, NRCS). Most of the erosion occurs during the winter and spring months during the part of the crop rotation when winter wheat is in. The period between November and March is known as the "critical erosion period". The majority of the annual precipitation occurs during this period. Other conditions, such as continuous freezing and thawing of the soil, and the condition of the soil (surface roughness) along with the lack of sufficient surface residue, contribute to fields being vulnerable to erosion during this critical period. Smooth ground, with low residue levels, allows the rainwater to freely run off when the soil profile is filled.

The ideal type of seeding is to maximize the amount of seed to soil contact. This increases the germination rate and adds to an overall successful field seeding. The conventional seeding operation involves primary tillage to break up clods and incorporate residues from the previous crop and involves many secondary tillage trips using cultivators, rod weeders, packers and drills. Each tillage operation breaks down the adhesive soil properties while physically smoothing the field. This condition leaves the field vulnerable to erosion if certain weather conditions exist.

In wheat growing areas where the precipitation is higher, soils are deeper, and crops are grown either annually or two out of three years, farmers have successfully used alternative methods of seeding referred to as no-till seeding, reduced-till seeding and direct seeding.

Whether tillage, planting, or harvesting the best strategy for water erosion control is to reduce soil detachment. Keeping the soil in place is the easiest and often the most effective approach. Soil management to preserve organic matter, soil structure, and tilth aids in infiltration and thus reduces detachment. Residue and vegetative cover can also reduce transport by slowing the rate of runoff. Thirty percent of residue cover reduces erosion by about 50%, compared to bare soil. Keeping sufficient cover on the soil is a principal erosion control practice. Desired amounts of residue can be achieved through the choice of tillage implements, speed of operation, and timing of tillage.

Contour tillage and increasing soil surface roughness are techniques used to reduce soil loss. Tilling on the contour provides furrows perpendicular to the slope, which act as collection basins and slow runoff. Roughening the soil surface at critical times with the proper tillage implement creates surface storage, enhances infiltration, slows runoff, and can produce erosion-resistant clods. Reducing the length of slope also helps control soil erosion by reducing transport.

Deposition occurs when the soil particle is no longer moved by the force of water. Practices that provide a sink which traps sediment are: (1) close-growing grasses, legumes, and small grains used on level ground, (2) terraces, (3) surface roughness, (4) stripcropping, and water and sediment control basins. These practices all slow the movement of water below the critical speed, which allow settling of soil particles.

Nutrients

Site properties are important in determining potential for nutrient and pesticide movement to surface or ground water. These site properties are: (1) hydrologic soil group, (2) soil permeability, (3) organic matter, (4) soil texture, (5) soil erodibility, (6) soil pH, (7) flooding potential, and geologic conditions and depth to ground water.

Hydrologic Soil Group is an excellent indicator of a soil's potential to transport pesticides or nutrients, either by surface runoff or percolation. Soils are categorized into four hydrologic groups (A, B, C, and D). Hydrologic group D soils have the highest runoff potential, followed by group C, B, and A soils respectively. Conversely, hydrologic group A soils have the highest leaching potential, followed by group B, C, and D soils. See Physical Description of Landuse part for Hydrologic Soil Group ratings for characteristic cropland soils in the Okanogan Watershed.

Soil Permeability is a measure of the ease with which water moves or is transported through a soil.

Organic Matter is important in providing adsorption sites and in promoting pesticide breakdown.

Soil Texture is an indication of the relative proportion of sand, silt, and clay in soil.

Sheet and rill erosion (soil erodibility) provides transport of those nutrient and pesticides, which are strongly adsorbed and bound to soil particles.

Soil pH is a measure of the degree of its acidity or alkalinity and can affect runoff or leaching by determining the electrical charge of certain chemicals.

Flooding (Flooding Potential) can have a large effect on the amount of pesticides and nutrients lost to surface water.

Geologic Conditions and Depth to Ground Water also determine the likelihood of pesticide or nitrate leaching to ground water.

The same three principles involved in wind and water erosion (detachment, transport, and deposition) also apply to nutrient and pesticide movement. In the case of nutrients and pesticides, the principle of availability is also a factor. Before a nutrient or pesticide can become an environmental problem, it must be available for movement. Some nutrients and most pesticides that move off-site do so while dissolved in water. Other nutrients such as phosphorus, and a few pesticides are adsorbed or tightly bound to soil particles.

Pesticides and nutrients are most susceptible to runoff while they are in the "mixing zone." The mixing zone is a thin layer at the soil surface where overland flow, chemicals, and soils intermix during runoff. The mixing zone is often only 1/10 to 1/3 of an inch in thickness. Once the chemical is below the mixing zone, it is usually less susceptible to runoff losses, with the exception of nitrate. Because nitrate is weakly adsorbed, it can readily move into surface water from subsurface lateral flow.

The chief nutrients that can adversely impact water quality are nitrogen and phosphorus. This is primarily caused by agriculture and urban activity (Carpenter, et al. 1998). Certain compounds may be toxic, plankton blooms may occur, and an increase in biochemical oxygen demands (BOD) may occur.

Contamination of ground water aquifers by nitrate nitrogen can be a serious problem in areas of irrigated agriculture due to the large amounts of nitrogen fertilizer that are normally used to ensure satisfactory yields. The potential for nitrate contamination depends on several factors: (1) soil texture and structure, (2) timing and amount of irrigation and rainfall, (3) the amount of nitrogen in the soil at the time of deep percolation, and (4) depth to the water table.

Nitrogen that exists as organic matter or in crop residue is immobilized and will not likely move into water supplies. At the ammonium step of the nitrogen cycle, nitrogen is adsorbed or bound to soil particles. In this form, it may be transported to surface water with eroding soil, but is unlikely to leach into ground water. At the nitrate step of the cycle, nitrogen is soluble. Nitrate can be transported from the root zone by percolating water or to surface waters by subsurface lateral flow, tile drainage, or overland flow. In one study of 86 rivers, nonpoint nitrogen sources were responsible for more than 90% of nitrogen inputs to more than half of these rivers (Carpenter et al., 1998).

About 99% of the total phosphorus in soils is tied up in compounds that are not readily available to plants. Of the three major nutrients, phosphorus is the least mobile in the soil. This does not mean that phosphorus will not move off-site. The majority of phosphorus remains on cropland, with only 3 - 20% leaving by export to surface waters. Phosphorus, both inorganic and organic, can readily be transported to surface water along with eroding soil particles. Phosphorus can also be moved off-site while dissolved in water.

Plants require many nutrients besides nitrogen and phosphorus for proper growth. These are usually referred to as micronutrients or microelements. Examples are macro potassium, zinc, boron, sulfur, calcium, and magnesium among others. These are generally not as much a concern as nitrogen and phosphorus in terms of potential pollution (Canessa & Hermanson, 1994).

Pesticides

The primary factors that decide a pesticides fate are; (1) the pesticide properties, (2) the soil properties, (3) site conditions, and (4) the application process. The important pesticide properties include adsorptivity, degradation rate, solubility, and volatility (Canessa & Hermanson, 1994).

Adsorptivity is a measure of how strongly the pesticide (chemical) bonds to soil particles. The higher the adsorptivity, the less likely it is that the chemical will be leached through the root zone. However, high adsorptivity means that chemicals can move with sediment during soil erosion.

Degradation rate is a measure of how fast the pesticide breaks down into other chemicals. The longer it takes a chemical to break down, the more opportunity there is for detachment and transport.

Solubility is a measure of how well the chemical dissolves in water. A highly soluble chemical can move readily with water.

Volatility is a measure of how fast a chemical evaporates. Highly volatile chemicals should be injected into the soil or worked in quickly to prevent losses.

The use of pesticides in the United States is approximately 1,100,000 pounds per year. Herbicides account for 64 percent of total usage, insecticides 18 percent, and fungicides 8 percent.

WILDLIFE

Extent

The diversity of plant communities is indicative of the historical and present diversity of wildlife species found in the Okanogan River watershed. Plant communities in the basin range from the sub-alpine in the high elevations of the Tiffany Mountain area and Pasayten Wilderness to shrub-steppe of the lower elevations along the Similkameen and Okanogan Rivers. Human influences and in general the condition of the watershed has had an impact on the wildlife resource. This section describes, in general terms, historical as well as current conditions of the wildlife resource. Changes in wildlife species and/or numbers, over time, may be indicative of changes in watershed conditions. These indications, however, should be used in conjunction with other indicators, to describe watershed condition.

The Okanogan River watershed has historically supported a wide range of wildlife, as its varied topography and vegetation would suggest. Mule deer populations have fluctuated greatly. In the 1800's when European man first arrived, mule deer populations were apparently extremely low (Ziegler, 1978). In the current century, deer populations have fluctuated widely with historic highs in the 1950s and 60s (Fitkin, 1997). Reasons for these population movements have been cited by numerous authors as having been caused by severe weather conditions, overused winter range, and/or hunting pressure. In recent times, white-tailed deer populations have been increasing partially as a result of habitat changes and humans encroaching on traditional mule deer winter ranges
(Fitkin, 1997).

Prior to 1900, bighorn sheep roamed over much of the area, but by the turn of the century had all but disappeared. The last native bighorn sheep was killed near Loomis about 1915 (Okanogan River Basin Level B Study, 1977). They were reintroduced in the Sinlahekin Habitat Management Area in 1957 and on Mount Hull in 1970 [Washington State Department of Fish & Wildlife (WDFW), 1995].

"Upland game birds, native and introduced, at first reacted favorably to man as dry land farming increased winter feed, fence rows provided increased cover and small farms produced a variety of crops. Changes in crops, farming methods, grazing, and abandonment of upland dry land farms have all contributed to the decline"(Okanogan River Basin level B study 1977).

Fur bearing animals were extensively trapped in the early 1800's (the Hudson Bay Trading Company had a business location here) and by the turn of the century were practically nonexistent. Reintroduction and protective management have restored harvestable populations of some of these animals (Okanogan River Basin Level B Study, 1977).

Numerous exotic (non-native) species have been introduced to the basin. These exotics for the most part were introduced as game animals. Some of the upland game species were planted yearly by the Washington Department of Wildlife (now WDFW). This practice of stocking exotic wildlife for "put and take" hunting was stopped in 1983 (Ware, 1998). Declines in populations of pheasant and chukar since that time are, at least partially, a result of this policy change combined with declines in habitat or weather conditions. Table 3.16 is a listing of the species introduced into the Okanogan River watershed.

History

In earlier times, there was little concern about the impact of activities on the flora and fauna of the area. Consequently, activities of the early European settlers did impact local wildlife resources. Some specific examples of these activities included the early cattle drives, development of agriculture, and forest management activities. The development of orchards, in particular as well

TABLE 3.16
Introduced Species

Species	When Introduced	Current Status/Remarks
California Bighorn sheep	Native – reintroduced in 1957 Aeneas Mt. (Sinlahekin HMA); 1970 Mt. Hull, Omak Lake not known.	Located on Mt. Hull, Aeneas Mt, & N. of Omak Lake – limited hunting on the Mt. Hull herd
Chukar	Unknown	Unknown
Hungarian partridge	Unknown	Unknown
Ring-necked pheasant	Unknown	Unknown
Turkey (Rio Grande subspecies)	1991- through 1995, 63 birds – Chiliwist Wildlife Area	Hunted population since 1992. Population appears to be stable (WDFW annual report 1997)
California quail	Unknown	Unknown
Red fox (there is also the native Cascade red fox)	Unknown	Documented

as other agriculture fragmented habitats used by wildlife and hindered movement by various species. This is probably best characterized by movement of mule deer between their seasonal ranges. Habitat changes brought about by agriculture and forest management may have benefited some species, for example white tailed deer.

There is specific information on the current condition of wildlife habitat in the basin found in the various watershed assessment documents developed by the Okanogan National Forest, the Loomis Forest Plan developed by the Washington State Department of Natural Resources (DNR), and habitat surveys and plans prepared by the WDFW. These are good references for use when planning projects.

The "Current Condition/Trend of Wildlife/Habitat" on pages 3 & 4 of the Wildlife section of the Colville Indian Reservation "Integrated Resources Management Plan" Executive Summary provides a good summary of current conditions of the entire basin.

In general, habitat conditions continue to decline through land development in the basin. This is best illustrated by the loss of habitat needed by sharptail grouse. For example, Ziegler (1979) documented a 51% decline in waterbirch and aspen from 1945 to 1977 in Johnson Creek. In addition, 13% of landowners contacted in Okanogan County were planning to remove waterbirch or aspen (Ziegler, 1979). J. Patterson (personal communication) reports that much winter habitat in Okanogan County has been lost to home sites and a lek (a strutting ground for sharp-tailed grouse) was destroyed by a recreational subdivision. Hofmann and Dobler (1988a) also reported the loss of waterbirch in two locations in Okanogan County in less than three months of observation. Sharptails no longer used these areas after waterbirch was removed (Hofmann and Dobler, 1988a). Waterbirch buds are the primary food of sharptailed grouse during the winter (Hays et al., 1988).

The WDFW has a program of identifying Priority Habitats for fish and wildlife in the state. Priority habitats are "habitat types with unique or significant value to many species". An area classified and mapped as priority habitat must have one or more of the following attributes:

- comparatively high fish and wildlife density;
- comparatively high fish and wildlife species diversity;
- important fish and wildlife breeding habitat; important fish and wildlife movement corridors;
- limited availability;
- high vulnerability to habitat alteration;
- unique or dependent species;

(WDFW, 1996).

Some of the priority habitat types known to exist within the Okanogan River management planning area can be found in "The Priority Habitats and Species List" published and updated annually by the WDFW.

Current Condition

Severe winter weather conditions have significantly reduced mule deer populations since 1992. The hard winter of 1996-97 was especially hard on the local herds. "Qualitative observations from land managers, biologists, and long time residents, as well as harvest figures, suggest the populations may be half of what it was in the mid 1980's and early 1990's"(Fitkin, 1997). A shorter season and reduced number of hunters in 1997 along with easier over wintering conditions during the 1997-98 winter has been beneficial to the herds.

"Deer damage is a chronic problem in the Omak district. During severe winters, deer are often forced onto low elevation private property in close proximity to human development. At such times, damage to orchards, haystacks, and landscaping can be significant" (Fitkin, 1997).

There are numerous upland birds and small game animals in the Okanogan basin. Most of these species are dependent upon the riparian zone along rivers and creeks.

Principal waterfowl species of the basin include Canadian goose, mallard, wood duck, common merganser, coot, teal, green-winged teal, American widgeon, common goldeneye, Barrow's goldeneye, ruddy, ring-necked duck, lesser scaup, and bufflehead. Less common species included northern pintail, shoveler, harlequin duck, redhead, canvasback, blue-winged teal, cinnamon teal, gadwall, and whistling swan.

Rivers, streams, ponds, and lakes supply nesting and feeding areas for many species of waterfowl. The many glacial-formed ponds and lakes provide basic needs for nesting of mallards, teal, ruddy, ring-necked and other ducks. These same areas provide needed resting areas for some of the less common species as they are migrating through the area.

Meandering portions of the Okanogan and Similkameen Rivers provide excellent goose and duck nesting areas. The Canadian goose use is enhanced by the presence of adjacent pasturelands, which provide tender grass shoots for goslings.

Surveys for neotropical birds and their habitats have been done only in recent times and these surveys are only on forested uplands. Therefore, there is little or no data to base trends that might relate to watershed condition.

Riparian and Wetlands

Riparian comes from the Latin word riparious, which means “bank [of stream].” Riparian habitat is exceptionally important in the western United States due to the presence of water and lush vegetation, typically surrounded by harsher, drier, less productive environments (Chaney et al., 1990). There is approximately 1,086 miles of streamside riparian vegetation (543 miles of flowing waterways) within the Okanogan River Basin in the United States (USFS, Okanogan National Forest, unpublished data).

The native riparian vegetation in the shrub steppe region of the Columbia Basin is characterized typically by shrubby thickets of snowberry, wild rose, cow parsnip, common chokecherry, bittercherry, mock orange, red osier dogwood, water birch, willow, cottonwood, and quaking aspen (Naef and Knutson, 1993). Succulent herbs of the ground layer include sticky geranium, northern bedstraw, fescue, waterleaf, and bracken fern (Naef and Knutson, 1993). These thickets tend to have a natural spotty distribution, occurring in varying sized patches at irregular intervals along streams with grass and forb-based riparian communities in between (Nelson, 1989).

Large woody vegetation species commonly found in riparian areas within the Okanogan River Basin include Englemann spruce and subalpine fir (Kovalchik, 1993). These species are usually found at higher elevations. Other large woody riparian vegetation species recognized within the Okanogan River Basin include cottonwood, ponderosa pine, and Douglas fir. Western red cedar was also recognized in the Okanogan River Basin but not in abundance (Kovalchik, 1993). Red osier dogwood and mountain alder are common throughout the basin as well as quaking aspen, which is limited to moderate and low elevations (Kovalchik, 1993).

Historically, alterations to native vegetation communities in the Columbia Basin Province have been extensive (Evans, 1989). One of the effects of European influence on vegetation in the Columbia basin was the introduction of the horse which took place in the mid to late 1700’s (Evans, 1989). As human population increased in the area the demand for livestock grew. The livestock industry developed from horses to sheep and cattle. Today’s economy is primarily agricultural, and most of the present-day appearance of the vegetation reflects this (Evans, 1989). Domestic animals alter the composition of the vegetation by consuming the most palatable species. Consequently, the unpalatable species have more opportunity to increase their numbers relative to the others, and eventually come to dominate many communities. Over much of eastern Washington, where livestock grazing has been unregulated, regeneration of palatable hawthorne (*Crataegus douglasii*), chokecherry (*Prunus virginiana*) and other riparian plant species have been suppressed, leading to the establishment of non-native communities of bluegrass (*Poa spp.*) and exotic weeds such as thistle (*Cirsium sp.*), teasel (*Dipsacus sp.*), dandelion (*Taraxacum sp.*) and Reed's canary grass (Naef and Knutson, 1993). Remnant cottonwoods and other deciduous trees are occasionally found, but these are usually aged trees, tall enough to be out of reach of browsing livestock (Naef and Knutson, 1993). Tree seedlings and saplings are notably absent in many riparian areas (Naef and Knutson, 1993).

Little information exists regarding the current condition (species composition, seral stage, areas of disturbance) of riparian vegetation within the Okanogan River watershed. The most recent information was provided by the Natural Resources Conservation Service (NRCS) in 1994. The NRCS conducted a survey of the riparian vegetation and bank stability along the Okanogan River from Oroville to Tonasket, Washington, approximately 21.6 river miles. Over nine river miles need rehabilitation by re-establishing vegetation, 3.6 miles require implementation of bank stabilization methods such as rock toes, and nearly five miles require re-sloping of the bank prior to other rehabilitation methods (NRCS, 1994). The primary cause of this stream-bank degradation was from the loss of woody vegetation due to overuse by livestock (NRCS, 1994).

During fall and winter when herbaceous vegetation is not actively growing and low in crude protein, livestock switch to browsing on the shoots of young woody shrub and tree species. Consequently, if grazing is unregulated, recruitment of many woody riparian species, such as black cottonwood, can be greatly reduced.

Riparian habitats are influential to the water quality of adjacent aquatic systems (i.e. lakes, rivers, and creeks). Riparian vegetation provides shade which shields the water from direct solar radiation and moderates extreme temperature fluctuations during summer and keeps streams from freezing during the winter. Riparian vegetation helps stabilize banks by maintaining masses of living roots which reduce surface erosion, mass wasting of stream banks, and consequently reduce sediment delivered to the stream channel (Platts, 1991). Riparian ecosystems also act as reservoirs, storing run-off in soil spaces and wetland areas and diminishing erosive forces caused by high flow events. The presence of streamside vegetation also reduces pollutants, such as phosphorus and nitrates, by filtering these compounds and binding them to soil. This filtering or binding allows microbes time to break down chemicals, which may be toxic, before entering stream channels, lakes, or being absorbed by plants.

Not only is riparian vegetation important to water quality and soil conservation, but it also plays an integral role for fish and wildlife habitat. Riparian vegetation contributes nutrients to the stream channel from litter and terrestrial insects falling in. Riparian vegetation also contributes logs which provide in-stream fish habitat by creating cover and forming pools, shaping the channel, retaining nutrients and improving bank stability. Riparian vegetation also maintains stream temperatures by shading solar radiation from the water surface during the summer and insulating the stream from heat loss during the winter (Murphy and Meehan, 1991). As stream size increases, riparian vegetation has a less direct effect upon the aquatic system. However, small streams can be a substantial source of cool water to connected larger streams and rivers. Therefore, riparian vegetation along small streams has a direct effect upon the water quality to larger waterways.

Riparian vegetation is typically more diverse and more productive than environments adjacent to the riparian area. Riparian vegetation is important to wildlife as migration corridors for mammals, and winter cover for resident birds. Riparian areas are known to span ridge tops, and are found at a variety of elevations. Eighty percent of bird species are dependent upon the riparian environment for part of their life cycle. Riparian areas offer structural difference and more complex habitats.

As stated earlier, information regarding the condition of the riparian ecosystem in the Okanogan River Basin is limited. However, if the 1994 study is any indication, it suggests that the current condition of the riparian habitat in the Okanogan River Basin is marginal and not functioning properly. Consequently, the water quality is adversely affected in the Okanogan River and connected waters.

Shaw and Fredine (1956) defined wetlands as, "lowlands covered with shallow and sometimes temporary or intermittent waters. Cowardin et al. (1979) suggests wetlands must have one of the three attributes: 1) at least periodically the land supports predominantly hydrophytes (a plant growing in water); 2) the substrate is predominantly un-drained hydric soil (characterized by an abundance of moisture); or 3) the substrate is non-soil and is saturated with water or covered with water during some time during the growing season of each year.

Since wetlands occur in a transition zone, between terrestrial and aquatic ecosystems, a change in the amount, timing, or chemistry of the water supply can have a unique change in the surrounding environment. Wetlands, maintain flows by, at times, storing large amounts of water created by snowmelt or precipitation, thus reducing the amount of overland runoff and surface erosion. The water contained in a wetland is often filtered of contaminants, such as bacteria, nutrients, and chemicals, by seeping from the basin through the ground before being delivered to a lake, river, or aquifer.

Permanent wetlands cover the land surface throughout the year in all years (Cowardin et al., 1979). Seasonally flooded wetlands are defined as present for extended periods especially early in the growing season, but is absent by the end of the season in most years (Cowardin et al., 1979). Currently there are 23,422 acres of wetlands in the Okanogan River Basin (K. Snider, National Wetlands Inventory, unpublished data). Approximately 20,590 acres are seasonal wetlands and 2,832 acres are permanent wetlands (K. Snider, National Wetlands Inventory, unpublished data).

Historically the total acreage for wetlands within the State of Washington is estimated to be approximately 1.35 million acres (Peters, 1990). The current amount of wetlands in Washington is estimated to total 938,000 acres (Peters, 1990). This is a reduction of 31% (loss of 412,000 acres) from pre-settlement wetland acreage. However, according to Peters (1990), knowledge of wetlands has increased, classification schemes have changed, and inventory techniques have greatly improved. Therefore historical data are not refined enough to make comparisons by specific habitat types nor geographical areas.

Wetlands affect the amount, timing and chemistry of run-off water (snow melt and rain). Therefore, wetlands have a direct affect upon the water quality of connected waters (creeks and rivers). Overall, the amount of wetland environment in the state of Washington has been substantially reduced (31%) since pre-settlement (Peters, 1990). Although comparisons between historical data and current information is not compatible over site specific areas, the trend indicates a substantial reduction in wetland habitat and may be a factor in reduced water quality in the Okanogan River Basin.

TRANSPORTATION

Extent

Transportation methods described by this characterization include road, rail, and air. Federal, state, county, and private roads exist within the Okanogan River watershed, one rail line lies along the Okanogan River valley, and several airports exist, at or near communities such as Omak and Tonasket.

Transportation provides benefits including movement of goods for commerce and products from harvest areas to market or production facility. Access to property, emergency services, and travel are other benefits.

For the purposes of this document, improved and unimproved roads are examined. Improved roads are hard surfaced (asphalt or gravel & oil) such as State Route 97 or the Conconully Highway. Unimproved roads are constructed of native soil material, which may or may not be surfaced with gravel.

4,357.2 miles of roads exist within the watershed [Washington State Department of Natural Resources (DNR), Geographic Information System (GIS) Data, 1996]. The Okanogan County road system amounts to less than 900 miles. Of these 900 miles, approximately 33 of these miles are within 200 feet of the listed waterways. Washington State Department of Transportation (DOT), Okanogan County, or the cities manage most of the improved roads. The United States Forest Service (USFS) also has a road system of improved main access roads.

No comprehensive database exists which identifies the amount of unimproved roads currently existing within the watershed. The amount and area accessed by unimproved roads within the Okanogan River Basin is expected to be vast. The large number and variety of land ownerships makes road inventory and management difficult. Secondary roads providing access to homes, rural properties, range and forest management sites are generally unimproved.

There are approximately 85.5 miles of railroad in the Okanogan River Watershed (Buck Workman, personal communication, 1998). Almost all of the railroads are located in the Okanogan River Interfluve. The predominant railroad line is generally located within one-half mile of the

Okanogan River from its confluence with the Columbia River to Oroville. At one time, the railroad turned west at Oroville and proceeded up the Similkameen River Valley to the US-Canadian Border.

History

The road and rail system was established around the beginning of the 1900's. Mining and homesteading required suitable access for transportation equipment. Horse, horse-drawn wagon, steamboat, and soon after, rail and automobile were utilized.

A web of routes was developed which followed traditional travel corridors. The traditional travel corridors typically followed river and stream drainages. This system has changed somewhat in extent and location. Some routes have been abandoned, such as a rail line to Molson. Various roads have fallen into disuse. Changes in property boundaries, ownership objectives, and methods of resource utilization have occurred. Urban and residential development has spread. The current trend toward more, smaller rural ownership parcels is associated with a growing system of unimproved roads and more year-round and shared use. However, many of the current road locations are those initially developed during the era of horse and steam power.

Rail lines were first developed in Okanogan County purely for commerce purposes. These purposes included hauling goods and foodstuffs to the region then in return hauling processed and unprocessed natural resources out of the watershed such as timber and ore. In 1906 the first rail service to Molson in the Nine Mile Creek Watershed began (Wilson, 1990). In 1912, construction began on the rail line that now exists in the Okanogan River Interfluve. This work was being done by James J. Hill’s Great Northern Railroad and connected Oroville with Wenatchee to the south.

During the 1920’s and 1930’s a number of railroad lines were built and put into service into the forested drainages of the Okanogan River Basin. The most notable and by far longest lasting of these was the narrow gauge rail line into the Omak Creek watershed. Construction of this line began in January of 1924 (Lewis, 1980). This line was put in along the banks of Omak Creek from the Biles Coleman Lumber mill, the present day location of the Quality Veneer and Lumber mill. Over a period of several years, the tracks were extended past the small community of Disautel. At the time the line was abandoned in 1948 it had an overall length of 22.85 miles (Lewis, 1980).

The early construction phase of this rail line included putting a railroad grade through Omak Creek Canyon near St. Mary’s Mission. This would become the most difficult portion of the grade for the construction workers. To get the grade through the canyon a special hard rock excavating crew from Spokane was hired. The crew removed 10,000 cubic yards of rock from the canyon (Lewis, 1980). Much of this overburden was blasted or dropped into Mission Falls directly below the right-of-way. This has since become a major concern as this extra material has blocked anadromous fish passage to the waters above the falls. The Colville Confederated Tribes (CCT) and the USDA Natural Resources Conservation Service (NRCS) completed the removal of this overburden during the fall of 1999.

The Biles-Colman narrow gauge railroad was unusual from most logging railroads throughout the west. The railroad was constructed and maintained well throughout its history. One item to note is that the railroad ties were not treated with creosote as most are even today because of the ready access to timber at the mill (Lewis, 1980).

Current Condition

Roads are owned and maintained by a variety of entities. The two primary categories of ownership are private and public.

The construction, maintenance, and use of public roads are guided by government agencies, such as communities, the Okanogan County, DOT, USFS, and DNR. Along with construction and maintenance, responsibilities for public safety, protection of water quality, and weed control are also maintained. Generally, these agencies have developed policies and programs, and provide funding to meet these requirements.

Private property owners typically own roads crossing their property. Easements and road use permits allow for use by more than one owner. This typically occurs where a road provides access to several ownerships. In some situations, roads provide physical access to multiple ownerships without legal easement.

Private owners have many of the same responsibilities as public road managers. Legal requirements for the protection of water quality and weed control are similar. In the case of road use by more than one entity, easements or agreements may specify the different parties' responsibilities; otherwise, the ultimate responsibility stays with the owner on whose land the road lies.

Currently there is no new construction of railroad lines in the Okanogan River Watershed. The focus of energies is in maintaining the (100 foot average) right-of-ways that currently exist. Maintenance includes periodic brush cutting, and chemical application of herbicides, and occasional track or railroad tie replacement. The chemicals listed in Table 3.17 are applied by the Cascade & Columbia River Railroad along their right of ways on an as needed basis between March and June.

Table 3.17
Chemicals Applied to Railroad Right-of-ways for Maintenance

Chemical	Application Rate	Chemical	Application Rate
Diuron	6-8 Lbs./AC	2-4-D	1-2 Qt./AC
Oust	2-3 Oz./AC	Tordon	1-2 Qt./AC
Telar	1-3 Oz./AC	Banvel	1-2 Pts./AC
Krovar	6-8 Lbs./AC	Escort	½-1½ Oz./AC
Round Up	2 Qt./AC		

Trend

In recent years, mileage of roads (excluding roads maintained by Okanogan County) has increased. The reasons for a new road may include residential development, access to newly created property parcels, and timber harvest.

More than 20,000 acres of land has been divided into smaller lots, generally 20 acres in size, since 1994. The road system has grown to provide access to each parcel. The USFS new road construction levels have decreased to a small amount. The DNR is constructing roads to conduct timber harvest, and is actively abandoning some roads to limit the overall inventory of road they manage on the Loomis State Forest.

Traffic on all roads is increasing. Increased traffic is related to population growth, both in county and regional, increased commerce, travel, and recreation. Many roads previously providing access to single ownerships now have multiple users. Rural traffic in the past was typically associated with range and timber management and secondarily, recreation. Substantial use now occurs for residential access, and recreational use has grown. The residential use occurs year-round as compared to former temporary or seasonal use.

Recognition of roads' deleterious effects on water quality and aquatic habitat are increasing. Standards for the protection of these resources are rising as well.

Therefore, the need for regular road maintenance is increasing due to these factors. This need is most often not met on private roads serving multiple ownerships where use and maintenance are not coordinated.

With no new construction of railroads in the Okanogan River Watershed, the trend for this landuse is somewhat stagnant to slowly declining. As stated earlier the focus is on maintaining the active railroad lines.

Relationship to Water Quality Concerns

Forest and rangeland roads exist to provide access and allow utilization of land and resources. However, roads often affect streams directly by accelerating erosion and sediment loadings, by altering channel morphology, and by changing the runoff characteristics of watersheds (Furniss et al., 1991).

Erosion occurs when material is available, becomes detached and is transported. Roads increase the erosion potential by detaching soil particles from larger aggregates, removing vegetation, and increasing run-off. More effective and efficient methodologies for erosion control including design when constructing and maintaining roads is needed. Additional concerns include runoff from roads, which may carry hazardous materials such as automobile fluids (oil, gasoline, antifreeze) and other contaminants.

Vegetation provides stability to soils and reduces erosion. Ground cover, such as grasses, reduces surface erosion by binding soil particles, reducing energy of overland run-off and dissipating the energy of raindrops to detach soil. The roots of shrubs and trees increase the stability of soils particularly on steep slopes (Platts, 1991). Removal of vegetation can increase the vulnerability of soils to erosion, or detachment and transport. This erosion is often evident where the construction of cut and fill slopes has removed vegetation which provided soil stabilization, exposed bare soils to energy provided by weather (rain, snow-melt, wind), and usually increased slope steepness causing greater sediment delivery distances.

Roads constructed across slopes may intercept sub-surface water flow, creating surface flow. These increase surface erosion and may cause landslides, particularly in fragile soil types. Roadbeds, often impermeable to water, channel flow and transport fine sediments further than natural conditions causing an increase in surface erosion. Improperly drained roads can exacerbate this condition by accumulating water and discharging concentrated flow into non-drainage areas, which results in severe erosion, usually in the form of gullying and landslides (Furniss et al., 1991). Other factors which can increase surface erosion from roads (surface composition and road maintenance) will be addressed later. Failure of stream crossings, diversions of streams by roads, washout of road fills, and accelerated scour at culvert outlets are also potential sources of sedimentation in streams within roaded watersheds (Furniss et al., 1991).

Increased sedimentation in streams following road construction can be dramatic and long lasting. The sediment contribution per unit area from roads is often much greater than that from all other forestry practices combined, including log skidding and yarding (Gibbons & Salo, 1973). By far, excess sediment generation is greatest from roads, particularly when constructed near stream channels, either intermittent or perennial, and much greater if construction creates conditions for mass soil failures and landslides (Waters, 1995). Most road locations within 200 feet of a stream were shown to deliver a percentage of sediment volume to the stream channel (Ketcheson & Megahan, unpublished). The 200-foot threshold is a threshold utilized by the State of Washington's watershed analysis program.

Road location may be the single most important factor causing impacts to aquatic resources. The presence of a road adjacent to a stream can increase stream temperatures due to the canopy removal for road construction and maintaining accessibility. A road located near a stream channel often reduces the size of the flood plain (depositional area) and likely delivers sediment from the road surface across the fill-slope or concentrates sediment through culverts and directs it to the stream channel. In addition, a road that is adjacent to a stream often provides easy access by humans and livestock. This can result in an increase in soil compaction, removal of large wood component (fire wood cutting and timber harvest), removal of a soil-stabilizing vegetation by over-grazing causing bank erosion and vertical cutting, and bank collapse due to hoof slide.

Both road use and stream type affect water and habitat impacts when roads are located near streams. Short-term construction projects near high gradient streams typically have only temporary effects (Waters, 1995). This is due to high-energy flows, which flush away light sediment deposits. Conversely, forest roads that are constructed for long-term use and are adjacent to low discharge, gentle gradients, usually have large sediment deposits with long-lasting effects (Waters, 1995).

A direct relationship exists between the linear distance of roads within the watershed and adverse cumulative impacts to aquatic resources within and beyond the basin. Total road lengths of four miles per square mile in the basin of the Clearwater River, Washington produced sediment more than four times natural rates (Cederholm et al., 1981). It was also determined that the percentage of fine sediment in fish spawning gravels increased above natural levels when more than 2.5% of basin area was covered by roads (Cederholm et al., 1981). Excessive sediment loading of streams can result in channel braiding, increased width-depth ratios which can reduce available fish habitat and increase water temperature, increased incidence and severity of bank erosion, reduced pool volume and frequency, and increase sub-surface stream flows.

Standards of construction and maintenance also affect potential water impacts. Construction standards include appropriate water crossing location and approaches, culvert or bridge size, fill material stabilized by armoring, road surface ballast, revegetated cut and fill slopes, appropriately located ditch and road surface drainage, and road gradient fit to local topography. Maintenance consists primarily of surface grading to maintain ditch and road surface drainage, water crossing cleanout or repair, and other measures needed to prevent erosion of the road surface and cut and fill slopes. Maintenance frequency can vary with the amount and timing of road use. Road closures or other use restrictions can effectively reduce maintenance costs.

Stream crossings and instream work require a Hydraulic Project Approval (HPA) from Washington State Department of Fish & Wildlife (WDFW) or the CCT depending upon project location. The HPA provides conditions for the work needed to minimize water quality impacts and aquatic habitat degradation. Construction of forest roads and timber haul roads on private and state land requires an approved Forest Practices application obtained from DNR. The Forest Practices rules require construction standards and maintenance as needed to prevent water quality degradation.

Railroad operations degrade water quality conditions very little once the rail line has been constructed and has been established. It is during the construction and early years of railroad lines that the largest and most significant impact to water quality is incurred.

Railroad lines are typically put along streams because this offers the gentlest slope for the locomotive(s) to pull. In addition, most railroad lines were constructed at or near the turn of the century without concerns for water quality degradation. Finally, many smaller lines (mainly early 20th Century logging railroads) were almost continuously uprooted and placed back down in a different location causing even further destruction of the landscape (Lewis, 1980).

Railroads continue to degrade water quality after construction from standard maintenance and operation, which causes sediment contribution from the railroad bed. First, as a part of the normal operating maintenance, the right of ways are usually sprayed by various herbicides as mentioned earlier and these chemicals can enter surface waters even under careful application techniques. Secondly, sediment transport from the railroad bed can have an adverse impact upon water quality. The sediment is most pronounced where the railroad bed is within 200 feet of a stream or lake. It is in this sense that established railroads are very similar to graveled roads.

Impacts on Riparian/Wetlands

Although studies conducted in the Okanogan River Basin targeting road impacts upon water quality are few, existing information indicates roads as a major contributor to reduced water quality.

A limited road erosion inventory performed during the USFS Toats Coulee Watershed Analysis calculated erosion rates from roads at 27.9 to 30.4 tons per acre of road prism per year. Forty percent of roads surveyed delivered sediment to streams ranging between 22.1 and 30.5 tons per mile of road.

Information on density of forest and rangeland roads (miles per square mile) is not complete in the Okanogan River Basin, but is available for certain sub-basins. The USFS has analyzed the headwater region of Salmon Creek and found the road density to be 2.2-miles/sq. mile (USFS, unpublished data). However, in contrast, a road density of approximately 6.38 miles/sq. mile was identified within the Omak Creek Watershed [Natural Resource Conservation Service (NRCS), 1995). The road density in most sub-basins in the Okanogan River Valley is greater than the density of roads identified by Cederholm et al. 1981 (four miles per square mile) that causes sediment in streams greater than natural erosion rates.

The USFS determined the amount of road miles within 200 feet of stream channels for seven sub-basins (Table 3.18). The NE Okanogan sub-watersheds (Nine Mile, Tonasket, Mosquito, and Bonaparte Creeks) have the largest amount of road miles (65.5) within 200 feet of a stream, with 80% of that attributed to non-Forest Service roads. The SE Okanogan sub-watersheds [Omak Lake, Duley Lakes/Joseph Flats, and East WRIA (Water Resources Inventory Area)] have the least amount of road miles (27.0) within 200 feet of a stream. This information should be considered together with other site and road characteristics, such as hillslope, soil texture, vegetation, road construction standards, use and maintenance. Within this distance to streams, both improved and unimproved roads in the Okanogan are likely to have substantial increases in sediment delivered to stream channels. Stream characteristics, habitat, and other beneficial uses are also factors in measuring impact.

Table 3.18
Road miles within 200 feet of streams

Sub-watershed	Non-Forest Service	Closed Forest Service	Open Forest Service	Total
Bonaparte Creek	41.4	1.7	5.1	48.2
Mainstem Okanogan	56.0	4.7	1.5	62.2
NE Okanogan	52.4	2.4	10.7	65.5
SE Okanogan	25.4	0.9	0.7	27.0
SW Okanogan	31.1	0.1	0.7	31.9
Salmon Creek	19.6	6.6	19.9	46.1
Similkameen River	43.1	0.2	7.2	50.5

Source: Unpublished data from USFS

Many unimproved roads in the Okanogan River Basin are constructed of native material with little ballast or surfacing. Such road surfaces erode readily, creating a need for frequent cross drainage. Recommended frequency of waterbar placement providing road surface and ditch drainage was developed by Paul Packer in 1967 then modified by the Okanogan National Forest staff to meet local conditions (Table 3.19).

Roads composed of native material with little rock also do not hold their shape well when

Table 3.19
Waterbar frequency recommended for roads on Okanogan National Forest.

Road, % grade	Waterbar spacing, feet
0-2	200
3-4	180
5-6	160
7-8	140
≥9	120

soft and wet. These conditions occur regularly during the autumn, winter breakup, and spring. Road use at these times can cause rutting of the road surface, compromising road drainage and greatly increasing erosion. Follow-up grading of the road surface improves driveability but simply disguises the chronic erosion, which may regularly damage water quality. Grading off soft, wet road surfaces produces sunken roads with few opportunities for drainage.

Water crossing and fill failures have occurred regularly during high water periods, degrading water quality and requiring expensive repairs. Increased care is needed in planning for water and debris passage capacities and fill stability during construction and repairs. In places, erosion of road fills is chronic, due to faulty road drainage or lack of fill protection such as rock armoring or vegetation.

Roads located immediately adjacent to or within the channel migration zone of streams are eroded during runoff periods. Again, water quality suffers and maintenance costs rise. Cut slope erosion is chronic at specific sites and is often associated with improved or mainline roads, which have correspondingly larger cuts and fills. Ditches may then transport sediment and deliver it to streams.

Roads are expected to be the greatest contributing source of sediment to streams in the basin. Sedimentation is occurring due to road locations near or adjacent streams, inadequate stream crossings, fill and cut slope stabilization, and road surface and ditch drainage. Private roads providing access to multiple ownerships often have no coordinated use and are maintained less regularly, leading to increased erosion and sedimentation.

Railroads affect riparian areas and wetlands in much the same ways as roads. Railroads produce the same results as roads when they are placed within the channel migration zone of a stream, and sediment runoff from the surface of the railroad bed is the same as automobile roads. However, railroads are not nearly as prevalent as roads are throughout the basin, considering that the only active railroad is the Cascade-Columbia River Railroad. This equates to 0.3 miles of railroad per square mile in the entire Okanogan River Basin. Railroads and railroad operations contribute very little overall in the form of sediment and other contaminants.

FISHERIES

History

Over hundreds of years, northwest Native American tribes developed an economic and social dependence upon large runs (7.5 million/year) of Columbia River salmon. Traditional fishing areas like Celilo Falls and Kettle Falls were focal points during salmon runs (May-Aug.) for many different tribes netting, spearing, drying and trading salmon. Early European explorers and trappers remarked at the “millions” of salmon ascending Kettle Falls. As many as 40,000 salmon may have been taken by native fishermen around Kettle Falls in the early 1800's. In the mid-1800's some of these runs became erratic and greatly reduced in numbers. Major salmon shortages in the mid-Columbia were noted by whites in the late 1820's and early 1830's and again at Kettle Falls in the 1880's. Indians were starving and had abandoned some of the traditional fishing spots due to lack of returning adult salmon. This points to the importance and unpredictability of ocean rearing and survival conditions, which could be a contributing factor in today’s declining runs (Schalk, 1986).

By the mid-1800's, early European settlers in the Columbia River area soon emulated the Indian fisheries by building and developing commercial canneries and net sites in the central and lower reaches of the Columbia River. This harvest peaked at 2.3 million fish in 1883. From 1889 to 1922, the resource sustained an average annual harvest of 25 million pounds. Average yield was approximately 1.3 million fish from 1890-1920, with a steady decline since 1920. From 1923 to 1958, the harvest was depressed to about 5 million pounds. Beach set nets were often pulled in by teams of horses due to the weight of the salmon. Fish wheels operated 24 hours a day. These early canneries developed in the area surrounding the mouth of the Columbia River and eventually depleted some of the salmon runs before the first dams were designed.

Between 1890 and 1920 spring and summer chinook harvests were declining and to maintain production the harvest shifted to fall chinook. In 1908, President Teddy Roosevelt said, “The salmon fisheries of the Columbia River are now but a fraction of what they where 25 years ago.” By 1912, the ocean commercial fishery had begun at the Columbia River delta, with a fleet of 1,000 trolling boats. As the remaining runs were lost or reduced due to major hydroelectric dams, smaller irrigation diversion dams and commercial fishing, a shift was made to hatchery production. Today hatchery-raised salmon make up 80% of the total harvest.

As Depression Era government plans developed in the later 1920's to control flooding and produce cheap electricity, ten dams were planned across the Columbia River. In 1933, Rock Island Dam was the first completed. In that same year, construction began on Grand Coulee Dam. In 1938, Bonneville Dam came on line and by 1941, Grand Coulee began production of electricity. Although the biology and engineering were available during the construction period, a choice was made to not include a fish passage into or around Grand Coulee Dam. As a result, salmon spawning was forever eliminated upstream of the dam, which includes the mainstem Columbia and it’s tributaries.

The Columbia Basin began to expand and develop because of the resulting irrigation and cheap hydroelectric rates. By 1956, the pool behind The Dalles Dam was completed and flooded and ended Celilo Falls, the traditional tribal fishing area (NW Power Planning Council, 1992).

By 1958, all non-Indian commercial fishing in the Columbia River above Bonneville Dam had ended. In 1967, Hells Canyon Dam was completed and blocked upstream migration of adult chinook salmon on the upper Snake River (NW Power Planning Council, 1992).

Current Conditions

Habitat needs of salmonids vary with the time of year, and life stage of the different species. Habitat needs include food, cool water temperatures, spawning substrate, cover and adequate productivity. Successful salmon spawning in the Okanogan Basin requires water temperatures from 3.9° to 20.0° C. The water needs to be able to flow easily through gravel (6.5 mm in diameter) or pebbles in the redds (nests) in which the eggs are deposited. Water provides oxygen to the eggs and alevins (yolk sac fry) before emergence. Silt and sediment carried by high flows can fill in gravel, reducing water flow to eggs and causing suffocation or blocking the emerging fry.

Cover includes water depth, water turbulence, boulders, undercut banks, overhanging vegetation, and large woody debris. Cover protects fish from predation, provides diversity within stream reaches, and increases productivity. Typically, fish populations respond by increasing in numbers and size as the amount of cover increases. Often more than one habitat variable effects fish populations. Excess silt and sediment can reduce productivity of spawning gravel and reduce pool size and increase temperatures (Bell, 1986).

- Chinook require larger spawning gravel. 1-4 years ocean rearing
- Sockeye rear in lakes and spawn in tributaries to lakes. 2-4 years in ocean
- Steelhead trout are basically anadromous rainbow trout, which spend 1-4 years in ocean.

Extent

The Okanogan Watershed currently supports anadromous runs of chinook salmon (Oncorhynchus Tshawytscha), sockeye salmon (Oncorhynchus Nerka), and smaller runs of steelhead (Oncorhyncus Gairdneri). Inland species include mountain whitefish (Prosopium Willaimsoni), rainbow trout (Oncorhynchus Mykiss), cutthroat trout (Oncorhynchus Clarki), and eastern brook trout (Salvelinus Fontinalis). In general, run strength of chinook salmon has declined slightly in the Okanogan River over the last 20 years, and has increased slightly in the Similkameen River (Chapman et al., 1994a). Adults enter the Okanogan River from July through late September, with the spawning run peaking in mid-October.

Other species in the watershed include: bridgelip sucker (Catostomus Columbianus), large scale sucker (C. Macrocheilus), sculpin (Cottus Rhotheus and Confusus), chiselmouth (Acrocheilus Alutaceus), peamouth (Mylocheilus Caurinus), northern squawfish (Ptychocheilus Oregonensis), longnose dace (Rhinichthys Cataractae), redside shiner (Richardsonius Balteatus), and burbot (Lota Lota) (Pacific Rivers Council, 1996).

Various warm water species which have been introduced into the Okanogan watershed include: largemouth bass (Micropterus Salmoides), smallmouth bass (Micropterus Dolomelui), white crappie (Pomoxis Annularis), bluegill (Lepomis Macrocherus), yellow perch (Perca Flavescens), pumpkinseed sunfish (Lepomis Gibbosus), black bullhead (Ictalurus Melas), and walleye (Stizosledion Vitreum). These species are favorites of many sports anglers. They also provide a large biomass of fish in the basin, and contribute to predation on juvenile salmon in the pools behind the mid Columbia dams.

Summer chinook spawn in limited areas between Zoesel Dam and Malott in the mainstem Okanogan, In the Similkameen River summer chinook spawn from Enloe Dam downstream to Driscoll Island.

Fry emerge from the gravel from January to the end of April. Juveniles rear for a few months to a year. Many juveniles rear in the mid Columbia impoundments after leaving the Okanogan after 1 to 4 months.

There is no current evidence of Spring Chinook in the Okanogan drainage in the US. Historical records indicate Spring Chinook in three or possibly four drainages.

1. Salmon Creek, prior to 1906, Okanogan Irrigation District diversion dam construction (Craig & Suomela, 1941).
2. Lake Osoyoos upstream tributaries (Chapman et al., 1995).
3. Omak Creek (possible) (Fulton, 1968).
4. Similkameen (possible) (Craig & Suomela, 1941).

The Okanogan River sockeye run is one of two remaining major sockeye runs in the lower 48 states. The Wenatchee River is the other run. Run strength is variable from a low of 1,662 in 1994 to a high of 127,857 in 1966. The ten year average from 1986-95 is 28,460. Lake Osoyoos is the primary rearing area for this sockeye run coming up the Okanogan, since it has good rearing conditions and produces good size sockeye smolts (1 yr.+ = 87 to138mm Fork Length). Most of the adult sockeye spawn in the mainstem Okanogan River upstream from Lake Osoyoos. Spawning occurs from early October to early November.

Adult upstream migration of sockeye is sometimes delayed by high water temperatures in the lower Okanogan River during July and August (Pratt, et al 1991). Schools of adult sockeye often stage at the confluence of the Okanogan River waiting for a drop in water temperatures, often caused by an upstream rain event.

Few wild steelhead currently use the Okanogan River. Incomplete historical records exist, but Mullen, et al (1992) assert very few steelhead used the mainstem of the Okanogan River. Historically Salmon Creek, Omak Creek, and the Similkameen River had small runs of steelhead, which were eliminated or reduced by passage barriers on each stream. Because of high temperatures and sedimentation, the Okanogan River has poor spawning and rearing habitat for steelhead, and is primarily used as a migration corridor to smaller, clearer and colder tributaries.

In the early 1960's, the Washington State Department of Fish and Wildlife (WDFW) began the steelhead hatchery program. This resulted in over-harvests of wild fish in mixed stock fisheries, which include both native and hatchery fish (Douglas, Chelan, and Grant PUD’s, 1998).

Rainbow trout are the same species as steelhead trout which live, spawn and rear in upper tributaries and are not anadromous. They are known to be in Salmon Creek, Omak Creek, Toats Coulee, Sinlahekin Creek, Bonaparte Creek, and Tonasket Creek, as well as other smaller tributaries (Douglas, Chelan, and Grant PUD’s, 1998).

Salmon Creek and Loup Loup Creek used to support bull trout populations, but the introduction of brook trout and resulting hybridization of the species has resulted in the extinction of bulltrout in the Okanogan River Basin (Douglas, Chelan, and Grant PUD's, 1998).

Trend

Omak Creek lies entirely within the Colville Confederated Tribes (CCT) reservation and has the potential to establish a self sustaining steelhead population. The CCT provided access to 60km of steelhead habitat by removing a "velocity barrier" created by a culvert at the Quality Veneer and Lumber mill near the confluence with the Okanogan River. After the culvert was modified 21 adult summer steelhead were observed Jerry Marco (personal communication, 1997). Through a joint project the Natural Resource Conservation Service (NRCS) and the CCT removed large boulders from the approximately 1/4 mile stream reach of Mission Falls which were a barrier to upstream fish passage. The source of the boulders was from the construction of a railroad grade located along the ridge of the canyon.

Several water quality parameters including water temperature, turbidity, fecal coliform, and total bacteria are outside of CCT standards (NRCS, 1995). Causes of non-compliance is due to poor livestock grazing practices, close proximity of feed lots and septic tanks to the stream channel, limited riparian vegetation and high width to depth ratios (NRCS, 1995).

A likely cause of increased water temperature, high turbidity, and high width to depth ratio in Omak Creek may be the high road density in the basin. Cederholm et al. (1981) found road densities of four miles per square mile produced sediment four times the natural rate. The road density within the basin is 6.38 miles per square mile (NRCS, 1995).

Salmon Creek contained anadromous fish including chinook, coho, and chum salmon, as well as steelhead trout and resident populations of rainbows, cutthroat and bull trout. According to testimony from early settlers, "people came from miles around to harvest salmon in Salmon Creek" [US Fish & Wildlife Service (USF&WS), 1941]. Chinook salmon in particular migrated up Salmon Creek in high water in the spring "in great numbers" (Mullen, et al., 1994).

Conconully was named Salmon City until the 1888 election when it was voted the county seat and the name was changed to Conconully. By the turn of the century, fifteen irrigation ditches were withdrawing water from Salmon Creek. By 1906, construction began on the Conconully Reservoir Dam and the main irrigation diversion dam located three miles upstream from the confluence with the Okanogan River. Upon the completion of the dams in 1910, salmon and steelhead were barred from the lower 14 miles of free flowing Salmon Creek and have become virtually non-existent today. The lower three miles have been seasonally dewatered since 1910. The 14 miles of Salmon Creek between the Conconully Reservoir Dam and the diversion dam passes through public and private lands. The stream reach on Bureau of Land Management (BLM) lands includes 2.5 miles of Salmon Creek just downstream from the reservoir dam and contains some of the best BLM fish habitat in Okanogan County. This section is physically isolated with almost no access or disturbance from humans or cattle (BLM, 1994 & 1995). The Okanogan Irrigation District and Colville Confederated Tribes are currently working together to restore minimum instream flows in the lower section (downstream of Conconully Reservoir) for anadromous and resident fish.

Low water temperatures, shade, and spawning gravel make portions of Salmon Creek ideal habitat for steelhead or salmon (Hansen, 1995). Upstream of the irrigation diversion dam, the average annual flows for Salmon Creek is 49 cubic feet per second. Occasionally, in high water years, the overflow from Conconully Reservoir allows the lower 3 miles of Salmon Creek to be re-watered and connected to the Okanogan River. During high water conditions, steelhead have been observed migrating up the three miles and leaping the diversion dam (Mullen et al., 1994; Steel, 1994). Currently the pool below the dam is not deep enough to allow steelhead to reach burst speed to leap the dam, which is 4.5 ft high.

Upper Columbia River spring chinook salmon were listed as endangered under the Endangered Species Act in March 1999, and Upper Columbia River steelhead as endangered in August 1997. This listing will affect uses along the Okanogan River and it's tributaries. Although the Okanogan does not provide good spawning or rearing habitat for steelhead and chinook (high temperatures and sediment), it does provide migratory passage to more favorable tributaries.

The recently released WDFW "Wild Salmonid Policy" Draft Environmental Impact Statement also proposes to restore wild salmonid runs to historical habitats blocked by dams and diversion ditches. Nearly 3,000 miles of salmon and steelhead spawning streams in Washington State are currently inaccessible by fish (WDFW, 1997).

The Okanogan Irrigation District (OID) manages and regulates the water flow from the Bureau of Reclamation (BOR) dams in Conconully to the irrigation ditch. (The OID's 50 year renewal of its BOR permit is due in 2002.) In low water years, the OID supplements low flows in the irrigation ditch with water pumped from the Okanogan River.

Currently resident fish include rainbow trout, cutthroat trout, brook trout in the creek, and kokanee salmon (landlocked sockeye) in the Conconully Reservoir, and largemouth bass in Conconully Lake. The kokanee salmon may be remnants of the original sockeye population or accidentally stocked by WDFW Ken Williams (personal communication, 1997). Kokanee salmon have been observed in the diversion ditch between the reservoir and Conconully Lake during spawning [US Forest Service (USFS), 1997).

Largemouth bass in Conconully Lake were the result of unauthorized stocking by private individuals and provide a large recreational fishery (Ken Williams, personal communication, 1997). Fish habitat in the upper Salmon Creek watershed has been altered by past management activities including mining, grazing, logging and road building. Stream surveys indicate that the drainages are deficient in pools, spawning gravel, and large woody debris (USFS, 1997).

Combinations of high temperatures and excessive erosion make the mainstem Okanogan River severely limited as fish habitat. The water temperatures often exceed lethal levels for most salmonids, and often limit the migration of sockeye upstream to Lake Osoyoos.

Temperatures upstream from Lake Osoyoos in Canada remained higher than 21° C for many days in July and August (Hansen, 1993). High temperatures are mostly the result of naturally low gradient flows and solar radiation. Even if the riverbank of the Okanogan River was covered by vegetation and trees, the water temperatures in the summer would still be excessive due to the north-south orientation, solar radiation, and the shallow depth of Lake Osoyoos (Ken Williams, personal communication, 1997). The riparian habitat in the mainstem Okanogan River is the most degraded of the four subbasins. The lack of vegetation contributes not only to high temperatures but also to erosion and sedimentation. Spawning gravels are very limited; juvenile rearing habitat almost doesn't exist due to the high turbidity in the mainstem Okanogan.

As these conditions continue in the Okanogan River, the quality of fish habitat, especially spawning and rearing habitat in the tributaries increases in importance to the entire watershed. The mainstem of the Okanogan River in British Columbia has 13 vertical drop structures (VDS) for flood control between Lake Osoyoos and Lake Vaseaux. These structures limit the sockeye spawning upstream from Lake Osoyoos. They may also reduce the sediment load by slowing flows during high water. Zoesel Dam controls the level of Lake Osoyoos and is jointly operated by the Oroville-Tonasket Irrigation District, Washington Department of Ecology (DOE), and British Columbia Ministry of Environment Lands & Parks (BCME).

The impounding of water from Zoesel Dam and other dams upstream adversely impact the passage of salmonids in the mainstem of the Okanogan River. Water releases to meet fishery needs are negotiated yearly by fisheries and irrigation managers from the United States and British Columbia. In 1976, DOE established base instream flows for the Okanogan River and ruled that no further appropriations of water from the Okanogan River would be allowed which might compromise these base flows.

The level B Okanogan River Basin Study (1977) attributed the water quality problems in the river to return flows of irrigation water, livestock impacts on the bank vegetation and stability, and erosion from non irrigated croplands.

Historically, the Similkameen River Basin contained 80% of the spawning substrate for the Okanogan Watershed (Chapmen et al., 1994a). Due to the placement of Enloe Dam in the early 1900's, only the lower 14 km of the Similkameen River is available to salmonids. That reach contains some of the highest densities of summer chinook redds in the Mid-Columbia River Basin. Conflicting evidence exists concerning the salmon and steelhead populations above Enloe Falls prior to the building of the dam. Some historians claim salmon never could negotiate the falls. According to 1898 literature, the Legend of Coyote, the coyote made a barrier of rocks to prevent salmon from entering the Similkameen (Teit, 1958). Archeologists from the CCT claim oral history evidence exists of salmon fishing weirs and accumulations of large fish spinal bones in the Similkameen fishing village middens (Adeline Fredin, personal communication, 1997). Examination of early photographs of Enloe Falls indicate that a series of falls and pools, approximately 8-10 feet in height, existed and that salmon migration was possible if the pools were of adequate depth. Inquiries to the Washington State University Anthropology Department, Simon Fraser University, and the University of British Columbia resulted in no evidence of salmon ever being in the upper Similkameen River above Enloe Falls.

The Similkameen River provides 75% of the average flows to the Okanogan River Basin. Like the Okanogan River, it has summer water temperatures up to 22° C precluding summer rearing by juvenile salmonids. Other than providing passage through Enloe Dam, little can be done to improve productivity of salmonids in the Similkameen River. The Mid-Columbia PUD's have developed a satellite remote hatchery and acclimation ponds in the stretch of the Similkameen below Enloe Dam. Highly erosive soils in the Similkameen River watershed have a high potential for erosion and have degraded spawning habitat in the lower reaches of the river. At this time, Canadian government officials and tribes are opposed to the introduction of salmonids above Enloe Dam. This is due in part to a fear of introducing disease to resident stocks above Enloe Dam.

There is no information available for Bonaparte Creek fish stocks.

Eastern brook trout, kokanee (from Palmer Lake), and rainbow trout currently exist in the Sinlahekin Creek sub-watershed. Hatchery rainbow, eastern Brook trout, and redband trout currently exist in Toats Coulee Creek, which is part of the Sinlahekin Creek sub-watershed.

Located on the Colville Reservation, Omak Lake is one of the largest lakes in the Okanogan County. It is a popular sport fishery for cutthroat trout. Special regulations apply on this lake. Single barbless hook and a two fish limit apply to this lake.

Lake Osoyoos is one of two primary rearing areas for sockeye salmon in the continental United States. Being 13 km or 7 miles long, relatively shallow, high in nutrients enriched from agricultural runoff, and fairly warm, Lake Osoyoos provides a relatively abundant food source producing good sized sockeye smolt. Eighteen species of fish inhabit the lake, and many are potential predators on juvenile sockeye. Water temperatures rise early in the year reaching nearly 18° C as early as May and 25° C by August (Allen and Meekin, 1980). Recent dissolved oxygen (DO) and temperature profiles indicate a thermocline which can cause Lake Osoyoos to be rearing limited for sockeye fry, particularly in the south basin (John Hansen, personal communication, 1997).

Water Quality Effects on Fisheries

Surface erosion from clean cultivation and rill irrigation was a very serious problem in the Okanogan Valley during the 1960's and 1970's. This soil loss has been greatly reduced as row crops have changed to alfalfa hay and irrigation has converted to overhead sprinklers. Adoption of "Best Management Practices" (BMP) by the US Department of Agriculture (USDA) has also contributed to reduction of soil losses and erosion. Best Management Practices are defined as "a practice or combination of practices, which are the most effective means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals".

The predominant soils that are the most erosive along the Okanogan River are the Colville silt loams, and the Bosel fine sandy loams. A 1994 NRCS study of erosive stream banks along the Okanogan River between Oroville and Tonasket has identified sites of bank erosion by length and river mile which are most critical and which would benefit from bank stability projects. A total of 14,600 meters of riverbank in 62 sites would benefit from woody vegetation treatment or rehabilitation. Most of the degraded riverbank sites were devoid of riparian vegetation. Riparian vegetation stabilizes the soils by providing rootwads, which retain the bank soils during high flows.

According to the NRCS, another 23 sites would benefit from rock barbs and or rootwads to reduce bank cutting. A streambank restoration demonstration project was completed in 1995 along 500 meters of highly erosive bank near Ellisforde. The restoration included bank sloping, rootwads, rock placement and willow/cottonwood plantings. By 1997, much of this streambank restoration has failed in flood conditions due to inadequate size and placement of barbs (NRCS, 1994).

Excessive silt and sedimentation in the Okanogan and Similkameen Rivers negatively affect fish habitat and result in constant damage and problems for irrigation withdrawals from the rivers. Eighty percent of the Similkameen River Basin lies within Canada and contributes 75% of the volume of water to the Okanogan River.

Although the water quality in the Similkameen River in Canada is considered to be good according to the BCME, it is the primary source of the silt and sedimentation which enters the Okanogan River. (See the Fisheries Trend section on the Okanogan and Similkameen Rivers.)

SOILS AND GEOLOGY

Extent

The majority of the watershed is in the Okanogan Highlands physiographic province, which extends eastward from a line defined by the Sinlahekin and Salmon Creek watersheds and the lower Okanogan River. Rolling mountainous terrain, broad rolling till plains, and a stair-step series of glacial outwash terraces above the river, have been formed by the geologically recent glacial activity of the area. The continental ice sheet was over a mile deep in the Okanogan Valley at Omak. The higher elevation mountainous landscape is characterized by moderate slopes and broad, rounded summits.

The bedrock geology of the area consists of granitic, metamorphic, metasedimentary, sedimentary and volcanic rock. The majority of the area consists of granite, granodioritic gneiss, and orthogneiss, which form the relatively coarse material. Recent glaciation has modified and masked large areas of this bedrock geology and deposited glacial till, glacial outwash, glaciofluvial material and eolian sand as the dominate parent materials. The Okanogan and Similkameen Rivers have deposited recent materials that form the soils of the floodplains and low stream terraces. Geologically recent volcanic eruptions from Mount Mazama, Glacier Peak and Mount St. Helens have greatly contributed ash to the area soils. Depth and degree of mixing of the ash mantle varies with aspect and topography. Protected areas under the forest canopy have the best undisturbed deposits.

Colville and Okanogan soils are on floodplains, terraces, and low broad alluvial fans along the major rivers and creeks. They are nearly level, very deep soils formed in alluvium. The Colville soils are somewhat poorly drained and the Okanogan soils are well drained.

Pogue, Cashmont, Quincy, Skaha and Ewall are range soils that formed on terraces, terrace escarpments and dunes at lower elevation along the Okanogan River. These are typically very deep, excessively and/or well drained, nearly level to very steep. They are formed in glacial outwash and eolian sand.

Conconully, Disautel, Malott, Nighthawk, Nespelem and Wagberg are range soils on glaciated upland sites. Conconully, Disautel, Malott and Wagberg soils are very deep, well drained, gently sloping to very steep soils formed in till from granitic rock, with a component of loess and/or volcanic ash in the upper part. Nighthawk soils are formed in till from metasedimentary rock and Nespelem soils are formed in glacial lake sediments on dissected terraces.

Other upland range soils formed in residuum and colluvium from bedrock are Swakane, Couledam, Wynhoff, Schalow, Timentwa and Bakeoven. Swakane and Couledam soils are shallow, well drained, steep to very steep soils formed in granitic and orthogneiss bedrock. Wynhoff and Schalow are moderately deep and very deep, well-drained soils formed in metasedimentary rock with a component of loess and volcanic ash in the upper part. Timentwa and Bakeoven are deep and very shallow, nearly level to very steep soils formed in basaltic till and material weathered from basalt bedrock on glaciated plateaus.

Molson and Koepke soils are located on glaciated uplands adjacent to more closed canopy forested sites in the northern part of the watershed. These are very deep, well drained, nearly level to steep soils formed in volcanic ash and loess over till from granitic and metamorphic rock. These soils have a dark colored surface on deeply dissected glacial plains. These areas tend to be range sites on south slopes and forested sites on more north facing slopes.

Donavan, Whitestone, Vanbrunt, are mesic forest soils (ponderosa pine) on south facing backslopes and shoulders of glaciated hills and mountains. They range from moderately deep to very deep, well drained with gentle to very steep slopes. These soils formed in granitic till and residuum with a component of volcanic ash and loess in the upper part. Rufus soils formed in material from metasedimentary and metamorphic rock.

Forested soils formed in till from granitic sources include Nevine, Louploup, Republic, Merkel, Stepstone and Pebcreek. These are mostly Douglas-fir sites at higher elevations in the glaciated mountainous areas. They range from very deep to moderately deep to dense glacial till with a mantle or component of volcanic ash. This zone also consists of the Oxerine, Coxit and Nahahum soils formed in colluvium and residuum from metasedimentary rock with a mantle or component of volcanic ash. Other forested soils in this zone include Cedonia, Hudnut, Stapaloop, Wapal, Karamin and Martella. These soils are formed on terraces and terrace escarpments. Cedonia, Hudnut, Stapaloop and Wapal are very deep, well drained soils on nearly level to very steep slopes. Cedonia and Hudnut soils were formed in glacial lake sediments and outwash with a component of loess in the upper part. Stapaloop and Wapal soils were formed in glaciofluvial deposits and glacial outwash with a component or mantle of volcanic ash and loess. Karamin and Martella soils are very deep, moderately well and/or well drained soils on nearly level to very steep slopes. They are formed in glacial lake sediments and outwash with a mantle of volcanic ash and loess.

The subalpine fir forest at higher elevations consists of Manley, Myerscreek, Buhrig, Devore, Sitdown, Resner, and Finney soils. Manley and Myerscreek soils formed in dense glacial till from granitic rock with a mantle of volcanic ash on backslopes and footslopes of glaciated mountains. Buhrig and Devore soils formed in residuum and colluvium from granitic and metamorphic rock with a mantle of volcanic ash 7 to 14 inches thick. These soils are on shoulders and ridges of mountains. Sitdown and Resner soils are on glacial outwash terraces with a mantle of volcanic ash. Finney soils formed in colluvium and residuum from metasedimentary rock with a mantle of volcanic ash on backslopes and shoulders of mountains.

The northwest corner of the watershed is in the North Cascade Mountain province. This area consists, by contrast, of rugged, steeply dissected mountains commonly rising above timberline to elevations of 7,000 feet. Most peaks and ridges have typical alpine glaciation features such as cirques, cirque lakes, knife-edged ridges, and steep pointed peaks. Avalanche chutes are common along the U-shaped valley sideslopes. Andic Haplocryods, Typic Vitricryands, Andic Cryochrepts, Vitrandic Cryochrepts and Andic Cryumbrepts are the typical soils formed in till, colluvium and residuum from sedimentary, volcanic and granitic sources.

The following soil information has been extracted from the two completed National Cooperative Soil Surveys covering the Okanogan Watershed. These are the Soil Survey of Okanogan County Area, Washington (1980); and the Soil Survey of the Colville Reservation, Washington (presently unpublished but manuscript completed in 1988). The USDA Soil Conservation Service [now the Natural Resources Conservation Service (NRCS)] completed these surveys.

Soil is a natural body on the earth in which plants grow. It consists of organic materials and minerals. Soils differ in their appearance, composition, productivity, and management requirements in different localities and within short distances in the same locality. The properties of the soil at any given place are determined by five factors:

1. the physical and mineralogical composition of the parent material;
2. the climate under which the soil material has accumulated and has existed since accumulation;
3. the plant and animal life on and in the soil;
4. the topography, or lay of the land;
5. the length of time the forces of soil formation have acted on the soil material.

These factors as they occur in the Okanogan Valley are described below:

Parent material is the weathered rock or unconsolidated material in which soils form. Most of the soils in the valley formed in materials derived mainly from volcanic ash and glaciation. There are six kinds of parent material in the valley: volcanic ash, glacial till, glacial lacustrine deposits, glacial outwash, weathered bedrock and recent alluvium. Most of the cropland soils formed in glacial outwash.

The main climatic factors that influence soil formation are temperature, amount of precipitation, and seasonal distribution of precipitation. Climate affects the soil through its influence on weathering, leaching of carbonates, translocation of clay, reduction and transfer of iron, and rate of erosion. In the Okanogan Valley most of the precipitation falls during the winter. The effectiveness of summer rainfall is negligible. Usually summer storms are intense and of short duration.

The average annual temperature at Omak, Washington is about 49 degrees F with the average temperature in January at about 24° F. The soil is generally frozen for a short period in winter. The average temperature in July is about 72° F.

Plants, microorganisms, earthworms, and other forms of life on or in the soil are active in soil forming processes. They provide organic matter, help to decompose plant residues, affect the chemistry of the soil and hasten soil development.

Topography influences the soil forming processes by affecting runoff, drainage, and microclimate. In level areas, runoff is very slow. Much of the water drains through the soil, and some evaporates. In sloping to steep areas, runoff generally increases with increasing slope. The more water that enters the soil, the greater the depth to which the soil is leached and weathered. The Okanogan Valley is long and narrow with the valley sides rising rapidly in a series of terraces with steep ridges and uplands bordering both sides of the valley. Between the valleys are broad rolling till plains.

The length of time required for the formation of a given kind of soil depends largely on the other factors of soil formation. An estimate of the age or maturity of a soil is based on the kinds, the thickness, and the arrangement of genetic horizons. Generally, the greater the numbers of genetic horizons, the more mature the soil. Most of the soils in the Okanogan Valley have minimal horizon formation. The length of time that soil-forming factors have been active has allowed only for accumulation of organic matter and some translocation of carbonates, iron and aluminum and small amounts of clay.

Sedimentation Analysis

The purpose of the sedimentation analysis and study is to present some observations and sediment yield estimates for 28 subwatersheds within the Okanogan River Basin (See maps 3-6). For this level of study, sedimentation estimates are best used for a relative comparison of yields between large subwatersheds. This process can lead to targeting specific subwatersheds for a more detailed sediment yield evaluation for both on and off site impacts. Four additional watersheds were subdivided and added to the total. Thirty Pacific Southwest Interagency Committee (PSIAC) units were analyzed.

There are 20 subwatershed units in the U.S. that has a direct delivery to the Okanogan River (see maps 3-6). Additional PSIAC sediment yield model analysis was completed in June of 1998 to characterize the erosion contributions of all of the major perennial tributaries that entrain and transport sediment to the Okanogan. Subwatersheds labeled with an 'X' do not have an outlet to the Okanogan River; however, they are identified as part of the Water Resources Inventory Area (WRIA). These subwatersheds have no potential surface sediment water quality runoff related impacts on the Okanogan River.

The PSIAC sediment yield model was used in the Okanogan Basin to characterize and evaluate sediment yields in 28 subwatersheds (see maps 3-6). This model is most effective when an interdisciplinary approach is used to evaluate the factors that affect the movement of sediment. PSIAC uses the following nine factors to evaluate average annual sediment yield:

1. Surface Geology
2. Soils
3. Climate
4. Runoff
5. Topography
6. Ground Cover
7. Land Use
8. Upland Erosion
9. Channel Erosion and Sedimentation Transport

Each of these nine factors are generally described at a field level basis, scored on a worksheet with a description of observed conditions, and rated based on the scale that best describes those observed conditions. The cumulative scores of the nine factors are tallied, then located on a sedimentation graph that best represents the regional or local soil runoff conditions. Local detention basins or reservoirs are often used to calibrate the ratings relative to a sedimentation graph. Geographic Information System (GIS), soil inventory maps, digital elevation models, land use and cover maps, and other cartographic maps, are typically the kinds of thematic data that are used, to aid field evaluations and to complete a PSIAC analysis.

The PSIAC study area includes all of the Okanogan River Basin below Lake Osoyoos and a limited portion of the Similkameen River drainage, primarily the U.S. side (1.6 million acres). The drainage area above Lake Osoyoos was excluded from this study because of the lake's ability to function as a sediment trap. The amount of actual sediment yield from the Lake Osoyoos drainage is minimal. The majority of the sediment yield is trapped within Lake Osoyoos.

Some Canadian subwatershed sediment yields are considered in this evaluation. The Similkameen River includes two principle drainages, the Pasayten and Ashnola.

This study should be considered only as a broad river basin assessment pertaining to sediment yield estimates from various landuses and hydrologic unit classifications. The basin assessment identifies the types of issues and interactions in the major river basin. As a result, the assessment can provide the necessary link to ensure that the watershed analysis provides information relevant to broader concerns. The assessment should also aid to interpret the evaluation results as they relate to the broader concerns.

The Similkameen River drainage, located in Canada, needs additional inventory and analysis to generally assess its sediment yields to the Okanogan system. After flowing across the U.S.-Canadian border the Similkameen River often flows into Palmer Lake during high flows and contributes an unknown amount of sediment and possibly other contaminants. PSIAC reconnaissance of this drainage area indicates that the majority of the sediment yield to the Similkameen River originates from the streambanks of the Similkameen and some of its tributaries. The upper reaches of the Similkameen are in relatively good condition and controlled more by outcrops of rock. Nonetheless, aerial reconnaissance of the upper region shows some point sources associated with roads and mining that impact the Similkameen. The lower reaches contain more glacially derived materials in the banks and channel bottom and are more sensitive to hydrologic and geomorphic changes within the Similkameen drainage.

Several of these layers were available in digital form from the U.S. Forest Service (USFS) and the NRCS GIS in Spokane, Washington. All 28 sub-watersheds were characterized by either aerial and/or ground survey. Consultation and local knowledge from the NRCS district conservationist, hydrologist, range conservationist, stream geomorphologist and Okanogan Conservation District (OCD) project coordinator were used in the field evaluation process.

The PSIAC summary in Table 3.20 shows the top sub-watersheds for sheet and rill erosion are the Similkameen River, Bonaparte Creek, upper Salmon Creek and the Sinlahekin drainage's. The Similkameen River flows from Manning Park, through the South Okanogan, then south across the U.S. border. It is important for fisheries and recreation, as well as being a major transboundary watercourse. The PSIAC rating for the Similkameen represents a sheet and rill sediment yield of 1.2 acre-feet per square mile per year or 3.5 tons per acre per year. The forests within the drainage have been logged extensively over the years and contain miles of access roads that contribute to the overall sediment load to the Similkameen. Active mining operations such as the ones near Princeton and Hedley contribute to the overall accelerated erosion within the drainage, but the actual sediment yield to the Similkameen from these sources is difficult to state with this level of evaluation. The Ashnola and Pasayten drainages were separated from the Similkameen drainage due to an overall difference in watershed erosion characteristics, streambank erosion, road network, and wilderness areas.

The Bonaparte Creek subwatershed is a large drainage including high mountains and broad valleys capped with glacial till, outwash, or moraines subject to erosion if there is not adequate cover. The streambanks in the lower third of the drainage are near vertical and show a large amount of exposed tree roots and bank sloughing. The relatively high yield rate in this drainage is linked to streambank instability. It's recognized that major storm flows (especially rain on snow events) or certain landuse practices in the upper sub-watersheds can cause instability.

Road mileage for the initial evaluation in 1997 is included in that reconnaissance report. Only road lengths within 200 feet of a tributary were included. A riparian habitat report by NRCS shows that of the 27 miles of creek 10 percent is severely impacted, 44 percent is moderately impacted and 46 percent is slightly impacted. The factors used to determine the condition rating included: type of vegetation, amount of vegetation, condition of vegetation, grazing impact, human or other impact, width of riparian habitat, degree of erosion, and diversity of vegetation. The boundaries of the various riparian condition groups are recorded on NRCS aerial photos. Other resource inventories, stream cross-sections and engineering data are available through the NRCS. It appears that this subwatershed yields approximately twenty (20) percent of the overall sediment to the Okanogan River.

The upper Salmon Creek watershed flows into Conconully Reservoir and Lake. These two water bodies trap 75 percent or greater sediments estimated from the upper Salmon drainage or approximately 50 to 60 acre feet per year. This estimate could be verified and PSIAC estimates calibrated with a reservoir sediment survey of the area. The reservoir sediment information could be extrapolated to other subwatersheds in the Okanogan Basin for more accurate prioritization of the subwatersheds. The Salmon Creek subwatershed is currently the focus of an effort to assess the feasibility of establishing salmonid habitat in Salmon Creek downstream of the reservoirs. This subwatershed is used heavily for recreation and has been extensively logged in the past. The lower stem of Salmon Creek includes 6,728 acres of extremely steep, rocky valley walls with Salmon Creek winding through a tight riparian corridor comprised of pastureland, cropland, and wetland vegetation. Flows in this part of the Salmon Creek subwatershed are controlled by releases from Conconully Reservoir.

The Sinlahekin drainage passes through Palmer Lake just before joining the Similkameen River. Eventually, the Sinlahekin deposits a large percentage of its bedload into Palmer Lake. Only what is in suspension passes through and on to the Similkameen River. A quantifiable bedload and suspended load evaluation would be needed to estimate how much is deposited in Palmer Lake and the associated wetlands and how much is transported in suspension to the Similkameen.

If the estimated PSIAC amount of 336,731 tons per year is used, a relatively small amount of this ever reaches the Okanogan River. A gross estimate for the delivery ratio with a watershed of this size is 20 percent. In other words, 80 percent of the estimated PSIAC yield from the watershed is trapped in the valley, Palmer Lake, and other depressions. So, about 67,000 tons of sediment passes through Palmer Lake and adds to the suspended sediment load in the Similkameen system below the lake. The principal landuse is forest with logging and rangeland near Palmer Lake. Secondary land use activities include but are not limited to recreation and orchards (Jerry Barnes, Personal Communication).

The Tunk Creek subwatershed contains mostly private land used for grazing. Irrigated and non-irrigated cropland comprise 534 acres mostly situated adjacent to tributaries and Tunk Creek. The slopes on the north side of the valley extending about 3 miles downstream and upstream of Synarep show an extensive drainage network. This network of gully-like drainage’s potentially developed from historically higher runoff periods during the last ice age or from overgrazing after settlement of the area. The upper watershed is forested with some road development and logging.

Antoine Creek is situated in the northeast portion of the Okanogan Basin on the U.S. side and contains 3,072 acres of irrigated and non-irrigated cropland in the lower, broad valley of this subwatershed. Initial PSIAC values of this area did not indicate significant problems. Observations made during additional flights and aerial photo review of, in June 1998, indicate some lateral recession and downcutting of Antoine Creek into the valley sediments. The upper watershed is primarily national forest. The county road through the valley acts as a conduit for runoff from funneling rainstorm flows and spring snowmelt into culverts. Some of the bank erosion appears to coincide with these culvert placements through the valley.

The Tonasket Creek subwatershed contains 3,900 acres of dryland and irrigated cropland and accounts for approximately 3 to 4 percent of the overall sediment yield to the Okanogan River. Tonasket Creek outlets just downstream of Lake Osoyoos and contributes a portion of the high bedload and suspended sediment load seen in this reach of the Okanogan. Future discussion of the sediment loads and streambank stability in this upper region of the Okanogan will have to include the Tonasket drainage and land use characteristics in the upper watershed.

In addition to PSIAC, two procedures were used: one for estimating roadbank erosion and the other for sedimentation rate comparisons. The sedimentation rates were compared to a more detailed PSIAC study in the Omak Creek watershed. The roadbank erosion evaluation procedure is called the, "direct volume method”. The watershed yield comparison method is called, "the ratio method equation”. Both procedures were introduced by NRCS at the Soil Conservation Service National Symposium in Ventura, California, 1989. These procedures were offered as additional tools to aid PSIAC and other sedimentation evaluations. The roadbank direct volume method can also be applied to streambanks. Roadbank erosion estimates were completed in an initial reconnaissance of the Okanogan River Basin in the autumn of 1997. Observations from a second aerial reconnaissance of the river basin in June 1998 show that the original roadbank erosion estimates can be adjusted down an average of about 30 percent.

In 1994, an interdisciplinary team completed a streambank erosion and stability inventory on the mainstem of the Okanogan River between Oroville and Tonasket. Nearly 22 river miles were inventoried. The following features were surveyed on both banks for a total of 43.2 miles:

1. reach location
2. bank slope
3. vegetation of bank
4. vegetation on shore
5. bank type
6. bank height
7. length of eroded bank
8. potential for stabilization

Aerial photo series dating back to 1963 were used to help estimate average annual yearly erosion along specific streambank areas (lateral recession). A more detailed discussion of the results, rates and potential effects will be included in the current conditions.

History

Several kinds of historical developments have impacted changes in sediment rates and runoff since the time of early settlement in the basin. The kinds of settlements and their impacts on the Okanogan Basin are common throughout many locations in the Western U.S. The most significant impacts began in 1880's when mining and timber removal were common. Some hillsides were denuded and washed away resulting in high sediment yields in an 1894 flood and subsequent high flood frequency flows. In some of the lower elevations, with limited annual precipitation, the loss of upland native grass species resulted in less desirable cover and less forageable plants. This impact, due to overgrazing in the earlier part of this century, has lead to increased runoff and less infiltration.

Current Condition

The PSIAC model estimates the average annual sediment yield in each subwatershed. The "Ventura Direct Volume Measurement" technique estimates sediment contributions from specific sources. Figure 3.1 from the "Okanogan River Basin Erosion and Sedimentation Yield Reconnaissance" report summarizes the erosive conditions of 1.64 million acres of the watershed. Figures 3.1 and 3.2 show current condition and characterize the comparisons between the 30 subwatersheds modeled:

1. Figure 3.1 shows that the Similkameen subwatershed has the highest erosion rate of 1.18 Ac ft per square mile (same as 3.5 tons per acre).

2. Figure 3.1 shows that the first 13 subwatersheds designated as T1 to T2, Yield, 1,107,035 tons per year, which is 70% of the total modeled sedimentation.

3. The Similkameen River and Bonaparte Creek subwatersheds yield 531,295 tons per year which is 33% of the total yield (See Figure 3.2-Pie Chart); yet, these two subwatersheds are only 9.5% of the total land areas modeled.

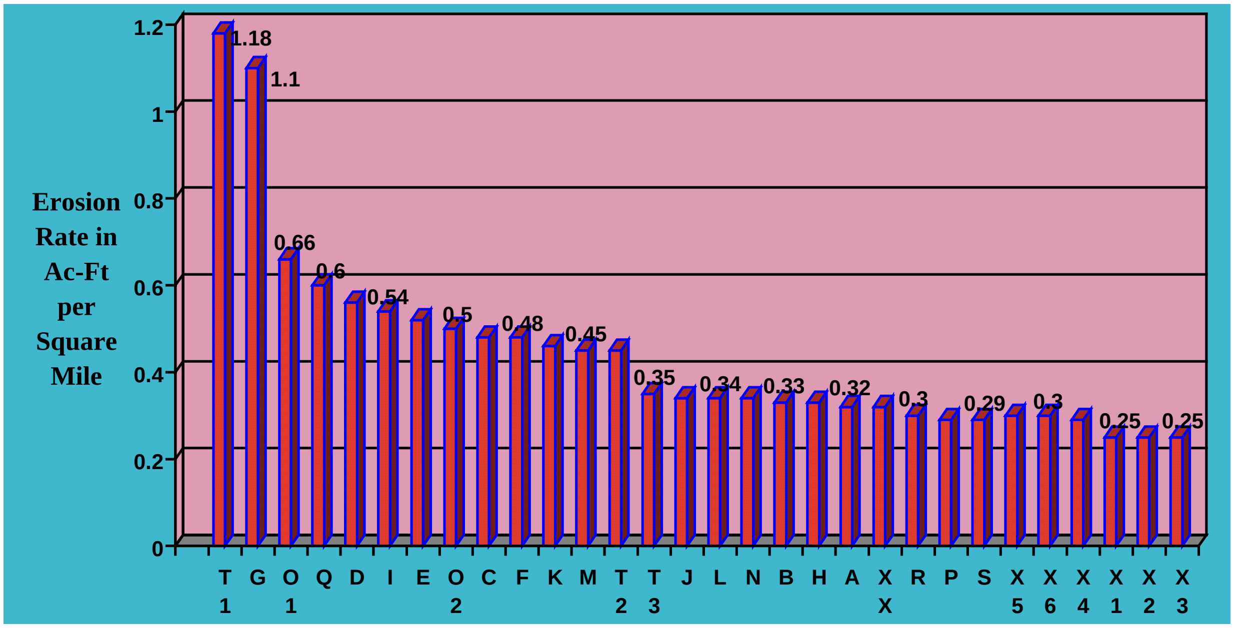
4. Subwatershed A, Okanogan Interfluve, yielded 12.4% of the sediment yield. Subwatershed A is also 12.4% of the total land area modeled (see Figure 3.2).

5. Similkameen River and Bonaparte Creek yielded the highest amounts of roadbank erosion per unit areas.

In 1972, the United States Geological Survey completed a sedimentation study on the Enloe Reservoir, "Potential Transport of Sediment from Enloe Reservoir by the Similkameen and Okanogan Rivers". The study was undertaken to determine the probable effects on the Similkameen and Okanogan Rivers of the removal, transport, and deposition of sediment deposited behind Enloe Dam on the Similkameen River, if the dam were removed."

Under conditions existing in 1972, the average annual suspended-sediment discharges at Nighthawk, located six miles above the Enloe Dam, were 134,000 tons per year. Over a 51 year period, 2.4 million tons of sediment, largely sand, settled into the Enloe Reservoir. Most of this material is considered bedload or particles large enough in the sand-sized categories to settle out. The average yearly amount of sediment settling out from the period of 1920 to 1972 in the Enloe Reservoir was 47,000 tons. "Fluvial sediment has been deposited in the reservoir until, as of 1971, the depth of water behind the 53-foot-high dam averaged less that 20 feet." Depth at the Enloe dam rose an average of 0.65 feet per year from 1920 to 1972.

Figure 3.1



Subwatersheds

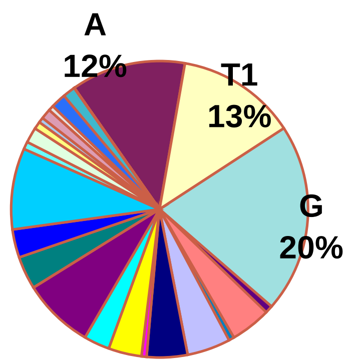
T1-Similkimeen River
G -Bonaparte Creek
O1-Salmon Upper(N W)
Q -Sinlahekin River
D -Mosquito Creek
I -Tunk Creek
E -Antoine Creek
O2-Salmon-Lower
C -Tonasket Creek
F -Siwash Creek

K -Omak Creek
M -Loup-Loup Creek
T2-Ashnola
T3-Pasayten
J -Wanacut Creek
L -Chiliwist Creek
N -Tallant Creek
B -Nine Mile Creek
H -Chewiliken Creek
A -Okanogan Interfluve

XX-Columbia Inter-WRIA
R -Aeneas Creek
P -Browns Lake
S -Spectacle Lake/Whitestone
X5-Aeneas Lake
X6-Wanacut Lake
X4-N. Fork Pine Creek
X1-Omak Lake
X2-Duley Lakes/J. Flats Area
X3-Fish Lake Basin Area

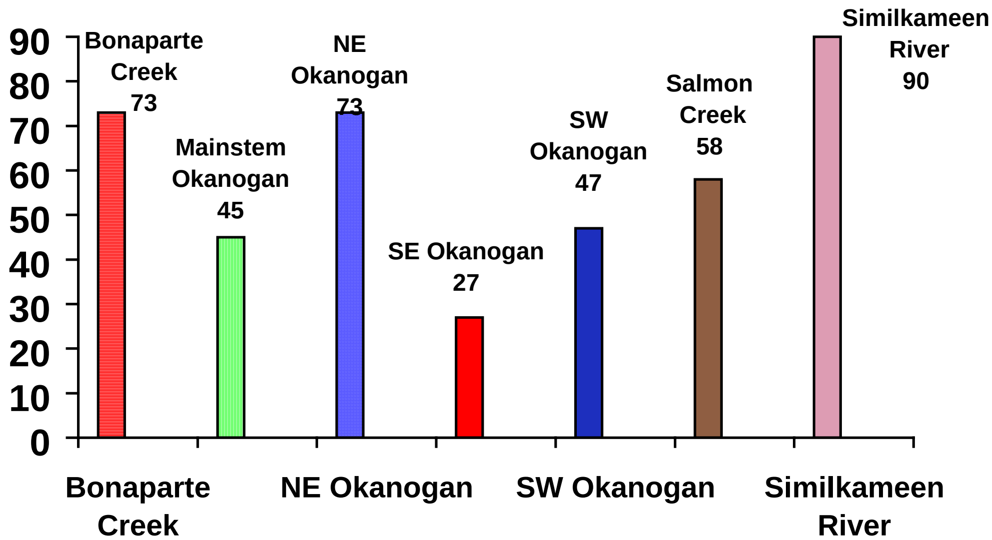
Ranking of sub-watersheds by sediment contribution to the mainstem Okanogan River

Figure 3.2



Pie Chart Showing Percent of Total Erosion of the Significant Watersheds (Similkameen-T1, Bonaparte-G, and Okanogan Interfluve-A)

Figure 3.3



Comparison of estimated road bank erosion within 200 feet of stream (estimated tons per mile).

Streambanks and Mainstem Channel Morphology Changes (Stream Geomorphology)

The loss of riparian species by either direct removal and/or overgrazing has lead to substantial losses in streambank stability and floodplain development throughout most of the Okanogan Basin (both Canada and the U.S. sides). Stream inventories completed on 22 miles of the mainstem of the Okanogan River in 1994 and 30 miles on Omak Creek in 1992, indicate that the loss of riparian vegetation may adversely affect water temperatures.

In the 22 mile-1994 stream survey study, it was noted that "26,300 feet of river surveyed needed sloping prior to establishing streambank vegetation. The total estimated number of feet of riverbank needing vegetative rehabilitation is 47,900 feet (9.07 miles). This represents 21 percent of the total riverbank (228,000 feet) between Oroville and Tonasket.

The areas suffering from severe erosion lacked any substantial vegetative cover on the banks. Of particular concern was the lack of any woody vegetative cover. This type of cover provides large fibrous root systems critical for holding and binding the riverbank soils together. “It was observed, time after time, where one cottonwood or willow tree root would be holding against the energy of the main river current and acting like a point, deflecting the energy back out from the bank for a distance, protecting areas below from eroding".

In conclusion, "The most severe erosion sites on the Okanogan River are predominantly located in the first thirteen and one-half miles of river from the dam by Oroville to approximately the Ellisforde Bridge. This is also where the river has the most sinuosity per linear mile. The aerial photos indicate this area of the river as being the most dynamic over the many thousands of years. It is, most likely, the convergence of the Similkameen River that creates this instability.” Lateral migration (the shift of a meander laterally) in this area has been documented to be as much as 70 feet in one year (because of an extraordinarily high flood event) on the Hegdal site.

Lack of vegetation has more of an immediate negative effect on smaller tributaries than the Okanogan River mainstem. This is due to the loss of shade, thus allowing the smaller streams greater exposure to direct sunlight. Native riparian species were tall and dense enough on the smaller streams that most of their channels were shaded and kept cool throughout warmer times of the year.

Because the relationship between turbidity and suspended sediments is poorly understood and not easily collected, it is difficult to establish a level of water quality impact directly related to the amount of upland and streambank erosion. However, streambank erosion on the mainstem of the Okanogan is likely to affect water temperature. Excessive deposition or erosion has the potential to negatively affect riparian areas, wetlands, and water quality, in the Okanogan watershed, particularly on the mainstem between Oroville and Monse.

On the Okanogan mainstem, another kind of problem exists due to the lack of vegetation and root cohesion in the streambanks. This loss of large woody streambank vegetation ultimately has a negative impact on water temperatures. Streambank erosion negatively affects water temperatures on the mainstem by its impact on the width to depth ratio of the channel at bankfull dimension. As streambanks recede, the channel becomes wider and shallower. Once again, more of the total water column from bank to bank, which incidentally is shallower, is exposed to direct sunlight. A deeper-narrower channel with an effective floodplain exposes less of the channel to sunlight, while more energy is needed to penetrate a deeper water column to raise temperatures in a healthy river system.

An example of the river widening process was documented at a site above Tonasket called, "Hegdal". At the Hegdal site, aerial photo coverage was compared and measured at the same scale from different years. The aerial photos were taken 28 years apart between 1963 and 1991. In this 28-year period, a 1900-foot section at the Hegdal site lost 4.5 acres of ground to the bankfull channel.

The average bankfull river width at the Hegdal site in 1963 was 332 feet. The average bankfull river width in 1991 was 438 feet. This is an increase in width of 24% in a 28-year period. The lateral recession rate during this 28-year period was 3.8 feet per year. This reflects an average yearly streambank loss of almost 4 feet occurred during that time frame. A more detailed inventory and analysis should be completed on the mainstem of the Okanogan River to document the overall increases in bankfull channel widths.

On June 2nd and June 3rd of 1998, a comprehensive aerial reconnaissance was completed throughout 3 million acres of the watershed. Aerial reconnaissance of the Okanogan Lake north of Osoyoos was not completed because of its trap efficiency and minimal impacts on bedload and suspension movement below the dam near Okanogan Falls. All 28 subwatersheds were re-evaluated, at a planview perspective, from a helicopter for Pacific Southwest Interagency Committee (PSIAC) re-evaluation and roadbank cutting. Over 500 miles of various stream corridors of the Okanogan River System were evaluated and photographed for general geomorphic conditions and problem analysis. The Okanogan River was flowing at 11,900 cubic feet per second (cfs) on June 2nd at Tonasket. The June 2nd flow was 88% of bankfull discharge.

Some significant findings from the aerial reconnaissance indicate the following:

1. A substantial mileage of the Similkameen above the border is in a braided condition. Much of the system has extraordinarily high width to depth ratios (wide and shallow) at bankfull flow conditions. This wider and shallower condition will negatively impact water temperatures in the Similkameen River system. Where the banks are not riprapped above the border, they are often unstable. The braided portions, cumulatively, have become a significant source of sediment and erosion.

2. As the flight continued past these braided portions and towards Princeton, the appearance of turbidity and brown coloration's of the waters noticeably decreased. There are unstable-steep banks located next to the Princeton mine.

3. The Ashnola and Pasayten Rivers were noticeably clear during this higher runoff time of the year.

4. Most of the 1997-PSIAC ground and air reconnaissance findings appear to be consistent with the 1998 PSIAC and streambank air reconnaissance.

5. The subwatersheds of Bonaparte Creek, Salmon Creek, Antoine Creek, and Omak Creek to a lesser degree had noticeable streambank failures, as indicated in PSIAC. Some of these areas are taking on higher width to depth ratios, in addition to lacking, streambank vegetation and woody debris.

6. Very large clear-cuts where noted near the Hedley mine and throughout much of the Similkameen River drainage. A more in-depth analysis would be needed in order to evaluate their impacts.

7. Most of the findings from the 1994 interdisciplinary streambank erosion and stability inventory on the mainstem of the Okanogan River between Oroville and Tonasket were easily observed from this flight. This area will continue to have geomorphic and fish habitat conditions in a downward trend until stable, geomorphically compatible practices are implemented to lower width to depth ratios. Also large woody debris, streambank stability, and riparian plantings are essential to this system.

8. In a few areas, like Bonaparte and Salmon Creeks, meander reconstruction would be appropriate to bring back functions and values of streams and riparian areas.

A more in-depth study of stream geomorphology on the mainstem of the Okanogan and Similkameen Rivers and Salmon Creek would aid in developing stream restoration alternatives. Such an inventory is scheduled to be completed on the lower 14 miles of Salmon Creek in 1999.

WATER QUALITY CONDITIONS

Extent

The Okanogan and Similkameen Rivers are both classified by the state of Washington as Class A Waters (Chapter 173-201-A-130 WAC, 1992). Waters classified as such are required to meet, or exceed, the standards established for the various uses including: water supply, recreation, fish (migration, rearing, spawning and harvesting), wildlife, agriculture, and commercial uses.

The WAC's also establish standard criteria for compliance with the classification. Specifically, temperature should not exceed 18°C, pH should occur within the range of 6.5 to 8.5, dissolved oxygen should not fall below 8 mg/L, and fecal coliform counts should be below the geometric mean of 100/100ml. When natural conditions result in water temperatures exceeding 18°C, no increases will be allowed which raise the receiving water temperature by greater than 0.3°C. In addition the US Environmental Protection Agency (EPA) has established the drinking water standard for Nitrate at 10 parts per million.

The Washington State Department of Ecology (DOE) has been monitoring ambient water quality conditions on the Okanogan and Similkameen Rivers since October of 1977 at Malott, Okanogan and Oroville. The data record for these stations has been sporadic at some and continuous at others, but in all cases sufficient data has been collected to demonstrate average conditions and trends. A number of abandoned flow monitoring stations were identified, and records included, in the Initial Watershed Assessment prepared by the Montgomery Water Group, Inc. In addition, the US Geologic Survey (USGS) has been collecting water quality information at Oroville and Malott on a monthly basis since the mid 1970's (see Tables 3.23 and 3.24).

Table 3.21

	Class A Water Standards	**Class AA Water Standards**
Temperature	18° C	16° C
Dissolved Oxygen	8 mg/l	9.5 mg/l
pH	6.5 – 8.5	6.5 – 8.5
Turbidity	5 NTU over background	5 NTU over background
Fecal Coliforms	100/100ml	50/100ml

(Source: WAC 173-201A-030)

It is worth noting that of the 25 saline lakes identified in the state of Washington, 21 are located in the Okanogan Watershed, see Exhibit 3.1 in the appendix (Bennett, 1962).

In 1996 the DOE submitted, to the EPA, a revised evaluation (based on the Class A Water Standards) of surface waters in the state for inclusion on the §303(d) list. The Okanogan River was included for violations of temperature, dissolved oxygen, pH, DDE, DDD, and PCB standards. The Similkameen River was included on the list for violations of the temperature and pH standards, and Salmon Creek was included for instream flow violations (Millan, 1997).

Nitrogen is the most prevalent gas in the atmosphere but plants can only use it in the fixed form of Nitrate or Ammonia. Nitrogen gas is converted to its useable forms through the process of fixation, ammonification, and nitrification. The process of denitrification returns the nitrogen to its unusable gaseous state. In temperate regions, such as the Okanogan, soil nitrate levels will vary with the season and soil moisture conditions. Fall and winter rains typically remove nitrates from the soil and none is naturally added during this period because the cold weather prohibits mineralization and nitrification (WATERSHEDSS, 1997). In surface waters, nitrate is quickly returned to the organic state by the photosynthetic action of aquatic plants, both rooted and phytoplankton (Chow, 1964).

The growth of macrophytes and phytoplankton is stimulated primarily by nutrients such as phosphorus and nitrogen. The primary concern about this growth is focused on lakes and estuaries since growth in flowing waters is thought to be controlled more by light penetration, timing of flows, and type of substrate in the stream or river bottom (WATERSHEDSS, 1997).

The nitrate values recorded on the Okanogan and Similkameen Rivers are well below any action level for health standards as shown in Table 3.22, and thus acceptable for all Class A water uses. Common sources for Nitrogen (nitrogen, nitrites and nitrates) include on-site sewage disposal systems, discharges from municipal sewer treatment plants, irrigation system return flows, fertilizer applications for both agricultural and residential uses, waterfowl congregating on the waterbody, and atmospheric deposition.

Dissolved oxygen is important in natural water because virtually all fish and microorganisms require it. Typical dissolved oxygen concentrations, reported for natural water in streams and rivers throughout the world, are 3 to 9 mg/L measured as the concentration of dissolved oxygen in fresh water at saturation, at a water temperature of 20°C (Mays, 1996). The amount of dissolved oxygen that can be held by fresh water is dependent on the water temperature and atmospheric pressure. When the temperature of water rises, its ability to hold oxygen decreases as happens when atmospheric pressure drops due to rising elevations. These two conditions tend to offset each other somewhat in that as the atmospheric pressure drops due to rising elevations so does the temperature of the water.

The principal source of oxygen in fresh water is from the atmosphere with losses and acquisitions occurring through the air/water interface. A secondary source of oxygen in fresh water is from the growth of aquatic plants such as algae. During the daylight hours, when photosynthesis is occurring, the algae are producing oxygen and a supersaturated condition may develop. At night, the algae consumes oxygen and may create anoxic or anaerobic conditions (Chow, 1964).

The oxygen in rivers and streams is depleted by the bacterial oxidation of the suspended and dissolved organic matter discharged to them from both natural and human sources, and by the oxygen demand of sludge and benthic deposits (Tchobanoglous & Schroeder, 1985).

The recorded dissolved oxygen values in the Okanogan River system are generally very good, even during the summer months when the water temperatures are elevated. Average concentration levels are either near or over saturation values at all stations for the critical summer months. The station at Malott has the lowest saturation values, as might be expected since the monitoring station is located below the major communities in the basin population with their respective sewage outfalls and stormwater discharge points. There is also very little turbulent water between the Okanogan monitoring station and the Malott station to facilitate reaeration.

In the data provided by the DOE EAP lab there were a few data sets taken at the Malott monitoring station on the same day but at different times. These values reflect a significant increase in dissolved oxygen from the morning to mid-day readings (10-12%), possibly indicative of the presence of algae in the river that is producing oxygen during the daylight hours.

A very important property of water, sometimes disregarded, is temperature. The temperature of the water significantly influences many important physical, chemical, and biological processes. Surface water temperatures usually approximate the ***average*** seasonal air temperatures (Chow, 1964).

The Okanogan and Similkameen Rivers both demonstrate increased temperatures during the months of July and August, and the Okanogan maintains elevated temperatures into September (see

Table 3.23). The temperatures are consistent with the values recorded at the monitoring stations in Canada (Province of British Columbia, 1996). Due to the high ambient air temperatures in the Okanogan River Basin during the summer months, and the fact that the water temperature tends to stabilize at the average air temperature, the elevated temperatures are suspected to be a naturally occurring condition. The plot of ambient air temperature at Oroville, and water temperatures at Malott, Oroville, and Okanogan demonstrates a definite correlation between the air and water temperature (see Figure 3.4 in Appendix C).

The temperature of water affects some of the important physical properties and characteristics of water such as density, specific weight, viscosity, surface tension, thermal capacity, enthalpy (heat content), vapor pressure, specific conductivity and conductance, salinity, and solubility of dissolved gases (e.g. Oxygen and Carbon Dioxide) (Mays, 1996). Factors that contribute to increasing water temperatures are sedimentation, industrial discharges, stormwater runoff, hydromodifications, irrigation return flows, loss of riparian vegetation, and water withdrawals.

pH is an extremely important variable because it is the controlling factor determining the solubility of most metals, and because most microorganisms can only survive within a narrow pH range (Mays, 1996).

The average pH values measured in the basin have risen approximately 0.3 points over the last 20-30 years (see tables 3.22 and 3.23). While elevated to the upper limits of the desired range, this condition may be exerting a positive stabilizing effect on the heavy metals by keeping the metals sorbed onto the soil particles and sediments, and out of solution (WATERSHEDSS, 1997). Influences on the pH level include acid mine drainage, atmospheric deposition (acid rain), calcium, calcium carbonate, effluent water and land use practices. Exhibits 3.2 and 3.3 in the appendix display the average flow and pH for each month. Exhibit 3.3 also displays the variation between the 1977-1986 period and the 1987-1996 period when the pH varied significantly.

The presence of fecal coliform bacteria has become the accepted standard for establishing the presence of bacterial contamination (Viessman & Hammer, 1985). It has been observed that the ratio of fecal coliforms and fecal streptococci that are contained in human feces are significantly different from the ratios found in feces of other animals. Therefore, it has been suggested that the ratio of the fecal coliform (FC) count to the fecal streptococci (FS) count in a sample can be used to indicate whether the suspected contamination derives from human or animal wastes. Typical data on the ratio of FC to FS counts for humans is more than 4 to 1, while in animals the ratio is generally less than one (Tchobanoglous & Schroeder, 1985).

However, the ratio should be used with care because of differential die off of the FC and FS bacteria. Thus as the distance from a sewage treatment plant outfall increases the ratio can change, and naive interpretation of the ratio could be misleading (Mays, 1996). Table 3.25 demonstrates that various warm-blooded species contribute widely ranging amounts of Fecal Coliform and Fecal Streptococci bacteria.

The fecal coliform values recorded for the monitoring stations are generally quite good with the Malott station having 9 exceedences in 163 recorded samples. The Okanogan station had 5 exceedences in 128 observations, while the Oroville stations recorded 0 exceedences on the Okanogan (190 observations) and 1 exceedence on the Similkameen (208 observations) (DOE - EAP Lab, 1977-1997). The State water quality standards allow for up to 10% of the samples to exceed the published standard as long as the mean value of the samples is below 100 colonies per 100 ml.

The observations were very erratic with high peak values interspersed with very low values, indicative that the source was other than a constant contributor such as a regular sewage treatment plant discharge or collection of failing on-site sewage systems. The source could be the result of: flood events that caused overloading of the sewage treatment plants with a subsequent discharge of less than fully treated wastes. Additional sources of contamination might include an animal carcass in or adjacent to the river; rainfall events that create surface runoff from animal stockyards or feedlots; wild animals adjacent to the watercourse; or a concentration of waterfowl in the vicinity of the monitoring station.

Turbidity is a measure of the degree to which light traveling through a column of water is scattered by the suspended inorganic and organic particles contained within it. The higher the concentration of particles the greater the diffraction of the light. Turbidity is commonly expressed in terms of Nephelometric Turbidity Units (NTU's), with the lowest values representing the clearest water.

The test is conducted by shining a light, of known output, through a column of water and measuring, with a photo-cell, the incoming light and comparing it to that emitted. The sediments in the water reflect the incoming light and the “dirtier” the water the greater the percentage of light reflected.

The shape of the sediment particles can influence the NTU readings since clay particles will have much higher surface area to mass ratios than will sand particles. Due to this situation, the total suspended solids may provide a better indicator of sediment problems in the basin.

Accepted turbidity readings in water designated for recreational use is up to 5 NTU’s, for drinking water it is 1 to 5 NTU’s while for fish, sight feeding is restricted above 50 NTU so it is desirable to not have the NTU value exceed 50 on an instantaneous basis or 25 on a ten day average (WATERSHEDSS, 1997). During the late summer and fall months, when the Summer Chinook salmon are entering the river the recorded turbidity values are all very low.

A review of the turbidity readings at Malott, Okanogan, and Oroville for the months of May, June and July (1978-1996) shows relatively good water quality from a turbidity standpoint. The May average for the stations was 16.5, 7.7 and 2.9 respectively on the Okanogan and 8.7 on the Similkameen. During June (peak flow month) the values are 17.1, 21.8 and 2.2 on the Okanogan and 13.7 on the Similkameen.

The peak values recorded on the free flowing sections of the Okanogan and Similkameen were collected in the late fall and winter months. At Malott the highest reading was 176 on November 13, 1990, at Okanogan it was 180 on March 2, 1982, and the Similkameen had its highest reading of 74 on November 13, 1990 (no data taken at Okanogan from 1988 to 1995). Based on a review of the data it appears that the highest sediment loads are produced during extreme storm events rather than from normal snowmelt. Exhibits 3.4 and 3.5, in the appendix, display the relationship between flow and turbidity on both the Similkameen and the Okanogan Rivers.

Contributions to turbidity can come from a variety of sources including: sewage treatment plant outfalls that discharge organics during periods of sewage by-pass; nutrients released from bottom sediments during seasonal turnovers in lakes or changes in water current in rivers and streams; silt, sand, clay and organic material dislodged by rainfall and carried in surface runoff; and numerous human activities including lawn care, agricultural practices, and waste disposal practices.

A review of the average flow values for the monitoring stations at Oroville, Okanogan and Malott (Exhibits 3.8-3.10 in the appendix) reveals that the flows at Okanogan average considerably higher in June than either the combined flows at Oroville or the flow at Malott (below Salmon Creek). This raises questions concerning the validity of flow data from the Okanogan station and a recalibration of the gage should be undertaken.

The suspended sediment readings track very well with the flows as demonstrated in Exhibits 6 and 7, in the appendix. Sand has been reported to be a significant problem with irrigation pumps withdrawing water from the river system. The months of May and June have the highest average readings of suspended sediment, a period during which significant quantities of water are withdrawn. Additional monitoring of the river for sediment over the entire vertical water column would be desirable and a grain size analysis conducted to assist in identifying the sources. Primary sources for sediment are erosion from forest fire burn areas, agricultural practices, cut and fill slopes on roadways, highway maintenance practices, construction sites, logging operations and strip mines (including gravel operations).

Ground Water

There have been a number of studies conducted in the watershed on groundwater although it is still a relatively unknown quantity regarding deep, hard rock aquifers. Kenneth Walters of the DOE prepared a report entitled “Water in the Okanogan River Basin, Washington” in 1974 that provided a general overview of ground water conditions as related to the shallow aquifers located primarily in the valley bottoms. The following material is found in his report on page 11.

> “Alluvial and glacial sedimentary deposits, ranging from a few feet to several hundred feet thick, contain the main volume of ground water in the basin, with sand and gravel layers constituting the principal water-bearing zones. Most of the sedimentary deposits occur in or adjacent to major valleys and are underlain by rather impermeable bedrock which consists principally of granitic and various metamorphic rocks; limestone, dolomite, and basalt form the bedrock in small areas. Generally, the bedrock establishes the floor of the ground water reservoir, although cracks in the bedrock below the water table become filled with water, and limestone, dolomite, and basalt formations yield small quantities of water to springs and wells.”

> “In some places, the sedimentary deposits are thick and consist almost entirely of sand and gravel containing large quantities of ground water. In other cases, the deposits hold little water, being thin or consisting mostly of clay or poorly permeable glacial till.”

Ground water in the Okanogan Watershed differs from the surface water in that it is generally more mineralized and the chemical composition varies more, but is still acceptable for most common uses. There have been occurrences of excessive iron and sulfates that render the water less palatable. Ground water in the basin typically runs hard to very hard and is therefore less desirable for certain household uses such as laundry and dishes. The ground water temperatures, as measured at a number of wells ranged from 11° to 16°C with the shallower zones tending to produce the cooler water (Walters, 1974). Walters reported nitrate test results for nine wells in the basin with the values ranging from 0.3 to 4.9 parts per million – below the Safe Drinking Water Act standard of 10 parts per million.

Due to the sedimentary nature of the shallow aquifers, there exists a fairly high potential for pollution of the ground water supplies from activities carried out on the ground surface. A more detailed analysis would be required to determine the existence and extent of any "hard rock" aquifers.

The overwhelming majority of residents in the watershed rely on ground water for their domestic needs, with the few exceptions utilizing springs. Of the regulated water systems in the watershed only a small percentage have completed wellhead protection plans as required by the Washington State Department of Health (John Callen, personal communication, 1997).

SEWAGE DISPOSAL

Extent

The consequences of not properly treating and disposing of sewage can be significant. Untreated sewage attracts flies, rodents, and other pests, creates offensive odors, lowers property values and generates health hazards. Of the top five human parasitic diseases (ascariasis, hookworm, malaria, trichuriasis and amoebiasis), only malaria is not directly spread in sewage (Kaplan, 1987). Of these health problems only ascariasis (roundworms) are commonly found in the Okanogan River Watershed (John Callen, personal communication, 1997).

Historically on-site sewage (OSS) disposal systems have provided for the treatment and disposal of human wastes in the unincorporated areas of the Okanogan River Watershed. In the incorporated cities and towns of the watershed this was also true until the development of collection and centralized treatment systems (Okanogan - 1948, Omak - c1947, Tonasket - 1947, Oroville - 1949, Conconully - 1980).

Subsurface soil absorption has been used almost exclusively for on-site disposal of wastewater because of its ability to meet the public health and environmental criteria without the necessity for complex design or high cost. A properly designed, constructed, and maintained OSS performs reliably over the long term with little attention. This is due to the large natural capacity of the soil to assimilate wastewater pollutants [Environmental Protection Act (EPA), 1980].

The OSS is an anaerobic digester (septic tank) form of treatment system producing effluent that is discharged to the soil through a subsurface network of pipes known as a leachfield. While presenting a potential source of pollution, when individual systems fail to function properly and/or when they are installed at densities higher than an area's soils can accommodate, the OSS is very efficient at treating human wastes when properly installed and maintained.

The Okanogan County Health District (OCHD) oversees on-site systems under 3500 gallons per day, which are not on the Colville Reservation. They have adopted design standards (BD of Health Resolution 96-003, 1996) that take into consideration soil type and depth, slope, and proximity to water bodies when approving the siting and design of a system. These standards are to be considered state of the art and go beyond the minimum by requiring that a licensed designer or Professional Engineer design all on-site systems in Okanogan County. The OCHD standards are based on the Washington State Department of Health minimum criteria, issued as Chapter 246-272 of the WAC's. The OCHD has been permitting on-site systems since the mid 1960's (John Callen, personal communication, 1997).

The Colville Confederated Tribes (CCT) oversee the installation and maintenance of on-site systems on reservation lands. The Tribe has an Onsite Wastewater Management Plan prepared, in 1982, as part of their 208 Water Quality Management Plan. This document outlines the procedures for the design, installation and maintenance of on-site systems on reservation lands. The County Health District works in close cooperation with the CCT on sewage disposal issues that involve non-tribal members that own land within the reservation boundary (Montgomery, 1982).

In the case of on-site systems exceeding flows of 3500 gallons per day, but less than 14,500 gallons per day, the Washington State Department of Health has jurisdictional authority to issue permits, while systems over 14,500 gallons per day require approval of the Washington State Department of Ecology (DOE). In the case of all systems over 3500 gallons per day, approval by the Okanogan County Public Works Department is required prior to construction of any portion of the system.

At the present time, the total number of on-site systems within the watershed is unknown, but the OCHD is currently entering all systems into a database, to allow for better monitoring and control. This effort is projected to be completed in late 1997 or early 1998 (John Callen, personal communication, 1997). The development of this database will be a vital element for the development and implementation of a plan to monitor all OSS performance in Okanogan County, by January 1, 2000 (WAC 246-272-15501).

The disposal of the biosolids (septage) removed from the septic tank, as well as toilet vaults and Porta-Potti's, during routine maintenance, is typically handled in Okanogan County through topical land application. The biosolids are spread on the surface of the ground, lime is applied to stabilize the material, reduce odors and pest attraction, and is then tilled in. Each septic tank pumper in Okanogan County has one or more permitted sites for the disposal of septage. This is necessitated in part by the fact that none of the publicly owned treatment plants are designed to treat septage (J.J. Bellinger, personal communication, 1997).

The publicly owned sewage treatment facilities in Omak, Okanogan, Oroville, Tonasket and Conconully are all operated by the respective municipalities under the guidelines and overview of the DOE. Oroville and Omak employ oxidation ditch technology, Okanogan uses Rotating Biological Contactors, while both Conconully and Tonasket use lagoon systems. Table 3.25

contains the design parameters, discharge limits and actual discharge values at the various facilities, as provided by the DOE.

Like on-site sewage systems, treatment plant effluent can produce detrimental impacts on receiving water quality. Unlike on-site systems, it is common for municipal treatment plants to discharge directly to surface water bodies. In the Okanogan River Watershed (US portion) two municipal treatment plants discharge to the Okanogan River (Omak and Okanogan), while one discharges to the Similkameen River (Oroville). The DOE, through the National Pollution Discharge Elimination System (NPDES) permit process, sets the monitoring requirements and testing schedule for each of the treatment plants, and collates and reviews the collected data. The Conconully system is a lagoon treatment process that employs land application for disposal of the effluent, by means of irrigation. The Tonasket treatment plant discharges its effluent to groundwater rather than directly to the river, although the discharge point is only 50-60 feet from the Okanogan River.

Municipal treatment plants are required to test their effluent for various parameters including pH, temperature, dissolved oxygen, biochemical oxygen demands (BOD), total dissolved solids, ammonia, chlorine residual (if applicable), and fecal coliforms. This information is filed monthly with the DOE in the form of Discharge Monitoring Reports.

The major potential pollutants in OSS effluent are phosphates, nitrates and pathogens that may, in the event of system failure, contaminate surface or ground water. A properly functioning OSS is very effective at removing phosphates and, coupled with the fact that most laundry detergents are now phosphate free, the potential for phosphate pollution from on-site systems has been greatly reduced.

The causes of OSS failure are usually related to one or more of the following: improper siting and design of the drainfield, poor construction techniques, overloading, inappropriate pumping and cleaning of the septic tank, loss of soil percolation capacity due to clogging of interparticular spaces, or groundwater saturation of the drainfield bed. The failure of an OSS drainfield may result in seepage of effluent onto the soil surface layer where humans may come into contact with it, effluent which is not fully treated may be allowed to enter groundwater; and effluent may enter lakes and streams fostering the growth of algae and related organisms (Marsh, 1991).

The life of an OSS is highly variable, depending upon proper use, maintenance, and siting. Most OSS leach fields have a 15 to 20 year life expectancy. Improper maintenance will cause even a well-designed system to fail in a much shorter period of time. A number of alternative on-site sewage disposal systems can accommodate site limitations that traditional systems cannot. However, maintenance is more critical to keep these systems functioning properly.

Nitrate is another potential source of water degradation in the Okanogan River watershed. High nitrate levels in water may be contributed to by agricultural practices, municipal sewage treatment plants, landscape maintenance practices, and on-site sewage systems. Nitrogen can be found in one of three forms in water: ammonia, nitrate, and nitrite.

Table 3.25

MUNICIPAL TREATMENT PLANT SPECIFICATIONS

All of these forms can occur depending upon environmental conditions. Nitrogen is an important nutrient in water due to its being highly mobile, and unlike phosphates is not readily adsorbed to soil particles within the soil profile. High levels of nitrogen can accelerate aquatic plant growth and be toxic to fish, and elevated nitrate levels in drinking water can cause health problems in children.

Since shallow ground water and surface waters are primarily in continuity within the

Design Parameters					
City	Flow (mgd)	BOD(lb. /day)	TSS (lbs./day)	Pop. Equiv.	Discharge Pt.
Omak	1.89	1200	1380	6000	R.M. 29.9 Okanogan River
Okanogan	0.54	1007	1056	3755	R.M. 24.8 Okanogan River
Tonasket	0.25	296	296		Groundwater ~56.5 R.M. Okanogan River
Oroville	0.632	440	506	2200	R.M. 4.0 Similkameen River
Conconully #	0.076/0.03	165/50			Land Application
# summer values/winter values					

DISCHARGE LIMITS (Monthly values)				
	pH	BOD (mg/L)	TSS (mg/L)	Fecal Coliform (colonies/100 ml)
Omak	6.0-9.0	30	30	200
Okanogan	6.0-9.0	30	30	200
Tonasket	6.0-9.0	60	145	200
Oroville	6.0-9.0	30	30	200
Conconully*				230

ACTUAL EFFLUENT DISCHARGE VALUES (Average 7/96 to 6/97)						
	Flow (MGD)	pH	BOD (mg/L)	TSS (mg/L)	Fecal Coliform colonies/100ml	Pop. Equiv.
Omak	1	7.2	4.1	4	65	4455
Okanogan	0.45	7.4	16.4	12.1	84	2460
Tonasket	0.192	8.65	30.8	51.5	18150**	1025
Oroville	0.36	7.9	3.8	6.2	120	1500
Conconully*	0.035	8.3	206.3	134.5		196
*Conconully values are inflow only					**Total Coliform	

Source: the State Discharge Permits for the Facilities and Discharge Monitoring Reports

Watershed, there is a potential for elevated levels of nitrates to occur in shallow domestic wells on the valley floors, and testing domestic wells for nitrate, on a periodic basis, may be desirable.

There is some confusion regarding the extent of fecal coliform contamination in the Okanogan River Watershed. The 1994 supporting documents to the §305(b) report (DOE, 1994), state that the Okanogan and Similkameen are both impaired for use because of fecal coliform contamination. The 1996 §305(b) report (DOE, 1996), does not list fecal coliform as one of the parameters exceeding standards on the Okanogan or Similkameen, nor does the 1996 §303(d) list (Millam, correspondence, 1996). A review of the DOE EAP data collected over the past 20 years at Malott, Okanogan, and Oroville shows occasional samples that exceed parameter standards but no pattern of violation (DOE, 1977-1997).

Fecal coliform counts are used as an indicator of sanitary quality of water and provide an indication for the potential of other water-borne pathogens to be present. Fecal coliform bacteria are present in the intestines or feces of warm-blooded animals. Therefore, high fecal coliform levels may be caused by humans, livestock, wild animals and/or waterfowl. However, the contribution from each source is not known. Agricultural contributions could include direct livestock access to streams, surface runoff, and improper manure storage, utilization and disposal.

In 1988, the DOE conducted a Receiving Water Survey at the Okanogan Wastewater Treatment Plant to determine the effects of the treatment plant discharge on water quality during low flow periods. The results, while not conclusive, did demonstrate that the effluent grab samples contained higher fecal coliform counts than were permitted (Carey, 1990). In the last year, the effluent fecal coliform counts have averaged considerably lower than the permitted values, reflecting improved disinfection of the effluent prior to discharge. The river reach containing the Okanogan wastewater treatment plant outfall has been proposed for the 1998 §303(d) list for fecal coliform contamination as a result of this study.

Nutrient enrichment of lakes, ponds, and reservoirs from wastewater seepage is one of the factors contributing to the deterioration of water quality in the United States and Canada. When nitrogen and phosphorus, the nutrients of greatest concern, enter a water body, the productivity of algae and other aquatic plants can rise substantially, resulting in greater organic mass. This vegetative mass not only fills in the water body, but as it dies and decays, the consuming bacteria use up some or all of the available dissolved oxygen. In time, the water's dissolved oxygen content declines on a permanent basis, water temperatures increase, fish species change to less desirable ones, and the water body converts into one that is often deemed unsightly and smelly (Marsh, 1991). This process, known as eutrophication, is a naturally occurring one, but can be accelerated by human activities.

Municipal sewage treatment facilities generally contribute similar pollutants to the receiving waters, as do on-site systems. In addition, they frequently accommodate other types of waste flows and thus, may discharge other pollutants. The waste flows may contain storm water, parking lot runoff, industrial waste, and commercial flows such as from laundromats and restaurants. Such flows can result in the capacity of the system being exceeded, or deliver wastes the system was not designed to accommodate. The typical municipal treatment facility produces a high quality effluent on a consistent basis and, while contributing to the degradation of water quality, generally provides greater protection than would the number of OSS required to serve the design population, at the required density.

The soil types in the Okanogan River Watershed have all been identified by the Natural Resource Conservation Service (NRCS) as having features unfavorable for effective sewage drainfield use. A review of the Soil Survey of Okanogan County Area shows that all soil types existing on a side slope of 8% or more were listed as having moderate restrictions for siting septic tank absorption fields. This classification was done when leachfields were typically installed as level beds and therefore slope became a consideration. The technology utilized in the construction of an OSS has advanced greatly over the last 30 years and the restriction imposed by slope is no longer a major concern. The survey is typically done to a three acre accuracy and should not be the sole factor to determine whether a site is suitable or not, for an on-site system. A site specific assessment should be done on each site to determine any limiting factors and what type of on-site system (Gravity, Pressurized, Sand Filter, etc.) should be used to provide appropriate protection to the water resource.

The development of a site specific critical area map identifying limitations for siting on-site sewage systems may be desirable. This information could be used by cities and the county to develop appropriate land use designations, and by the OCHD when siting sewage systems. Further, this information would be beneficial to the public, particularly prospective property buyers.

A review of the individual treatment plant design and operating characteristics, and discussion with pertinent personnel, provided the following assessment of existing conditions and future plans.

The Omak facility's average annual discharge values were all within the required operating range for its permit values. The City of Omak is currently in the design stages of upgrading its facility to provide further capacity and enhanced treatment capability (Sheldon, personal communication, 1997).

The Okanogan treatment plant is currently running at 83% of design hydraulic capacity on an annual basis with an annual BOD removal rate of approximately 90%. A Plan to Maintain Adequate Capacity was prepared by the City in 1995 and submitted to DOE. An Infiltration and Inflow report was also prepared and submitted to the DOE in 1995. This report included smoke testing of all sewer mains in the system to determine leakage points, roof drain connections and any storm sewer interties (Davidson, personal communication, 1997). Specific plans and needs for upgrading the Okanogan Sewer Treatment Plant include the following:

- Add Two Rotating Biological Contactors
- Increase Digester Capacity
- Replace the Archimedes Screw Pumps at the Headworks of the Plant
- Extensive Collection System Replacements

The Tonasket plant has experienced significant problems in the past with meeting the discharge limits of their permit. The hydraulic capacity of the plant is currently at 77% and a Plan for Maintaining Adequate Capacity was submitted to DOE in 1996. As an interim measure, pending completion of on-going studies, the DOE recently issued interim effluent limits for use until June 30, 1999 (Barwin, correspondence, 1997). The effluent monitoring is conducted by taking a random grab sample from the final treatment cell (Jensen, personal communication, 1997). The plant has significant algae growth occurring in the effluent cells and this will contribute directly to the high BOD, TSS and pH values recorded. The Town is in the process of installing an influent flow meter and evaporation monitoring station, and recently completed the construction of 5 monitoring wells for the purpose of conducting a study to determine if the liners in the treatment cells are leaking (Rampley, personal communication, 1997). This monitoring will also involve sampling the Okanogan River both upstream and downstream of the treatment facility. The Town recognizes that improvements to the treatment plant will be forthcoming. The Town, through its engineering consultant, is currently developing a General Sewer Plan and related reports that address capacity, infiltration & inflow, residual solids management, groundwater impacts, and assessment of biological activity in the lagoons (Barwin, correspondence, 1997).

The Oroville treatment plant has been receiving more BOD than the design values, but the City has had a review done of the plant capacity. When the new State Discharge Permit is issued in 1998, this value will be revised to reflect the current capacity (Jim Milton, personal communication, 1997).

The Conconully treatment plant is currently operating at 85-100% of design capacity from a hydraulic loading standpoint (varies with interpretation of when the summer months are). This system discharges effluent for only a couple of months per year - with the lagoons holding all flows the balance of the year.

Several areas within the watershed have been identified as potentially benefiting from the installation of centralized sewage facilities in the future. Such facilities could include extending collection lines from an existing publicly owned treatment facility, or installing a stand alone collection and disposal system to serve a small community.

Specific areas identified included the communities of Malott, Loomis, and Riverside as well as the areas along the west and east sides of Lake Osoyoos. Malott, Loomis and Riverside would possibly be best served by a Septic Tank Effluent Pumping (STEP) system discharging to a series of community drainfields. The areas around Lake Osoyoos would be best served by extension of service from the City of Oroville.

The Town of Riverside is currently in the process of developing a comprehensive sewer plan, which will identify their specific needs and potential solutions.

MINING IN THE OKANOGAN RIVER WATERSHED

Extent

Mining in the Okanogan Watershed was conducted with a variety of extraction methods, including placer mining (panning and sluice boxes), and hard rock underground operations with their associated stamp mills and tailing piles. The placer miners generated immediate impacts on water quality in the basin through the displacement of the gravels in the bottom of the streams, and also the excavation of the stream banks in their search for gold and other precious metals. Their actions likely resulted in siltation and loss of aquatic life along some reaches. The only significant placer mining in the Okanogan River Watershed occurred on the Similkameen River between Oroville and Nighthawk.

The hard rock, or lode, mining generated impacts on water quality of a different nature than that of the placer mining. When the mineshafts were driven underground they often intercepted groundwater that had to be pumped out of the shaft, and discharged to the waterways, with no treatment. The mine water typically contained dissolved minerals and was frequently highly acidic in nature, often capable of killing the aquatic life in the immediate vicinity of the discharge and potentially creating impacts for a considerable distance downstream. The waste rock left from the driving of underground workings and tailings piles left from the reduction of the ore could be long term sources of acid mine drainage containing heavy metals and other contaminants.

The mines and associated towns required considerable quantities of timber for reinforcing the shafts, erecting the dwellings and commercial buildings, and providing heat during the winters. This demand led to extensive logging in the immediate vicinity of the mining camps.

While the mining of precious metals played a significant role in the development of the County, the extraction of non-metallic minerals (sand, gravel, gypsum, limestone, epsonite, etc.) has generated much greater financial benefit to the residents (Wilson, 1990).

The Tonasket Ranger District of the Okanogan National Forest completed an assessment of the Salmon Creek drainage in 1997. This document states the following with regard to "recent" mining activity in the basin.

> "The only patented claim within the Forest boundary is the Jessie Moore mine in the North Fork Salmon Creek drainage. Claims that have had a recent of intent or operation plans for ground disturbing activities include Silversmith Group (1981), Quimine (1981), and the Day Star Group (1981). In addition the Mar-Mac mine had an approved operations plan for road construction in 1983, and was later restaked in 1993 and renamed Plata #1. The price of silver and lead will be the main factor influencing any mineral activity in the Salmon watershed."

Currently the price of silver languishes at 5 to 6 dollars per ounce, the same as it was in the mid 1970's.

In 1995, the Okanogan County Health District received a Site Hazard Assessment Block Grant from the Washington State Department of Ecology's (DOE) Waste Management Grant program to conduct initial investigations and site hazard assessments on existing mine sites in Okanogan County. The purpose of an initial investigation is to determine whether a hazardous material has been released from a site that has demonstrated reasonable cause to believe such a release may have occurred. Initially 150 potential sites were screened down to 36 sites selected for review. These sites were located throughout Okanogan County, with 25 sites being within the Okanogan River watershed (Huchton, 1997).

The initial investigations revealed 6 of the 25 sites to be either "active" sites or too insignificant to warrant a full investigation. An additional three sites were determined to be "clean" and no further action was recommended. The remaining 16 sites were tested and certain elements were found to be above the levels for which cleanup is recommended under the Model Toxics Control Act (MTCA) at one or more sites: lead, arsenic, zinc, cadmium, copper and antimony. The cleanup action levels were extracted from the MTCA, for both soil and water contamination, and are listed in Table 3.26. The sites tested in the field and the results of the testing are listed in Table 3.27. A number of the sites were also identified as presenting physical danger to the public due to a variety of causes including rotten or inadequate shoring, or unstable rock masses.

Analysis of the data reveals that arsenic appears to be above cleanup levels in water when it is found to be greatly above cleanup levels in the soil. This observation should be confirmed with further review of the raw data collected in the study to assure the presence of water at all sampled sites.

Lead and arsenic were the most frequent metals found to be above cleanup level in both the soil and water. Lead is easily tied up in the soil matrix and once bound to the soil particles has been shown to not move significantly in the soil column. Arsenic, while attaching itself to soil particles, is more prone to slowly migrate through the soil column and enter the groundwater.

The DOE will conduct Site Hazard Assessments at each of the identified sites, as time and staffing allow, to determine the severity of the problem, rank the individual sites, and initiate remediation, if required (Abbott, personal communication, 1998).

STORMWATER MANAGEMENT

Extent

Stormwater management encompasses a number of activities generated by rainfall and snowmelt runoff over the surface of the ground. These activities include the erosion process, sedimentation transport and deposition, stream channelization, and pollutant loading impacts on receiving waters. The volume and rate of stormwater runoff is determined in large part by the percentage of area covered by impervious surfaces. While urban areas typically have larger percentages of impervious area and generate more surface runoff than do rural areas, stormwater management is an issue that involves the entire watershed. It is recognized that while the overwhelming majority of the Okanogan River Basin is rural in nature, and therefore not covered with impervious surfaces, there are a number of rural land use activities that contribute. The communities in the watershed have the potential to exert a significant impact on water quality due to their being located on or adjacent to the major watercourses. Stormwater discharges may occur in the form of either a point source (e.g. culvert discharge) or a non-point source (e.g. overland surface flow).

Current Condition

Neither Okanogan County nor any of the incorporated communities within the watershed have in place an adopted Comprehensive Stormwater Management Plan or Erosion and Sediment Control ordinance that provides water quality protection. However, floodplain, shoreline and zoning regulations are routinely used to review and condition land use applications to control surface water runoff within the incorporated areas, and less intensively in the unincorporated areas (Chris Branch, personal communication, 1998). The Washington State Department of Ecology (DOE), acting under the authorization of the Environmental Protection Agency (EPA), requires that all disturbed sites greater than 5 acres in size obtain National Pollution Discharge Elimination System (NPDES) coverage under the General Permit issued for this activity. This entails the filing of a Notice of Intent to conduct land disturbing activity on a site 5 acres or larger and that the project will implement best management practices with regard to erosion and sediment control.

Trends

On January 9, 1998, the EPA posted proposed stormwater requirements in the Federal Register, whereby all sites of one acre or larger being disturbed shall be obligated to comply with the conditions of the appropriate General Permit or obtain their own NPDES permit. The proposed regulations eliminate any exemptions currently granted to counties and municipalities for complying with the requirements of the act. The DOE anticipates these regulations becoming effective in the year 2000.

Relationship to Water Quality

Stormwater impacts water quality and fish and wildlife habitat in two ways; the introduction of pollutants and rapid changes in the quantity of flow. Stormwater transports numerous pollutants into rivers and streams, including nutrients from fertilizers, oils and other hydrocarbons from highways and parking lots, paper and plastic litter, pesticide and herbicide residuals, sediments from construction sites and highway maintenance practices, and untreated animal wastes.

Pollutant loading, also referred to as nutrient loading, is one of the most serious and widespread problems caused by water pollution in North America. Nutrients are typically dissolved minerals and organic material that nurture growth in aquatic plants such as algae and bacteria. Among the many nutrients found in natural waters, nitrogen and phosphorus are usually recognized as the most critical ones, because when both are present in large quantities they can induce accelerated rates of biological activity. Massive growths of aquatic plants in a water body will lead to (1) a change in the balance of dissolved oxygen, carbon dioxide, and micro-organisms; and (2) an increase in the production of total organic matter. These changes lead to further alterations in the aquatic environment, such as:

1. Acceleration of the eutrophication process
2. Increased cost of water treatment by municipalities and industry
3. Shift in fish species to rougher types such as carp
4. Decline in recreational value
5. Decreased water clarity
6. Decline in aesthetic quality; for example, increase in unpleasant odor
7. Water chemistry

In the course of flood events, pollutants that are not commonly found in surface waters may be introduced into the river. The high flow levels associated with a flooding river accelerate stream bank erosion, increase sediment loading, and frequently encourage people to alter natural drainage courses in an attempt to minimize the amount of land or “improvements” impacted by the flooding. The frequency of flooding is often increased by human activity due to a reduction in the ability of the soil to absorb the precipitation through compaction and an increase in impervious surfaces. The combination of these factors results in the same flood flow level being achieved with decreasing amounts of rainfall. Increased sediment, altered natural drainage courses, and degrading stream banks all negatively impact water quality. These impact the use of the water for domestic purposes, fish and wildlife habitat, irrigation supply, and recreation opportunities.

Development within the floodplain of the watercourses often results in contamination of the river during flood events. This is due to the floodwaters flushing the area and carrying with it the debris, sediments, and pollutants from parking lots, commercial structures, farm lots, orchards, and residential dwellings.

Clearing land for urban development, road construction, gravel pit operations, and agricultural use may aggravate flooding conditions also by making soil more available for transport into drainage systems. High intensity forest fires are another potential source of sediment and nutrients since they remove the vegetation and root system holding the soil in place. The deposited sediment impairs the functioning of the natural channels and man-made storm conveyance systems by decreasing their carrying capacity.

Runoff from rural and urban residential areas will often contain increased levels of coliform bacteria, nitrates [from fertilizers and on-site sewage (OSS)], pesticides (from multiple sources), metals (from automobile emissions and rusting metal), and oil and grease from leaking engines and dumping of waste oil.

The cumulative effects of development have a potential to impact stormwater in the Okanogan River Watershed. There are hundreds of vacant parcels within the watershed. Most of them were created from short plats that did not require erosion control/drainage plans. As "infilling" occurs on these lots, cumulative stormwater and erosion problems may develop that will not be addressed by drainage plans for single family residences. Without an overall plan or outline for movement of stormwater over and through the landscape, solutions to stormwater problems will not be comprehensive or an efficient use of funds. Regional stormwater management planning conducted on a basin-wide basis is beneficial because it incorporates the entire watershed and allows for analysis and planning to address cumulative stormwater impacts.

Depending on the type of industry, industrial sources can include concentrations of heavy metals and certain hydrocarbons. Industrial activities can also affect suspended sediments, pH, turbidity, dissolved oxygen, temperature, etc. The DOE maintains a Hazardous Sites List for the State of Washington. Within the Okanogan River Watershed a total of nine hazardous sites were identified on the February 17, 1998 list as published by the DOE. Five of the sites listed were service stations. Of the nine sites identified, all but two had completed a remedial action plan or were in process. The two sites without a remedial action plan in place were the Tonasket Post and Rail operation and the Loomis Chevron (both were ranked as a level 5 site - the lowest ranking).

The NPDES requires any industry that discharges process wastewater to a surface water to obtain an NPDES permit for their discharges. NPDES stormwater permits are also required for specified categories of industries that have discharges of stormwater runoff to surface waters. Currently there are 56 active stormwater permits industries in the Okanogan River Watershed. The amount of impact from the unpermitted industries is unknown. In addition, any construction activity that disturbs more than five acres of land is required to obtain a NPDES construction permit.

Construction of the transportation system in the watershed has been one of the largest impacts in terms of water pollution. During the initial construction phase and subsequent maintenance operations, several thousand acres of land have had the vegetation removed and the underlying soil exposed to the forces of wind and water.

Runoff from road surfaces carry contaminates such as heavy metals from exhausts, sediments from sanding operations, litter thrown out of vehicles, rubber particles from tires, and asphalt materials.

Specific actions that affect water quality include the use of de-icing compounds, application of sand for traction control, herbicide applications to control weeds, snow removal operations and routine maintenance operations such as seal coating.

The Washington State Department of Transportation (DOT) maintains almost 175 miles of highway in the watershed and has made significant changes to their maintenance operations in the past several years to provide better protection to the water resource. These measures include:

- Use of vacuum trucks to clean catch basins and bridge drains rather than flush them out, with the material being recycled or properly disposed of.
- Application of liquid deicers, in the fall and spring, in lieu of sanding.
- Modification of sand gradation specifications so a "cleaner" sand is being used.

The Endangered Species Act listing of the Steelhead trout will have an influence on several of the maintenance operations currently conducted by the DOT. These would include weed control operations, culvert cleaning, sanding and deicing practices (Gary Meyers, personal communication, 1997).

WDOT has a significant number of culverts in need of cleaning, which is a serious problem for them, particularly those that carry live streams or discharge to them. The physical setting of some of the state highways, in close proximity to stream banks, creates a problem for maintenance crews working to keep the roads safe for travel.

Okanogan County Public Works does not have in place any written directives detailing how maintenance practices are to be completed. The department is in the process of developing such guidelines (Gariano, personal communication, 1997).

Commercial areas traditionally have discharged stormwater runoff with relatively high concentrations of metals, oil, and grease. The contaminants are typically derived from parking lot runoff that empties into storm drains. Commercial stormwater impacts can be avoided with appropriate storm drainage and erosion control plans.

Storm water management within the urban areas of the watershed is the responsibility of the individual towns and cities. The following statements are taken from their respective comprehensive plans.

The Greater Omak Area Comprehensive Plan (November 13, 1993) states that the only portions of the planning area to be served with a storm drainage system lie within the corporate limits of the City of Omak. The plan makes recommendations for the following actions to be undertaken.

1. Install a storm drain system in the Ross Canyon/Juniper Street Area.
2. Install a storm drain system in the Kenwood/Bartlett/Maple Street area.
3. Install a storm drain system in the Locust/Oak Street area.
4. Continue upgrades to the City of Omak drainage system.
5. Eliminate direct piping of storm runoff to the river.

In addition to these specific steps the plan recommends that a stronger emphasis be placed on storm water runoff in all development proposals and that suitable land be set aside as parks and other open space for use as storm water catchment and dispersal facilities. It is the current policy of the City to require all development in areas of the city outside the downtown core, where storm sewer is available, to provide onsite disposal of stormwater through the use of drywells (Fred Sheldon, personal communication, 1998).

The City of Okanogan does not have a storm drainage plan. The Elmway area of the city is in need of a storm drain system to avoid recurring problems with flooding. The City does require that all development projects be planned such that the storm water discharge after development be no greater than that prior to development, and that all stormwater be passed through bio-swales, etc. for water quality protection (Bill Grimes, personal communication, 1998).

The Town of Tonasket Comprehensive Plan, adopted by the Tonasket Town Council, January 12, 1993, states the following with respect to Storm Drainage:

> "The Town's storm drainage system ... has not received much attention in recent years. An inventory of the system was not conducted for the Town's Capital Improvements Plan; however, the system is known to be in relatively poor condition. Additionally, all storm water drains directly to the Okanogan River, an issue that seriously needs attention in the near future.
>
> RECOMMENDATION (from the comprehensive plan):

- A storm water drainage plan should be prepared in the near future.
- Zoning code updates should include standards that address impervious surfaces in order that storm water drainage is absorbed by natural means."

The Town of Tonasket uses the Uniform Building Code, Tonasket Shoreline Master Plan, Floodplain Damage Prevention Ordinance, State Environmental Policy Act (SEPA), and Zoning to review and condition land use development proposals. Tonasket's shoreline regulations are more current and tend to have much stricter development standards than the County's. In recent years it has been the policy of the Town to require on-site management of stormwater, whenever possible. Additionally, zoning regulations prohibit the removal of vegetation within 15 feet of Siwash and Bonaparte Creeks where the Shorelines Management Program does not apply. The Town is currently working on zoning regulations that limits the development of impervious surfaces in all residential areas where storm sewers do not exist. Finally, the Tonasket Comprehensive Plan includes provisions indicating the Town's policy to protect "Critical Areas" as required by the Growth Management Act, using existing regulations (Chris Branch, personal communication, 1998).

The City of Oroville adopted a Comprehensive Plan on October 17, 1995 and addressed storm water in the following manner:

> "The city has little problem with storm drainage, due to the generally flat terrain, porous soils and low rainfall. There are few streets with curbs and gutters to concentrate runoff. Future development may require a storm drainage system to be constructed if not properly managed; however, no plans for such facilities are expected in the immediate future.
>
> RECOMMENDATION (from the comprehensive plan)

- A storm water drainage plan should be prepared in the near future.
- Zoning code updates should continue to include standards that address impervious surfaces in order that storm water drainage is absorbed by natural means.
- Proposals for new construction should include on-site storm water treatment."

The City of Oroville uses the Uniform Building Code, Oroville Shoreline Master Plan, Floodplain Damage Prevention Ordinance, SEPA, and Zoning to review and condition land use development proposals. Oroville's shoreline regulations are more current and tend to have much stricter development standards than the County's. In recent years, it has been a regularly enforced policy of the City to require on-site management of stormwater through the use of biofiltration swales, catch basins and drywells. The Oroville Zoning Code limits impervious coverages in all residential areas since they are not served by stormwater sewage systems. The Oroville shoreline regulations prohibit the removal of vegetation in all Conservancy Shoreline Designation areas which include: areas 25 feet landward from the Ordinary High Water Mark of the Okanogan River; 50 feet landward on a portion of the Similkameen; and all areas waterward of the diked portion of the Similkameen River (Chris Branch, personal communication, 1998).

The Town of Conconully has a comprehensive plan but it does not mention storm drainage in it and they rely on the Okanogan County subdivision standards for any development that occurs within the town. The town is served by several segments of storm drain system. The storm drain discharge is passed through either a gravel filter or vegetation lined open ditch prior to release.

The Town of Riverside has not prepared a comprehensive community plan nor does it have a comprehensive storm drainage plan.

Development in the rural portions of the watershed is subject to review and approval by the Okanogan County Planning Department. The Okanogan County zoning code and subdivision ordinances contain minimal reference to stormwater management issues in them.

United States Environmental Protection Agency: EPA administers the Federal Clean Water Act (CWA). The CWA gives the EPA the authority to implement water quality protection programs. EPA initiated the NPDES permitting program. The EPA has ultimate jurisdiction for water quality on the Colville Indian Reservation under the "Federal Water Pollution Control Act". EPA has delegated non-point source control to the Tribe, but retains point source control through the NPDES permit program. Currently EPA administers a discharge permit for Quality Veneer and Lumber. On is pending for Colville Precision Pine. Colville Precision Pine has an EPA stormwater permit also.

Washington State Department of Ecology: While EPA is the lead agency for NPDES permits, the Washington State has been delegated the authority to review, condition, and issue NPDES permits. The baseline stormwater permit also requires construction activities disturbing 5 acres or more to obtain coverage if there is a potential for discharge of stormwater to surface waters. Permits are written and compliance monitored by the state. The program requires any industry that discharges process wastewater to a surface water to obtain a NPDES permit for their discharges. Permits include sampling requirements and set limits on the kinds and amount of pollutants that can be discharged.

There are currently 56 dischargers in the Okanogan Watershed that have permits under the NPDES and State Waste Discharge Permit Program (WAC 173-216), these include:

1.) NPDES Minor Permits - 3 Municipal, 3 Industrial.
2.) NPDES General Permits - 37 Industrial and 2 Fish.
3.) NPDES State to Ground - 2 Municipal, 6 Industrial.
4.) NPDES State to Public Owned Treatment Works - 3 Industrial

DOE's Water Quality Program developed the Stormwater Management Manual for the Puget Sound Basin that sets design standards for stormwater systems (DOE, 1992). This manual was designed to specifically apply to western Washington; however, various portions have been applied to eastern Washington. DOE is in the process of modifying this manual to make it site specific to eastern Washington. Included in the "Eastern Washington" version will be cold weather Best Management Practices (BMP's) to accommodate the different climatic conditions.

Washington State Department of Ecology, Okanogan County & Municipalities: The Shoreline Management Programs, pursuant to the Shoreline Management Act, contain regulations for development that provide an array of opportunities to address stormwater issues. When properly applied, all state and federal agencies have an opportunity to influence the outcome for development permits issued under the authority of SEPA (Chris Branch, personal communication, 1998).

There are a number of other regulations on the books that are used where appropriate.

- Section 404, Clean Water Act, US Army Corps of Engineers
- Section 10 Permits, River and Harbors Act, US Army Corps of Engineers
- State Hydraulics Permit, Washington State Fish and Wildlife
- Colville Confederated Tribe Shoreline Management Program
- Okanogan County Critical Areas Ordinance
- Washington State Environmental Policy Act
- Colville Tribes Water Quality Standards, Chapter 4-8 Colville Tribal Code
- 40 CFR 131 Water Quality Standards for the Colville Indian Reservation in the State of Washington, US EPA

4 Problem Identification

This chapter identifies the land use activities by sub-watershed that the TAC and SAC believe contribute directly to or pose a risk to water quality degradation. The problems were identified using the observations of committee members, information from the characterization in this document (Chapter 3), and spatial data such as maps and aerial photos. The identification of a problem should in no way be construed as an effort to single out any particular landowner or activity. Water quality samples were not taken as a part of this project.

However, this does not mean the problems identified in this chapter are insignificant. It is the judgment of both the TAC and SAC that the activities identified are polluting or pose a considerable risk to pollute surface and/or ground water.

It is the intent of the members of the TAC and SAC that those who conduct the activities identified in this chapter will make an effort to determine for themselves as to whether their operations are a contributor to water quality degradation. They may also request assistance from the Okanogan Conservation District in making their determination if they so desire. If problems are found, landowners and operators are encouraged to review action items in this Okanogan Watershed Management Plan for possible solutions and to seek technical and/or cost-share assistance as required to address the problems.

Problems	Possible Effects
Aeneas Creek	
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Undersized culverts on private drives	Increased sedimentation, lower instream flows
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Aeneas Lake	
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Rural development	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Antoine Creek	
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity

Problems	Possible Effects
Hoof shear by livestock	Increased sedimentation, increased temperature, decreased dissolved oxygen, decreased flows, increased fecal coliform
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Bonaparte Creek	
Winter feeding areas adjacent to the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform
Hoof shear by livestock	Increased sedimentation, increased temperature, decreased dissolved oxygen, decreased flows, increased fecal coliform
Lack of riparian vegetation	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows
Rural development (especially sprawl east of Tonasket along Bonaparte Creek)	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity
Sediment from roads (specifically SR 20)	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Brown Lake/Johnson Creek	
Winter feeding areas adjacent to the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform
Lack of riparian vegetation (both rural and urban areas)	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows
Toxicity from urban – sewage treatment – individual wells and septic systems	Increased sediment, decreased dissolved oxygen, increased fecal coliform, increased toxicity, lower instream flows
Sediment from roads (specifically Riverside Cut-Off Road)	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Rural development	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity

Problems	Possible Effects
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Chewiliken Creek	
Winter feeding areas adjacent to the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Lack of riparian vegetation	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows
Lack of information on creek conditions and trends	Unknown alterations to water quality
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Chiliwist Creek	
Winter feeding areas adjacent to the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Irrigation de-watering creek	Lower instream flows, increased temperature, decreased dissolved oxygen, altered pH,
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Columbia River Interfluve – East	
Herbicide and fertilizer application in orchard near river	Increased toxicity, altered pH, decreased dissolved oxygen
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Columbia River Interfluve – West	
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Log storage areas adjacent to the streams	Increased sediment, increased toxicity, altered pH.
Winter feeding areas adjacent to the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform

Problems	Possible Effects
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Duley Lakes/Joseph Flat Area	
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Fish Lake Basin Area	
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Rural development	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Loup Loup Creek	
Sediment from roads (specifically SR 20)	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Irrigation de-watering creek (diversions to outside of sub-watershed)	Lower instream flows, increased temperature, decreased dissolved oxygen, altered pH,
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Mosquito Creek	
Herbicide and fertilizer application in orchard near creek	Increased toxicity, altered pH, decreased dissolved oxygen
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Nine Mile Creek	
303(d) listing	DDT in sediment
Rural development	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity

Problems	Possible Effects
Herbicide and fertilizer application in orchard near creek	Increased toxicity, altered pH, decreased dissolved oxygen
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
North Fork Pine Creek	
Winter feeding areas adjacent to the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform
Confined pastures (also corrals) on the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Okanogan River Interfluve	
303(d) listings	Temperature, Fecal Coliform, Dissolved Oxygen, DDT, 4,4'-DDE, 4,4'-DDD, PCB-1260, PCB-1254
River widening and becoming shallower	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows
Sediment damaging irrigation systems	Increased sedimentation, increased temperature, decreased dissolved oxygen
Unstable Streambanks	Increased sedimentation, increased temperature, decreased dissolved oxygen
Lack of riparian vegetation	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows
Hoof shear by livestock	Increased sedimentation, increased temperature, decreased dissolved oxygen, decreased flows, increased fecal coliform
Rural development (specifically in the flood plain)	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity
Herbicide and fertilizer application in orchard near creek	Increased toxicity, altered pH, decreased dissolved oxygen

Problems	Possible Effects
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Omak Creek	
303(d) listings	Temperature, Dissolved Oxygen, pH
Rural development	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity
Commercial impacts on riparian zone adjacent to the mouth of the creek	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, lower instream flows
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Poor past forest practices such as skid trail placement	Increased sediment, decreased dissolved oxygen, lower instream flows, increased temperature
Hoof shear by livestock	Increased sedimentation, increased temperature, decreased dissolved oxygen, decreased flows, increased fecal coliform
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Omak Lake	
303(d) listing	Temperature
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Salmon Creek	
303(d) listing	Instream Flow
Irrigation de-watering creek	Lower instream flows, increased temperature, decreased dissolved oxygen, altered pH,
Hoof shear by livestock	Increased sedimentation, increased temperature, decreased dissolved oxygen, decreased flows, increased fecal coliform
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity

Problems	Possible Effects
Fish passage blockages	Less available fish habitat
Poor past forest practices such as skid trail placement	Increased sediment, decreased dissolved oxygen, lower instream flows, increased temperature
Rural development	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity
Winter feeding areas adjacent to the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Similkameen River	
303(d) listings	Temperature, Arsenic
Unstable streambanks from Shankers Bend to the Canadian border	Increased sedimentation, increased temperature, decreased dissolved oxygen
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Lack of riparian vegetation	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Kaaba Texas Mine tailings near Nighthawk	Increased toxicity, altered pH
BLM has a fenced off area outside of the golf course in Oroville that is a "Super Fund Site". Unclear what is being cleaned up	Increased toxicity, altered pH
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Sinlahekin Creek	
Unstable streambanks (Toats Coulee Creek to Palmer Lake and Palmer Lake to Similkameen River)	Increased sedimentation, increased temperature, decreased dissolved oxygen
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Irrigation de-watering Toats Coulee Creek	Lower instream flows, increased temperature, decreased dissolved oxygen, altered pH

Problems	Possible Effects
Lack of riparian vegetation	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Siwash Creek	
Irrigation de-watering creek	Lower instream flows, increased temperature, decreased dissolved oxygen, altered pH,
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Confined pastures (also corrals) adjacent to the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Spectacle Lake/Whitestone Lake	
Winter feeding areas adjacent to the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform
Lack of riparian vegetation	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows
Rural development	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Tallant Creek	
303(d) listing	DDT
Confined pastures (also corrals) adjacent to the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Sediment from roads (specifically SR 20 winter maintenance)	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Irrigation de-watering creek	Lower instream flows, increased temperature, decreased dissolved oxygen, altered pH,

Problems	Possible Effects
Herbicide and fertilizer application in orchard near creek	Increased toxicity, altered pH, decreased dissolved oxygen
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Tonasket Creek	
Sediment from roads (specifically County road adjacent to Tonasket Creek)	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Rural development	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity
Herbicide and fertilizer application in orchard near creek	Increased toxicity, altered pH, decreased dissolved oxygen
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Tunk Creek	
Confined pastures (also corrals) adjacent to the stream	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, increased fecal coliform
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Commercial impacts on riparian zone adjacent to the mouth of the creek	Increased sedimentation, increased temperature, decreased dissolved oxygen, lower instream flows, altered pH
Rural development	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Wanacut Creek	
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Sediment from roads	Increased sediment, increased temperature, decreased dissolved oxygen, increased toxicity
Rural development	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity

Problems	Possible Effects
Noxious Weeds	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased toxicity
Wannacut Lake	
Heavy grazing having an adverse effect upon the plant community	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform.
Rural development	Increased sedimentation, increased temperature, decreased dissolved oxygen, increased fecal coliform, increased toxicity
Noxious Weeds	Increased sedimentation, increased toxicity

5 Action Items

The Okanogan Watershed Water Quality Management Plan was prepared to be a voluntary program. State water quality laws allow the Department of Ecology to delegate water quality planning responsibility to local governments with local control and responsibility for implementation. In support of this effort, the Department has promoted, with grant funding, such local planning. It is the intention and expectation of the project sponsors (Okanogan Conservation District and Okanogan County), and the project participants (Stakeholder's Advisory Committee and Technical Advisory Committee), that the action items described and implied in this project will be implemented on a voluntary basis.

It is recognized that the quality of the environment is not only a local benefit and responsibility but also is required by state and federal law. It is the intention of the authors of this document that the successful implementation of this plan will help put the control of natural resource issues in the hands of the local community

The following action items are based upon the best available science and knowledge accessible to the project participants at the time it was created. This plan is considered a living document, in that it is updated and amended as new knowledge is gained.

Table A in Appendix C lists problems by sub-watershed, the associated *most likely* effects on water quality, and the action items that address the problems. The information found in this section is a narrative description of the identified problems and the suggested action items.

Water quality standards for the Okanogan River basin are established in Chapter 173-201A_WAC. These standards were created many years ago and undergo review on a three-year basis for updates based on new data and knowledge. The Okanogan River and all of its tributaries are classified as "Class A" waters which stipulates a range within which certain parameters are desired to be. For example, the rule stipulates that temperature for "Class A" waters should be no higher than 64° F (18° C). It should be recognized that the existing classifications were established over twenty five years ago, as part of a state wide stream classification effort, with no special modifications specific to the Okanogan River.

Typically, streams within the watershed are tested by the Washington Department of Ecology, U.S. Geological Survey, and the Colville Confederated Tribes for many different water quality parameters. The Washington Department of Ecology reviews this data and it is often used to determine which streams are not meeting the established standards. The segments of streams that are found to be violating a parameter may then be submitted for inclusion on the Section 303(d) list, except water bodies located on the Colville Reservation, which is maintained by the EPA per the federal Clean Water Act.

The Washington Department of Ecology develops a proposed Section 303(d) list every two years with opportunity for public input. In the Okanogan River basin, several stream segments are currently listed for violating state standards. The majority of the listings are found in the Okanogan and Similkameen Rivers themselves partly because these rivers are the only ones in the basin routinely investigated. The parameters that were in violation included temperature, dissolved oxygen, arsenic, DDT (and its breakdowns), PCB's, low flow, fecal coliform, and pH.

The Washington Department of Ecology as lead agency is required under the 1972 Federal Clean Water Act to take specific steps to ensure that water quality criteria are met. This could include but is not limited to: (1) additional monitoring to ensure that initial data are correct, (2) assessing the stream's natural condition, (3) completing and implementing watershed plans, and (4) developing Total Maximum Daily Loads (TMDL).

1. Additional monitoring can show that the exceeding levels of pollution were temporary, due to natural conditions, and have been cleaned up, or they can show that the problems are increasing and possibly assist in identifying the pollution source.

2. With additional monitoring the background (natural) levels of the stream can be identified in some cases. As an example temperature can be modeled and if found to be above the state standard of 20° C, then the state standard stipulates that any single human activity can not raise the temperature of the water more than 0.2° C above background levels.

3. Watershed planning is the process the county's leaders have chosen to utilize in addressing water quality problems within the Okanogan River Watershed. In this process, a stakeholder group has reviewed water quality data, prepared a detailed characterization of the watershed, and drawing on their own experience and knowledge, identified problems, action items and priorities.

4. Total Maximum Daily Loads (usually developed by the Washington Department of Ecology) are developed from an intensive study of the complete hydrologic system, in which all sources of pollution are identified and quantified. Then the system is modeled to determine the maximum amount of pollutant a system can receive without causing a violation of the established criteria. When this is completed, permits are issued to the polluting entities, which set the discharge standards they must meet.

Temperature Action Items

Temperature is a water quality concern because it has a direct impact upon dissolved oxygen levels, municipal and irrigation supplies, ability to absorb BOD (biochemical oxygen demand) levels, and lifecycle of resident and anadromous fish.

In the Okanogan River basin, water temperatures were found to range from a low of 56° F (in Aeneas Creek) to a high of 84° F (in the Okanogan River near Malott) during the summer of 1998 according to unpublished data collected by the Colville Confederated Tribes. This range of temperatures is due in part to the wide variety of stream systems (width-depth ratios, gradients, aspect), solar inputs (amount of riparian canopy cover), industrial inputs, ambient (surrounding) air temperature, irrigation return flows, and the source of the water (spring melt, ground water, etc.).

At this time, the Okanogan River is listed on the Washington State 303(d) list for multiple temperature exceedences. It is very probable that the 64° F (18° C) temperature limit would be exceeded under historic natural conditions. These natural conditions may also be worsened by human activity. Water temperature has been tested at and/or very near the U.S.-Canadian border and found to be violating Washington's temperature standard. Also, there is currently limited information on many of the tributary streams concerning temperature, or any of the other water quality parameters.

There have been some preliminary investigations conducted by the Washington Department of Ecology's Environmental Assessment Program (EAP), formerly known as the Environmental Investigations and Laboratory Sciences Program (EILS) that looked at the correlation of the ambient air temperature and water temperature. The data visually shows that water temperature appears to have a very strong correlation to surrounding (ambient) air temperature in the Okanogan River basin. This preliminary information can be found in the characterization section of this document.

Numerous natural accounts identify the Okanogan River as warm during the low flows of most years. In addition, data published in this document shows that as ambient air temperature increases during the day, the water temperature increases at nearly an identical rate. This strongly indicates that due to the wide shallow channel and the corresponding large surface area exposed to the warmer air, water temperatures may be closely related to ambient air temperature in the mainstem Okanogan River. Should further monitoring (which is recommended here) show that the river temperature does in fact track very closely to ambient air temperature, then it can be deduced that air temperatures have had this impact on the river prior to the first European settlers impacts on the watershed.

T1. Develop a water temperature-monitoring program to define sources of temperature input.

The Okanogan Conservation District shall develop and establish a water quality monitoring program to complement the established DOE and CCT water quality monitoring programs. The District's program shall include the use of volunteers wherever possible to assess the conditions of water quality in the Okanogan River and its tributaries. The OCD, DOE, and CCT shall share their temperature data with the Okanogan Watershed Implementation Committee to assess water quality conditions. The Okanogan Conservation District should seek necessary funding to accomplish this task.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan County, Volunteers, WDF&W, USF&WS, USGS
Priority:	High
Cost:	Medium

T2. Review the data obtained under the monitoring plan described in action item T1. Conduct a statistical analysis of this data to validate a correlation between the ambient air temperature and the water temperature. With this correlation in place develop a temperature standard for the Okanogan River Watershed which reflects the natural background conditions.

The Okanogan Conservation District shall coordinate activities with interested parties including but not limited to the Okanogan Watershed Implementation Committee, DOE, CCT, and County to develop and recommend a reasonable revised temperature standard to the Department of Ecology. The Committee should develop this revised standard based on locally collected data that has been validated.

Lead:	Okanogan Conservation District
Cooperators:	Okanogan Watershed Implementation Committee, Okanogan County, DOE, CCT, WDF&W, USF&WS, USFS, BLM
Priority:	Medium
Cost:	Low

T3. Re-establish vegetation along stream banks where practical.

The Okanogan Conservation District shall seek funding to implement and/or develop cooperators cost-share programs which will allow landowners in the watershed to re-establish vegetation along streams. The increased shading of streams should result in long term improvement to tributary water temperature as well as habitat, and may contribute to mainstem improvements in water temperature. The reestablishment of vegetation will enhance stream bank stability and reduced erosion. The OCD shall work with private volunteer landowners and agriculture groups, such as the Cattlemen and the Horticulture Association, to identify willing participants.

Lead:	Okanogan Conservation District
Cooperators:	Cattlemen, Horticulture Association, Okanogan County, WSUCE, NRCS, Landowners, DNR, Cities & Towns, WDF&W, USF&WS, USFS, BLM, CCT
Priority:	Medium
Cost:	Medium

Fecal Coliform Action Items

Fecal Coliform is a bacteria found in warm blooded animals and humans. Elevated levels of fecal coliform in surface waters are an indicator of the presence of pathogens, which can cause serious human health problems. This can restrict the beneficial use of water for domestic and recreation purposes, both of which are important to the residents of Okanogan County.

In addition to, fecal coliform, there are other forms of coliform, which can be monitored. Total Coliform is the test of choice for drinking water supplies. Fecal Streptococcus is another form of coliform associated with human sources of waste. The ratio of Total Coliform to Fecal Streptococcus has been used as an indicator of the presence of human waste but is very imprecise. New technology has recently been developed which, will allow for the more precise identification of the source of coliform bacteria.

It is the desire of the committee to more carefully characterize the presence of coliform in the Okanogan River and use that characterization as a baseline for measuring success over time, and for measuring progress in addressing identified sources. A source of coliform has been identified as possibly originating from winter cattle feeding operations. Such feeding areas are frequently located in valley bottoms near streams. Rapid snow melt and runoff can wash this source of fecal material directly into tributaries and streams. It is proposed that these areas be targeted for farm management plans and best management practice (BMP) implementation to address this identified issue. Monitoring over time with a high degree of certainty as to the source appears to be the most effective and efficient way to address high levels of coliform bacteria which has been listed as a violation to water quality standards for the Okanogan mainstem.

FC1. Develop a coliform-monitoring program to establish base line data, assisting in identifying specific sources and types of coliform, and monitor the progress in reduction efforts.

The Okanogan Conservation District shall develop and establish a coliform water quality monitoring program to complement the established DOE and CCT water quality monitoring programs. The District's program shall include the use of volunteers wherever possible to assess the conditions of water quality in the Okanogan River and its tributaries. The OCD, DOE, and CCT shall share their coliform data with the Okanogan Watershed Implementation Committee in order to assess progress and to develop action plans to address future identified sources. To complete this the Okanogan Conservation District should seek necessary funding to accomplish this task. Fecal coliform is a concern because of potential human health risks and the adverse impacts it can have on water quality criteria such as dissolved oxygen. See recommendations of Appendix A “Water Quality Modeling Assessment of the Okanogan River”.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan Health District, WDF&W, Cities & Towns
Priority:	High
Cost:	Medium

FC2. Implement a voluntary cost-share and Best Management Practice implementation program that will reduce and/or eliminate fecal bacteria inputs from confined animal feeding operations and/or corrals, winter feeding areas, and open range where there is identified negative impacts.

Funding should be sought to develop a program that may include but not be limited to developing waste management plans, implementing on-farm Best Management Practices to limit the impacts of feeding operations, and information and education activities to make landowners aware of the issue. This program will reduce the impacts nutrients have such as potential human health risks, and algae population explosions.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan Health District, Okanogan County Cattlemen, DNR, WDF&W
Priority:	High
Cost:	Medium

FC3. Develop and offer an information and education plan while exploring the possibility of making state revolving loan funds available for landowners to repair or replace existing septic systems.

Providing landowners with the knowledge of how to determine if their on-site-septic system (OSS) is failing and what the consequences of not repairing them are to the aquatic environment. Information about who can test a system, what the costs are for testing, and what would be needed to repair or replace an OSS could be provided through handouts and presentations. The potential for providing low interest loans to landowners to make necessary changes to their OSS should be investigated and implemented if available.

Lead:	Okanogan County Health District
Cooperators:	DOE, CCT, Okanogan Conservation District, Okanogan County, WSUCE
Priority:	Medium
Cost:	Medium

Dissolved Oxygen

Dissolved oxygen refers to the amount of available (usable) oxygen present for aquatic organisms including, microorganisms, fish, and plants. Dissolved oxygen concentrations are measured as mg/L (milligrams per liter). Typical dissolved oxygen concentrations, reported for natural water in streams and rivers throughout the world, are 3 to 9 mg/L measured as the concentration of dissolved oxygen in fresh water at saturation, at a water temperature of 20°C (Mays, 1996).

The presence and/or absence of dissolved oxygen can be affected by several factors. These factors include but are not limited to water temperature (the warmer the water typically the lower the dissolved oxygen), water disturbance (typically the calmer the water the lower the concentration), and presence of microorganisms (microorganisms, typically algae, consume and create dissolved oxygen). All of these items are major factors of influence in the Okanogan River system. While the levels of dissolved oxygen can be influenced by many factors, in the Okanogan River proper two primary factors affect dissolved oxygen. It is expected that the two primary factors that cause dissolved oxygen standard violations are temperature, and the presence of microorganisms.

Elevated temperature decreases dissolved oxygen concentrations by reducing the ability of water to hold oxygen. Elevated temperature causes other problems as described in this section. Large populations of microorganisms can cause relatively large diurnal (daytime to nighttime) fluctuations of dissolved oxygen. Microorganisms create oxygen during daylight hours through the process known as photosynthesis. This can create a condition of "super saturation" or extremely high levels of dissolved oxygen during the day. Adversely, during nighttime hours the same microorganisms that created oxygen with sunlight then consume dissolved oxygen causing low levels of dissolved oxygen. Large populations of microorganisms can cause these large fluctuations in dissolved oxygen, which may be potentially harmful to other aquatic inhabitants. One cause for the large populations of microorganisms is the introduction of phosphates and other nutrients into the aquatic environment. Typically, phosphates and nutrients are introduced through runoff from agricultural fields, or through detergents and soaps used in homes.

The Stakeholder's Advisory Committee, in conjunction with the Technical Advisory Committee, feels there is a need to better correlate the interaction of temperature and dissolved oxygen in the Okanogan River Watershed. Looking at the location of DOE water quality monitoring stations and the known presence of large colonies of algae and high water temperatures, there may be a direct correlation to the violations of water quality standards. In addition, the Okanogan River is a wide, gently sloping river system that receives high amounts of direct solar radiation and little if any reaeration activity, that can negatively affect the levels of dissolved oxygen along its course.

DO1. Develop and implement a monitoring program to evaluate the causes of fluctuation in dissolved oxygen. It shall also identify possible steps to mitigate, resolve, and or eliminate the violations of state water quality standards.

Currently, there is a question about the exact causes and effects of diurnal changes in dissolved oxygen. It is recommended that the levels of dissolved oxygen be monitored on an hourly basis at several locations throughout the Okanogan River Watershed as a means of determining whether diurnal changes in dissolved oxygen concentration are occurring.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan County, WDF&W

Priority:	High
Cost:	Medium

DO2. Initiate an educational program that informs the agriculture producers about the potential problem of nutrient overloading and offers solutions in the form of Best Management Practices.

The introduction of phosphates and other nutrients into aquatic systems results in accelerated growth of aquatic vegetation, which can produce large diurnal changes in dissolved oxygen concentration. Runoff from agriculture fields typically includes phosphates that were applied in the form of fertilizers. Because of the large areas that are covered by agricultural fields in the watershed this can be serious when considering the cumulative effect basin wide.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan County, Okanogan County Horticulture Association, Okanogan County Cattlemen's Association, WSUCE
Priority:	Medium
Cost:	Medium

DO3. Initiate an educational program to inform watershed residents and business owners on the impacts of phosphates in aquatic environments.

The introduction of phosphates and other nutrients into aquatic systems should be limited to reduce the potential for large diurnal changes in dissolved oxygen. The effects of phosphates found in typical laundry detergent, dishwasher soap and other household detergents is a cumulative problem just as severe as runoff from agricultural fields. Users of soap and detergent other than homeowners, such as car washing facilities and commercial buildings and businesses, are included in this item.

Lead:	Okanogan County
Cooperators:	Cities, & Towns, DOE, CCT, Okanogan Conservation District, WSUCE
Priority:	Medium
Cost:	Medium

pH Action Items

pH is a measure of alkalinity or acidity in a substance. It is measured on a scale of 0-14. The closer pH is to zero the more acidic the substance and the closer pH is to 14 the more alkaline the substance. pH is important in the Okanogan River basin as a determining factor in the solubility of most metals and because most microorganisms can only survive in a narrow range [generally between 6.5 and 8.5] (Mays, 1996).

pH is usually determined by natural geology and human inputs. Humans influence pH by the introduction of acid rain, runoff from mining operations, periodic chemical spills, and stormwater runoff from city streets and parking lots. Water quality monitoring data shows an increase (0.3 points on average) over the past twenty years. The effects, let alone the causes, of this increase are uncertain at this point.

Further monitoring is necessary to better track the effects of this increase in pH and to identify possible sources for the increasing values.

PH1. Develop and implement a monitoring program to evaluate the effects and sources of pH and possible steps to mitigate, resolve, and or eliminate the violations of state water quality parameters.

Currently there is a great deal unknown about the exact causes and effects of the pH levels observed in the Okanogan River system. The pH levels should be monitored to determine possible sources and effects on the aquatic environment.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan County
Priority:	High
Cost:	Low

DDT Action Items

DDT and its breakdowns (4,4'-DDD, 4,4'-DDE) have been found in the Okanogan River Basin at levels that exceed state water quality standards. The use of DDT has been banned for more than 20 years, but the chemical breaks down very slowly and remains attached to soil particles. DDT was widely used as a pesticide from the 1940's through the early 1970's. Concentrations of DDT and its breakdowns are typically found in the sediments of streams, the receiving waters of such streams and in edible fish tissue. This holds true in the Okanogan River Watershed.

There are four water bodies found on the 1998 proposed 303(d) list for excursions (beyond allowable limits) in the state's DDT water quality standards. These include Tallant Creek, Ninemile Creek, Osoyoos Lake, and Elgin Creek near Shellrock Point in Omak.

It is not really possible to identify the source of DDT as it is interspersed throughout the basins in question and only through erosion of bank and streambed soils does DDT get transported. Because of this, the most effective way to combat the presence of DDT is to stabilize banks and streambeds.

DDT1. Identify sources of contamination and BMPs to be implemented.

The Okanogan Conservation District should work with willing landowners along identified problem reaches to identify possible sources of DDT contamination. After the sources of contamination have been identified, the Okanogan Conservation District should work with landowners and other water quality specialists from the Washington Department of Ecology to identify the best BMPs to resolve the introduction of DDT to surface waters.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan County, Okanogan Horticulture Association, WDF&W
Priority:	High
Cost:	Medium

DDT2. The Okanogan Conservation District shall seek funding to implement the BMPs identified through the survey established by action item DDT1 in this document.

The Okanogan Conservation District should work with willing landowners along Tallant, Nine Mile, and the Elgin Creek near Omak to implement BMPs that either properly dispose of DDT or reduce DDT contamination in sediments and edible fish tissue.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan County, Okanogan Horticulture Association, WDF&W
Priority:	High
Cost:	High

PCB Action Items

PCBs were found in edible fish (carp) tissue during tests taken in 1994. The fish samples were taken in the Okanogan River south of Malott near river mile 5. Although this is a serious health concern for individuals who may consume this type of fish (primarily bottom feeders), there is no other known health risks.

PCBs were primarily used as an insulator in electrical transformers. The manufacture of PCBs was banned in the United States in 1976 and very strict regulations were enacted to control the use and handling of all PCBs. There have been other uses for PCBs over the years from newsprint to caulking compound, however their use in transformers was by far the most extensive.

Because of the location of the test samples that were taken in 1994 tissue samples it is suspected that the levels of PCBs found in the fish are due to their local migration to the Columbia River between Wells Dam and Chief Joseph Dam. The exact source of the PCBs is unknown and the trend in contamination is undetermined.

PCB1. Monitor PCBs in edible fish tissue to determine trends in contamination and possible sources of pollution.

The Department of Ecology will share this information with the Watershed Implementation Committee and others to make the information available to all concerned individuals and increase the public's knowledge of the issue. Additionally, the information may be used by the Implementation Committee to identify future action items to resolve the issue.

Lead:	DOE
Cooperators:	CCT, Okanogan County, Okanogan Conservation District, Douglas County PUD, WDF&W, USF&WS, Okanogan County Health District
Priority:	High
Cost:	Medium

Instream Flow Action Items

Currently, there is only one stream in the Okanogan River Watershed that is listed on the Washington 303(d) list for low instream flow (Salmon Creek). However, there are numerous other streams where flows are reduced and/or completely diverted such as Tallant Creek. Instream flows are a concern due to the degradation of fish habitat and passage and impacts to other beneficial uses.

Establishing reasonable standards for instream flows is much more difficult and complex than setting standards for other parameters such as temperature and dissolved oxygen. Put simply, flows in creeks vary greatly from one year to the next and many creeks and streams in this region will naturally dry up every few years. Flows impact water quality by changing the volume of water available to dilute pollution inputs. Additionally, low flows may restrict beneficial uses such as human recreation, fish migration, and aesthetics.

The Stakeholder's Advisory Committee recognizes that water quantity and instream flows will be an issue for many years to come. Because of many competing beneficial uses such as irrigation, domestic water use, fish passage and spawning, and simple aesthetics there will always be conflict over where and how water is beneficially used. Everyone involved with this project is strongly opposed to reducing or adversely affecting any legal right to the water. However, there is also a feeling that existing water can be used more efficiently in places and that savings can be made. This project will make no recommendations as to how to put saved water into a stream, nor the legality of the issue of water rights and the conflict with instream flow. However, we can identify technical resources to those individuals who are interested in conserving water on their own free will.

IF1. Work with state legislators to provide incentives for water conservation.

Currently state water law stipulates quite simply that water right holders must "use it or loose it". This means that the holder of the water right must use the entire allocation of the water right every year to retain their full right. If the right holder doesn't use the entire amount of water some or all of the right may be taken away to be applied to another irrigators right or some other use. This creates a conflict for many water right holders because through innovation and advancements in technology they are able to conserve water and would but for fear of permanently loosing all or part of their water right. A system of rewards should be established in state water law/rule that will replace the current system which penalizes a water right holder for conserving water by taking all or part of their water right.

Lead:	Okanogan County
Cooperators:	Okanogan Horticulture Association, Okanogan County Cattlemen, Irrigation Districts, Okanogan Conservation District, CCT
Priority:	High
Cost:	Low

IF2. The Colville Confederated Tribes should continue to work cooperatively with the Okanogan Irrigation District and the irrigators of the district on issues relating to minimum instream flows and anadromous fisheries return to the lower reaches of the stream.

The Colville Confederated Tribes and the Okanogan Irrigation District have recently completed a joint study that examined the feasibility of restoring an anadromous fishery in Salmon Creek, increasing instream flows to meet the various life stages of anadromous fish while maintaining the ability of the district to continue water delivery to its users in accordance with its water rights. The study has indicated that it is feasible to accomplish this. The Colville Confederated Tribes (CCT) and the Okanogan Irrigation District (OID) are presently working on a program to implement strategies identified in the report.

Lead:	CCT and OID
Cooperators:	Private landowners, City of Okanogan, local, state and federal agencies.
Priority:	High
Cost:	High

IF3. Identify landowners that are interested in voluntarily water management Best Management Practices on their farm.

The Okanogan Conservation District should work with willing landowners and operators to install practices including, but not limited to, Irrigation Water Management Plans. The OCD should also work with irrigation districts and canal companies that are interested in improving efficiency of water delivery.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan County, Okanogan Horticulture Association, Irrigation Districts, WDF&W, USF&WS
Priority:	High
Cost:	High

IF4. Conduct a water availability and needs analysis of the Okanogan River Watershed by sub-watershed. This will also include locating the approximate boundaries of major aquifer regions and critical recharge areas.

Currently there is very little information on the amount of precipitation that falls in the Okanogan River Watershed. Little information is available on the amount of water that is trapped by vegetation, lost to transpiration, percolates to aquifers, or flows into streams. An analysis of these items will provide a strong background to local policy makers on identifying local beneficial uses of water and begin a baseline of local data. In addition data should be collected on impervious surfaces (pavement) and semi-pervious surfaces (compacted earth) to determine its impacts on the criteria listed above.

Lead:	Okanogan Conservation District
Cooperators:	Okanogan Horticulture Association, Okanogan County Cattlemen, Irrigation Districts, Okanogan County, CCT, WDF&W, USF&WS, USFS, DNR, Cities & Towns
Priority:	High
Cost:	High

IF5. Okanogan County should begin discussion with Canadian government officials to establish local control over the management of flows in the Okanogan River Watershed.

Presently the mainstem Okanogan River in Canada is controlled by a series of lakes that have flow control structures in place. The only flow control structure in the US is Zosel Dam at the mouth of Lake Osoyoos near the International Border. Currently the amount of flow down the Okanogan River is dictated by a joint agreement between the US and Canadian Federal governments. There needs to be more local, and joint control of the water flows from Canada.

Lead:	Okanogan County
Cooperators:	Okanogan Horticulture Association, Okanogan County Cattlemen, Irrigation Districts, Okanogan County, CCT, WDF&W, USF&WS
Priority:	High
Cost:	Low

IF6. Investigate the potential of additional water storage on the tributaries of the Okanogan River.

Currently there is very little water storage in Okanogan County. Because of strict environmental laws large water storage facilities (dams, reservoirs, etc.) will be nearly impossible to get approved. However, multiple small water storage areas may be feasible where the environment would benefit is possible. Okanogan County should investigate the possibility of creating water storage areas such as ponds, impoundments, wetlands, etc. that will provide sufficient late summer flows for fish migration and rearing, improved irrigation, and increased flows necessary to meet instream flow requirements. Okanogan County should also increase public awareness of the benefits of rehabilitating wetlands. In addition, small impoundments such as wetlands can assist with water quality by providing filtering of sediments and increase wildlife and recreational habitat.

Lead:	Okanogan County
Cooperators:	Okanogan Horticulture Association, Okanogan County Cattlemen, Irrigation Districts, Okanogan County, CCT, WDF&W, USF&WS, CCT, Okanogan County PUD
Priority:	High
Cost:	High

Arsenic Action Items

Arsenic is a chemical that can be found in the processing of mine tailings. Arsenic is an element that can be found naturally in the environment and thus high levels of it may not be indicative of human activity degrading water quality. However, knowing the mining activities past and present in the Okanogan River Watershed (including Canada) it is not surprising to see elevated levels of arsenic in the rivers of the basin.

The Similkameen River is listed on the 303(d) list for arsenic exceeding state standards. This listing is unusual however, that it specifically points to mining activities in Canada as the probable sources. Additionally, the 303(d) report states that DOE is considering revising the arsenic standard as there is increasing uncertainty regarding the accuracy of current arsenic criteria for human health.

Combining these two factors the Stakeholders Advisory Committee feels that it is necessary to continue to monitor the levels of arsenic in the Similkameen River. Secondly, local officials should work with Provincial Ministry of Environment, Lands, and Parks to reduce the levels of mine tailings that are captured in streams, and await any changes in the standards for human health.

A1. Monitor arsenic in the Similkameen River to determine trends in contamination and possible sources of pollution.

The Department of Ecology will share this information with the Watershed Implementation Committee and others to make the information available to all concerned individuals and increase the public's knowledge of the issue. Additionally, the information may be used by the Implementation Committee to identify future action items to resolve the issue.

Lead:	DOE
Cooperators:	CCT, Okanogan County, Okanogan Conservation District, WDF&W, USF&WS, DNR
Priority:	High
Cost:	Medium

A2. Local, State, and Federal water quality and human health officials should work with British Columbia officials to establish ways to reduce the amount of mine tailings and associated contaminants entering the streams of the Okanogan River Watershed.

Okanogan County should work with members of the B.C. government to express our concerns about the quality of water entering Washington State from B.C. Additionally, the County should work with other local agencies such as the Okanogan Health District, Colville Confederated Tribes, and the Okanogan Conservation District to assist Canadian officials in their identification of pollution sources and solutions.

Lead:	Okanogan County
Cooperators:	CCT, Okanogan Health District, Okanogan Conservation District, WDF&W, USF&WS, BC Ministry of Environment, BLM, DNR, International Joint Commission
Priority:	High
Cost:	Low

A3. Monitor the efforts to clean up the Kaaba-Texas Mine Tailings near Nighthawk.

The Bureau of Land Management, Environmental Protection Agency, and Washington State Department of Ecology are currently working together to assess the disposal and clean up operations for the Kaaba-Texas mine tailings pile. The Okanogan Highlands should monitor the efforts of these agencies to efficiently remove the tailings from the floodplain of the Similkameen River.

Lead:	Okanogan Highlands
Cooperators:	Okanogan Conservation District, Okanogan County, DOE, BLM, EPA, DNR
Priority:	High
Cost:	Medium

Turbidity and Sediment Action Items

Turbidity is a measure of the amount of light, which can pass through a water body. Turbidity is measured in NTUs (Nephelometric Turbidity Units), with the lowest values representing the clearest water. Testing turbidity is accomplished by the relatively easy task of shinning a light of a known output (candlepower) through a column of water and measuring the light that passes through with a photocell. This test may not properly characterize the turbidity and sediment conditions because the shape, dimension, and size of suspended soil particles in a column of water can affect the outcome of the test. Measurement of the total suspended solids (TSS) may provide a better indicator of sediment problems in the Okanogan River.

Most residents of the Okanogan River Watershed have witnessed the color of the Okanogan River during high spring run-off and generally attributed the bulk of the sediment source to the Similkameen and Canada. However, the number and types of sources of sediment input are astounding and complicated by the fact that the Similkameen River (the largest overall sediment contributor to the Okanogan River) carries sediment from Canada. High levels of sediment cause other problems in aquatic systems including, but not limited to, decreased dissolved oxygen, increased temperature, altered pH, stress on resident and anadromous fish, and economic effects due to impacts on irrigation systems.

Geologists and hydrologists identified the primary contributors of sediment in the Okanogan River Basin as part of this project. They identified the eroding banks along the Similkameen River (both U.S. and Canadian side) as the largest single contributor. However, there were many other sources including, but not limited to, mining activities in the Similkameen River Basin in Canada, eroding banks of the Okanogan River between Oroville and Tonasket, eroding banks along Bonaparte Creek, and runoff from poorly maintained and/or improperly constructed roads throughout the Okanogan River Basin.

TS1. Survey the Similkameen River from Keremeos B.C. to Nighthawk, WA (in cooperation with B.C. Ministry of Environment, Lands and Parks). This survey should identify specific areas that would benefit from the implementation of BMPs. In addition a sediment survey should be completed that will determine background (naturally caused or induced) erosion and sediment delivery and human caused erosion and sediment delivery.

Streambank stabilization along many of the watersheds streams is a serious issue. None however are as important as those found along the Similkameen River. More precisely the banks of the Similkameen River from Keremeos, B.C. to Nighthawk, WA. The Okanogan Conservation District shall work with the B.C. Ministry of Environment, Lands and Parks to install BMPs along the identified stretches, and educate landowners about activities they can undertake to further protect stream banks in the region.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan County, B.C. Ministry of Environment, NRCS, DNR, WDF&W, USF&WS, BLM, USGS
Priority:	High
Cost:	Medium

TS2. Update and expand a streambank stabilization survey completed by the Natural Resources Conservation Service in 1995.

Streambank stabilization along many of the watershed's streams is a serious issue. The Okanogan River between Oroville and Tonasket, Washington is no exception. Already the focus of several groups and agencies, the extent of the problem is so vast that the solution will take many years to fully implement. The updated and expanded survey should include a survey of tributary streams, including but not limited to, Bonaparte Creek. The survey shall identify specific BMPs that will address bank instability and landowners willing to voluntarily cooperate in implementation.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan County, , NRCS, DNR, USFS, WDF&W, USF&WS
Priority:	High
Cost:	Low

TS3. Implement BMPs as identified in the survey conducted under action item TS2 of this plan.

Streambank stabilization along many of the streams of the watershed is a serious issue. Bonaparte Creek contributes as much as twenty percent of the total sediment inputs into the Okanogan River in comparison to other watersheds (Similkameen River watershed is only calculated based on acres in the US). Much of this sediment is originating from streambanks along Bonaparte Creek and its tributaries. Additionally, there are serious streambank stabilization issues along the mainstem Okanogan River.

Lead:	Okanogan Conservation District
Cooperators:	Landowners, County Horticulture Association, County Cattlemen's Association, DOE, CCT, Okanogan County, NRCS, DNR, WDF&W, USF&WS
Priority:	High
Cost:	High

TS4. Develop construction standards and Best Management Practices to be applied to roads, public and private, built in the county.

Road construction, location, density, and maintenance play an important role in the introduction of sediment to streams. This is especially true where streams intersect roads and/or are generally within 200 feet of a stream. Many watersheds have high densities of roads and the roads were constructed near streams, and of a poor design. The BMPs should take into consideration, but not be limited to, new roads to be set back from streams, buffers between new roads and streams, and identifying new maintenance activities that reduce erosion and sediment inputs into streams. Additionally, clarification of maintenance responsibilities should be achieved for roads that are traveled by multiple owners (public and private).

Lead:	Okanogan County Public Works Dept.
Cooperators:	CCT, WDOT, DNR, USFS, NRCS, Okanogan County Noxious Weed Control, Realtors
Priority:	High
Cost:	Low

TS5. Okanogan County shall seek funding to determine impacts of roads on streams throughout the Okanogan River Watershed and identify standards including winter maintenance activities such as sanding and de-icing that may benefit from practice modification.

An issue that is not completely understood is the impacts of roads and road maintenance on aquatic environments. It is known that roads within 200 feet of a stream will contribute sediment to the stream. However, the exact impacts of this form of sediment input have not been established. Additionally, there is the risk of increased sediment inputs to streams from winter road sanding practices. Finally, a new treatment has been in use by the Washington Department of Transportation, which is a method of applying an environmentally friendly deicer to the road surface prior to snowfall or ice formation. This action item should fully assess the impacts of these practices and conditions and others related to this issue.

Lead:	Okanogan County Public Works Dept.
Cooperators:	CCT, WDOT, DNR, USFS
Priority:	Low
Cost:	High

TS6. The Cities and Towns of the watershed should seek funding (either individually or collectively) to develop and implement a comprehensive stormwater management plan.

Unrestricted stormwater runoff from city streets, parking lots and other impervious surfaces has an impact on water quality. The cities and towns should consider developing a plan, which would consider such things as requiring developments that have stormwater collection systems to treat stormwater on-site. The plans could also include requirements that all existing stormwater systems have treatment systems installed that will filter out much of the debris and chemicals that are often collected in such systems. Additionally, the plans should look at any existing storm sewer plans and develop alternatives to treating the stormwater versus costly treatment plants.

Lead:	Cities & Towns
Cooperators:	Okanogan County, WDOT
Priority:	Medium
Cost:	Low

TS7. Identify unused roads or road sections which are unstable and a sediment source.

Roads that are not needed by resource agencies for fire suppression, timber management, wildlife management, and important recreational use should be identified for obliteration.

Lead:	Okanogan County
Cooperators:	WDOT
Priority:	Low
Cost:	Medium

TS8. Use existing Best Management Practices to obliterate or abandon road sections as identified in TS7.

Several agencies have developed Best Management Practices for obliterating (removing permanently) roads that are no longer needed. These practices should be implemented by the various responsible agencies to reduce impacts of roads on streams, wetlands, and other water bodies.

Lead:	Okanogan County
Cooperators:	WDOT
Priority:	Low
Cost:	High

Information & Education and Data Acquisition Action Items

The transfer of knowledge and information to residents of the county is paramount. Not only will it be necessary to provide information and resources to the adults of our community so they may make more informed decision today, but providing water quality education to children will establish a strong base of local knowledge in future years.

Information sharing between local, state, and federal agencies is tenuous not because they don't interact, rather they store and catalog information differently and collect information on different parameters. This information can benefit everyone who is concerned about our natural resources if it was readily available. To add to this, many times a person must sort through many documents to find small pieces of information for which they are searching.

IE1. The Okanogan Conservation District shall seek funding to develop an information database similar to the Klamath Resource Information System. This information database should include water quality data and other pertinent natural resource data and the database should be accessible to the public.

Computerized databases of data will allow for faster dissemination, search capabilities and cataloging of natural resource data. A database similar to the Klamath Resource Information System will contain water quality data in table and graph form, photographs showing natural resource restoration projects, geographic information system maps, and actual natural resource documents scanned into the system for quick reference, searching, and review. Additionally, the database will allow for updating and sharing of information on a broad scale as it is contained solely on a computer CD-ROM. Finally, it is important that the information collected in this project be provided to local landowners and other interested persons so they are provided the opportunity to review the data just as the Stakeholder's Advisory Committee did. Furthermore, having data available in multiple formats will allow for the greatest opportunity of data transfer from one person to another.

Lead:	Okanogan Conservation District
Cooperators:	DOE, CCT, Okanogan County, B.C. Ministry of Environment, NRCS, DNR, Landowners, WDF&W, USF&WS, USFS, OCHD, Libraries, Schools, NCW RC&D
Priority:	High
Cost:	High

IE2. Compile a comprehensive inventory of roads, streams, and wetlands throughout the watershed and input the data into a GIS database.

A centralized GIS database that includes this data provides the opportunity to complete detailed analyses on impacts to water quality. In addition, information can be stored, updated and retrieved by various users. This data should be made available to the public and resource agencies for analysis and future planning.

Lead:	Okanogan County
Cooperators:	DOE, CCT, Okanogan Conservation District, NRCS, DNR, DOT, WDF&W, USF&WS, USFS
Priority:	Medium
Cost:	High

IE3. Continue to develop a comprehensive inventory of rural development patterns in order to determine and address impacts to water quality.

Rural development has a significant impact on aquatic environments if managed improperly. Currently there is no coordinated information available in a GIS database for analysis of development patterns. Rural development can affect virtually every one of the water quality criteria such as temperature, fecal coliform, and flow. Information on growth patterns will be useful for calculating the area of impervious surfaces, identifying areas that are potentially receiving high levels of nutrients from homeowner activities, and other concerns.

Lead:	Okanogan County
Cooperators:	DOE, CCT, Okanogan Conservation District, NRCS, DNR, DOT, WDF&W, USF&WS, USFS, Cities & Towns
Priority:	Medium
Cost:	Medium

IE4. Develop a comprehensive information and education program identifying the effects of illegal dumps and recommended clean-up practices to the landowners and encourage community service organizations to aid local citizens in the disposal of unwanted and illegal toxic materials.

The storage and disposal of common products, including but not limited to, household cleaning supplies, paint, pesticides, and fertilizers has a high degree of risk to water quality if done improperly. Improper disposal of these items and others, degrades water quality when the two come in contact. The implementation of a collection and disposal program in communities throughout the watershed will reduce the risk of improper disposal. In addition, an education program will heighten awareness of the danger of these practices. The program should include periodic disposal service in varying communities throughout the watershed to allow for the highest possible usage by residents.

Lead:	Okanogan County Health District
Cooperators:	DOE, CCT, Okanogan Conservation District, Okanogan County, Landowners
Priority:	High
Cost:	Medium

IE5. Ensure adequate enforcement of the Washington Forest Practices Act.

The Stakeholder's Advisory Committee fully supports the Washington Forest Practices Act and it's continued implementation. The Okanogan County Commissioners need to consult with the Washington Department of Natural Resources to ensure adequate enforcement of the Washington Forest Practices Act.

Lead:	Okanogan County
Cooperators:	Landowners, NRCS, DNR, USFS, WDF&W, CCT, Okanogan Conservation District
Priority:	Medium
Cost:	Low

IE6. The Okanogan Watershed Implementation Committee should develop a natural resources information packet for distribution to local residents.

The pamphlet might include a directory of agencies that have information or services about water quality and natural resources. Another item that may be included would be a list of commonly asked questions by first time landowners about necessary permits for building, land clearing, logging activities, noxious weeds and their control and the like. The packet could be distributed by local real estate agents to property buyers thus assuring the information reaches the landowners.

Lead:	Okanogan Watershed Implementation Committee
Cooperators:	Landowners, NRCS, DNR, USFS, WDF&W, CCT, Okanogan County, Cities & Towns, Okanogan Conservation District, Okanogan County Horticulture Association, Okanogan County Cattlemen's Association, Okanogan County Noxious Weed Control Board, WSCUE, and Common Sense Resource League.
Priority:	Medium
Cost:	Low

IE7. The Okanogan Watershed Implementation Committee should develop and host Best Management Practices workshops for local private landowners.

Small workshops that show participants how to plan, design and implement many of the Best Management Practices will facilitate information exchange between local, state, and federal agencies and the public. This will assist the private landowner that wishes to implement a best management practice without direct involvement by government agencies. Workshops can be coordinated with other implementation activities so participants can get an opportunity to see the application of BMPs and how they protect and enhance water quality.

Lead:	Okanogan Watershed Implementation Committee
Cooperators:	Landowners, NRCS, DNR, USFS, WDF&W, CCT, Okanogan County, Cities & Towns, Okanogan Conservation District, Okanogan County Horticulture Association, Okanogan County Cattlemen's Association, Okanogan County Noxious Weed Control Board, WSUCE, Common Sense Resource League
Priority:	Medium
Cost:	Low

IE8. Implement the water quality monitoring plan that is found in Appendix E of this plan.

It is absolutely essential that the Okanogan Watershed Implementation Committee have accurate water quality data for the streams, rivers, lakes, and wetlands of the watershed. To gain this information the Okanogan Conservation District should seek funding to implement the water quality monitoring plan that was developed as a part of this project and is included in Appendix E of this plan. This data collected from this plan will be key to the continued implementation of this plan.

Lead:	Okanogan Conservation District
Cooperators:	Landowners, NRCS, DNR, USFS, WDF&W, CCT, Okanogan County, Cities & Towns, Okanogan County Horticulture Association, Okanogan County Cattlemen's Association, DOE, schools, sporting clubs
Priority:	High
Cost:	High

IE9. Implement a historical photo plot monitoring program.

During the development of this plan, interest in historical photos of the watershed was expressed. On a few occasions some photos were produced, that showed different areas of the watershed near the turn of the century. The Stakeholder's Advisory Committee felt that these photos show us how things have improved in some respects and worsened in others. The focus of this action item will be to research old photos and identify the location they were taken from. With that information, a photo plot will be created from that site to show changes in the landscape over time. Then every five years photos should be taken from these locations so that a database of photos can be obtained for future planning and decision making purposes.

Lead:	Okanogan Conservation District
Cooperators:	Landowners, Okanogan Historical Society, NRCS, DNR, USFS, WDF&W, CCT, Okanogan County, Schools, Recreation Groups
Priority:	Medium
Cost:	Low

IE10. Develop sub-watershed committees to assist with the implementation of this plan.

The Okanogan Watershed Implementation Committee (OWIC) should investigate the development of sub-watershed committees to assist them in reviewing data and implementing action items of this plan. These committees would work closely with the OWIC to review data that is collected and identify voluntary actions that local residents of their respective sub-watersheds could implement.

Lead:	Okanogan Watershed Implementation Committee
Cooperators:	Landowners, Okanogan Historical Society, NRCS, DNR, USFS, WDF&W, CCT, Okanogan County, Schools, Recreation Groups, Okanogan Conservation District, WSUCE, Common Sense Resource League
Priority:	Medium
Cost:	Low

Landowner Assistance Action Items

Humans affect water quality by interacting with the water resources we have. We do this in many ways, some obvious and glaring, others not obvious. Through careful management of our activities, we can reduce the amount of impact that is imposed on the human environment. Most often individuals will implement management changes on their own free will when they learn new ways to reduce impacts on the environment. However, with the economics of the area and the amount of resources available to today’s landowner, implementing expensive changes is difficult.

There are many groups and agencies available that offer assistance in various forms to private landowners. Groups such as the Okanogan County Horticulture Association, Okanogan County Cattlemen’s Association, irrigation districts, conservation district, and others offer technical advice, training, monitoring, and to some extent financial assistance to private landowners. One of the limiting factors to the programs and services these groups offer is that they are not widely known to all landowners (commercial agriculture and urban homeowner alike).

Providing technical resources, planning service, informational material, and even financial assistance to private landowners is a key to the improvement of water quality. Each of these groups and others should increase their outreach to the public by advertising their services, and providing information to landowners so they may make their own decision on what is best for their property.

LA1. Provide technical assistance, water quality information, and cost-share assistance to private agriculture producers.

Many large agriculture producers in Okanogan County currently operate with a comprehensive farm plan or even under a Coordinated Resource Management

Planning. Depending upon the number of acres concerned either type of plan would provide detailed conservation planning while allowing the producer to maintain profits and often improve profits. The Washington State University Cooperative Extension should develop an agriculture assistance program. This program may include, but not be limited to, Coordinated Resource Management Plan development and implementation, individual farm planning, sediment control, domestic animal waste management plans, and pasture management plans.

Lead:	WSU Cooperative Extension
Cooperators:	Okanogan County Cattlemen's Association, Landowners, NRCS, DNR, USFS, WDF&W, CCT, Okanogan County, Okanogan Conservation District, Okanogan County Noxious Weed Control Board
Priority:	Medium
Cost:	High

LA2. Provide technical assistance, water quality information, and cost-share assistance to private non-agriculture landowners.

Many non-agriculture landowners in Okanogan County could improve aspects of their property to gain water quality improvements. However, these landowners may not have the resources and/or expertise to implement these changes. Thus, the Washington State University Cooperative Extension should secure funding to assist non-agriculture landowners with improvements to their property that will benefit water quality.

Lead:	WSU Cooperative Extension
Cooperators:	Okanogan County, Landowners, NRCS, DNR, USFS, WDF&W, CCT, Okanogan County, Okanogan Conservation District, WSU Master Gardeners, Omak-Okanogan Tree Board
Priority:	Medium
Cost:	High

Management Plan Action Items

There are various management plans including waste management, rural development, flood plain management, and riparian management that would benefit the aquatic resources in the Okanogan River Watershed. These plans would provide goals and a framework for landuse management for future development and growth.

Currently population in the Okanogan Watershed is growing above the state average. To limit the potential impact of the additional new residents comprehensive plans will identify ways in which to deal with additional waste, development, and impacts from natural flooding. Additionally, this planning will assist policy makers to make the transition to dealing with state Growth Management Act compliance.

The management plans suggested here are intended to provide local government decision-makers such as city councils, county commissioners, and other with tools by which to protect water quality and maintain healthy growth in the economics of the area.

MP1. Okanogan County should work with watershed residents and interest groups to update and revise current comprehensive planning documents.

Un-planned and ill-coordinated rural development not only has adverse impacts on the local economy and services structure, but also can have adverse effects on water quality. Rural development stresses existing infrastructure such as water supply and sewage treatment, and without updates they can be adversely impacted. The updated rural development plan could address, but not be limited to, zoning recommendations, wellhead protection measures, riparian zone management options, and information sharing for small acre (less than 20 acres) landowners about proper land maintenance.

Lead:	Okanogan County
Cooperators:	Landowners, CCT, Cities and Towns
Priority:	Medium
Cost:	Medium

MP2. Okanogan County should work with watershed residents and interest groups to update the comprehensive waste management plan.

Disposal of human, industrial, and other waste is an expensive undertaking for all local governments. Identifying and developing sites for landfills takes years and virtually millions of dollars. Thus, management of waste is as much an economic issue as it is a water quality issue. The waste management plan would include, but not be limited to, identification of the proper disposal methods for hazardous waste (i.e. car batteries, chemical containers, etc.) and solid waste (domestic garbage). In addition, the plan would include development of an urban and rural recycling program (possibly including curbside recycling).

Lead:	Okanogan County
Cooperators:	Landowners, CCT, Cities and Towns, OCHD
Priority:	Medium
Cost:	Medium

MP3. Okanogan County shall initiate meetings with Canadian government officials to discuss a joint venture to protect, preserve, and enhance the water quality conditions of Lake Osoyoos.

There is immediate need to develop communication with Canadian government officials (including representatives of local municipalities) to discuss the possible implementation of a coordinated lake protection plan. There are many concerns about the health of this lake as there are increasing pressures from rural development, industries, and recreation. However, to sustain this valuable resource a joint effort will be necessary.

Lead:	Okanogan County
Cooperators:	Cities, & Towns, DOE, CCT, Okanogan Conservation District, B.C. Ministry of Environment, City of Osoyoos, Lake Osoyoos Water Quality Society, WDF&W, USF&WS, Canada Federal Dept. of Fisheries & Oceans
Priority:	High
Cost:	Low

6 Implementation Plan

Introduction

This chapter details the suggested timeline for implementation of the Action Items found in the previous chapter. This timeline is a suggestion for implementation based on the relative importance of each action item. The Stakeholder's Advisory Committee (SAC) feels that for implementation of the plan to take place, a reasonable schedule must be established for which lead groups can develop short and long-term plans.

Document Review and Approval Process

This plan will undergo several periods of review and public comment before being finalized by the SAC, the Watershed Committee, and the Washington State Department of Ecology (DOE). Throughout the development of this project the document has received numerous revisions based on comments made by members of all the committees involved. This document is the culmination of thousands of hours of meetings and staff preparation time. For the goals of this plan to be fully realized two things must occur. First, the plan must be implemented to the fullest ability of the implementing groups. Secondly, additional data must be collected to revise the plan as necessary for future years of implementation.

In the fall of 1999, this plan will be made available for public review and comment for a period of no less than thirty days. During this time two things will be occurring. Meetings with the lead groups of the action items will be established to review the action items for which they are responsible and come to a consensus of what exactly they are being asked to do and are willing and/or capable of completing. Additionally, a minimum of three public hearings will be completed throughout the watershed. Tentatively, these meetings will be held in Okanogan, Tonasket, and Oroville on different nights to allow the greatest possible attendance from the public.

After the public comment period is closed, the SAC will convene to review the comments. At that time, all relevant and pertinent comments will be addressed. All relevant and pertinent comments by implementing groups will be addressed at that time also.

Once all pertinent and relevant comments have been addressed, the document will be reprinted for submission to the Watershed Committee. The Watershed Committee consisting of the three County Commissioners and five Okanogan Conservation District Supervisors will review the document and hold at least one public hearing in conjunction with the DOE. After the public hearing the Watershed Committee will once again address all pertinent and relevant comments.

When the document is updated by the Watershed Committee based on the public comment they received, the document will be printed in final draft form for submission to the DOE. The DOE will hold their own public hearing to receive comment within sixty days of document submittal. The DOE will adopt the plan within sixty days of this final public hearing. At that time the plan will be finalized and printed in final form.

Lead Group

The lead groups identified in the action items were chosen based on their ability to coordinate and implement specific action items. Additionally, it is the consensus of the SAC that these groups will be the best groups for the tasks necessary to implement this plan.

During the public review and comment phase of plan development, meetings with proposed lead groups will be held to achieve consensus on assigned action items. When consensus is reached, each lead entity will provide a letter of concurrence to be included in the plan. Should consensus not be attainable with a proposed lead group, the implementation committee will be responsible for finding a new lead group or working with the lead group to develop an agreeable solution.

Finally, the lead group will be responsible for reporting to the Okanogan Watershed Implementation Committee (OWIC) for progress made in implementing assigned action items. This oral or written report to the committee will be done once each year at the January meeting of the OWIC. This report will facilitate progress made towards implementation of the entire plan and assist in identifying additional resources that may be necessary to implement the plan.

Implementation Committee

One of the primary outcomes of this plan will be the formation of the OWIC. This committee will be comprised of landowners who must ‘live with the results’ of their actions. Additionally, members should have enough community influence to make an impact by their decisions. Membership will be chosen by the Watershed Committee (Okanogan County Commissioners and Okanogan Conservation District Supervisors). When choosing the members of the OWIC emphasis will be given to those individuals that live and own land in the Okanogan River Watershed.

The membership of the OWIC should be comprised of the following groups:

Okanogan Horticulture Association	Okanogan Cattlemen’s/Cattlewomen's Association
Irrigation Districts	Environmental Groups
Okanogan Mining Association	Recreation Groups
Cities & Towns	Well Drillers
Lake Osoyoos Water Quality Society	Private Timber Management
Colville Confederated Tribes	Washington Dept. of Fish & Wildlife
Washington Dept. of Natural Resources	USDA Forest Service
Okanogan County Commissioners	Okanogan Conservation District Supervisors

The Watershed Committee is expected to give direction to the OWIC during the initial meetings and to ensure the group meets on a regular basis. The OWIC should meet a minimum of two times per year at regularly scheduled and advertised meetings to review the progress of plan implementation. The first meeting shall be in January 2001.

The committee should not be made any larger than the group listed above but rather draw from the resources (technical, financial, etc.) of their respective groups. Additionally, members must maintain an active status or risk being dropped to be replaced with others who can attend the meetings and ensure overall project success. Finally, members of the OWIC should be individuals who are solution oriented.

The OWIC will be responsible for prioritizing action items to meet the needs of the water resource and as may be necessary to fit funding and priority schedules of the assigned lead group. Furthermore, the committee should develop a mechanism for including "At Large" members (non-voting) so that concerned citizens may actively participate. "At Large" members should be included as members of sub-basin committees that provide and review data that is specific to the sub-basin they 'represent'. Lastly, the OWIC shall draw technical resources from within the member organizations and from outside sources as necessary to review data, identify problems, and identify solutions.

Implementation Schedule

The schedule of implementation is based upon the priority of the sub-watershed and whether action items specifically address 303(d) listings. Given the fact that the watershed may face regulation in the future should the 303(d) listings not be addressed, these problems have the highest priority. Action items are then based on addressing problems in the order of high, medium, and low priority sub-watersheds. However, there are a small number of action items that don't address problems in a specific watershed or 303(d) listings. These action items are things such as a water quality monitoring plan for the watershed, and information and education activities. Most of these general action items have a high priority for implementation due to the fact that they encompass many of the other action items and will facilitate the implementation of other high priority action items.

Again, implementation of any action item will be dependent upon the lead group's agreement (through a statement of concurrence) to implement the action item, and the group's ability to fund the action item. This is a necessary function to allow each entity to decide what actions they are willing to complete and to allow for funding and other resources to be obtained. The tier level of priorities will allow for a staggered implementation and give lead groups time to incorporate new tasks into their work plans and get resources in place to handle the additional action items. The SAC acknowledges the potential program impacts for some of the lead groups. With that in mind, the committee asks that each lead group incorporate the action items into their long range plans.

Estimated Costs & Budget

Estimated costs and a budget will need to be developed by each lead group. Implementation of all action items is contingent upon the lead group being able to fund it either through available funding, grants, or other sources. Having an action item identified with a lead group should, in no way, be construed as a requirement for said group to implement without available funding. Each lead group will need to develop a budget for each action item to include costs of any necessary materials, staff wages, cost-share, overhead, and other associated costs. The costs will be very dependent upon how each lead group is organized and how it is able to handle the influx of additional workload. Relative costs have been added to each action item such as high (greater than $100,000), medium ($50,000 to $100,000), and low (less than $50,000).

Another complexity in estimating budget for action items is the simple fact that many of the action items call for Best Management Practices (BMP's) to be applied on the ground. Each BMP will have a different cost each time it is applied based on the landowner's land-use goals, quantity of a practice that is applied, and any site particular modifications to the BMP if necessary. As a result, any cost estimates will be gross estimates until such a time as a specific inventory and work plan can be conducted and developed for each site and action item.

Glossary

303(d) List: List of water bodies that do not support one or more beneficial uses according to state and/or federal standards. This list is developed in Washington by the Department of Ecology and after a period of public review is submitted to the US Environmental Protection Agency for approval per the requirements of the 1972 Clean Water Act.

Acre-Foot: The amount of water necessary to cover one acre of land one foot deep with water. This equals 326,851 gallons or 43,560 cubic feet of water. This term is generally used to describe the storage capacity of lakes and reservoirs.

Adsorption: Attraction of ions or compounds to the surface of a solid.

Algae: Simple chlorophyll-containing plants. Single celled algae add organic matter to soil by photosynthesis.

Alluvial fans: A fan shaped deposit of sediment laid down by a stream at the foot of a slope.

Alluvium: A deposit of sand, silt, mud, or other debris left by flowing water in river beds, flood plains, lakes, etc.

Anadromous: Fish that hatch in freshwater, migrate to salt water and return to fresh water to spawn.

Aquatic Ecosystem: An association of plants and animals and their nonliving environment in an aquatic setting.

Aquatic: Growing or living in water.

Aquifer: Rock strata permeable to groundwater flow.

Aspect: A relative position of any object/body with respect to another.

Available Water Capacity: (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60 inch profile or to a limiting layer is expressed as:

High............................ More than 7.5 inches
Moderately high.................. 5.0 to 7.5
Moderate......................... 3.75 to 5.0
Low.............................. Less than 3.75 inches

Bankfull: The maximum amount of water a stream or river may carry before flooding occurs.

Basin: *See Watershed.*

Bed load: Coarse materials that are dragged along the bed of a stream by traction or by the rolling and bouncing motion of saltation; involves particles too large to remain in suspension.

Beneficial Use: Any use of water which is desired by the public. This includes, but is not limited to, irrigation use, human consumption, and recreation.

Benthic: Pertaining to the bottom or floor of a watercourse or waterbody.

Best Management Practice: Any activity that diminishes or eliminates pollution. These are activities that landowners and agencies often develop cooperatively to improve land use efficiencies while reducing impacts to natural resources.

Canal: A ditch or other open conveyance system used to carry water away from a natural or manmade water body for use elsewhere.

Canopy: The uppermost layer in a forest or woodland, consisting of the crowns of trees or shrubs.

Channel: An area that collects and carries concentrated water flow such as a stream or river.

Channelization: The modification (usually associated with dredging and/or straightening) of a stream or river reach.

Clean Water Act: Common name for the Federal Water Pollution Control Act. This act is enforced by the US Environmental Protection Agency.

Cobble: A naturally rounded stone, large enough for use in paving.

Colluvium: an unsorted mix of soil and mass-movement debris.

Conductivity: A measure of the ability of water or to convey electrical current.

Conservation: The protection and wise use of natural renewable resources.

Contamination: An undesirable change in the physical, chemical, or biological characteristics of air, water, soil, or food that can have an adverse affect on the health, survival, or activities of humans or other living organisms.

Contour Tillage: Tilling cross-slope to reduce erosion.

Coordinated Resource Management: A process where people with diverse interests in a land area or watershed, work together, by concensus, to coordinate their management. This is a voluntary effort that is being used extensively in Okanogan County.

Crest: The maximum stage of a flood event at specific points along a water course as the highest flows pass downstream.

Critical Area: An area that has significant environmental value that is often protected by local, state, and federal laws.

Crop Rotation: Planting a repeating sequence of different crops on the same piece of land.

Cubic Feet per Second (CFS): The measurement of water flows that is equal to one cubic foot of water (7.5 gallons) moving past a given point in one second.

Dam: Any structure that impounds or stores water in a stream, river, pond, or lake.

Delta: Alluvium located near the mouth of a creek, stream, or river.

Deposition: The process whereby weathered, wasted, and transported sediments are laid down.

Dissolved Oxygen: Oxygen that has passed into a solution/liquid.

Drainage Class (natural): Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained - Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained - Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained - Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained - Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically for long enough that, most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained - Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained - Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained - Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded.

Drainfield: The network of pipes or tiles through which wastewater is dispersed into the soil.

Endangered Species: Wild species with so few individual survivors that the species could soon become extinct in all or most of its natural range.

Eolian Soil Material: Wind-deposited soil material, mostly silt and fine sand.

Erosion: The movement/displacement and transport of rock and/or soil by forces such as water or wind.

Erosion Hazard: Susceptibility to wind or water erosion. The terms used in this plan are slight, moderate, high, and very high. These terms are relative and apply only in relation to other soils of the Okanogan and Colville soil surveys.

Estuary: The point at which the mouth of a river enters the sea and freshwater and seawater are mixed.

Eutrophication: "The increase of biomass of a waterbody leading to infillinf of the basin and the eventual disappearance of open water; sometimes referred to as the aging process of a waterbody." (Marsh, 1991).

Evapotranspiration: The loss of water to the atmosphere through its evaporation from the soil and by the transpiration of plants growing on land.

Fecal Coliform:

Floodplain: A plain bordering a river and made of sediment deposited during floods.

Forage: Food for living organisms, but generally used to describe food for grazing mammals.

Forb: Any herb, excluding grasses and plants resembling grasses.

Fry: Life stage of a fish from the time it hatches until it reaches 25 millimeters long.

Fungi: The plural of fungus.

Fungus: Any of a major group of nonmotile, filamentous organisms that lack chlorophyll and absorb their nutrients from dead or living organisms. Examples: Mushrooms, yeasts, toadstools, smuts, rusts, molds, and mildews.

Geographic Information System (GIS): Computer database system used to show spatial data and allow for overlays of multiple 'themes' to allow for analysis of various geographic and social distributions.

Geomorphic Changes: Changes in landforms.

Geomorphology: The science that analyzes and describes the origin, evolution, form, classification, and spatial distribution of landforms.

Glacial Outwash: Glacial drift deposited in water flowing away from a melting glacier—sorted by the running water.

Glaciation: The process of covering a part of the earth's or any planet's surface with ice or glaciers.

Gravel: Pebbles and rock fragments coarser than sand.

Grazing allotment: A designated section of land that is leased by permittees to graze a specific number of livestock.

Ground water: The water occupying the zone of saturation below the soil-water zone in bedrock and sub-soil zones.

Habitat: The environment with which an organism interacts and from which it gains its resources.

Headwater: The source or upper part of a river or stream.

Herbicide: Chemical that kills plants or inhibits growth.

Hydrology: The study of water flows and natural aquatic processes.

Hydromodifications: Changes in landforms due to water.

Infiltration: The downward entry of water into soil.

Interflow or Subsurface Flow: Lateral flow of water below the ground surface, resulting from obstruction of downward flow of deep percolation.

Lacustrine: Of a pond or lake.

Leaching: Removal of soluble material in solution from the soil by percolating.

Legumes: Plants such as soybeans, peas, clover, alfalfa, locust trees which host the *Rhizobia* bacteria that fix nitrogen.

Loam: Soil that is between sandy soil and clayey soil in texture.

Mass Wasting: Large scale erosion.

Meander: A bend or loop in a stream channel

Metamorphic Rock: Preexisting rock, both igneous and sedimentary, that goes through profound physical and chemical changes under increased pressure and temperature.

Microbes: A microorganism, especially a bacterium that causes disease or fermentation.

Moraine: The material directly deposited by a glacier - also the load carried in or on a glacier.

Natural Resources: Materials supplied by nature that are useful or necessary for life. Examples: Minerals, timber, land, and water.

Non-point Pollution: Pollution that originates over a broad area such as pesticide runoff from orchards, or sediment from roads and streambanks. This form of pollution generally can not be tracked back to its source.

Noxious weed: A plant that is harmful or injurious to health or physical well-being and that is difficult to prevent it from spreading.

Nutrients:

On Site Septic (OSS): Septic storage and processing systems that are co-located with the source of effluent. This is typically a private homeowners septic tank and drain field.

Peak flows: The highest water flow in a specific river or stream for a given time.

Perennial: Lasting through a number of years (more than one year).

Permeability: The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are:

very slow.............................< 0.06 inch
slow...................................... 0.06 to 0.2 inch
moderately slow.................. 0.2 to 0.6 inch
moderate............................. 0.6 to 2.0 inch
moderately rapid.................. 2.0 to 6.0 inch
rapid......................................6.0 to 20 inch
very rapid.............................> 20 inches

Pesticide: Chemical that is designed to kill or inhibit growth of an organism that humans deem undesirable.

pH:

Photosynthesis: The process by which green plants synthesize water and carbon dioxide and, with the energy from absorbed light, convert it into plant materials in the form of sugar and carbohydrates.

Phytoplankton: Tiny aquatic plants that drift or float in water.

Point Source Pollution: Pollution that originates from one source and with proper testing can be tracked back to the point of input.

Porosity: Having a porous quality or condition.

Porous: Having or full of pores/holes. Permeable by water, air, etc.

Precipitation: The substance separated out from a solution as a solid. The process of depositing moisture in the form of rain, dew, snow, etc.

Riparian: The area immediately adjacent to a stream or other water course that has a much higher productivity of biomass than areas that are further from the waterbody. This area is typically noted by dense vegetation that can be seen as green bands along streams in Eastern Washington.

Riprap: Broken rocks or concrete placed on a surface to stabilize it and help reduce erosion.

Runoff: The precipitation discharged in stream channels from a drainage area. The water that flows off the land surface without infiltrating in, is called surface runoff; that which enters the ground before reaching surface streams is called groundwater runoff or seepage flow from ground water.

Salinity: The concentration of natural elements and compounds dissolved in solution, as solutes.

Salmonids: A member of the fish family Salmonidae (Salmon).

Sand: Earth material consisting of grains of worn-down or disintegrated rock, mainly of silica, larger than silt but much smaller and finer than gravel.

Sediment: Earth, stones, and other matter deposited by water, wind, or ice.

Seral Plant Communities: The complete series of plants occupying a given area over hundreds or thousands of years from the initial to the final or climax stage.

Silt: Very fine particles of earth, sand, clay, etc., carried by moving water and deposited as sediment.

Silviculture: The cultivation of forest trees.

Soil Compaction: The process of pressing together of mineral particles, sediment, etc. to create hard-packed ground.

Soil Depth: Refers to the depth that plant roots use the soil, depth to bedrock, or other restricting layers or horizons such as indurated hardpans, fragipans, etc.

Soil Erodibility: A complex soil property and is thought of as the ease with which soil is detached by splash during rainfall or by surface flow or both. Soil erodibility is related to the integrated effect of rainfall, runoff, and infiltration on soil loss and is commonly called the soil-erodibility factor (K).

Soil Failure: When soil can no longer hold its natural geological placement due to erosion.

Soil Infiltration: Downward entry of water into soil

Soil profile: Sequence of layers of a soil

Soil Stability: Soil's ability to hold its natural geological placement.

Soil Structure: The term given to the shape of the aggregates of particles that form in a soil—blocky, platy, granular, prismatic.

Soil Survey: The examination, description, and mapping of soils of an area according to the soil classification system.

Soil texture: The cumulative sizes of particles in a soil sample

Soil-loss Tolerance: This term denotes the maximum rate of soil erosion that can occur and still permit crop productivity to be sustained economically. The term considers the loss of productivity due to erosion but also considers rate of soil formation from parent material, role of topsoil formation, loss of nutrients and the cost to replace them, erosion rate at which gully erosion might reasonably be able to implement.

Solubility: A substance's ability to dissolve.

Spawning: Mating process used by salmon.

Stakeholder's Advisory Committee: The citizens and agency land managers committee created for the development of this plan (see Acknowledgements Page).

Stewardship: The management of property or financial affairs.

Stomates: One of the small openings in the surface of plants, especially of the leaves. Stomates permit the passage of water and gases into and out of the plant. Also called the stoma.

Surface Tension: The force at the water's surface that resists being penetrated by small and /or microscopic particles or living things.

Suspended Load: The sediment carried aloft in a stream of water.

Technical Advisory Committee: The primarily agency technical staff committee created to assist the Stakeholder's Advisory Committee in the creation of this plan (see Acknowledgements Page).

Terrace: A flat, raised level of land with vertical or sloping sides, especially one of a series of such levels placed one above the other.

Terrestrial Ecosystem: A self-regulating association of plants and animals and their abiotic environment characterized by specific plant formations.

Thermocline: The middle temperature zone in a lake or pond that is thermally stratified—has the greatest temperature variation.

Threatened species: Wild species that is still abundant in its natural range but is likely to become endangered because of a decline in numbers.

Topography: The surface features of a place or region, including hills, valleys, streams, lakes, bridges, tunnels, roads, etc.

Toxicity:

Transpiration: The act or process of transpiring. The passage of a liquid or gas in the form of vapor through a surface, such as the passage of waste matter through the skin or moisture through the leaves of a plant.

Turbidity: Measure of clearness of water as a function of suspended sediment.

Vapor Pressure: That portion of total air pressure that results from water vapor molecules.

Viscosity: The friction within a fluid, and between that fluid and other substances, which causes the liquid to resist flowing and creates friction and drag when something tries to move through the liquid.

Water infiltration: Water access to subsurface regions of soil moisture storage through penetration of the soil surface.

Watershed: The land that water moves across, under, or through on its way to a stream, lake or ocean.

Watershed Committee: The committee composed of the Okanogan County Commissioners and Okanogan Conservation District Supervisors (see Acknowledgements Page). This committee is tasked with completion of this plan.

Wetland: A geologic depression that is generally wet all or most of the year and has moisture tolerant vegetation.

Yarding: The act of moving logs from a general area to a specific location (yard). Also known as skidding.

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Sheldon, Fred - City of Omak
Spittlehouse, Dave - British Columbia Ministry of Forests
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City of Omak
Town of Oroville
Town of Tonasket

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City of Okanogan
City of Omak
Town of Oroville
Town of Tonasket

Comprehensive Plans

Okanogan County
City of Okanogan
City of Omak
City of Oroville
Town of Tonasket

DRAFT

Water Quality Modeling Assessment of the Okanogan River

DRAFT REPORT

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SECTION 1. Introduction

1.1 Purpose

As part of the Watershed Planning process of the Okanogan River in Okanogan County, Washington, it was recommended (HCW-L, 1997) that the County adopt the EPA model BASINS as a comprehensive data-analysis and modeling system. This recommendation was made for the following reasons:

1. BASINS is being developed and supported by the EPA. This should ensure long-term EPA technical support, continued model upgrades, and ready acceptance from local regulatory agencies such as the Department of Ecology and EPA Region 10.

2. It is developed in a GIS framework, using ARC/VIEW, and has tools to update baseline GIS coverages.

3. BASINS includes tools to store, analyze and display hydrologic and water quality data at a number of spatial scales from watershed-wide to individual monitoring stations.

4. BASINS includes a range of well-known and well-supported simulation models including NPSM (including most of the HSPF capabilities), QUAL2E and a screening-level toxicant transport and fate model called TOXIROUTE. Later versions of BASINS may add additional models, such as WASP.

5. BASINS can be used for a wide range of studies, including TMDL evaluations, community-wide planning studies, and watershed-wide assessments.

The project team then discussed with Jim Milton (Washington State, Department of Ecology) and Dennis Beich (Okanogan County Water Resources) how this system might be applied to part of the basin to study and evaluate water quality processes. The discussion focused on how the QUAL2E component of BASINS might be used to examine the sensitivity of wastewater treatment plant loads along the main stem of the Okanogan River, and to illustrate improvements by reducing loads, simulating advanced wastewater treatment (AWT).

1.2 Approach

A decision was made to utilize QUAL2E (a component of the EPA BASINS model) to model the main stem of the Okanogan from Osoyoos Lake to just downstream of Malott. The approach was to develop the QUAL2E model using readily available information on channel geometry, hydrology, meteorology and water quality, including background and point source load data.

The resulting model would be calibrated and validated to the extent the data permitted to various low-flow (summer) flow conditions. Then, the model would be used, if possible, to evaluate the changes in river water quality conditions resulting from reducing the discharges of nutrients from the various wastewater treatment plants along the river, simulating a change from secondary to tertiary (advanced nutrient removal) treatment.

1.3 Scope

The study was accomplished through a number of tasks:

Task 1: Flow data from U.S. Geological Survey streamflow gages along the main stem of the Okanogan River were analyzed to determine low-flow conditions suitable for a "worst case" assessment of water quality loads to the river.

Task 2: A QUAL2E grid was set up along the length of the Okanogan River from Osoyoos Lake to downstream of Malott, with a resolution of one quarter of a mile.

Task 3: Loads to the Okanogan River from the various WWTP discharges were estimated from available data. The constituents included dissolved oxygen (DO), biochemical oxygen demand (BOD), temperature, fecal coliforms and nutrients.

Task 4: The model was run for various low flow conditions, and the results compared with existing water quality observations to examine how well loads were represented in the model. In general, "standard" kinetic coefficient values, obtained from such sources as EPA guidance documents and discussions with various agencies, were used.

Task 5: Performed sensitivity analyses. This included varying kinetic coefficients over their "expected" ranges, and varying the loads to evaluate the "uncertainty" in water quality impacts if these sources were doubled or halved.

Task 6: Preparation of a report documenting the work performed and conclusions drawn.

SECTION 2. Description of Study Area

2.1 Watershed Description

The study area of the Okanogan Watershed is located in the northern portion of central Washington. The entire 8,400 square mile basin reaches from its headwaters in the Province of British Columbia, Canada, to its confluence with the Columbia River in Washington (DOE, 1999). In the Canadian portion of the watershed, the Okanogan River is naturally regulated by several large lakes, and artificially regulated at Okanagan Lake for irrigation and flood control, before crossing the international border at Osoyoos Lake near Oroville (USGS, 1994). There are no impoundments downstream of Oroville. Near Oroville, the Okanogan River is joined by the Similkameen River and flows downstream past the communities of Tonasket, Omak, Okanogan, and Malott before entering the Columbia River near Brewster (Figure 1).

Figure 1. Study area location map

2.2 Okanogan and Similkameen Rivers

Downstream of Oroville a majority of the flow to the Okanogan River is from the Similkameen River as shown in Table 1 (HCW-L, 1998). Peak flows in the Similkameen and Okanogan Rivers typically occurs coincident with snowmelt in May and June (Figure 2). The channel slope near Oroville is relatively flat and during high spring runoff events inflow from the Similkameen River to the Okanogan River can reverse the direction of flow in the Okanogan River back towards Canada. Water quality data were typically collected at the USGS gages as well as at a number of other locations in the basin as shown in Table 2.

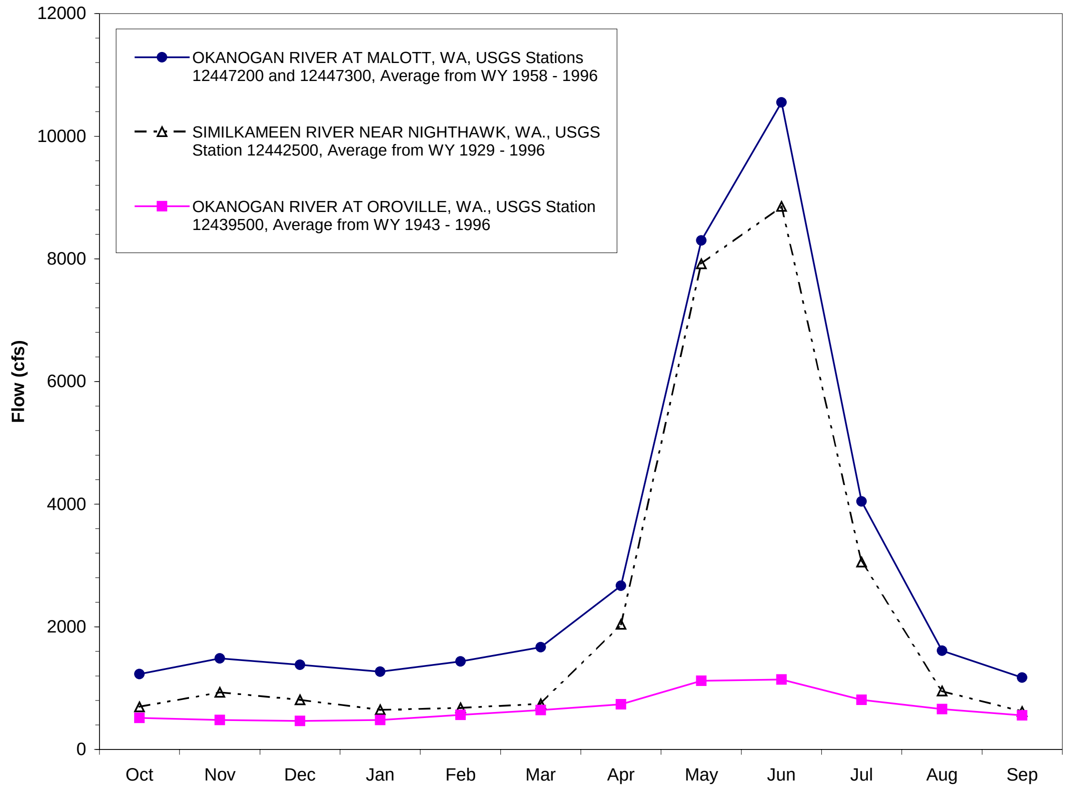
Table 1. Average daily flows at USGS gaging stations

USGS Station	Description	Period of Record (water year)	Average Annual Flow (cfs)
12442500	Similkameen River Near Nighthawk, WA	1911 - 1996	2,289
12439500	Okanogan River At Oroville, WA	1942 - 1996	676
12447200	Okanogan River At Malott, WA	1958 - 1996	3,063

Table 2. Water quality data sources

Station	Source	Station Description
49A190	DOE, 1999	Okanogan River at Oroville
48B070	DOE, 1999	Similkameen River at Oroville
OKS005	EPA, 1999	Okanogan River county road bridge, Ellisforde
49A180	DOE, 1999	Okanogan River at Tonasket
OKS004	EPA, 1999	Okanogan River USGS station near Tonasket
49A090	DOE, 1999	Okanogan River at Okanogan
49A070	DOE, 1999	Okanogan River at Malott
OKS001	EPA, 1999	Okanogan River county road bridge near Malott

Figure 2. Average monthly flow.



2.3 Point Source Locations

The communities of Oroville, Tonasket, Omak, and Okanogan operate treatment plants within the study area. Secondary effluent from the treatment plants is discharged directly to either the Similkameen or Okanogan rivers except at Tonasket where discharge is to infiltration basins. Table 3 shows the relative flow contribution from each of the treatment plants based on current design parameters (HCW-L, 1999).

Table 3. Design flow rates from the treatment plants within the study area

City	Average Daily Effluent Rate (million gallons/day)	(cfs)
Oroville	0.63	0.97
Tonasket	0.25	0.39
Omak[1]	0.99	1.5
Okanogan	0.54	0.84

[1]Dry weather flow

SECTION 3. Water Quality Model Development

3.1 QUAL2E Model Description

QUAL2E is a transport-fate model that uses a one-dimensional, advection-dispersion mass transport and reaction equation to model several water quality constituents in a branching stream system. The constituents include dissolved oxygen (DO), biochemical oxygen demand (BOD), temperature, algae as chlorophyll a (chl-a), organic nitrogen, ammonia (NH3), nitrite (NO2), nitrate (NO3), organic phosphorus (ORG P), dissolved phosphorus (DIS P), fecal coliforms (FC), an arbitrary non-conservative constituent, and up to three conservative constituents. Generally, QUAL2E is a steady state model, although meteorological data can be simulated dynamically. Solutions are determined using a finite difference equation with an implicit backward approximation.

3.1.1 Model Formulation

The QUAL2E model is designed to simulate the hydraulic and water quality components of a stream system. This is achieved by dividing the system into a series of elements each defined by individual physical characteristics (Figure 3). An equation to account for both the transport of mass and diffusion of a constituent (i.e. an advection-dispersion mass transport equation) is then computed across each element.

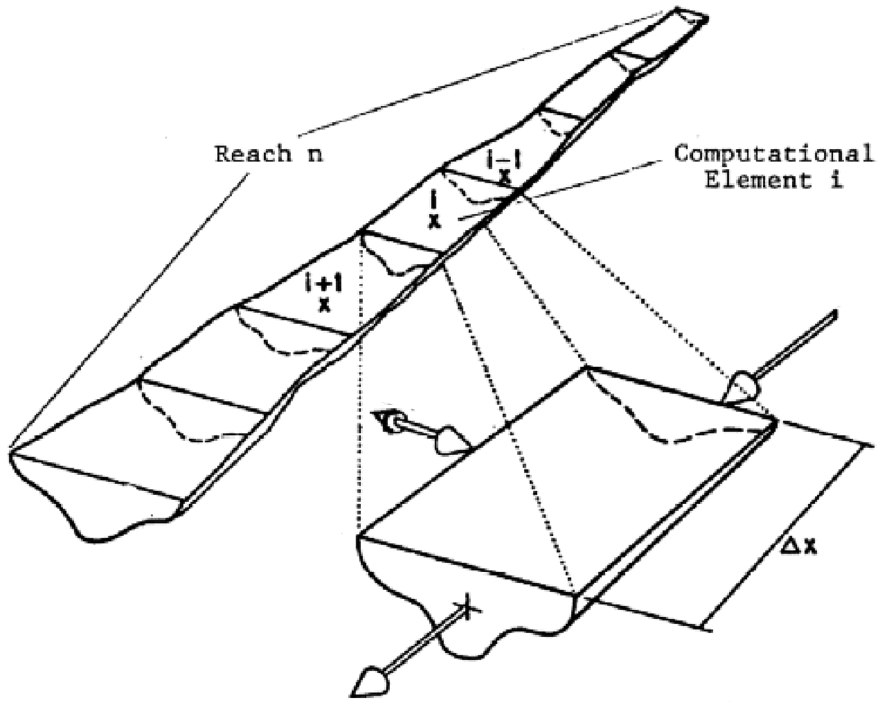
3.1.2 Constituents Simulated and Model Computations

QUAL2E was used to model the following constituents in the Okanogan Watershed:

- dissolved oxygen (DO)
- biochemical oxygen demand (BOD)
- temperature
- algae as chlorophyll a (chl-a)
- organic nitrogen
- ammonia (NH3)
- nitrite (NO2)
- nitrate (NO3)
- organic phosphorus (ORG P)
- dissolved phosphorus (DIS P)
- fecal coliforms (FC).

Concentrations of each of these constituents are required at headwaters and point loads in order to be simulated in the model.

Figure 3. Schematic of a discretized stream system (Brown, 1987)

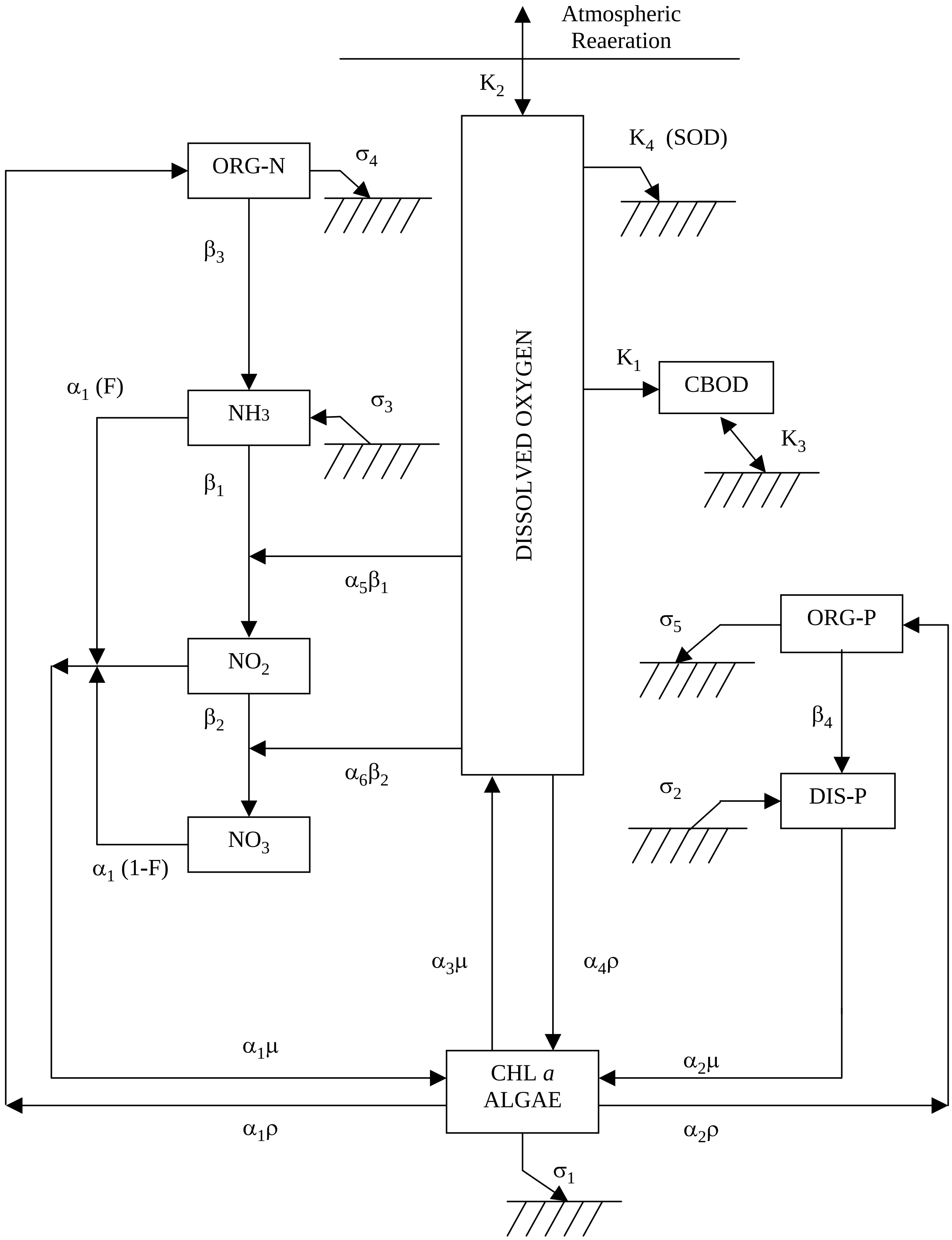


Mass balance is computed for each element

QUAL2E computations model the major interactions of the nutrient cycle, algae production, benthic oxygen demand, carbonaceous oxygen uptake, atmospheric aeration and their effect on the behavior of dissolved oxygen. The interaction of each of these constituents is shown graphically in Figure 4. Arrows indicate the normal direction of progression in a moderately polluted environment. Fecal coliforms do not react with these constituents and are therefore not shown on this diagram. Mathematical relationships for the individual reactions are detailed in Brown, 1987. The reaction rates and coefficients required for simulating these processes and a typical range for each parameter are presented in Appendix A.

Meteorological data are required for modeling temperature. Specific input data for QUAL2E are solar radiation, percent cloud cover, wet and dry bulb temperature, barometric pressure, and wind speed.

Figure 4. Major constituent interactions in QUAL2E



3.1.3 Limitations

QUAL2E is essentially a steady state model and therefore boundary conditions, flow, and pollutant loads are fixed for each simulation run. The exception to this is meteorological data, which can vary during a simulation. Parameters that are input into the model must therefore be representative of conditions over the period being simulated

QUAL2E is a one-dimensional model. Advection and dispersion are therefore assumed significant only in the main flow direction and each of the model elements is assumed to be completely mixed.

QUAL2E results, as defined in the source code, are reported to the second decimal place. In addition, constituent concentrations input into the model are often not collected beyond the second decimal place. Interpretation of model results beyond this limit of significant digits is not realistic although this hinders the analysis of trends near this threshold.

3.2 Model Input

Inputs for the QUAL2E model included hydraulic, headwater, point load, and meteorological data, in addition to reaction rates and coefficients. Much of this data was limited in availability. The model was calibrated using data representative of September 1996. Data for the months of July and August 1996 were used for verification. Headwater, point load, and meteorological data were typically selected as an average of daily values for a specific month. It is noted in the following text when this was not the case.

3.2.1 Hydraulics

Hydraulic parameters are required in the QUAL2E model to define depth and velocity in the channel. These data must be developed for each river reach in the model. Approximately sixty miles of the Okanogan River, from Malott to upstream of Oroville, and the first five miles of the Similkameen River, upstream from the Okanogan confluence, were modeled. Each section of the river was divided into reaches of not more than five miles in length, and then each of these reaches was discretized into quarter mile sections. Table 4 shows the approximate river mile location of cities, treatment plants, and gaging stations.

Table 4. Reference location to approximate nearest river mile

River Mile	Similkameen River Reference Location
5	USGS & Water Quality Gage.
4	Oroville Treatment Plant.
3	
2	
1	
0	Confluence with Okanogan River →

River Mile	Okanogan River Reference Location
78	Water Quality Gage
77	***Oroville***
76	
75	
74	Inflow from Similkameen River at Confluence.
73	
72	
71	***Cordell***
70	
69	
68	
67	
66	
65	
64	***Ellsforde***
63	
62	
61	
60	
59	
58	
57	***Tonasket.*** Water Quality Gage. Tonasket Treatment Plant.
56	
55	
54	
53	
52	***Janis***
51	USGS Gage.
50	
49	
48	
47	***Baker***
46	
45	
44	
43	
42	
41	***Riverside***
40	
39	
38	
37	***Cherokee***
36	
35	
34	
33	
32	
31	***Omak***
30	Omak Treatment Plant.
29	
28	
27	
26	***Okanogan***. USGS & Water Quality Gage.
25	Okanogan Treatment Plant.
24	
23	
22	
21	***Chillowist***
20	
19	
18	
17	***Malott***. USGS & Water Quality Gage.

Cross-sections were obtained at Oroville (both on the Similkameen and Okanogan), Tonasket, Omak, Okanogan, and Malott (USACE, 1972; WEST, 1996a, 1996b). Cross-section geometry, bed slope and Manning's *n* values were defined for each of these cross-sections (FEMA, 1977, 1982a, 1982b; WEST, 1996a, 1996b) and a stage-discharge curve, assuming normal depth, was determined at each cross-section. The curve was then fit to a power equation as required by the QUAL2E model. Each element in the model was then associated with coefficients from the power equation for the nearest cross-section.

3.2.2 Headwater Boundary Conditions

Flow and water quality constituent loads were required for both the Similkameen and Okanogan rivers to define the upstream boundary conditions. Data sources are shown in Table 5.

Table 5. Data sources for headwater boundary conditions

Flow:	Similkameen River near Nighthawk, WA, USGS Gage Station 12442500 Okanogan River at Oroville, WA, USGS Gage Station 12439500
Water Quality:	Similkameen River at Oroville, DOE Gage No. 49B070 Okanogan River at Oroville, DOE Gage No. 49A190

Discharge data have not been recorded at the USGS Similkameen River gage near Oroville (Station 12443500) since 1928 (USGS, 1999), therefore the upstream gage at Nighthawk was used.

The water quality parameters required for input into the QUAL2E model and recorded at the headwater gages for the simulation period were temperature, DO, fecal coliforms, NO2+NO3, NH3+NH4-, and total phosphorus. These parameters were sampled once each month and were used to represent monthly averages. BOD, chlorophyll a, organic nitrogen, nitrite, nitrate, NH3, and organic and dissolved phosphorus were not recorded for the simulation period, so these parameters were estimated for input into the model. Chlorophyll a and BOD data were extremely limited for all gages within the watershed. These values were estimated based on typical values observed at other locations at various times within the watershed. These were the best estimates given the available data and a similar approach was taken to determine values for organic nitrogen.

Combined nitrate plus nitrite was recorded at each station but not as individual values. An analysis was performed on the ratio of both NO2 and NO3 to NO2+NO3 over a period where all three values were recorded. Combined NO2+NO3 sampled at the headwaters was then divided by the average ratio for individual values of NO2 and NO3 and the upstream boundaries. NH3 in the model was assumed equal to the recorded value of NH3+NH4.

Organic and dissolved phosphorus concentrations were estimated to each be equal to half of the total phosphorus concentration.

3.2.3 Point Loads

The three wastewater treatment plants that discharge directly to the river (at Oroville, Omak, and Okanogan) were simulated as point loads in the QUAL2E model. Temperature, DO, 5-day BOD, and FC were sampled in the effluent of each of the treatment plants and reported in the treatment plant monitoring reports (City of Okanogan, 1996; City of Omak, 1996; City of Oroville, 1996). Nutrients were not reported in these reports and were therefore estimated. Typical secondary effluent contains approximately 32 mg/l nitrogen and 7 mg/l phosphorus (HCW-L, 1999). The nitrogen concentration was split proportionally to existing ratios of organic nitrogen, NH3, NO2, and NO3 to total nitrogen observed in the river. The total phosphorus concentration was split evenly between organic and dissolved phosphorus. Treatment plant effluent was estimated to have a chlorophyll a concentration equal to that of the headwaters.

3.2.4 Meteorology

Average monthly meteorological parameters were determined from stations within the Okanogan Watershed when available, although some data from outside the watershed were also used. Sensitivity analysis later showed that modeled results were not significantly sensitive to the input values.

Average monthly values of solar radiation, dry bulb temperature, and wind speed were obtained from the Public Agricultural Weather System (PAWS) gage at Tonasket (PAWS, 1999). Average monthly values of wet bulb temperature were computed from psychrometric tables using a monthly average of daily relative humidity and dry bulb temperature data at Omak (Lindsey, 1982; PAWS, 1999). Percent cloud cover and barometric pressure at Spokane were obtained from the Washington Regional Climate Center (WRCC, 1999).

3.2.5 Reaction Rates and Coefficients

Typical ranges of the reaction rates and coefficients used in the QUAL2E model are listed in Bowie, 1985 and Appendix A. Initial values were selected based on these tables, and sensitivity of the results within the provided ranges was later investigated.

3.3 Sensitivity Analysis

Sensitivity of results to the reaction rates and coefficients were analyzed using the September 1996 data. This was accomplished by varying one parameter within the expected range of values while keeping all other parameter values fixed. Although modifying reaction rates and coefficients affected the results (Appendix B), this change was typically minimal.

Sensitivity on the results of the meteorological data recorded outside the watershed were also analyzed. Most of the meteorological parameters have a range limited by constraints within the QUAL2E model. These parameters were varied within this range to test the sensitivity of the results. The greatest changes were due to wet bulb temperature and wind speed, which could each vary the water temperature by up to 10 degrees. Dry bulb temperature and cloud cover had much less of an impact on the September results. Solar radiation and barometric pressure had no significant influence.

3.4 Calibration - September 1996

3.4.1 Calibrated Values and Results.

Once the sensitivity of the model parameters was assessed, calibration focused on adjusting those causing the greatest change in model results. The model was calibrated to September 1996 data and the results are generally close to observed values. The constituent values were from samples taken once during the month and are assumed to be representative of typical values for the month. The calibrated rates and coefficients are shown in Appendix B. A comparison of calibrated to observed values are shown in Table 6. Calibration locations are Tonasket, Okanogan, and Malott.

Table 6. Comparison of observed to calibrated data for September 1996

Constituent	Data type	Calibration Location Tonasket	 Okanogan	 Malott
Temperature	OBS	65	64.4	64.9
(°F)	CAL	64.28	64.20	64.19
Nitrate + nitrite	OBS	0.013	0.023	0.025
(mg/L)	CAL	0.01	0.02	0.03
Ammonia	OBS	0.01	0.01	0.01
(mg/L)	CAL	0.01	0.01	0.01
Total phosphorus	OBS	0.017	0.022	0.019
(mg/L)	CAL	0.02	0.03	0.03
Dissolved Oxygen	OBS	9.8	9.8	10.1
(mg/L)	CAL	8.26	8.27	8.27
Fecal Coliforms	OBS	60	10	13
(#/100mL)	CAL	8.29	2.08	1.57

3.5 Verification - July and August 1996

3.5.1 Results

Once the model was calibrated, reaction rates and coefficients from the calibrated model were then used with headwater, point load, and meteorological data to verify the model. This was performed for both the months July and August of 1996 (Table 7 and Table 8). These results show that the selected rates and coefficients adequately predict conditions found during low flows (e.g., August). They may not appropriately represent the system during higher flows (e.g., July).

Table 7. Comparison of observed to verification data for August 1996

Constituent	Data type	Verification Location Tonasket	Okanogan	Malott
Temperature (°F)	OBS	70.3	71.4	71.6
	VER	70.69	73.0	73.44
Nitrate + nitrite (mg/L)	OBS	0.01	0.01	0.01
	VER	0.01	0.02	0.02
Ammonia (mg/L)	OBS	0.01	0.01	0.01
	VER	0.00	0.01	0.01
Total phosphorus (mg/L)	OBS	0.023	0.014	0.025
	VER	0.01	0.02	0.02
Dissolved Oxygen (mg/L)	OBS	9	8.7	8.1
	VER	7.66	7.42	7.38
Fecal Coliforms (#/100mL)	OBS	49	74	29
	VER	7.18	2.59	1.88

Table 8. Comparison of observed to verification data for July 1996

Constituent	Data type	Verification Location Tonasket	Okanogan	Malott
Temperature (°F)	OBS	70	70.9	70.7
	VER	71.46	73.25	73.67
Nitrate + nitrite (mg/L)	OBS	0.01	0.01	0.01
	VER	0.02	0.03	0.03
Ammonia (mg/L)	OBS	0.01	0.01	0.01
	VER	0.01	0.01	0.01
Total phosphorus (mg/L)	OBS	0.011	0.032	0.01
	VER	0.07	0.07	0.07
Dissolved Oxygen (mg/L)	OBS	8.6	8.1	8.2
	VER	8.12	7.60	7.52
Fecal Coliforms (#/100mL)	OBS	29	55	64
	VER	8.70	4.46	3.66

SECTION 4. Assessment of Results

4.1 Temperature

Temperature was calculated in the QUAL2E model using a comprehensive heat energy balance. The temperature model in QUAL2E has no direct calibration coefficients.

Considering the range of meteorological stations that were used to provide the various heat energy balance variables, QUAL2E does a very good job of calculating water temperature during August and September. Calculated temperatures were always within 2°F and often within 1°F.

Water temperatures in the Okanogan River during the summer months are influenced by a number of processes. Osoyoos Lake is relatively quiescent, and tends to heat up during the late spring and summer months resulting in temperatures several degrees warmer than the lower Okanogan River. However, inflows from the Similkameen River are generally much colder (5 to 7 °F during July though September 1996), and there is a significant drop in temperature following mixing of the two waterways downstream of their confluence. From this point, solar heating gradually warms the lower-altitude and slower-moving Okanogan River.

4.2 Nutrients and Algal Growth

Nutrients proved to be very difficult to simulate with QUAL2E in the Okanogan River for two main reasons. First, the nutrient concentrations observed are very low. Second, the observed and computed concentrations are at the limits of the numerical precision reported by the model.

QUAL2E output is reported to two decimal places. Therefore, a reported concentration of 0.02 mg/L, could be anywhere on the range of 0.0150-0.0249 mg/L. Water quality observations are also reported to two decimal places (occasionally to the nearest 0.005 mg/L). Taken together, therefore, differences between computed and observed values within 0.01 mg/L could be viewed as representing "good" agreement.

An additional complication is that water quality observations were not always reported as concentrations of variables required by the model. For example, observations were often reported for nitrites plus nitrates, whereas QUAL2E requires inputs of each type of nitrogen load. Also, observations were usually reported for total phosphorus, whereas QUAL2E requests input of organic and dissolved phosphorus separately.

Given the lack of information about the actual distributions of the forms of nutrients, the very low concentrations reported, and the precision reported in both the observations and QUAL2E output, the model generally reported all forms of nutrients within 0.01 mg/L during August and September 1996. Verification was not as good during higher flows in July. These values are considered to be sufficiently accurate for the purpose of calibrating and validating this preliminary water quality model of the Okanogan River.

The treatment plants were modeled using loads of 32 mg/L total nitrogen and 7 mg/L total phosphorus. Compared to background river concentrations on the order of 0.02 mg/L, this seems relatively large, and is typical of WWTP discharges nationwide (see, for example, Thomann and Mueller, 1987). The model does show local increases in nutrient concentrations immediately downstream of these discharges. However, even during low river flow conditions the WWTP discharges on the order of 1 cfs are very small compared to the river flow of about 1,000 cfs, and the various nutrient forms only increase by about 0.01 mg/L. This is confirmed by observations. Carey (1990) monitored the Okanogan River during October 1988, and reported nitrites plus nitrates of 0.02 mg/L just upstream of the Okanogan WWTP discharge, but only 0.01 mg/L downstream, and “high” values of 0.04 mg/L just downstream of the “boil”.

Algae use both nitrogen and phosphorus for growth. Thomann and Mueller discuss that lakes are considered to be oligitrophic (having very low algal growth potential) when concentrations of chlorophyll a (an indicator constituent) are less than 1-4 ug/L. [They do not report a similar criterion for rivers]. Only two data values of chlorophyll a, 8.8 and 4 ug/L sampled in 1979 and 1980 at Malott, were available for the entire watershed and these may be influenced by backwater effects from the Columbia River. However, all modeled results were less than 1 ug/L chlorophyll a, suggesting that upstream of Malott, at least, nutrient enrichment, eutrophication and algal blooms are not of concern.

Originally, it was intended to develop the QUAL2E model of the Okanogan River as a demonstration to simulate WWTP load reductions, as if tertiary treatment were provided to remove additional nutrients. After examining the model calibration and validation, it became clear that this exercise would not produce meaningful results. If the discharge of nitrogen from the WWTPs (nitrogen appears to be the “limiting” nutrient in this reach of the Okanogan River) was reduced, or even completely removed, the results would only be sensitive to the second decimal place (0.01 mg/L), and it would be difficult to distinguish between the effects of secondary and tertiary discharges. Therefore no model runs were conducted using varied WWTP loadings.

4.3 Dissolved Oxygen

Many water quality processes consume dissolved oxygen (DO). These include the neutralization of biochemical oxygen demand (BOD), the conversion of various nitrogen and phosphorus forms through the nutrient cycle, and algal respiration. However, their influence on DO concentrations in the Okanogan River is not clear, as constituent concentrations are generally very low. For example, neither observations nor computations show significant changes downstream of WWTP discharges.

In each of the three months modeled (July, August and September 1996), DO levels from Osoyoos Lake are relatively high, start dropping as some oxygen is consumed, increase again with mixing of the Similkameen River inflow, and then slowly drop downstream along the Okanogan River. A decline in DO would be expected as the water temperature increases.

Generally, the model seems to underpredict DO by up to 1 mg/L when compared to measured values. One possible cause of this could be the inability of the model to predict supersaturated conditions. It appears that DO consumption along the Okanogan River is generally quite small, in that there simply isn't sufficient oxygen consuming material in the water to cause major DO sags. However, there is sufficient DO demand that the model shows a small decline downstream of the confluence with the Similkameen River. In the Okanogan River, DO reaeration is sufficient to more than compensate for the use of DO. In fact, it appears that reaeration is sufficient to create supersaturated DO conditions (as shown by the high reported DO concentrations and their percent saturation values). However, while the model does replace some of the DO lost to water column kinetic processes, it does not appear to add additional DO through mechanical mixing processes such as due to wind which can lead (physically) to supersaturated conditions.

Although there was no BOD data available for 1996 the model results are similar to samples collected in 1972 and 1979 (EPA, 1999). BOD levels are relatively constant for these years indicating the lack of other BOD sources in the river.

4.4 Fecal Coliforms

Fecal coliforms were simulated using "observed" headwater loads from Osoyoos Lake and the Similkameen River, and loads measured at the individual WWTPs. A decay rate of 1.0 per day (near the median of the typical range for the parameter) was specified, which represents a relatively slow "T_{90}" rate of about three days. Even with the slow decay rate specified (a loss in mass of approximately 70 to 85%), the model calculations were considerably lower than observations. This suggests several things.

First, for each of the three months modeled (July, August and September 1996), there is a large increase in fecal coliform concentrations downstream of the confluence with the Similkameen River. In each month (particularly July 1996) the headwater concentrations in the Similkameen River were at least twice (and usually more) than the headwater concentrations from Osoyoos Lake.

Second, while modeled concentrations do not exceed 15 #/100 ml, observations at water quality monitoring stations along the Okanogan River are often considerably higher (up to 72 #/100 ml). Furthermore, loads from the various WWTPs seem to have little noticeable affect on main stem concentrations. This suggests that there are "other" sources of fecal coliform loads to the Okanogan River, which are not coming from the various WWTPs. This is somewhat confirmed by a water quality monitoring study conducted by the Department of Ecology in the vicinity of the City of Okanogan's WWTP discharge (Carey, 1990). The results showed (1) that fecal coliform concentrations were relatively high upstream of the discharge location, (2) that the upstream concentrations were, in fact, even larger than those downstream, and (3) the discharge from both the WWTP and a nearby apple processing plant did not have measurable effects on downstream fecal coliform concentrations.

SECTION 5. Discussion and Recommendations

5.1 Discussion

The water quality model was helpful in examining and evaluating a variety of water quality processes in the Okanogan River. The model focused on simulating "conventional" water quality constituents, such as temperature, dissolved oxygen, nutrients and fecal coliforms. The reason for focusing on "conventional" water quality constituents is that there are no known "point" source discharges of “toxic” constituents listed as having water quality standard exceedances. The “other” constituents listed as violating water quality standards include DDT (discontinued in the 1970s, but still present in soils) and PCBs (source unknown).

Temperature is a “listed” water quality constituent that regularly exceeds State of Washington water quality standards during warm summer months. It is clear that its origin is natural, and not greatly influenced by anthropogenic factors south of the Canadian border. While water temperatures are high leaving Osoyoos Lake, they are not significantly higher than those measured downstream, even following the mixing with cooler waters from the Similkameen River. It appears that the river is simply wide, shallow, and somewhat slow moving, and that there is sufficient summer heating to raise temperatures above water quality standards. Given the physical setting of the river, it is difficult to imagine any “mitigation” that could be reasonably proposed to lower high summer river temperatures.

The model was useful in illustrating that nutrient concentrations in the Okanogan River are very low, and that inflows from point sources, such as WWTPs, are small and quickly assimilated into the river even during the low-flow conditions found during the later summer months. Background nutrient concentrations are generally on the order of 0.02 mg/L, which is about two orders of magnitude smaller than concentrations found in rivers with algal bloom problems. During low-flow months, the river discharge is still about 1,000 times that of individual point source discharges. This means that following initial dilution (defined here as complete mixing with the river), the increase in the concentrations of individual nutrient constituents is only on the order of 0.01 mg/L. At these concentrations, while algae can theoretically develop, there is insufficient biomass to cause anything approaching a nuisance problem.

Nutrient and BOD concentrations are generally quite low in the Okanogan River, and initial mixing, even during low-flow months, is relatively high. Therefore, generally there is little significant demand on DO and DO levels usually remain high. Most of the DO concentrations measured represent supersaturation values, which not only confirms that oxygen demand is small, but also suggests that there is significant mechanical mixing in the river (probably due to wind shear) to force additional oxygen into the water column. Certainly, the model results do not indicate any anthropogenic process that would exert sufficient DO demand to cause violations of DO standards.

Finally, the model was not able to accurately simulate the along-river distribution of fecal coliforms, even with the relatively slow decay rate used. Again, there is so much potential mixing at each point source discharge location that it is clear that WWTP discharges cannot cause the elevated fecal coliform concentrations observed along the river. In addition, observed downstream concentrations are often higher than those upstream, and occasionally exceed water quality criteria, rather than declining as predicted in the model. If the elevated levels of fecal coliforms are not caused by WWTP discharges, then there must be additional loads to the system, responsible for producing the high concentrations occasionally observed and preventing the normal decay curve from applying.

5.2 Recommendations

The QUAL2E modeling and evaluation was useful in narrowing down issues to be addressed in identifying and quantifying water quality processes in the Okanogan River. This study shows that the major "conventional" constituent causing potential water quality violations is fecal coliforms. However, it is equally clear that its major source is not from WWTP discharges.

Another factor in recommending additional water quality studies, is that while it is believed other processes do not cause significant water quality problems, there are insufficient measurements to directly confirm this. Therefore, some additional measurements would be useful to confirm this conclusion.

The following specific recommendations are made to improve knowledge of water quality processes along the Okanogan River, to remove some processes from further consideration for causing water quality exceedances, and to isolate those processes that do:

1. It is clear that fecal coliform levels have the potential to cause water quality exceedances and are not entirely caused by discharges from point sources like WWTPs. A major study recommendation is to determine the quantities (flows and mass) of fecal coliform loads to the Okanogan River from <u>all</u> sources. These include not only WWTPs, but also non-point sources such as animal feed lots, septic tanks, and duck feces, etc.

2. Nutrient concentrations, observed and modeled, suggest that there is a very low potential for significant algal blooms in the Okanogan River above Malott. [It should be noted that algal blooms have been observed downstream in the backwater from the confluence with the Columbia River.] To confirm these low algal levels, it is recommended that chlorophyll-a be measured at all the major water quality monitoring stations for at least two years. Monthly measurements are preferable, particularly from the spring through the late fall (April-October). It is not believed that winter sampling is necessary.

3. Nutrient and BOD concentrations suggest that there is only a small demand on dissolved oxygen (DO) in the river. In addition, it is believed that algal concentration will be low, and that there will not be significant DO diurnal variations due to algal photosynthesis and respiration. To confirm this, it is recommended that several, intensive short-term studies be conducted at sites along the river. At a minimum, two sites should be selected and sampled during potential spring and fall algal bloom seasons. The study should sample for various nutrient forms, DO, temperature and chlorophyll-a at 3-hour intervals for two days each.

4. While the model did a reasonable job of reproducing observed water temperatures based on a comprehensive heat energy balance, the data provided to the model came from a variety of sources. An evaluation of the existing meteorological stations along the river should be done and one or two identified that could easily be augmented to measure the complete range of variables required as input to the heat energy balance.

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Appendix A. Range of QUAL2E Reaction Coefficients (Brown, 1987)

Variable	Description	Units	Range of Values
α_0	Ratio of chlorophyll-a to algal biomass	$\frac{\text{ug-Chla}}{\text{mg A}}$	10-100
α_1	Fraction of algal biomass that is Nitrogen	$\frac{\text{mg-N}}{\text{mg A}}$	0.07-0.09
α_2	Fraction of algal biomass that is Phosphorus	$\frac{\text{mg-P}}{\text{mg A}}$	0.01-0.02
α_3	0_2 production per unit of algal growth	$\frac{\text{mg-O}}{\text{mg A}}$	1.4-1.8
α_4	0_2 uptake per unit of algae respired	$\frac{\text{mg-O}}{\text{mg A}}$	1.6-2.3
α_5	O2 uptake per unit of NH3 oxidation	$\frac{\text{mg-O}}{\text{mg N}}$	3.0-4.0
α_6	O2 uptake per unit of NO2 oxidation	$\frac{\text{mg-O}}{\text{mg N}}$	1.0-1.14
μ_{max}	Maximum algal growth rate	day $^{-1}$	1.0-3.0
ρ	Algal respiration rate	day $^{-1}$	0.05-0.5
K_L	Michaelis-Menton half-saturation constant for light (Option 1)	Btu/ft^2-min	0.02-0.10
K_N	Michaelis-Menton half-saturation content for nitrogen	mg-N/L	0.01-0.30
K_P	Michaelis-Menton half-saturation constant for phosphorus	mg-P/L	.001-0.05
λ_0	Non-algal light extinction coefficient	ft-1	Variable
λ_1	Linear algal self-shading coefficient	$\frac{\text{1/ft}}{\text{ug Chla/L}}$	0.002-0.02

Variable	Description	Units	Range of Values
λ_2	Nonlinear algal self-shading coefficient	$\frac{1/ft}{(\mu g\ Chla/L)^{2/3}}$	0.0165 (Riley)
P_N	Algal preference factor for ammonia	---	0.0-1.0
σ_1	Algal settling rate	ft/day	0.5-0.6
σ_2	Benthos source rate for dissolved phosphorus	$\frac{mg\text{-}P}{ft^2\text{-}day}$	Variable
σ_3	Benthos source rate for ammonia nitrogen	$\frac{mg\text{-}O}{ft^2\text{-}day}$	Variable
σ_4	Organic nitrogen settling rate	day^{-1}	0.001-0.1
σ_5	Organic phosphorus settling rate	day^{-1}	0.001-0.1
σ_6	Arbitrary non-conservative settling rate	day^{-1}	Variable
σ_7	Benthal source rate for arbitrary non-conservative settling rates	$\frac{mg\text{-}ANC}{ft^2\text{-}day}$	Variable
K_1	Carbonaceous deoxygeneratrion rate constant	day^{-1}	0.02-3.4
K_2	Reaeration rate constant	day^{-1}	0.0-100
K_3	Rate of loss of BOD due to settling	day^{-1}	-0.36-0.36
K_4	Benthic oxygen uptake	$\frac{mg\text{-}O}{ft^2\text{-}day}$	Variable
K_5	Coliform die-off rate	day^{-1}	0.05-4.0
K_6	Arbitrary non-conservative decay coefficient	day^{-1}	Variable

Variable	Description	Units	Range of Values
β_1	Rate constant for the biological oxidation of NO3 to NO2	day $^{-1}$	0.10-1.00
β_2	Rate constant for the biological oxidation of NO2 to NO3	day $^{-1}$	0.20-2.0
β_3	Rate constant for the hydrolysis of organic-N to ammonia	day $^{-1}$	0.02-0.4
β_4	Rate constant for the decay of organic-P to dissolve-P	day $^{-1}$	0.01-0.7

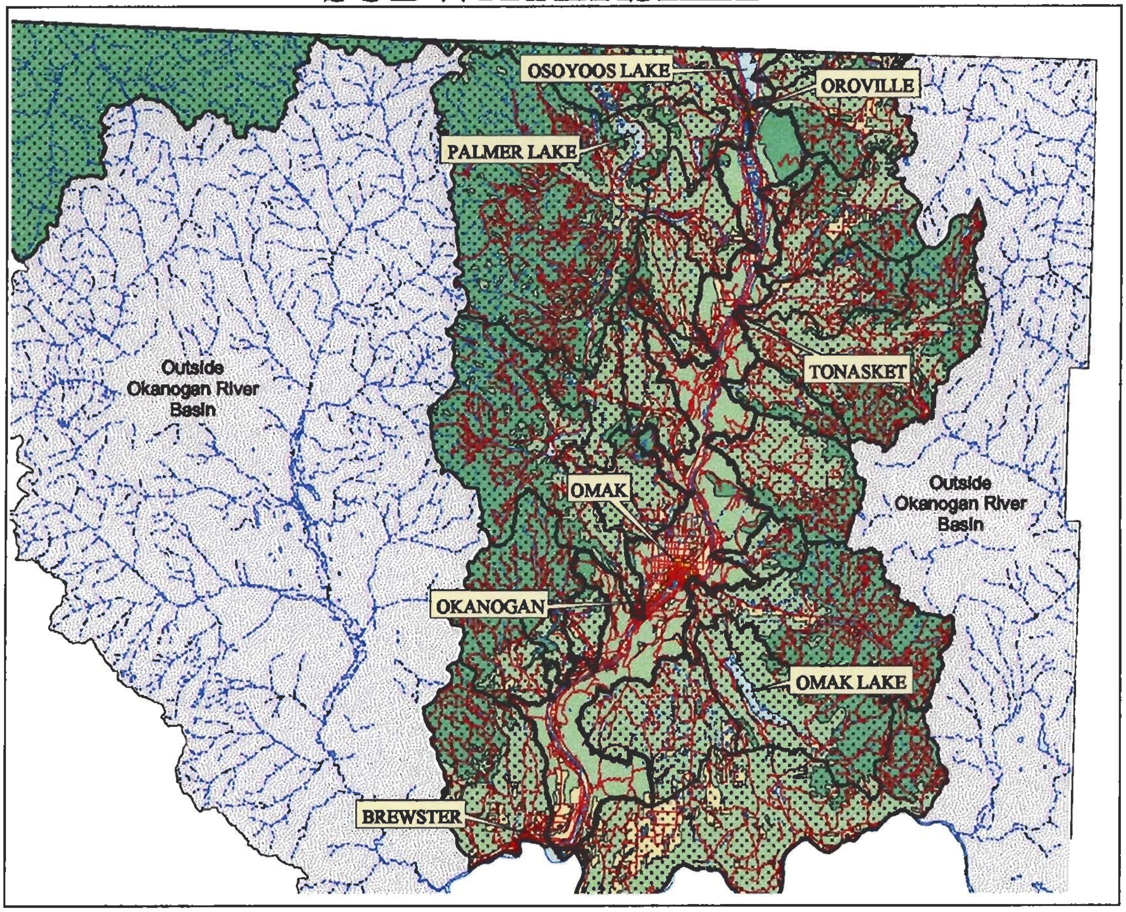
Appendix B. Calibrated Reaction Rates and Coefficients

Parameter	Initial Estimate	Minimum Value Tested	Affected Results	Maximum Value Tested	Affected Results	Final Calibrated Value
BOD Decay (k1)	*1.00*	*0.02*	*BOD, DO*	*3.40*	*BOD*	1.00
BOD Settling (k3)	0.10	0	No change	0.36	No change	0.10
SOD Rate (k4)	*0.10*	*0.00*	*DO increase*	*1.00*	*DO decrease*	0.10
Type Reaeration (k2)	Churchill	Various	(see below)	Various	(see below)	Churchill
O-N Hydrolysis (b3)	*0.10*	*0.020*	*N Cycle*	*1.080*	*N Cycle*	0.03
O-N Settling (s4)	*0.01*	*0.001*	*N Cycle*	*0.100*	*N Cycle*	0.01
NH3 Oxidation (b1)	*1.00*	*0.003*	*N Cycle*	*1.047*	*N Cycle*	1.00
NH3 Benthos (s3)	0.01	0.001	No change	1.090	No change	0.01
NO2 Oxidation (b2)	1.00	0.090	No change	2.000	No change	1.00
O-P Decay (b4)	*0.10*	*0.010*	*P Cycle*	*0.700*	*P Cycle*	0.10
O-P Settling (s5)	0.01	0.001	No change	0.100	No change	0.01
DIS-P Benthos (s2)	*0.01*	0.0004	No change	*1.140*	*P Cycle*	0.01
CHL-Algae (a0)	*50.00*	*1.000*	*N & P cycles*	100.000	No change	50
Algae settling (s1)	1.00	0.500	No change	0.600	No change	1.00
Non-Algal Light Ext (l0)	0.01	0.001	No change	1.000	No change	0.01
Coliform (k5)	*1.00*	*0.050*	*FC*	*4.000*	*FC*	1.00

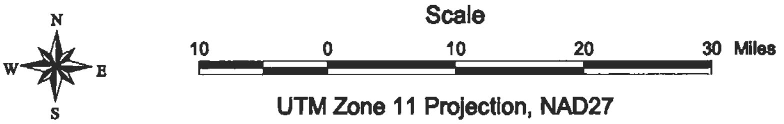
Parameter values in *italics* were modified during the calibration process.

Power Funciton, Single Coefficeint, and T.S. Voglow & Walace lowered DO. O'Connor & Dobbins, Owens, Ed & Gibbs, and Thackston & Krenkel had no change.

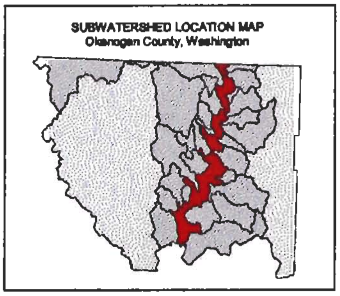
A - OKANOGAN RIVER INTERFLUVE SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	17,513.7	8.6
Range	140,640.8	68.8
Cropland: non-irrigated small grains	3,949.1	1.9
Cropland: non-irrigated pasture and hay	2,753.9	1.3
Cropland: irrigated hay	4,977.6	2.4
Cropland: irrigated orchard	24,729.6	12.1
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	4,151.9	2.0
Open Water	5,681.0	2.8
Total sub-watershed size	204,397.6	100%
Percent of Okanogan Watershed	12.26%	



UTM Zone 11 Projection, NAD27



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

Sources: The data shown on this map was compiled to meet a scale accuracy of 1:100,000. The subwatershed boundaries are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

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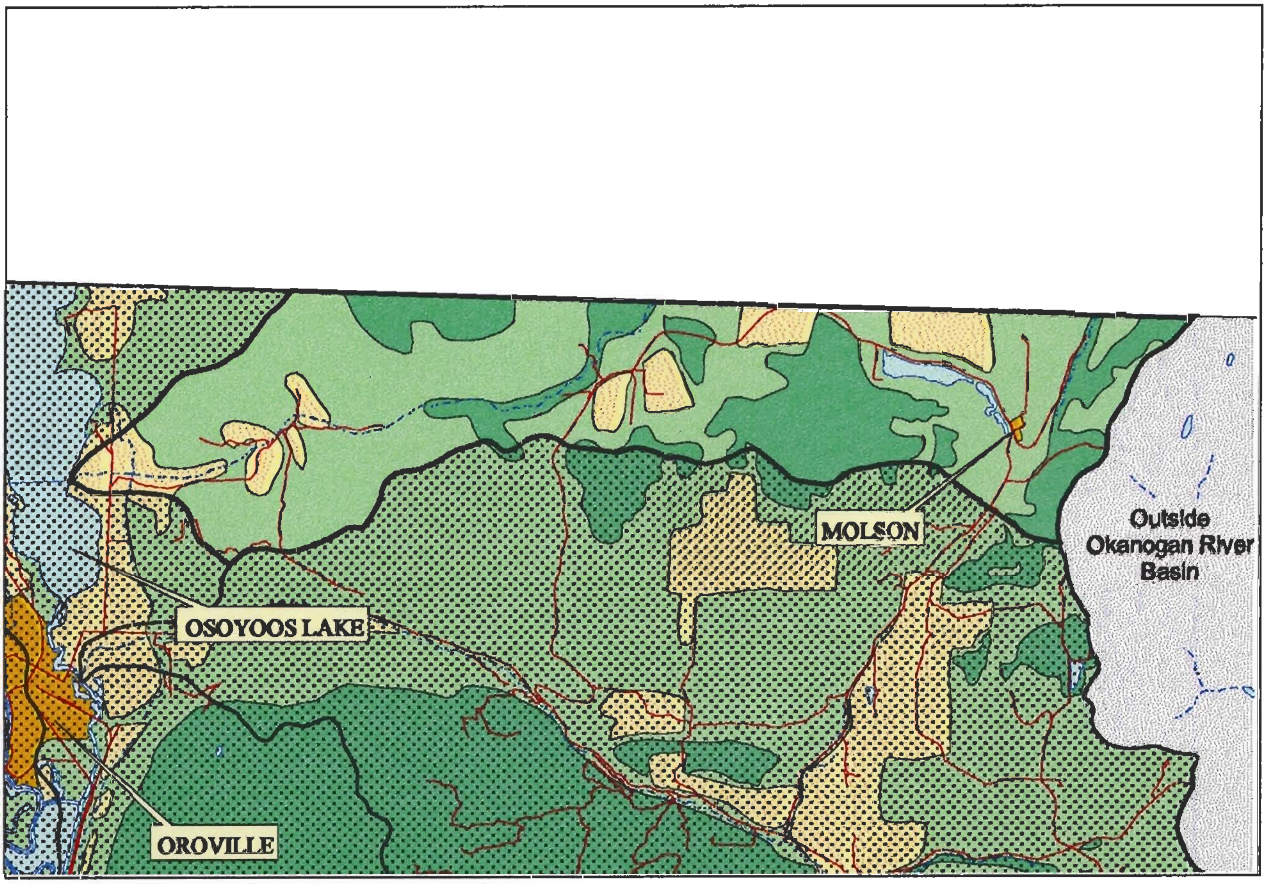
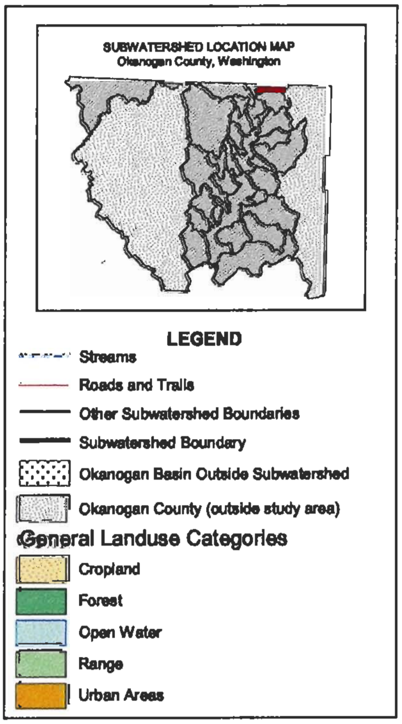
July 1998 (revised March 1999)

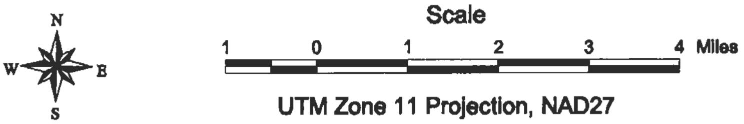
NOTE: All boundaries are approximate.

B - NINE MILE CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	3,603.7	26.7
Range	8,156.3	60.3
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	1,017.1	7.5
Cropland: irrigated hay	192.0	1.4
Cropland: irrigated orchard	405.9	3.0
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	16.1	0.1
Open Water	125.0	1.0
Total sub-watershed size	13,516.1	100%
Percent of Okanogan Watershed	0.81%	





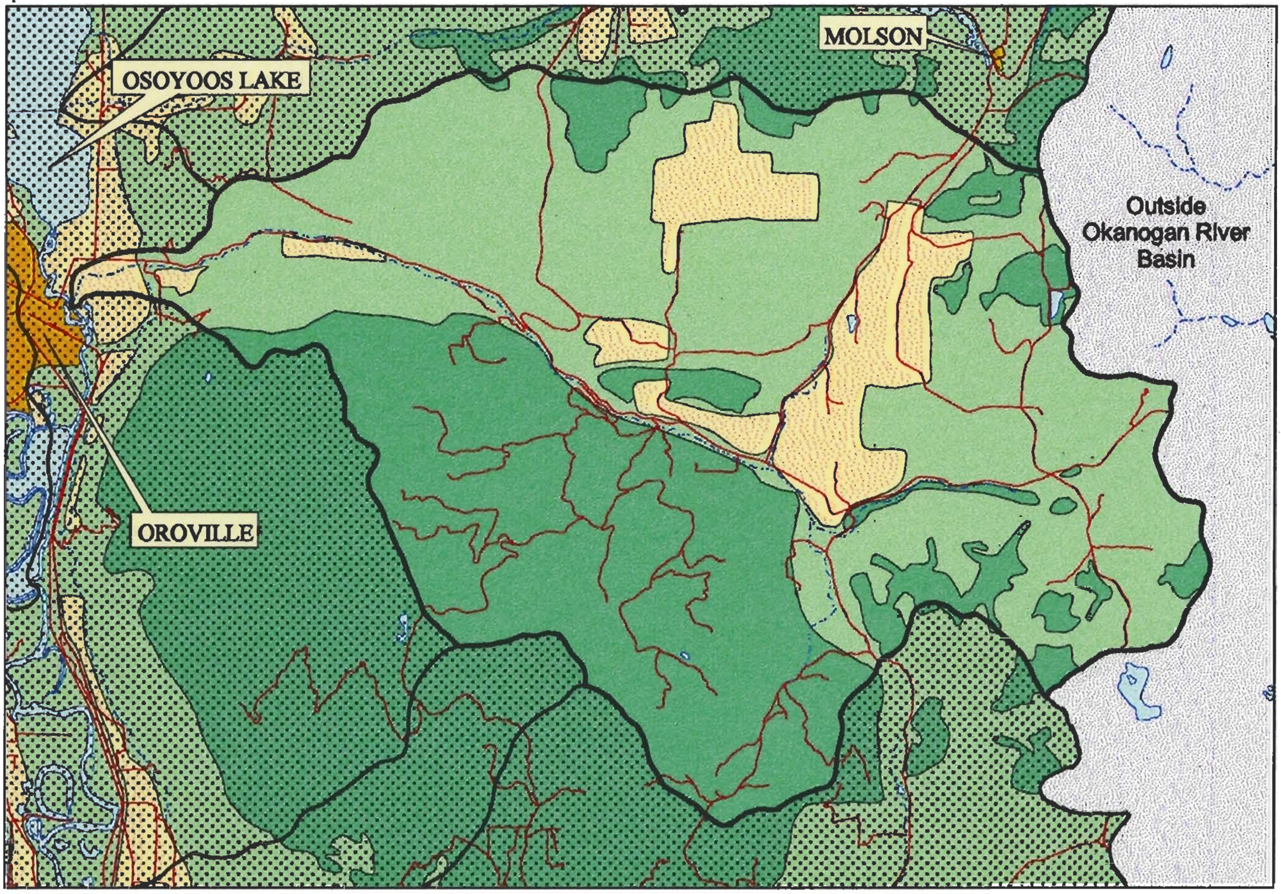
UTM Zone 11 Projection, NAD27

Sources: The data shown on this map was compiled to meet a scale accuracy of 1:100,000. The subwatershed boundaries are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

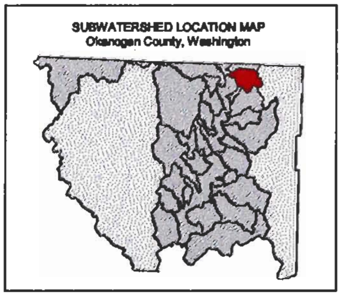
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

C - TONASKET CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	14,437.1	38.1
Range	19,229.2	51.0
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	3,906.9	10.3
Cropland: irrigated hay	0.0	0.0
Cropland: irrigated orchard	273.4	0.7
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	27.1	0.1
Total sub-watershed size	37,873.7	100%
Percent of Okanogan Watershed	2.27%	



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

Scale

1 0 1 2 3 4 Miles

UTM Zone 11 Projection, NAD27

Sources: The data shown on this map was compiled to meet a scale accuracy of 1:100,000. The subwatershed boundaries are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

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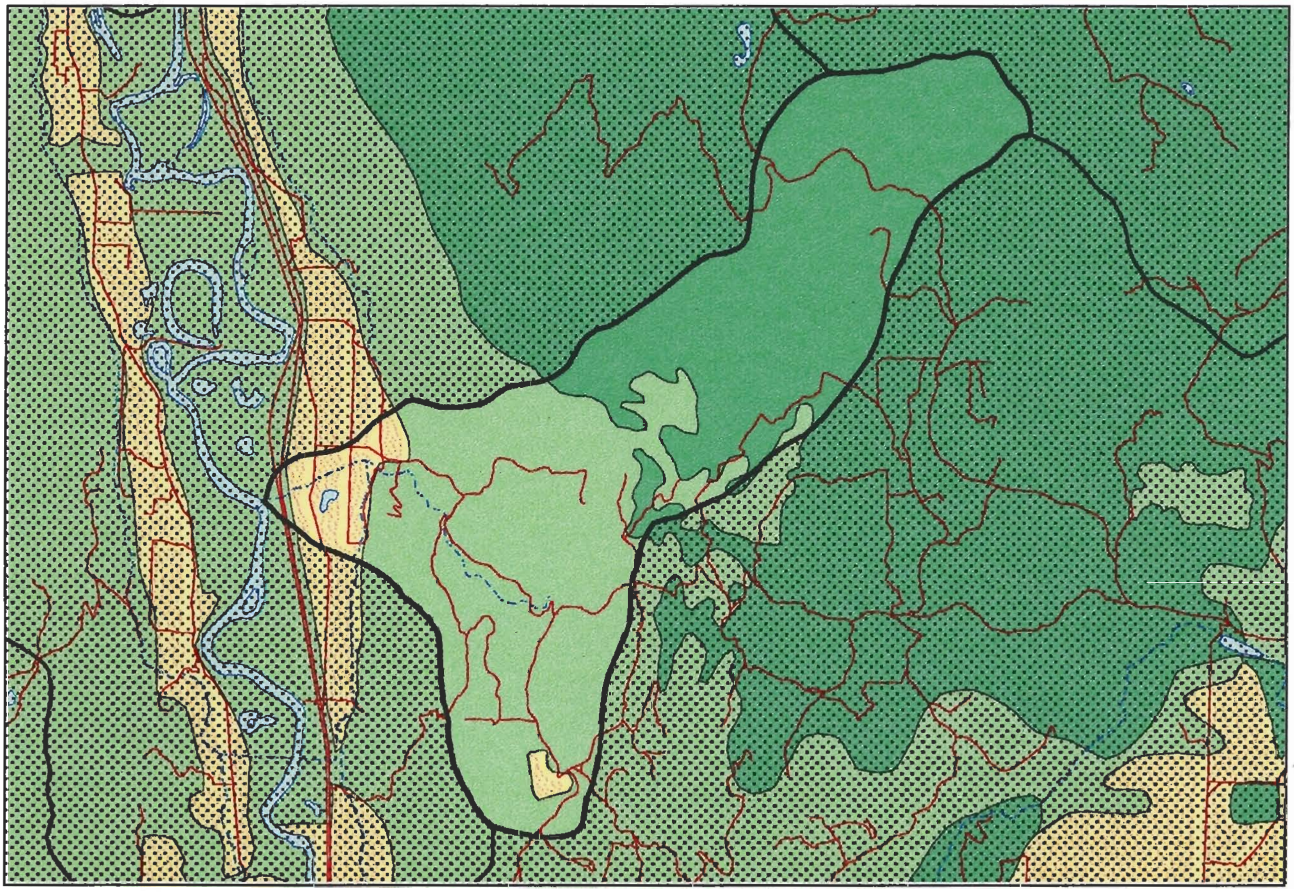
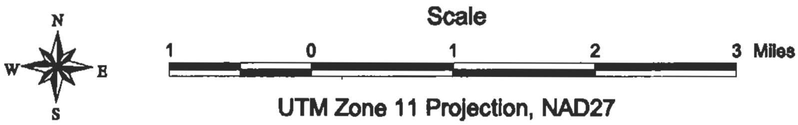
July 1998 (revised March 1999)

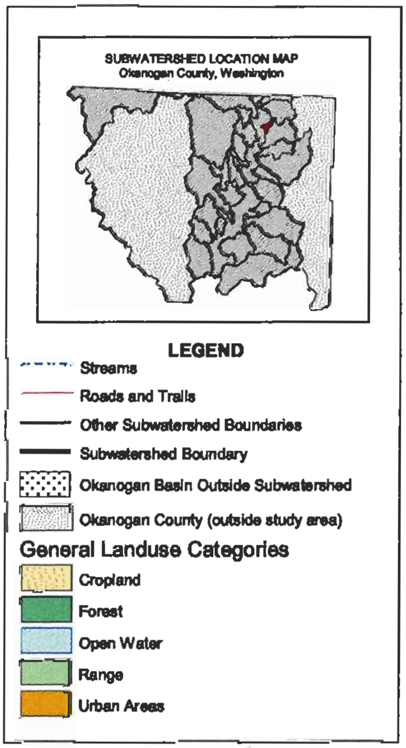
NOTE: All boundaries are approximate.

D - MOSQUITO CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	2,769.0	45.6
Range	2,971.1	48.8
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	40.8	0.7
Cropland: irrigated hay	0.0	0.0
Cropland: irrigated orchard	297.7	4.9
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	0.6	NS
Total sub-watershed size	6,092.5	100%
Percent of Okanogan Watershed	0.37%	





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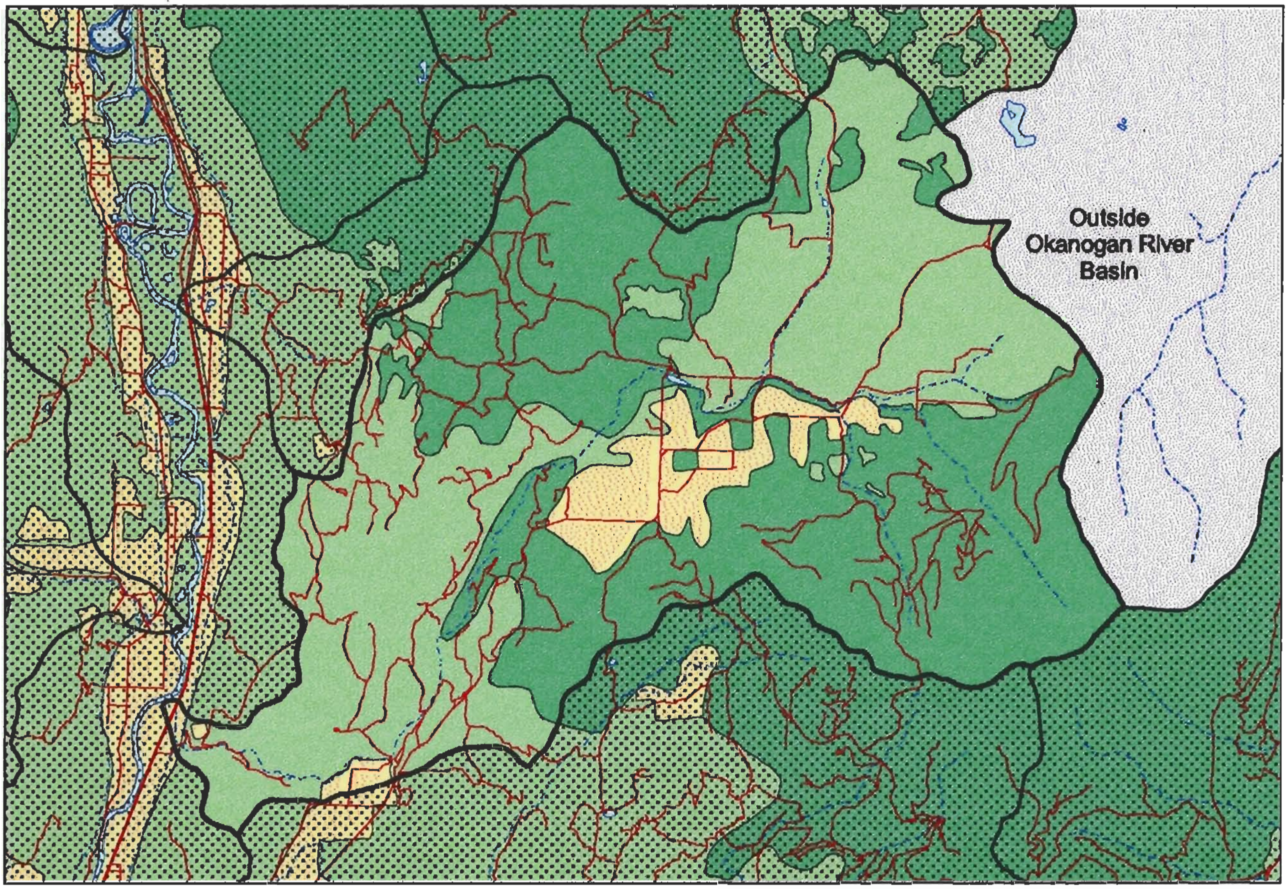
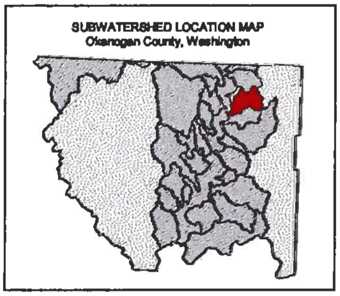
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

E - ANTOINE CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	22,809.4	48.9
Range	20,793.6	44.5
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	2,836.8	6.1
Cropland: irrigated hay	120.3	0.26
Cropland: irrigated orchard	114.8	0.24
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	15.2	0.0
Total sub-watershed size	46,690.1	100%
Percent of Okanogan Watershed	2.8%	



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

N
W E
S

Scale

1 0 1 2 3 4 5 Miles

UTM Zone 11 Projection, NAD27

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USDA Natural Resources Conservation Service
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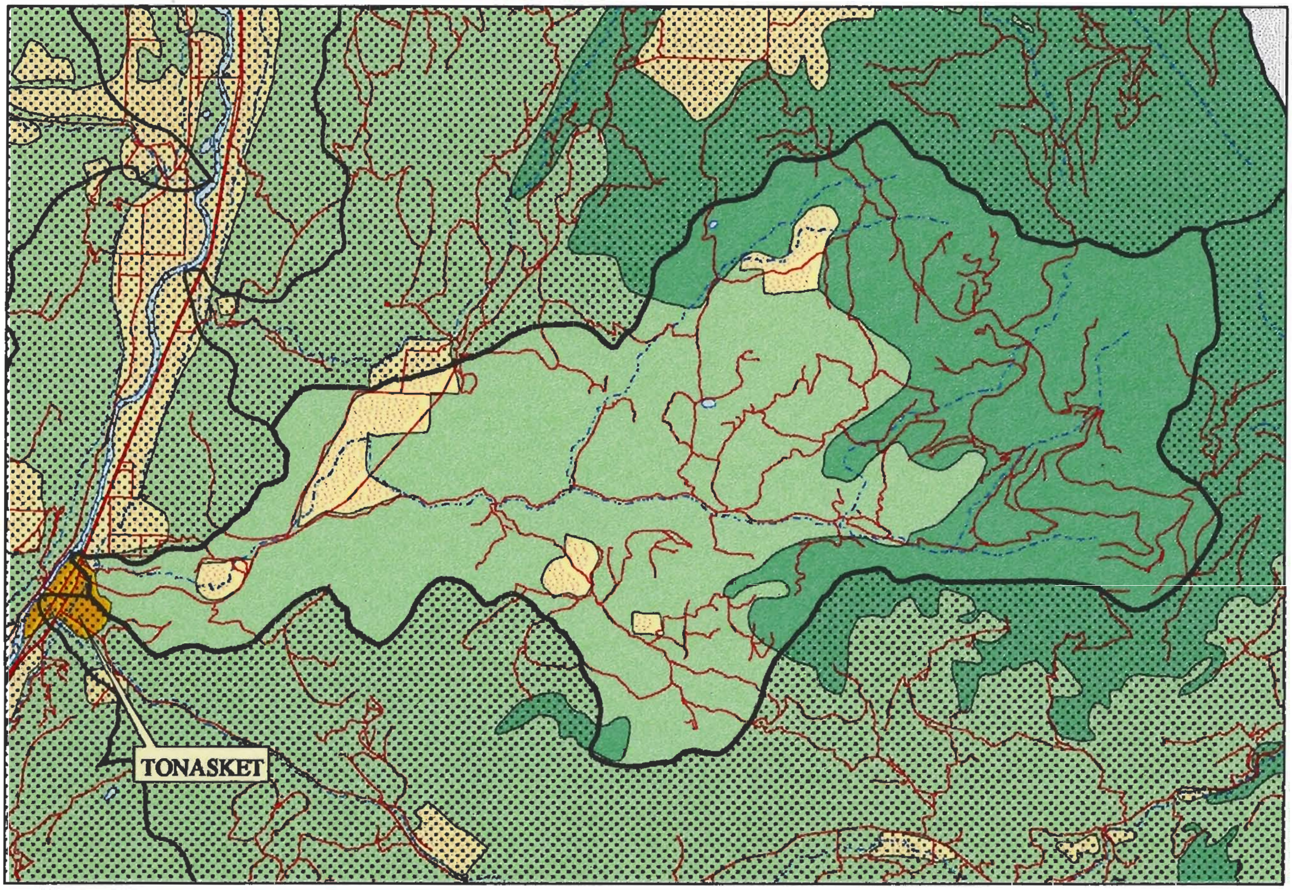
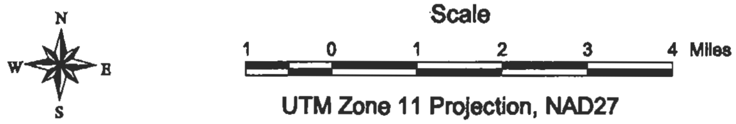
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

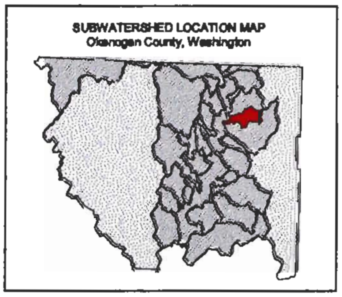
F - SIWASH CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	12,648.6	40.8
Range	16,690.4	53.8
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	927.1	3.0
Cropland: irrigated hay	649.0	2.1
Cropland: irrigated orchard	50.3	0.1
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	54.8	0.2
Open Water	11.5	0.0
Total sub-watershed size	31,031.7	100%
Percent of Okanogan Watershed	1.9%	



UTM Zone 11 Projection, NAD27



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

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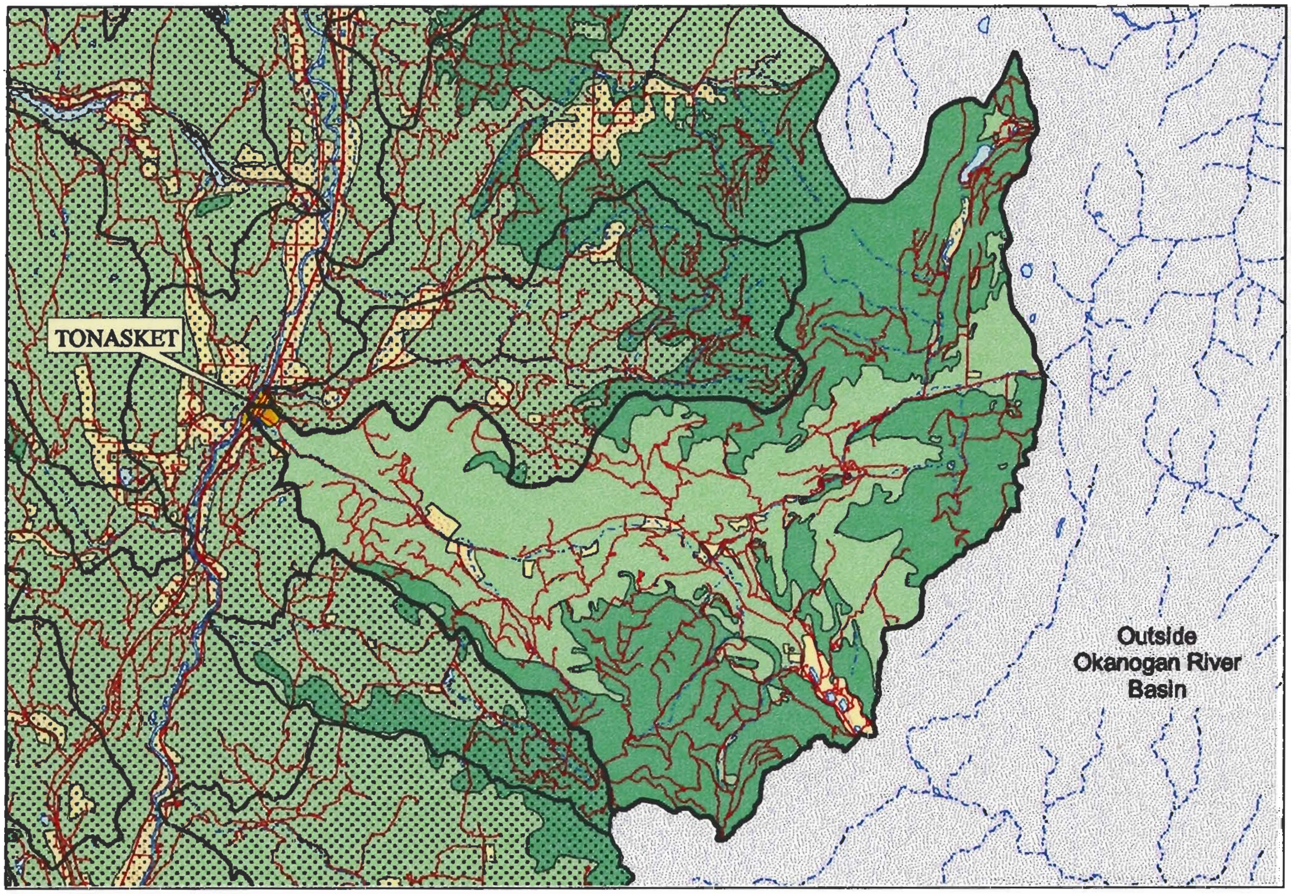
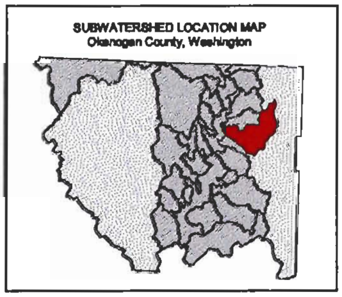
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998

NOTE: All boundaries are approximate.

G - BONAPARTE CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	48,750.6	49.8
Range	46,240.2	47.2
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	2,018.9	2.1
Cropland: irrigated hay	446.3	0.5
Cropland: irrigated orchard	0.0	0.0
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	172.2	0.2
Open Water	248.6	0.2
Total sub-watershed size	97,876.8	100%
Percent of Okanogan Watershed	5.87%	

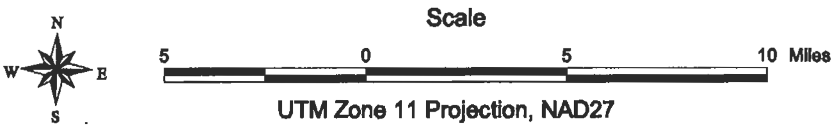


LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas



UTM Zone 11 Projection, NAD27

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USDA Natural Resources Conservation Service
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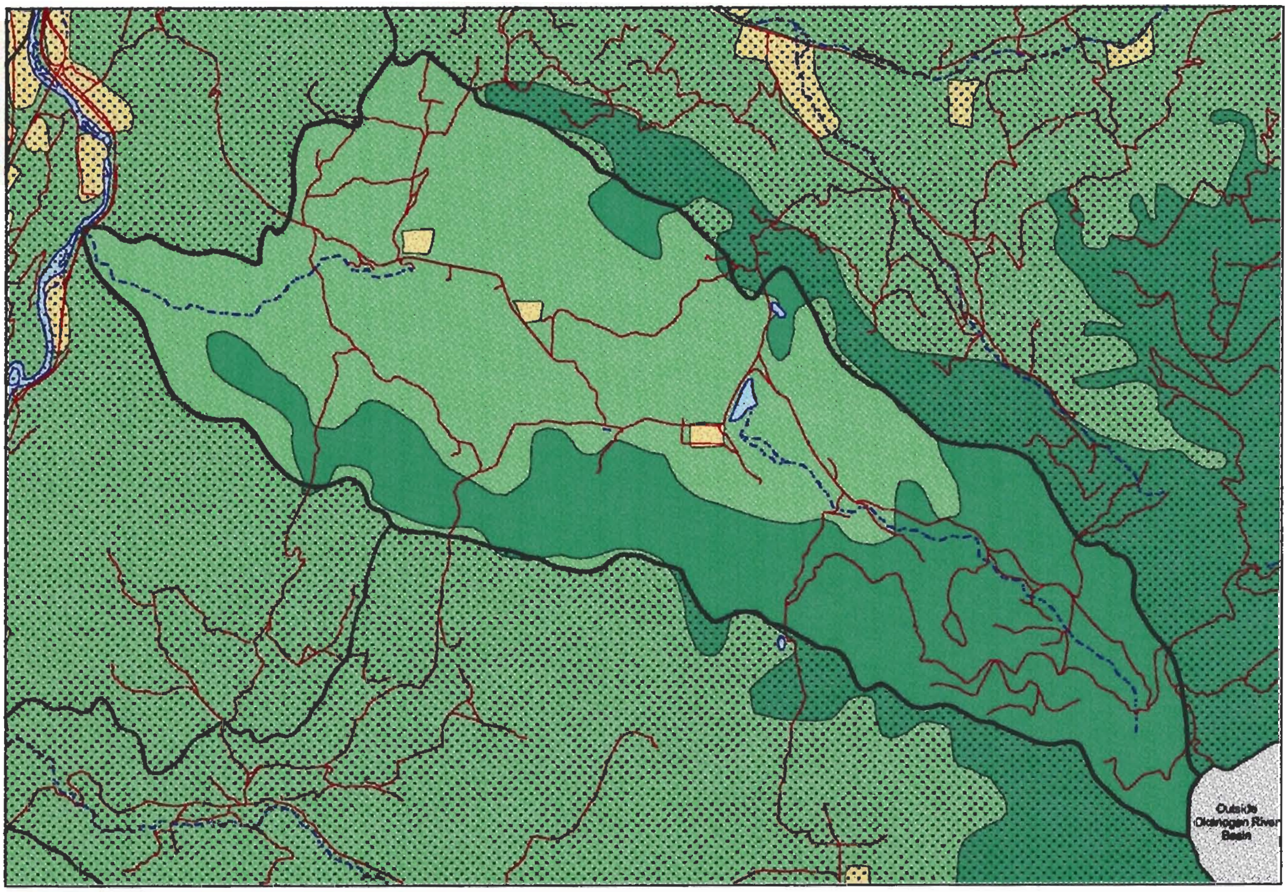
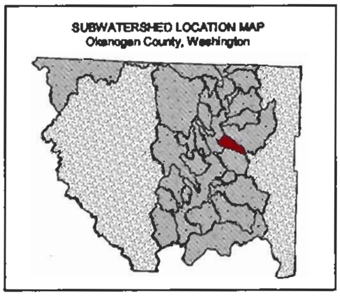
July 1998

NOTE: All boundaries are approximate.

H - CHEWILIKEN CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	7,017.3	41.0
Range	9,977.1	58.3
Cropland: non-irrigated small grains	100.3	0.5
Cropland: non-irrigated pasture and hay	0.0	0.0
Cropland: irrigated hay	0.0	0.0
Cropland: irrigated orchard	0.0	0.0
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	30.3	0.2
Total sub-watershed size	17,125.0	100%
Percent of Okanogan Watershed	1.03%	



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

N S E W

Scale

1 0 1 2 3 4 Miles

UTM Zone 11 Projection, NAD27

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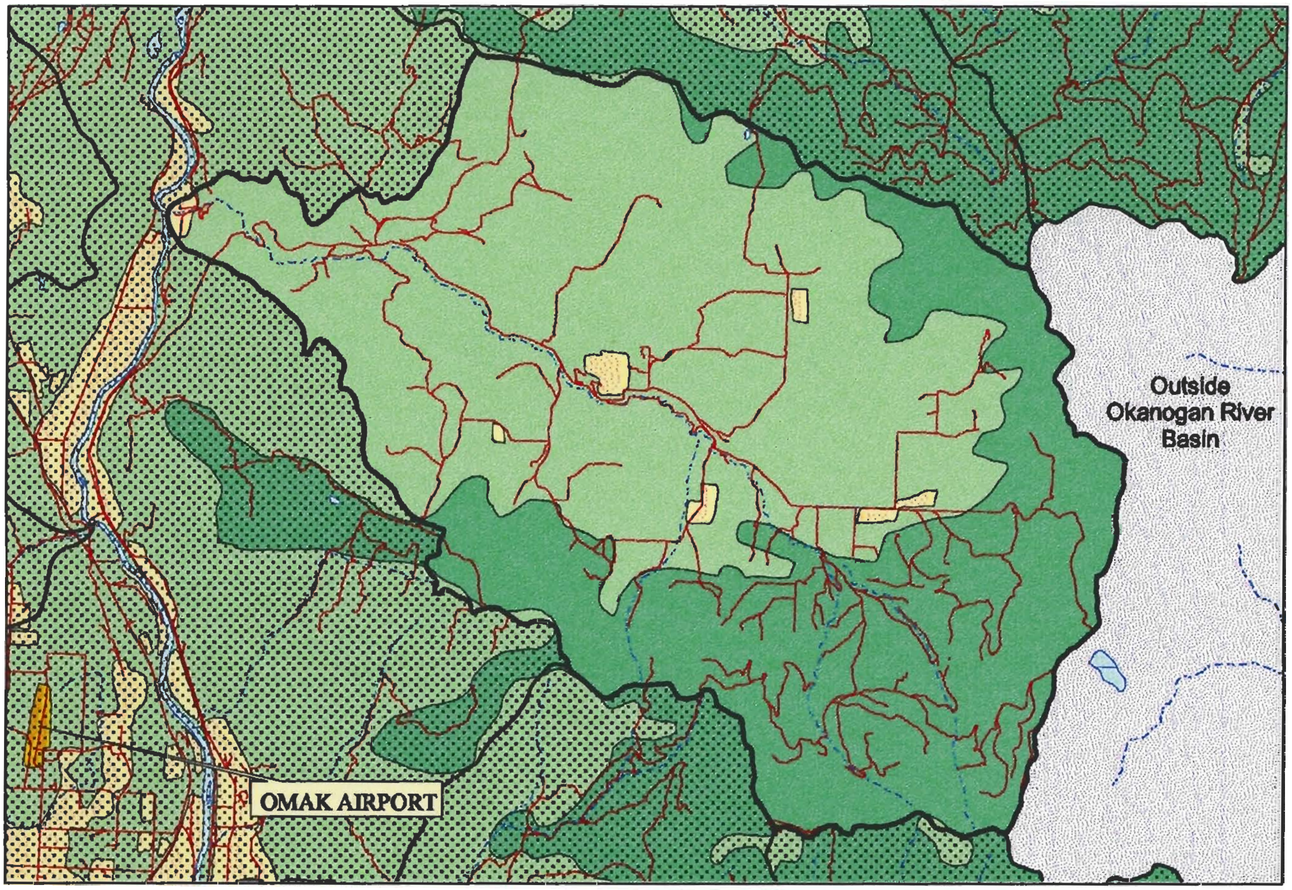
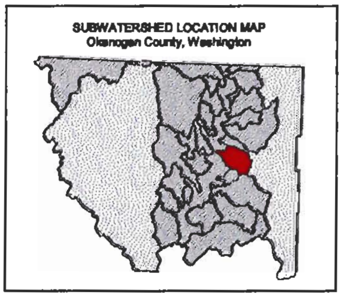
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998

NOTE: All boundaries are approximate.

I - TUNK CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	18,087.7	40.0
Range	26,960.2	59.1
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	301.9	0.7
Cropland: irrigated hay	140.2	0.2
Cropland: irrigated orchard	92.2	0.0
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	3.5	0.0
Total sub-watershed size	45,585.7	100%
Percent of Okanogan Watershed	2.73%	

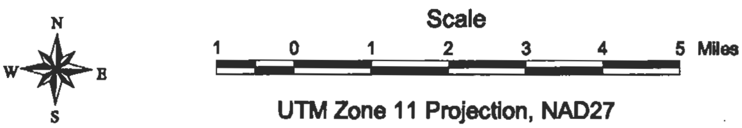


LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas



UTM Zone 11 Projection, NAD27

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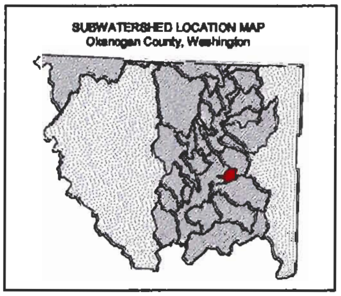
July 1998

NOTE: All boundaries are approximate.

J - WANACUT CREEK SUBWATERSHED

LANDUSE	ACREAGE	PERCENT
Forest	5,598.9	44.5
Range	6,585.9	52.3
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	92.8	0.7
Cropland: irrigated hay	317.7	2.5
Cropland: irrigated orchard	0.0	0.0
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	NS	NS
Total sub-watershed size	12,595.3	100%
Percent of Okanogan Watershed	0.76%	



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

N W E S

Scale

1 0 1 2 3 Miles

UTM Zone 11 Projection, NAD27

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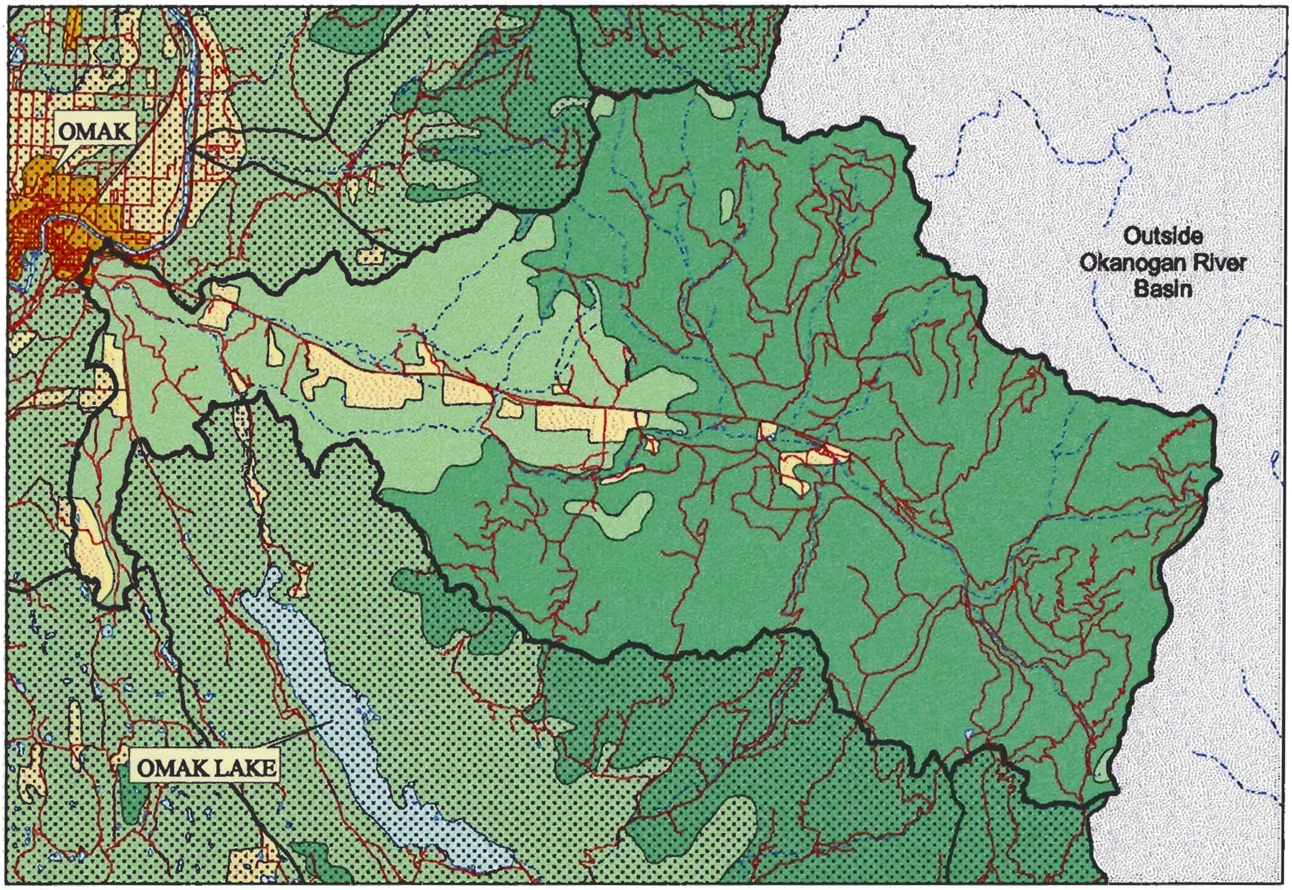
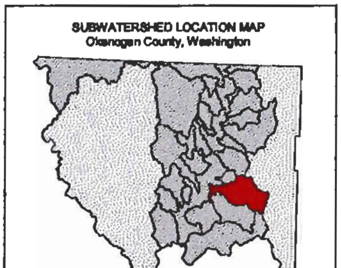
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998

NOTE: All boundaries are approximate.

K - OMAK CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	66,205.3	73.0
Range	20,662.3	22.8
Cropland: non-irrigated small grains	2,944.0	3.3
Cropland: non-irrigated pasture and hay	710.8	0.8
Cropland: irrigated hay	49.2	NS
Cropland: irrigated orchard	13.5	NS
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	88.9	NS
Open Water	16.8	NS
Total sub-watershed size	90,690.8	100%
Percent of Okanogan Watershed	5.44%	



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
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- Range
- Urban Areas

Scale

5 0 5 Miles

UTM Zone 11 Projection, NAD27

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USDA Natural Resources Conservation Service
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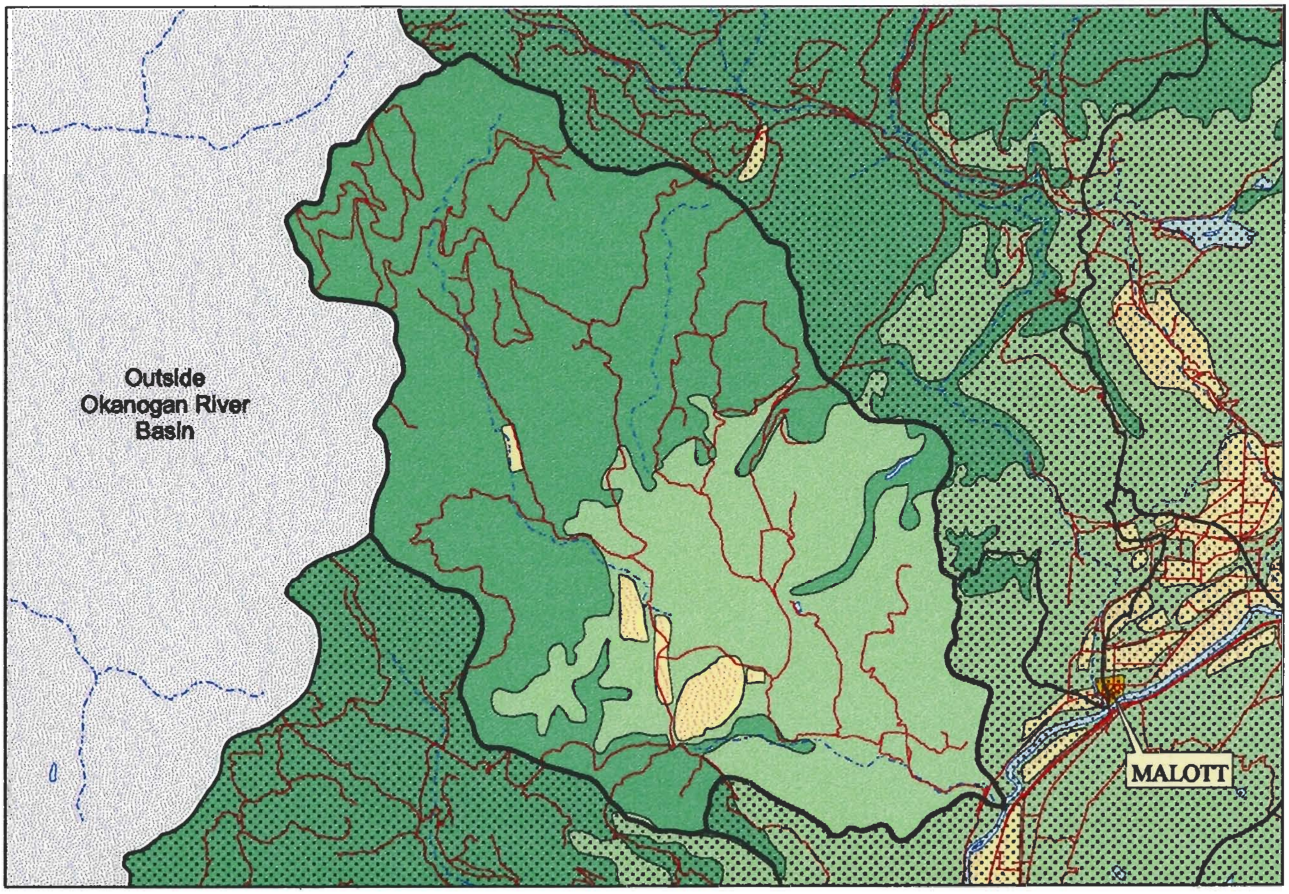
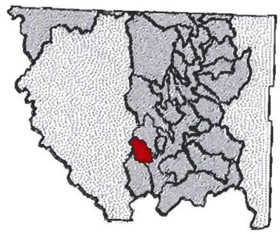
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

L - CHILIWIST CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	17,142.8	61.6
Range	10,053.0	36.1
Cropland: non-irrigated small grains	118.0	0.4
Cropland: non-irrigated pasture and hay	52.3	0.2
Cropland: irrigated hay	0.0	0.0
Cropland: irrigated orchard	0.0	0.0
Cropland: irrigated small grain	462.0	1.7
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	13.4	NS
Total sub-watershed size	27,841.5	100%
Percent of Okanogan Watershed	1.67%	



LEGEND

- Streams
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- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

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- Forest
- Open Water
- Range
- Urban Areas

N W E S

Scale

1 0 1 2 3 4 5 Miles

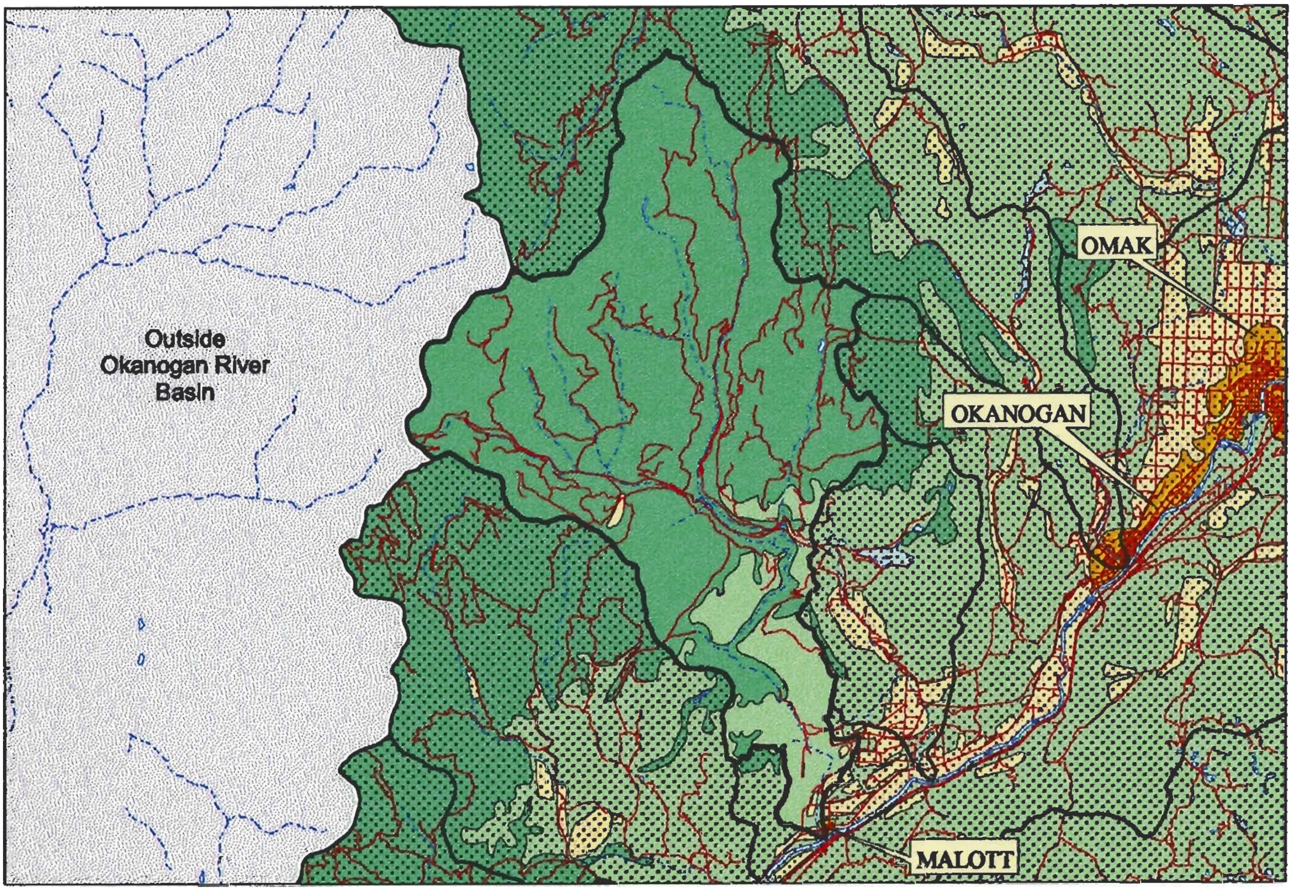
UTM Zone 11 Projection, NAD27

Sources: The data shown on this map was compiled to meet a scale accuracy of 1:100,000. The subwatershed boundaries are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

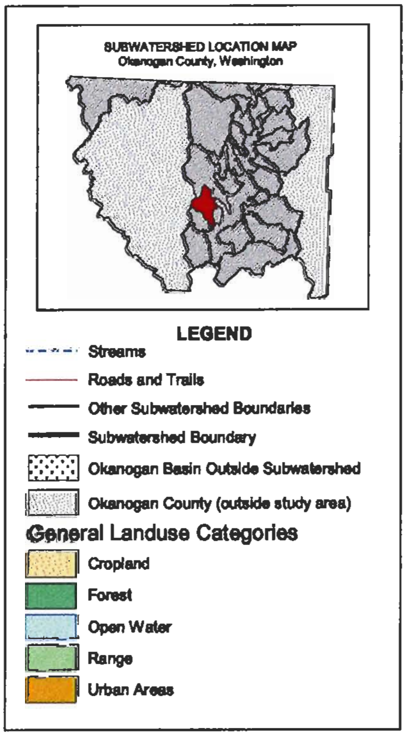
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998

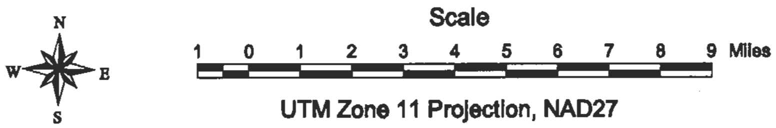
NOTE: All boundaries are approximate.

M - LOUP LOUP CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	35,356.2	86.5
Range	5,259.7	12.9
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	68.2	0.2
Cropland: irrigated hay	0.0	0.0
Cropland: irrigated orchard	149.4	0.4
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	12.4	NS
Open Water	22.3	NS
Total sub-watershed size	40,868.2	100%
Percent of Okanogan Watershed	2.45%	





UTM Zone 11 Projection, NAD27

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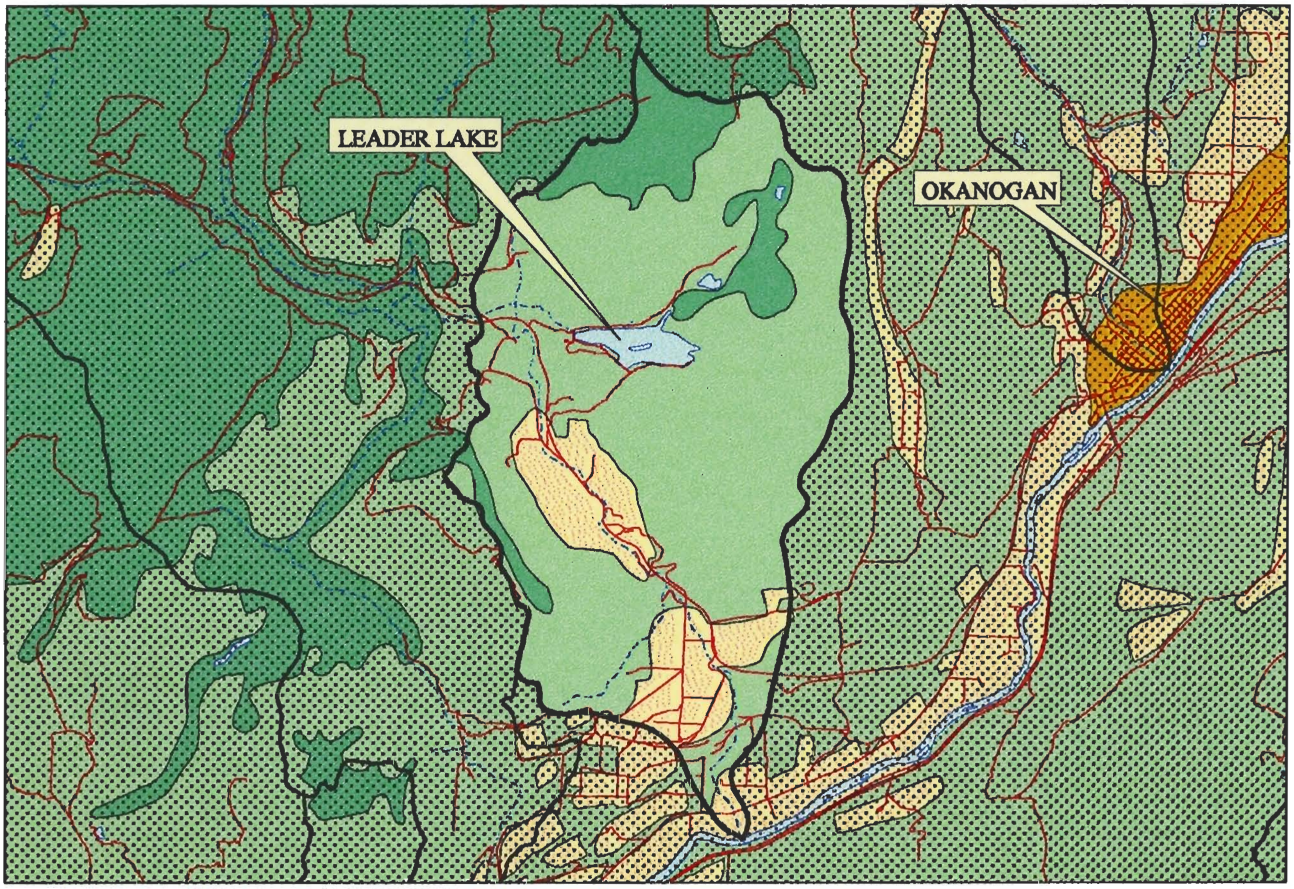
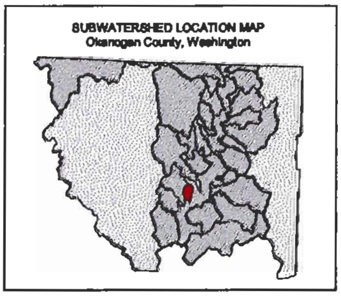
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

N - TALLANT CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	1,119.2	11.4
Range	7,166.0	72.9
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	0.0	0.0
Cropland: irrigated hay	172.9	1.8
Cropland: irrigated orchard	1,206.2	12.2
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	168.1	1.7
Total sub-watershed size	9,832.4	100%
Percent of Okanogan Watershed	0.59%	



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

Scale

1 0 1 2 3 4 Miles

UTM Zone 11 Projection, NAD27

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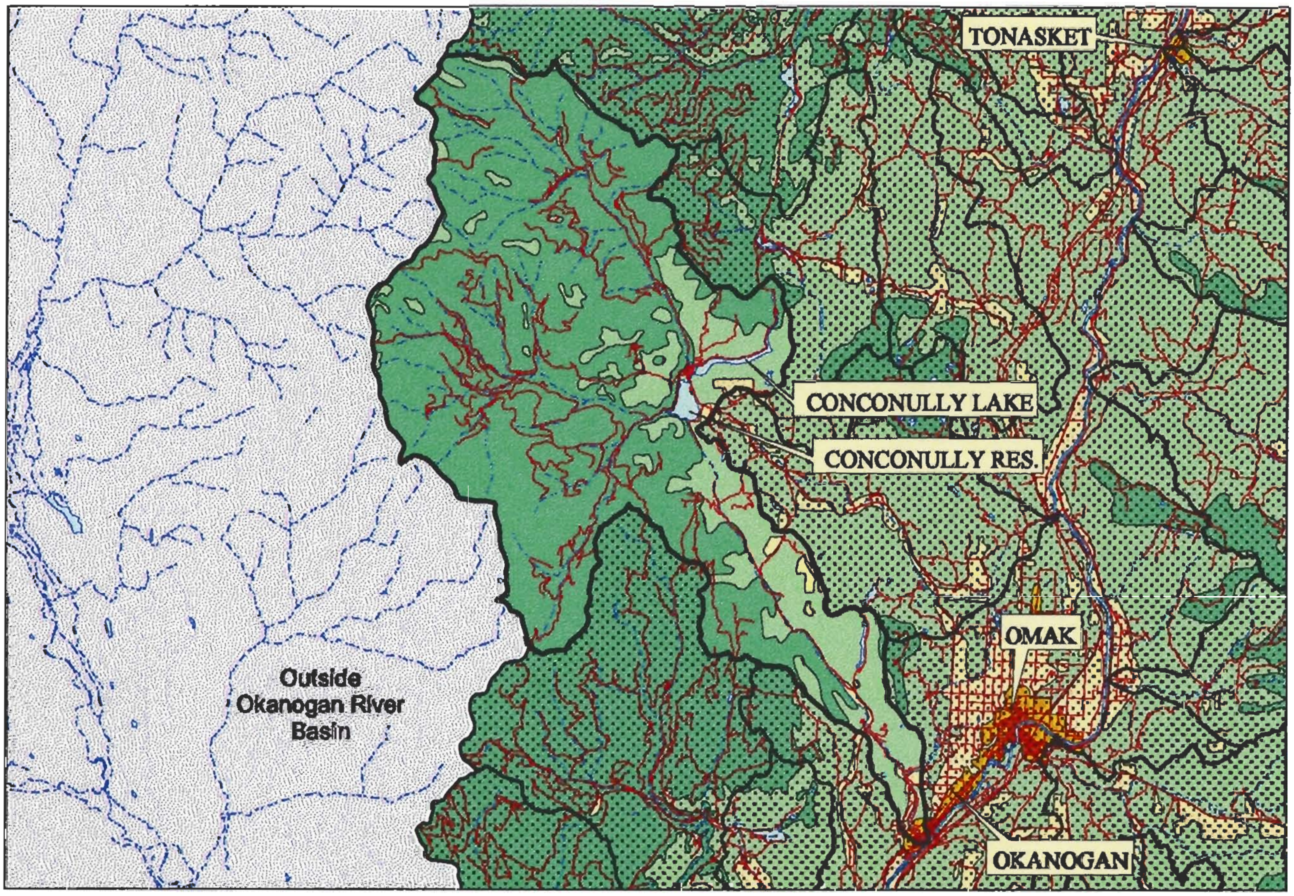
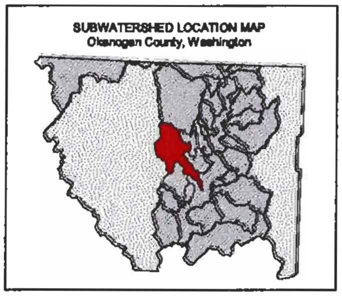
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

0 - SALMON CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	74,699.9	75.7
Range	21,651.8	22.0
Cropland: non-irrigated small grains	352.5	0.4
Cropland: non-irrigated pasture and hay	273.9	0.3
Cropland: irrigated hay	420.6	0.4
Cropland: irrigated orchard	222.4	0.2
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	230.2	0.2
Open Water	773.3	0.8
Total sub-watershed size	98,624.6	100%
Percent of Okanogan Watershed	5.9%	



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

Scale

5 0 5 10 Miles

UTM Zone 11 Projection, NAD27

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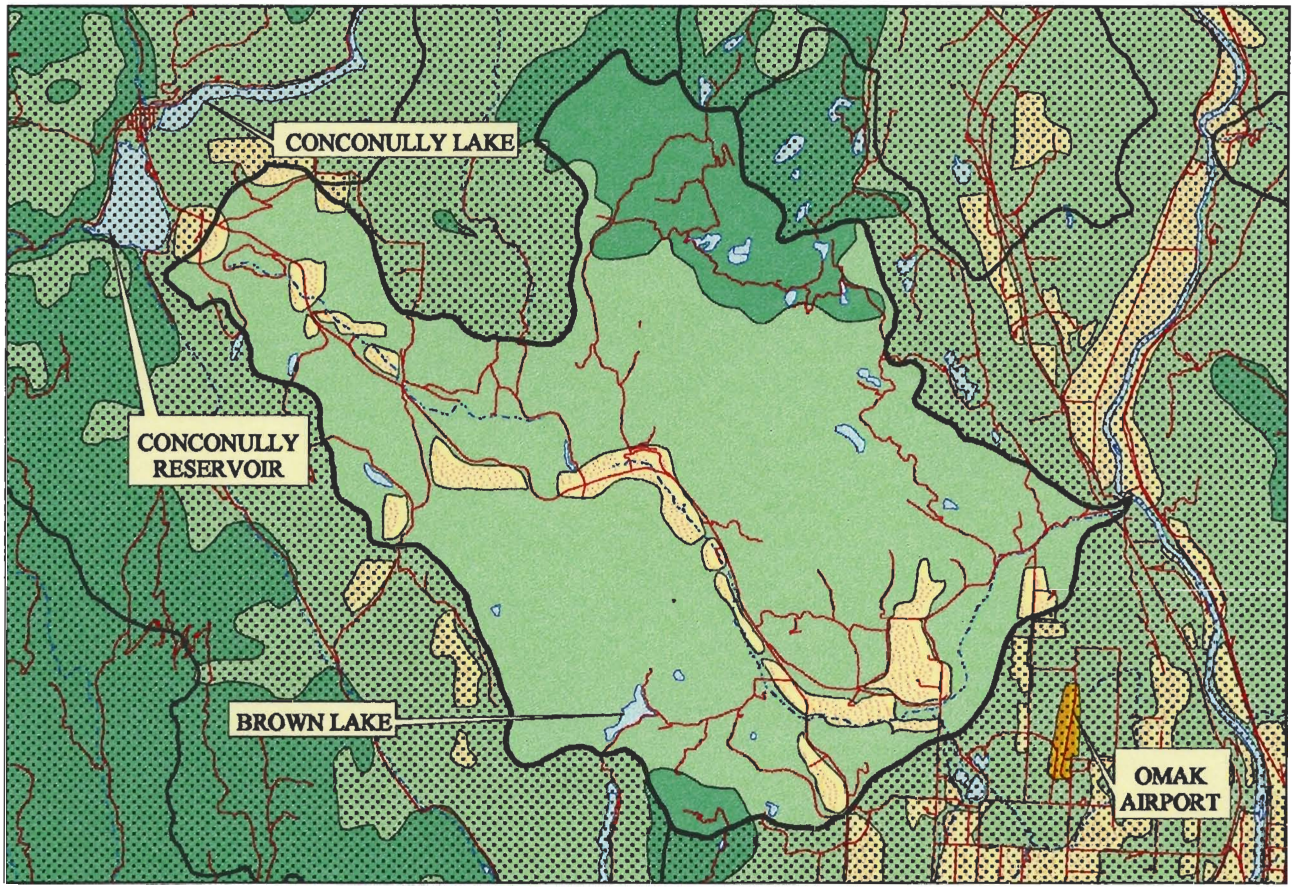
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

P - JOHNSON CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	3,622.4	12.6
Range	22,515.7	78.5
Cropland: non-irrigated small grains	76.9	0.3
Cropland: non-irrigated pasture and hay	981.5	3.4
Cropland: irrigated hay	1,038.3	3.6
Cropland: irrigated orchard	214.7	0.8
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	244.8	0.8
Total sub-watershed size	28,694.2	100%
Percent of Okanogan Watershed	1.72%	

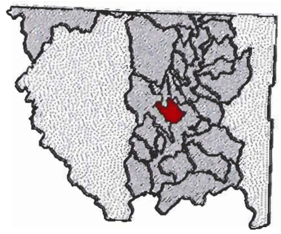
N W E S

Scale

1 0 1 2 3 4 5 Miles

UTM Zone 11 Projection, NAD27

SUBWATERSHED LOCATION MAP
Okanogan County, Washington



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

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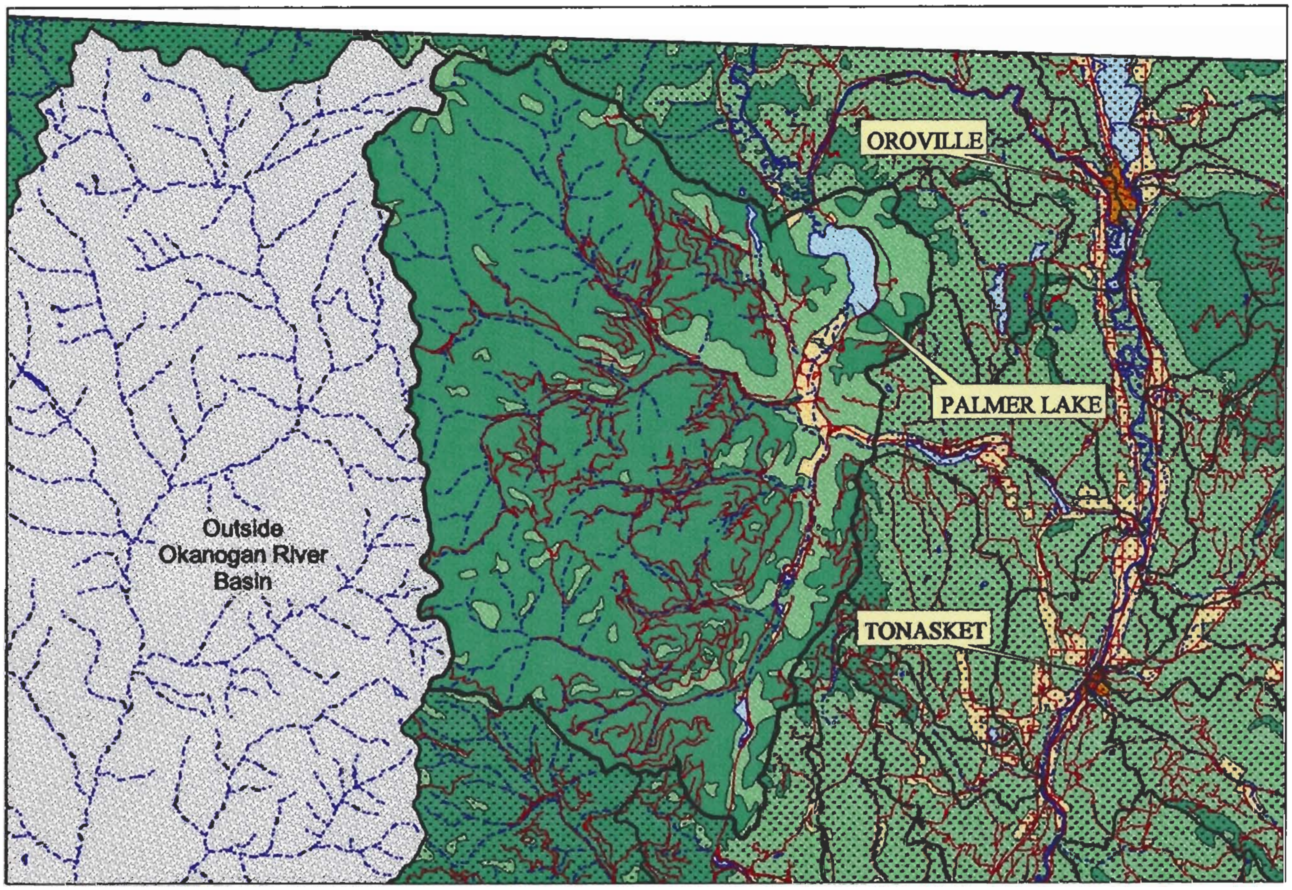
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised march 1999)

NOTE: All boundaries are approximate.

Q - SINLAHEKIN CREEK SUBWATERSHED



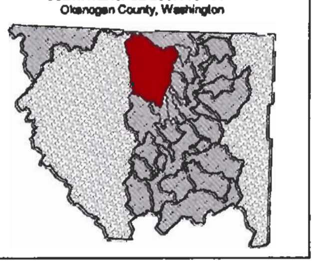
LANDUSE	ACREAGE	PERCENT
Forest	150,543.2	79.4
Range	33,799.7	17.8
Cropland: non-irrigated small grains	162.0	NS
Cropland: non-irrigated pasture and hay	838.1	0.5
Cropland: irrigated hay	1,096.5	0.7
Cropland: irrigated orchard	633.1	0.3
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	2,448.3	1.3
Total sub-watershed size	189,520.9	100%
Percent of Okanogan Watershed	11.36%	

N W E S

Scale

5 0 5 10 Miles

UTM Zone 11 Projection, NAD27



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

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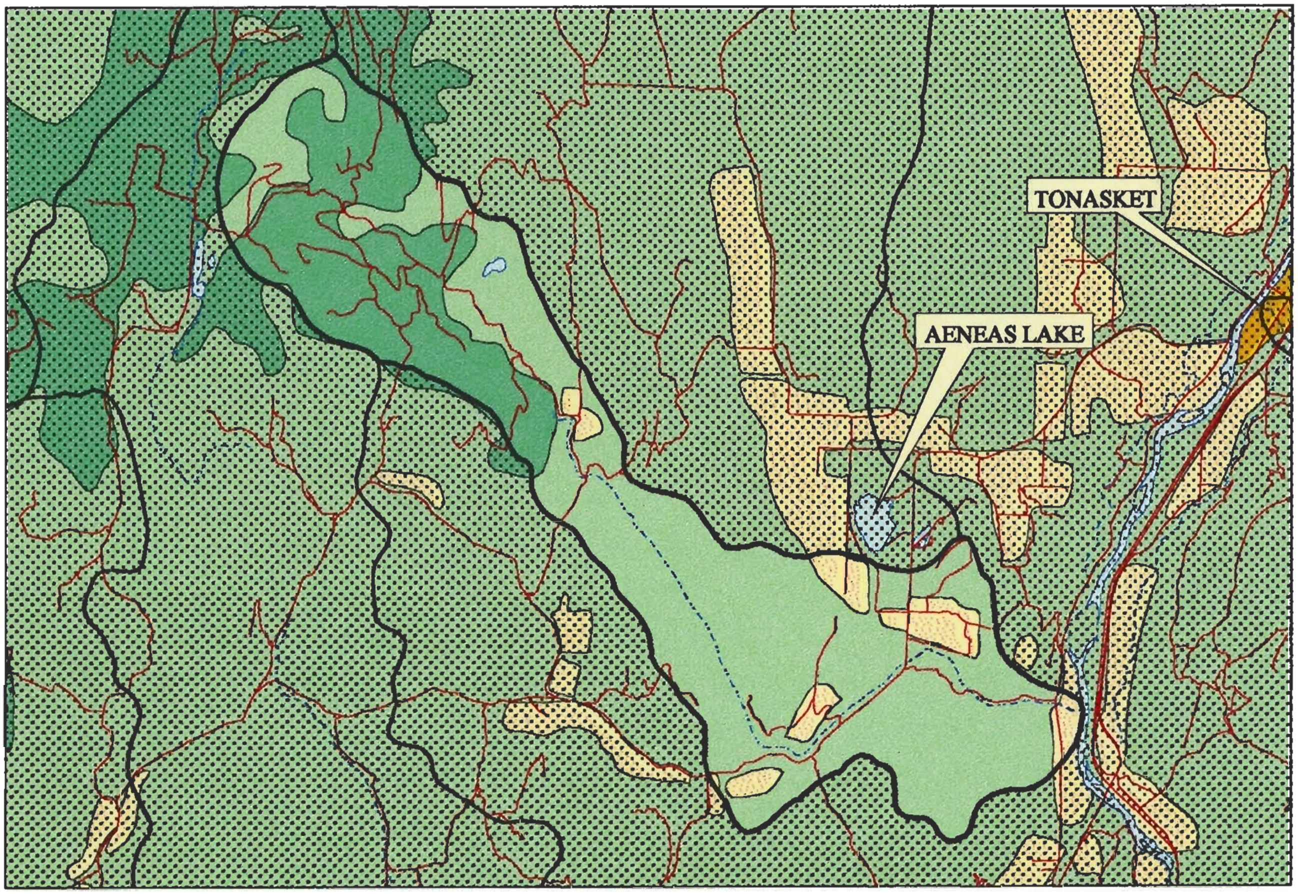
USDA

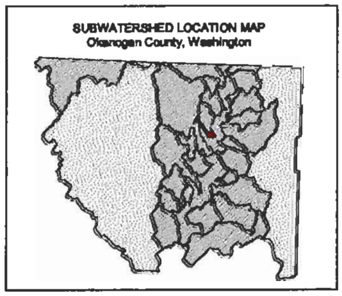
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

R - AENEAS CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	1,825.4	26.5
Range	4,603.3	66.8
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	218.5	3.1
Cropland: irrigated hay	61.9	1.0
Cropland: irrigated orchard	172.3	2.5
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	8.3	0.1
Total sub-watershed size	6,889.7	100%
Percent of Okanogan Watershed	0.41%	

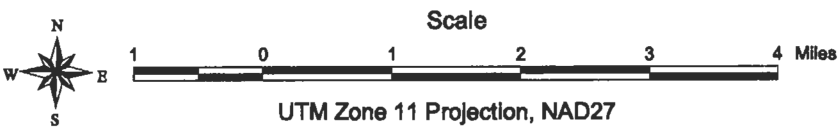


LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas



UTM Zone 11 Projection, NAD27

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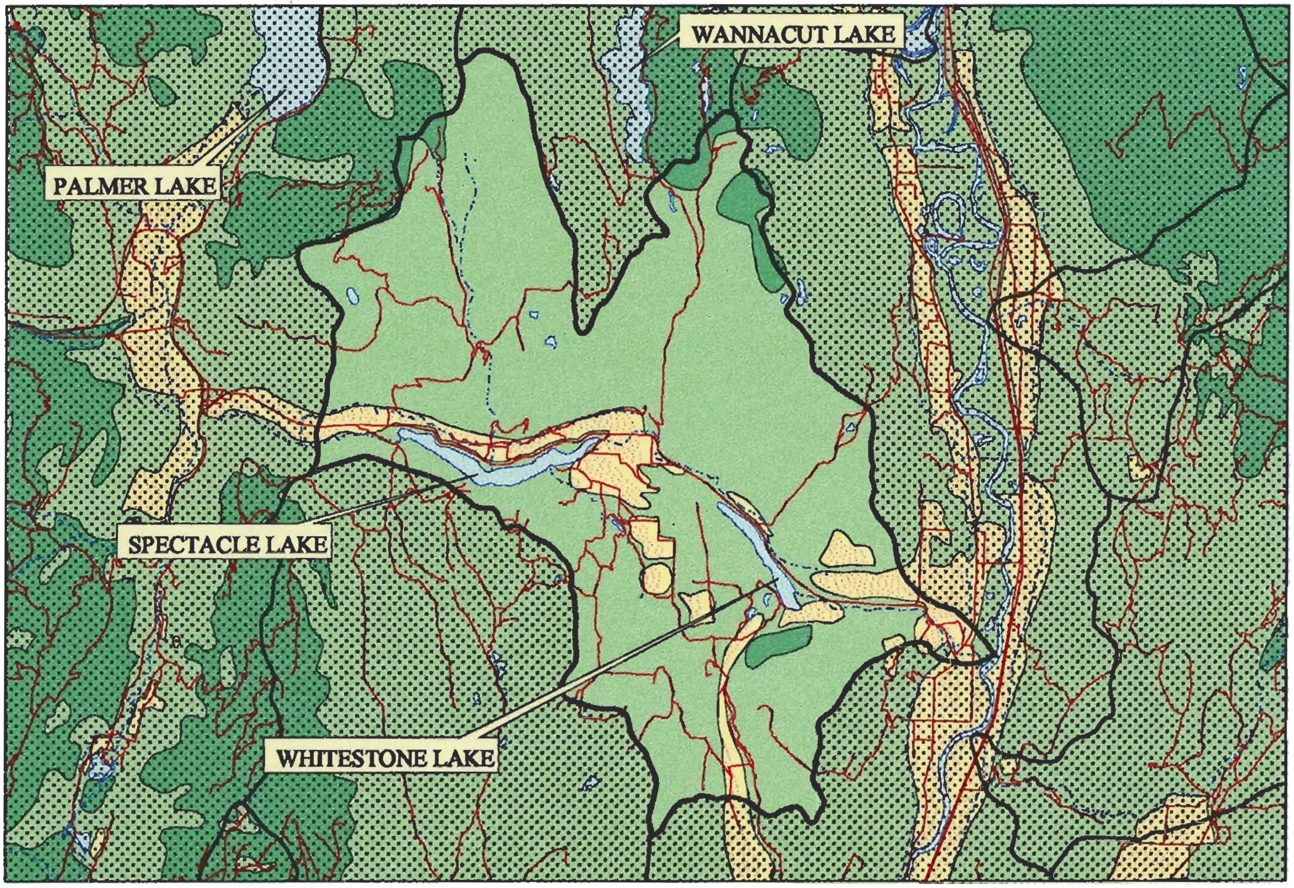
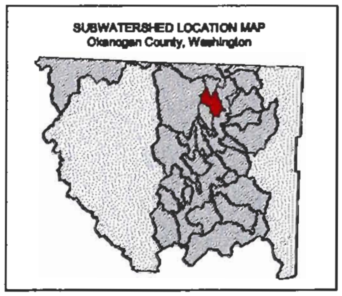
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

S - SPECTACLE LAKE/WHITESTONE LAKE SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	908.0	3.3
Range	23,188.6	84.8
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	376.1	1.4
Cropland: irrigated hay	347.2	1.3
Cropland: irrigated orchard	1,999.2	7.3
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	513.3	1.9
Total sub-watershed size	27,332.7	100%
Percent of Okanogan Watershed	1.6%	



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

Scale

1 0 1 2 3 4 5 6 Miles

UTM Zone 11 Projection, NAD27

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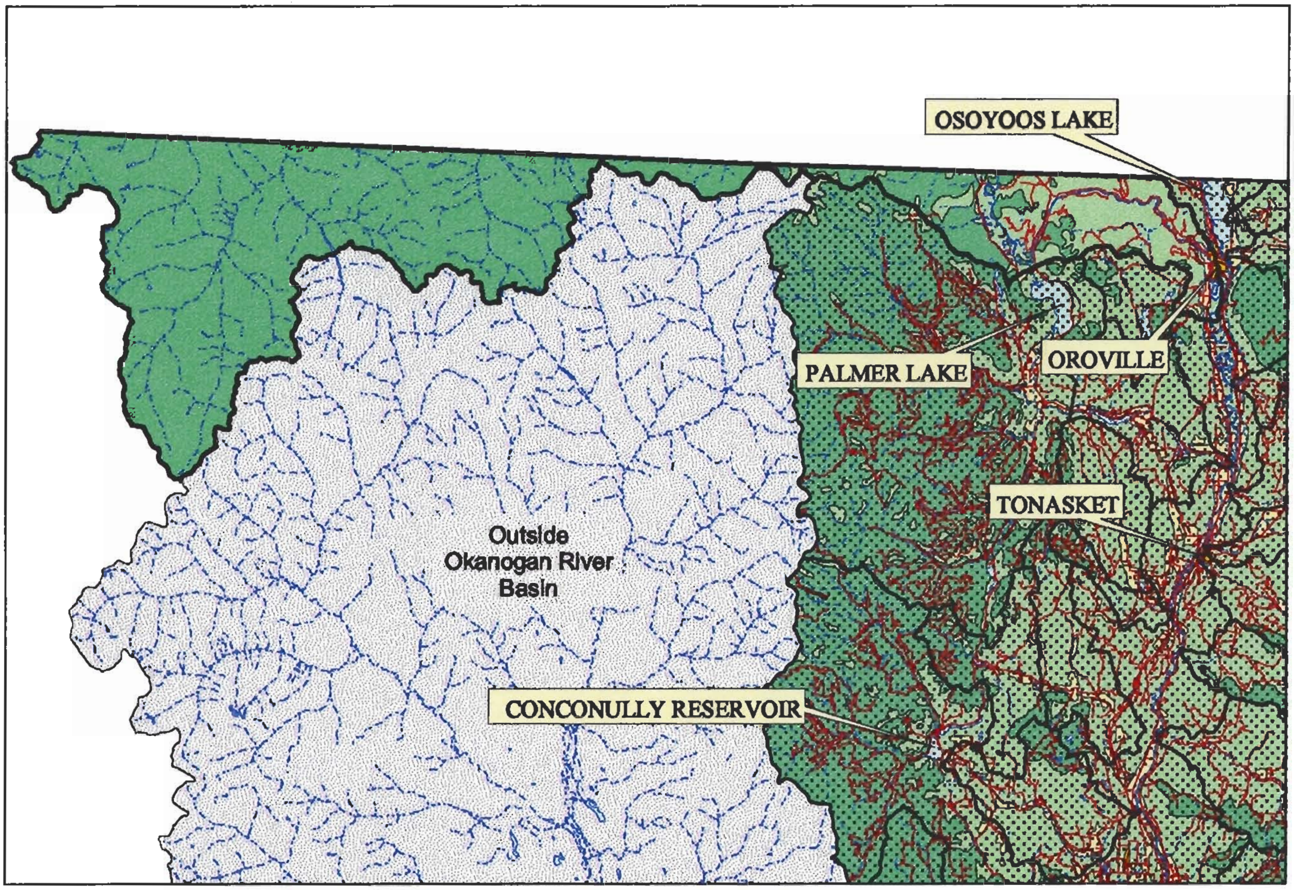
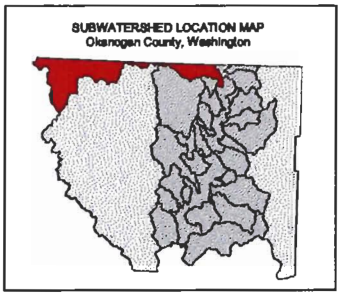
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

T - SIMILKAMEEN RIVER SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	192,464.5	84.2
Range	33,078.1	14.5
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	0.0	0.0
Cropland: irrigated hay	130.4	NS
Cropland: irrigated orchard	1,288.8	0.6
Cropland: irrigated small grain	0.0	0.0
Mined	23.6	NS
Urban	361.3	0.2
Open Water	1,190.0	0.5
Total sub-watershed size	228,536.7	100%
Percent of Okanogan Watershed	13.7%	

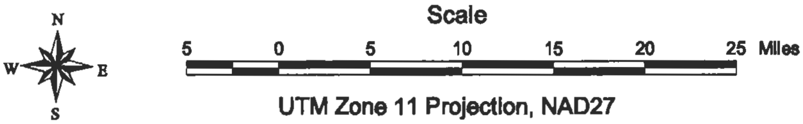


LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas



UTM Zone 11 Projection, NAD27

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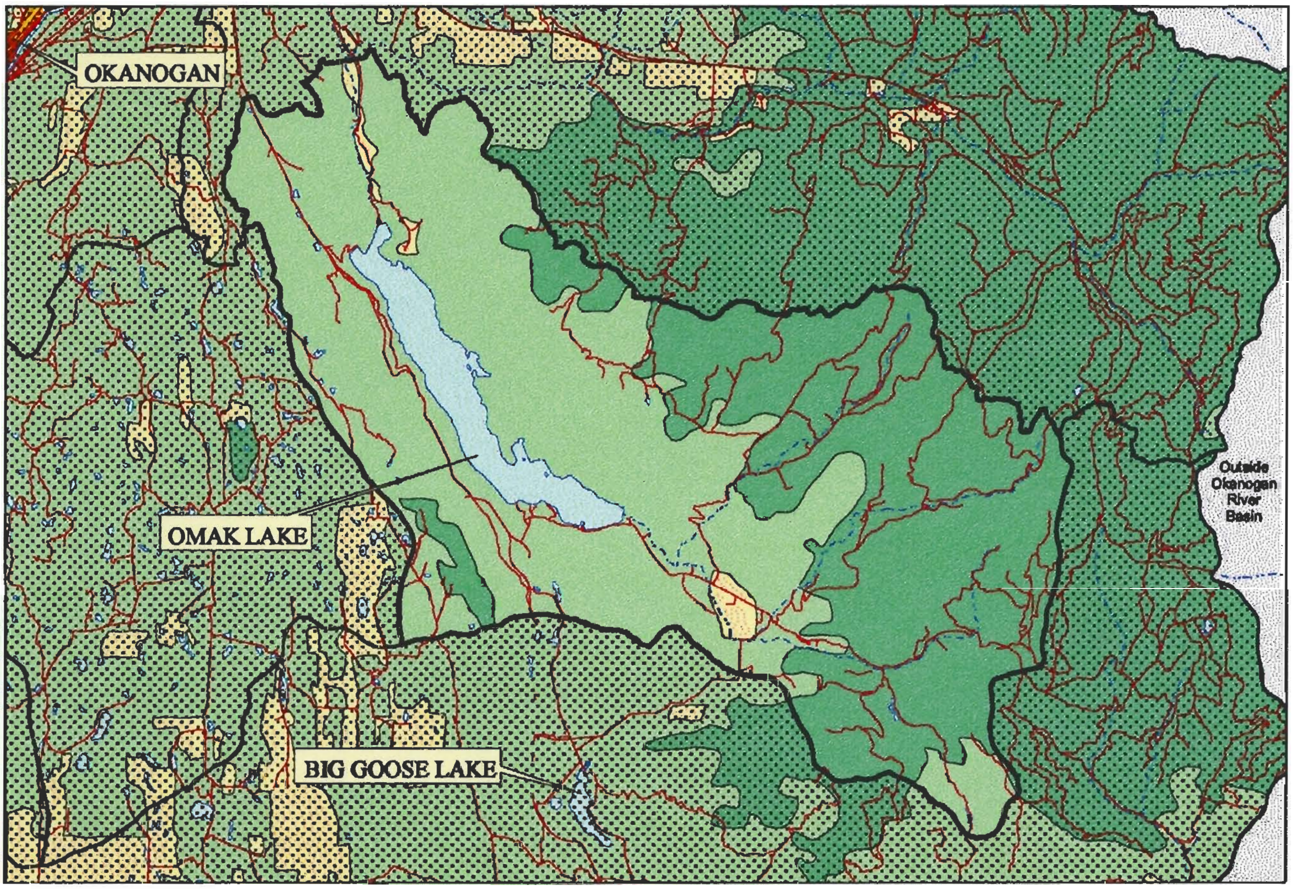
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

X1 - OMAK LAKE SUBWATERSHED



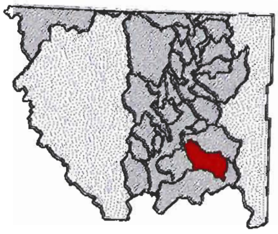
LANDUSE	ACREAGE	PERCENT
Forest	27,244.2	39.7
Range	37,154.0	54.1
Cropland: non-irrigated small grains	4.9	NS
Cropland: non-irrigated pasture and hay	0.0	0.0
Cropland: irrigated hay	888.9	1.3
Cropland: irrigated orchard	0.0	0.0
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	3,393.3	4.9
Total sub-watershed size	68,685.3	100%
Percent of Okanogan Watershed	4.12%	

Scale

1 0 1 2 3 4 5 6 7 8 9 Miles

UTM Zone 11 Projection, NAD27

SUBWATERSHED LOCATION MAP
Okanogan County, Washington



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

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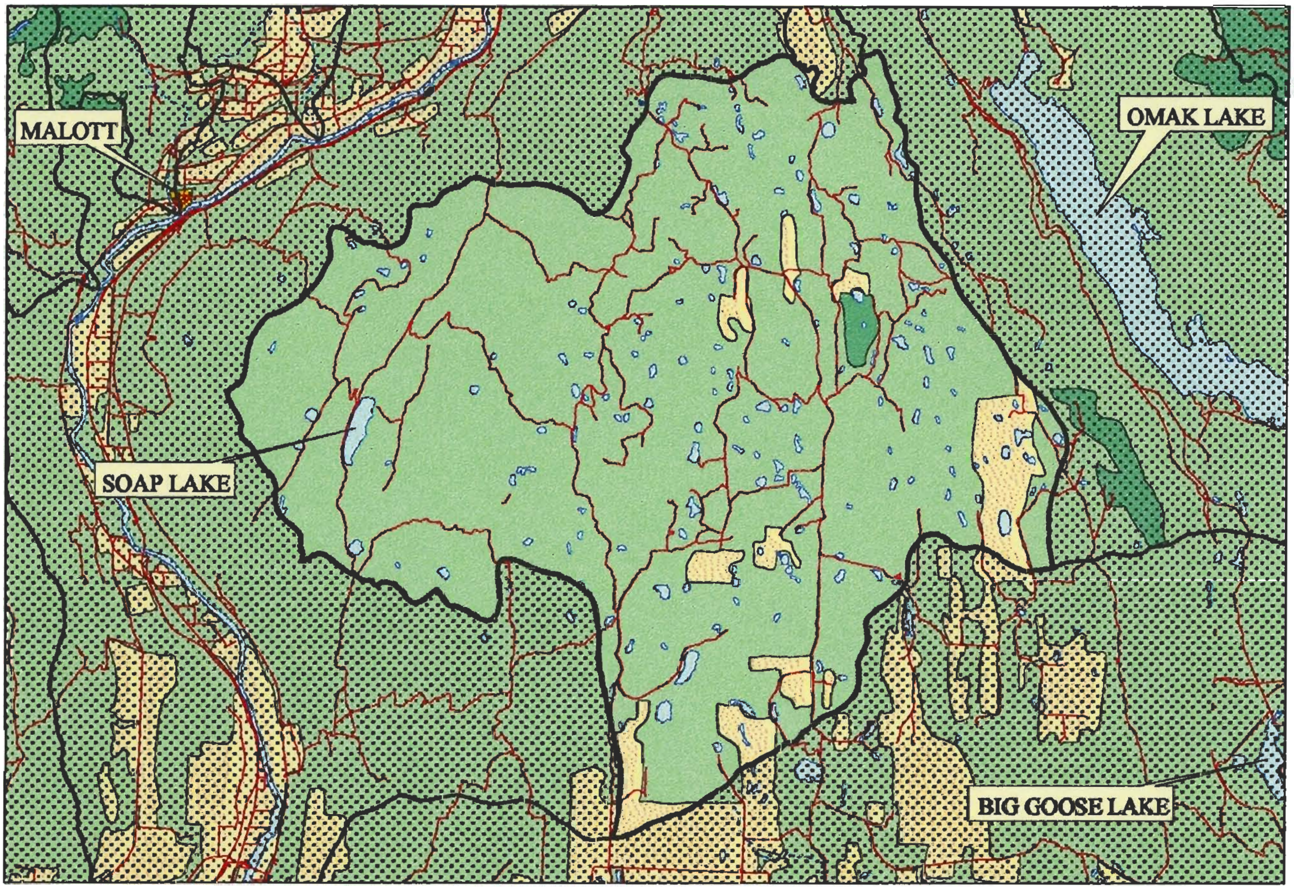
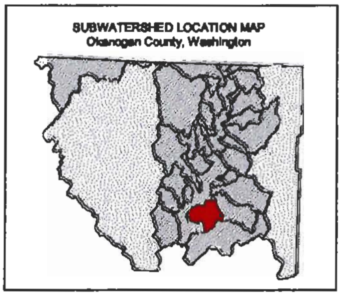
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

X2 - DULEY LAKES/JOSEPH FLATS SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	284.5	0.6
Range	46,457.9	90.5
Cropland: non-irrigated small grains	3,223.3	6.3
Cropland: non-irrigated pasture and hay	0.0	0.0
Cropland: irrigated hay	0.0	0.0
Cropland: irrigated orchard	0.0	0.0
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	1,353.6	2.6
Total sub-watershed size	51,319.3	100%
Percent of Okanogan Watershed	3.08%	



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

N W E S

Scale

1 0 1 2 3 4 5 6 7 Miles

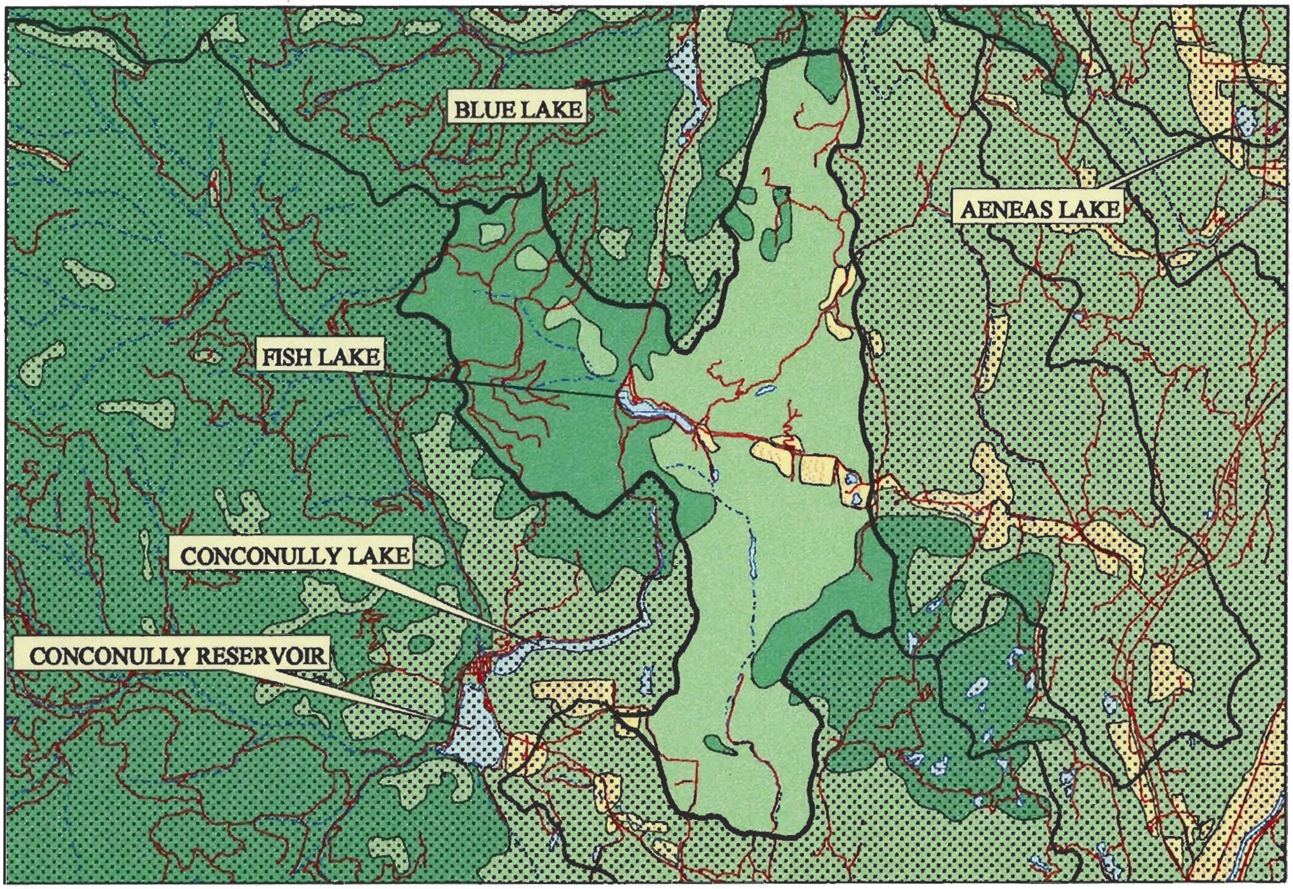
UTM Zone 11 Projection, NAD27

Sources: The data shown on this map was compiled to meet a scale accuracy of 1:100,000. The subwatershed boundaries are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

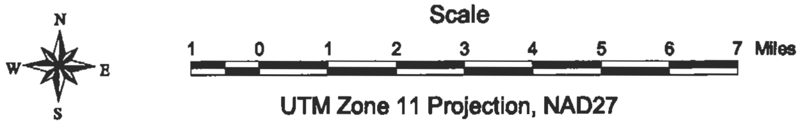
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

X3 - FISH LAKE BASIN SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	8,205.4	35.5
Range	14,152.4	61.2
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	467.6	2.0
Cropland: irrigated hay	177.3	0.8
Cropland: irrigated orchard	0.0	0.0
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	121.0	0.5
Total sub-watershed size	23,123.7	100%
Percent of Okanogan Watershed	1.39%	



UTM Zone 11 Projection, NAD27

LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

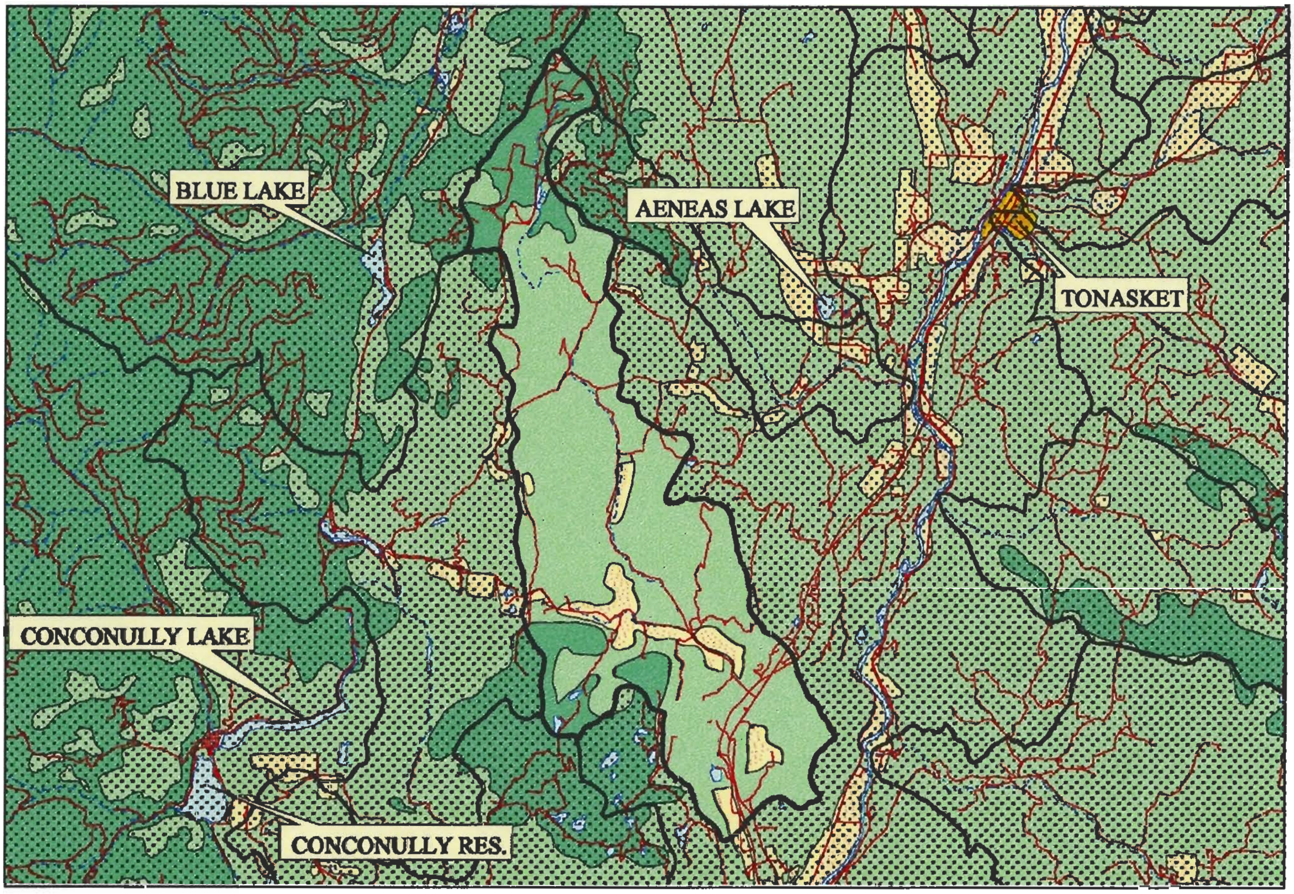
- Cropland
- Forest
- Open Water
- Range
- Urban Areas

Sources: The data shown on this map was compiled to meet a scale accuracy of 1:100,000. The subwatershed boundaries are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

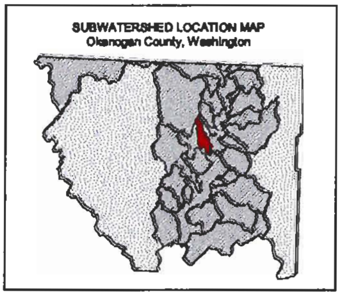
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

X4 - NORTH FORK PINE CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	3,465.2	14.5
Range	18,577.2	77.9
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	1,288.0	5.4
Cropland: irrigated hay	436.0	1.9
Cropland: irrigated orchard	0.0	0.0
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	74.3	0.3
Total sub-watershed size	23,840.8	100%
Percent of Okanogan Watershed	1.43%	

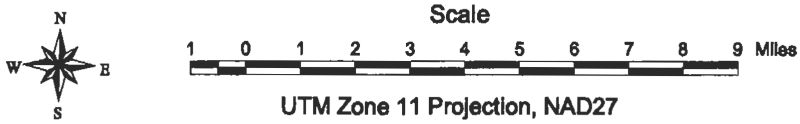


LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas



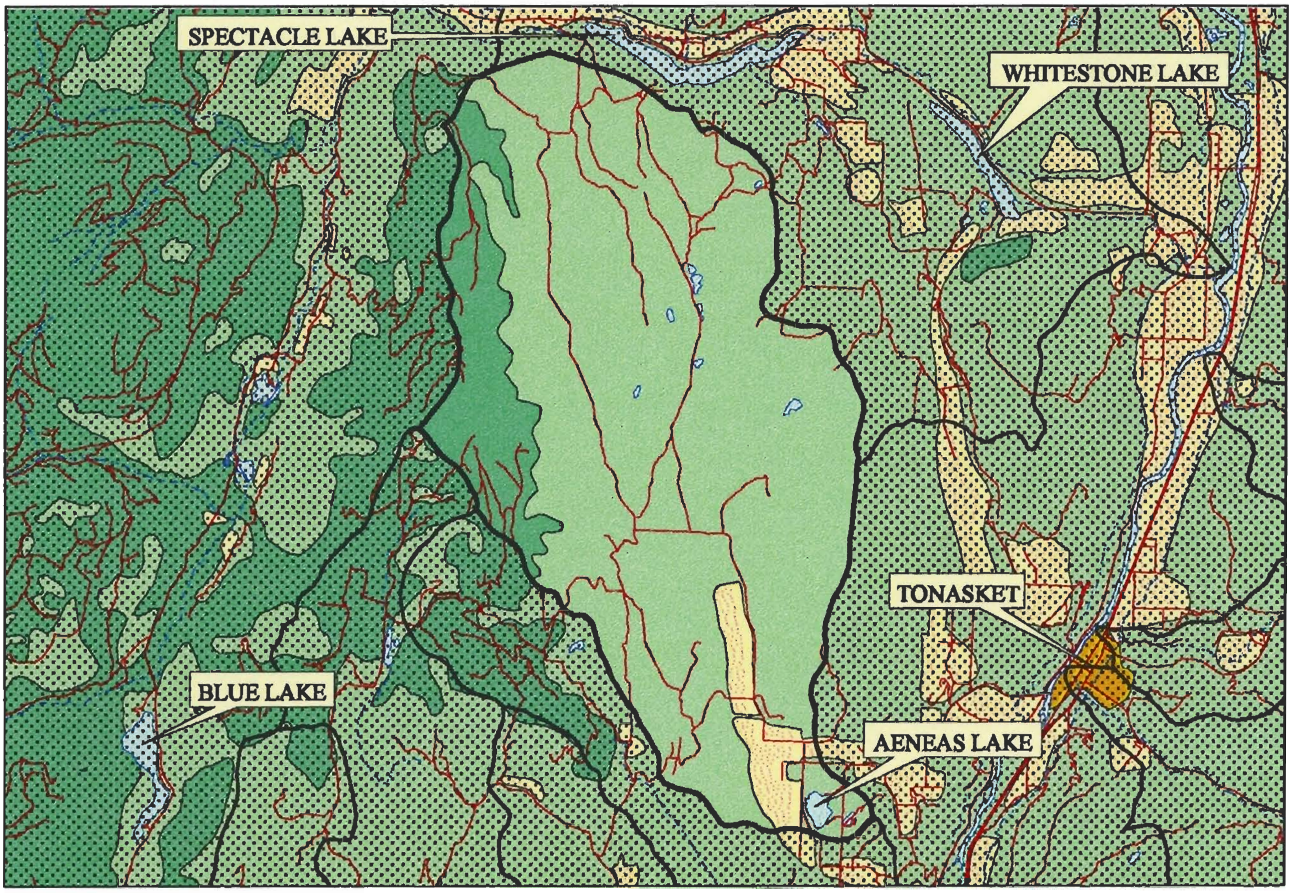
UTM Zone 11 Projection, NAD27

Sources: The data shown on this map was compiled to meet a scale accuracy of 1:100,000. The subwatershed boundaries are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

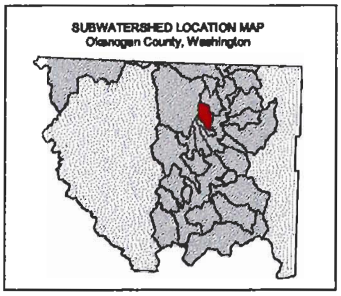
USDA
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised march 1999)

NOTE: All boundaries are approximate.

X5 - AENEAS LAKE SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	2,500.7	11.8
Range	17,785.6	83.7
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	25.5	0.1
Cropland: irrigated hay	336.3	1.6
Cropland: irrigated orchard	477.9	2.2
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	119.6	0.6
Total sub-watershed size	21,245.6	100%
Percent of Okanogan Watershed	1.27%	



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

Scale

1 0 1 2 3 4 5 6 Miles

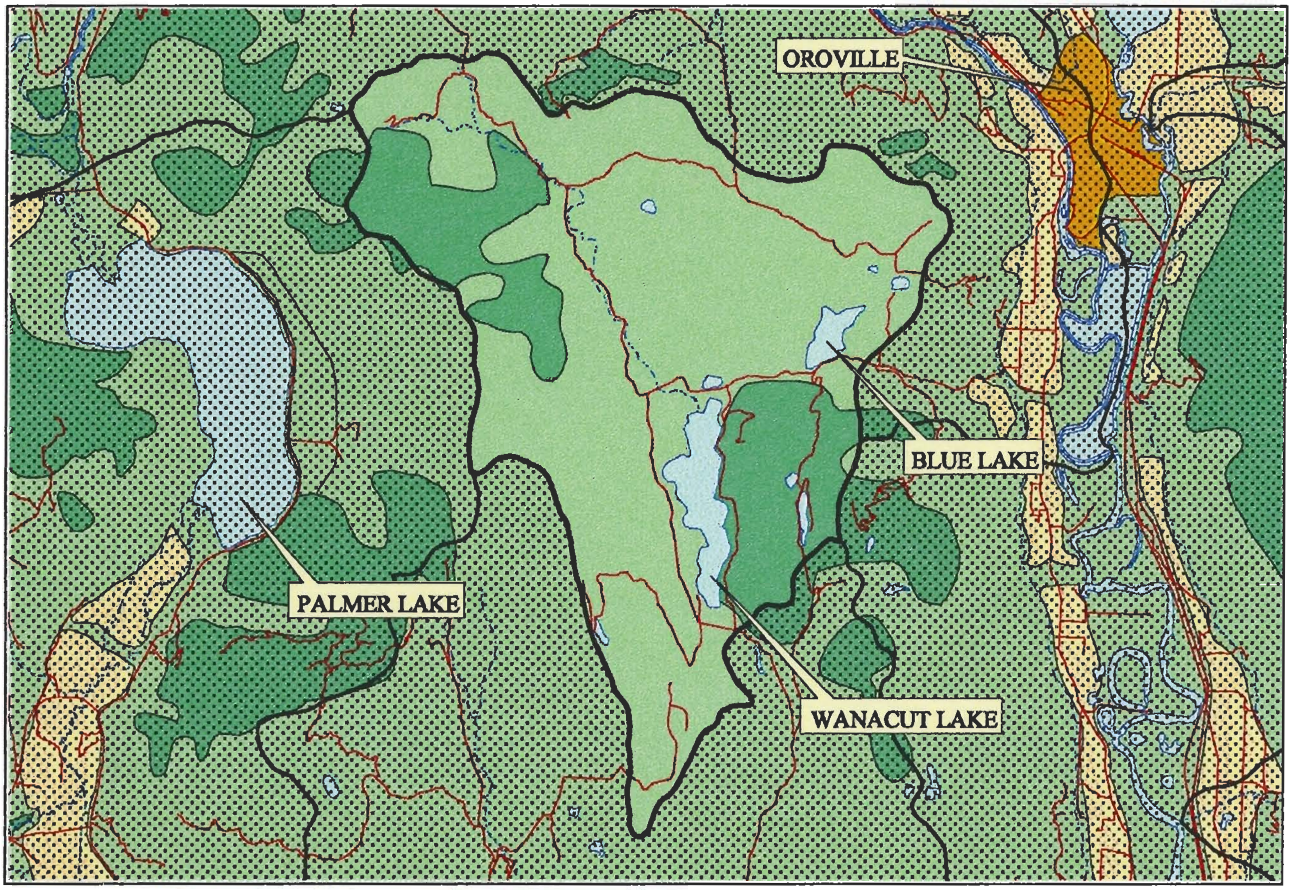
UTM Zone 11 Projection, NAD27

Sources: The data shown on this map was compiled to meet a scale accuracy of 1:100,000. The subwatershed boundaries are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

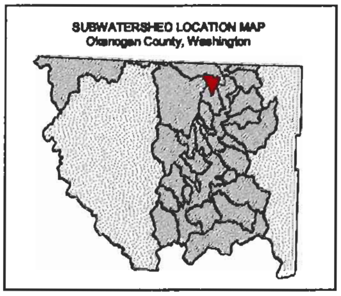
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

X6 - WANNACUT LAKE SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	2,926.3	21.1
Range	10,343.8	74.7
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	0.0	0.0
Cropland: irrigated hay	0.0	0.0
Cropland: irrigated orchard	0.0	0.0
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	583.2	4.2
Total sub-watershed size	13,853.3	100%
Percent of Okanogan Watershed	0.83%	



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

N W E S

Scale

1 0 1 2 3 4 Miles

UTM Zone 11 Projection, NAD27

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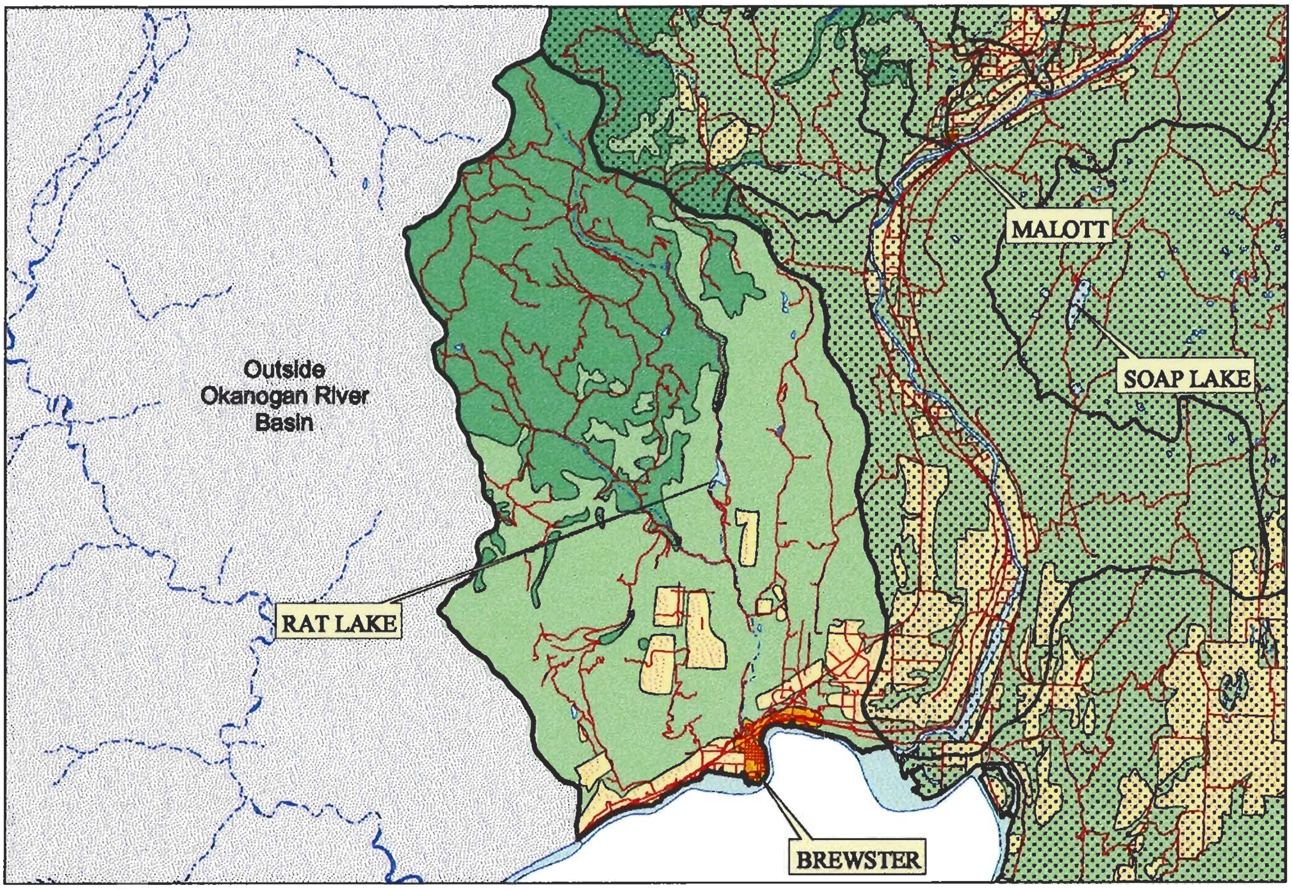
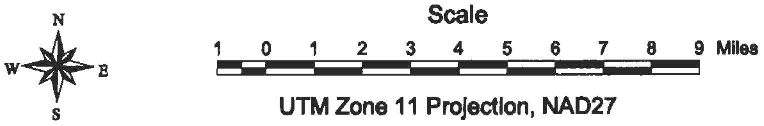
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

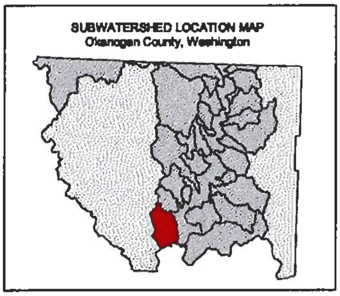
X7 - SWAMP CREEK SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	24,291.9	37.9
Range	34,548.6	53.7
Cropland: non-irrigated small grains	0.0	0.0
Cropland: non-irrigated pasture and hay	1,638.5	2.6
Cropland: irrigated hay	103.7	0.2
Cropland: irrigated orchard	2,812.3	4.4
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	649.0	1.0
Open Water	114.2	0.2
Total sub-watershed size	64,158.2	100%
Percent of Okanogan Watershed	3.85%	



UTM Zone 11 Projection, NAD27



LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas

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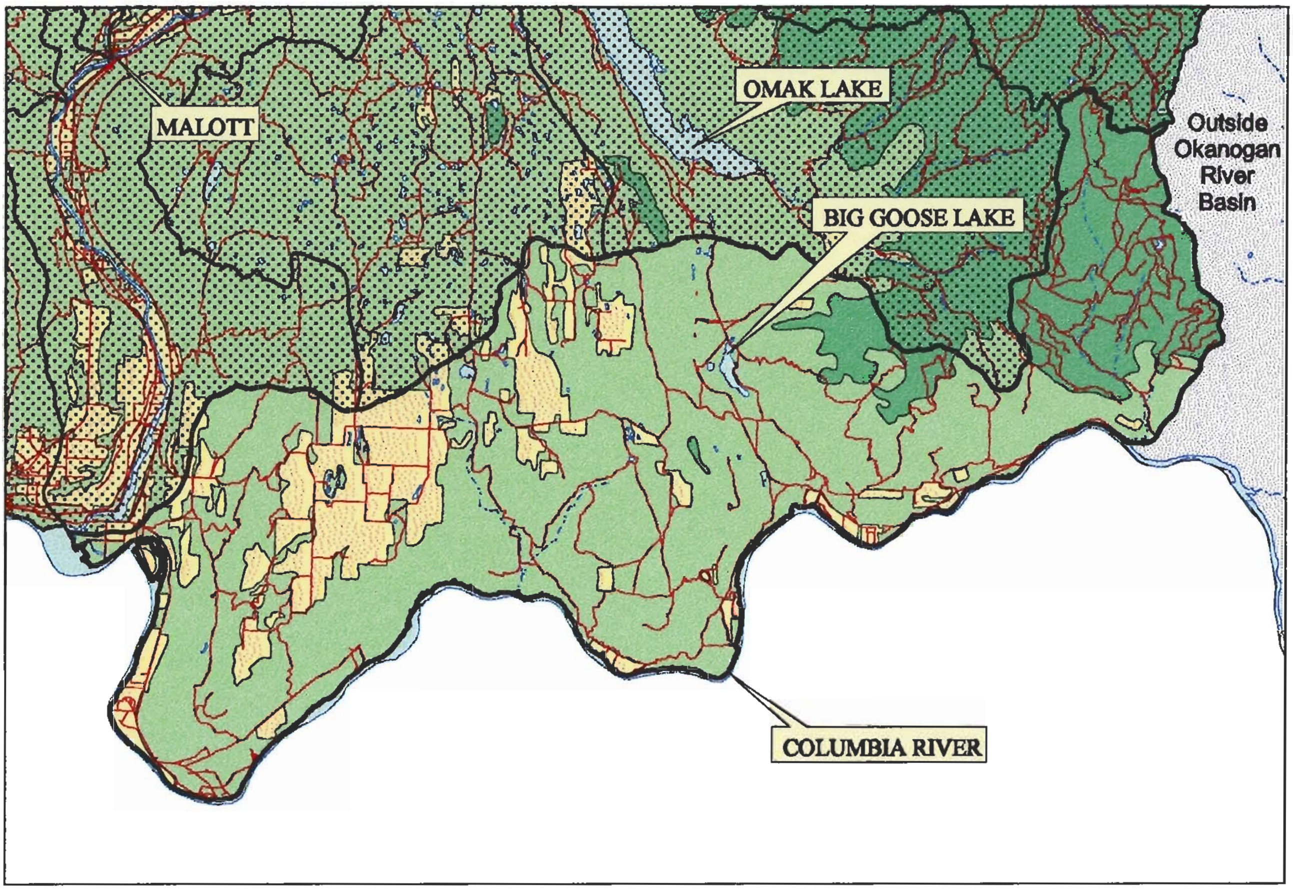
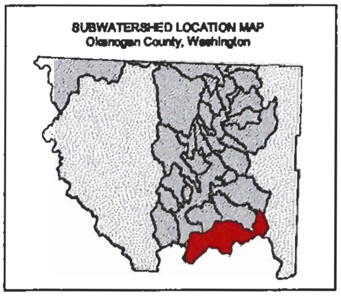
USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

X8 - COLUMBIA RIVER INTERFLUVE: EAST WRIA SUBWATERSHED



LANDUSE	ACREAGE	PERCENT
Forest	21,028.7	15.0
Range	95,753.8	68.4
Cropland: non-irrigated small grains	19,080.4	13.6
Cropland: non-irrigated pasture and hay	0.0	0.0
Cropland: irrigated hay	1,178.4	0.9
Cropland: irrigated orchard	2,186.9	1.6
Cropland: irrigated small grain	0.0	0.0
Mined	0.0	0.0
Urban	0.0	0.0
Open Water	727.3	0.5
Total sub-watershed size	139,955.5	100%
Percent of Okanogan Watershed	8.39%	

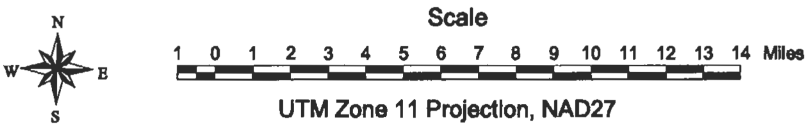


LEGEND

- Streams
- Roads and Trails
- Other Subwatershed Boundaries
- Subwatershed Boundary
- Okanogan Basin Outside Subwatershed
- Okanogan County (outside study area)

General Landuse Categories

- Cropland
- Forest
- Open Water
- Range
- Urban Areas



UTM Zone 11 Projection, NAD27

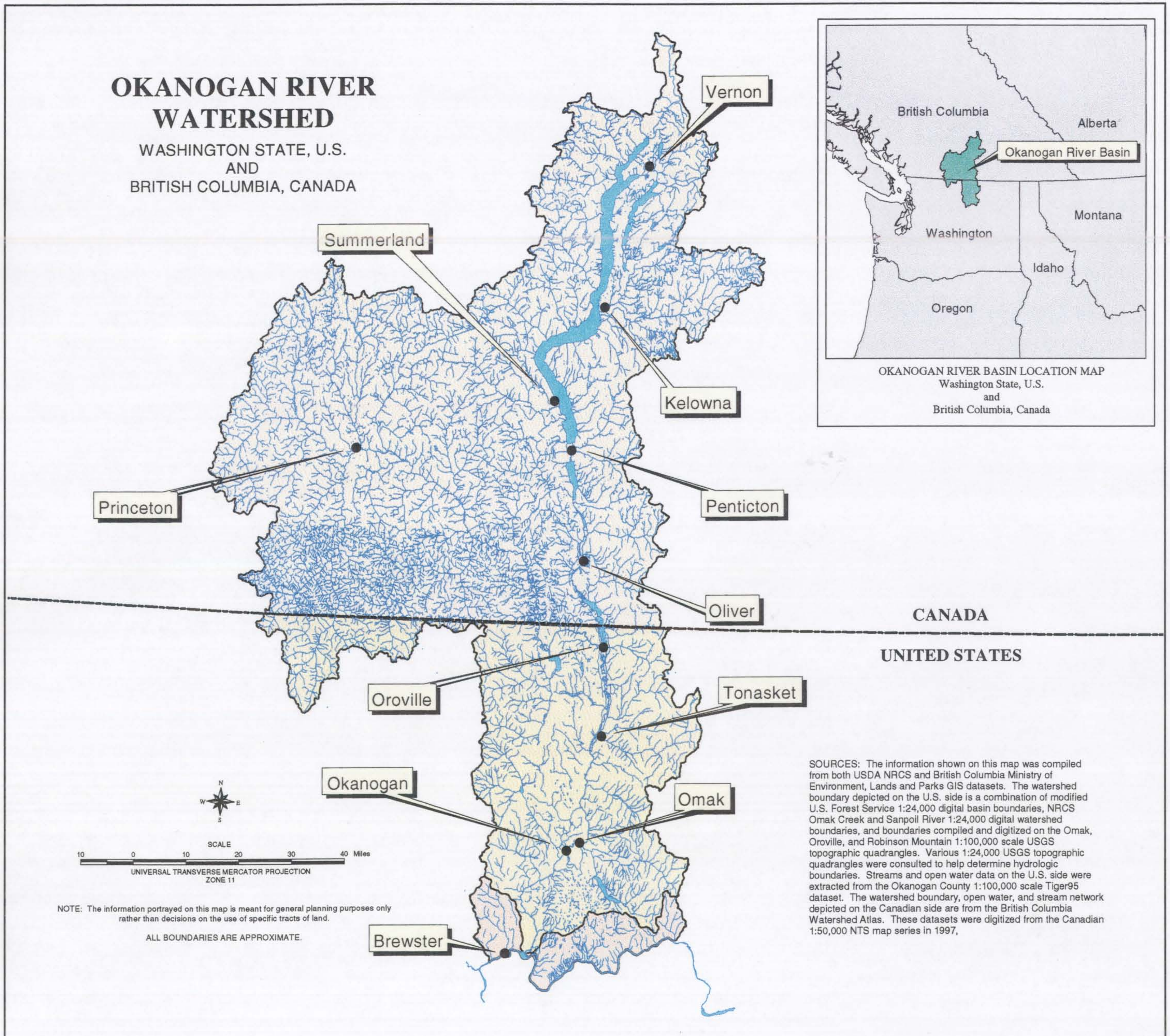
Sources: The data shown on this map was compiled to meet a scale accuracy of 1:100,000. The subwatershed boundaries are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

USDA Natural Resources Conservation Service
Washington State Office, Spokane
July 1998 (revised March 1999)

NOTE: All boundaries are approximate.

OKANOGAN RIVER WATERSHED
MAP 1

WASHINGTON STATE, U.S.
AND
BRITISH COLUMBIA, CANADA

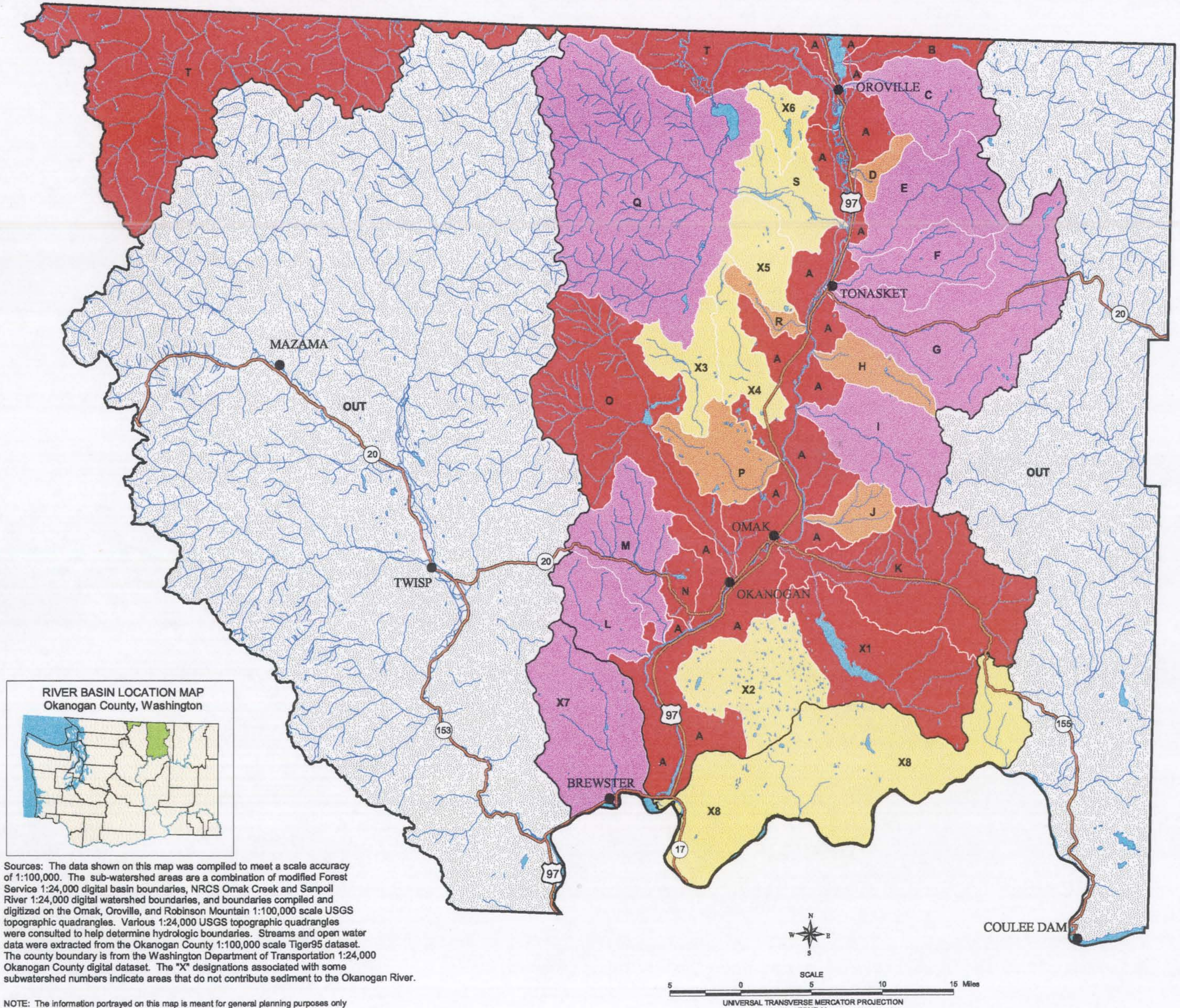


LEGEND

- Selected Cities
- Streams and Rivers
- U.S. - Canadian Border
- Open Water
- Canadian Portion of the Okanogan River Watershed
- U.S. Portion of the Okanogan River Watershed
- Areas Outside the Okanogan River Watershed Included in the Study

USDA Natural Resources Conservation Service
Washington State Office, Spokane
in cooperation with the
Okanogan Conservation District, January 1999

OKANOGAN RIVER BASIN
Priority Sub-watersheds
MAP 2
OKANOGAN COUNTY, WASHINGTON



LEGEND

- Towns
- (20) State Routes
- (97) U.S. Routes
- Major Roads
- Streams and Rivers
- Okanogan County Boundary
- Open Water

PRIORITY WATERSHED RANKINGS

- **HIGH PRIORITY**
- **HIGH PRIORITY (303d Listing)**
- **MEDIUM PRIORITY**
- **LOW PRIORITY**
- **OUTSIDE STUDY AREA**

SUB-WATERSHED LIST

A - Okanogan Interfluve	O- Salmon Creek
B- Nine Mile Creek	P - Johnson Creek
C - Tonasket Creek	Q - Sinlahekin River
D- Mosquito Creek	R - Aeneas Creek
E- Antoine Creek	S - Spectacle Lake/Whitestone Lake
F - Siwash Creek	T - Similkameen River
G - Bonaparte Creek	X1 - Omak Lake
H- Chewiliken Creek	X2 - Duley Lakes/Joseph Flats
I- Tunk Creek	X3 - Fish Lake Basin
J - Wanacut Creek	X4 - North Fork Pine Creek
K - Omak Creek	X5 - Aeneas Lake
L - Chiliwist creek	X6 - Wannacut Lake
M- Loup Loup Creek	X7 - Swamp Creek
N - Tallant Creek	X8 - East WRIA

NOTE: The watershed rankings were developed from a process by which potential impacts on water quality, listings in the Washington 303(d) list, and sediment contribution to the Okanogan River Mainstem were considered. This ranking was proposed by the Technical Advisory Committee and approved by the Stakeholder's Advisory Committee.

Sources: The data shown on this map was compiled to meet a scale accuracy of 1:100,000. The sub-watershed areas are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The "X" designations associated with some subwatershed numbers indicate areas that do not contribute sediment to the Okanogan River.

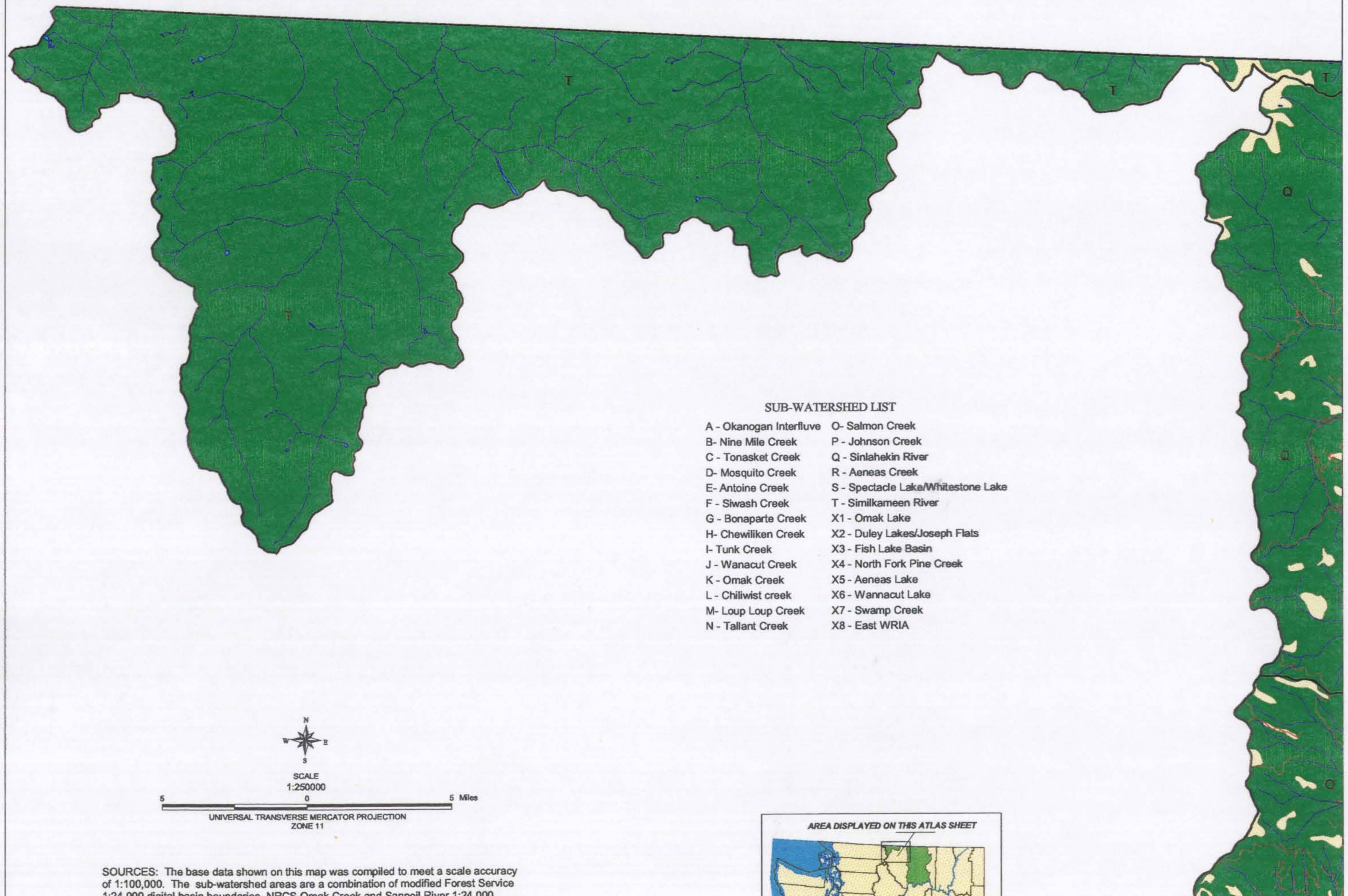
NOTE: The information portrayed on this map is meant for general planning purposes only rather than decisions on the use of specific tracts of land.

ALL BOUNDARIES ARE APPROXIMATE.

USDA Natural Resources Conservation Service
Washington State Office, Spokane
in cooperation with the
Okanogan Conservation District, January 1999

OKANOGAN RIVER BASIN LANDUSE ATLAS
MAP 3: NORTHWEST AREA

OKANOGAN COUNTY, WASHINGTON



RIVER BASIN LOCATION MAP
Okanogan County, Washington

SOURCES: The base data shown on this map was compiled to meet a scale accuracy of 1:100,000. The sub-watershed areas are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. The "X" designations associated with some subwatershed numbers indicate areas that do not contribute sediment to the Okanogan River. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from the Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

LEGEND

- Subwatershed Boundaries
- Primary Road
- Secondary Road
- Other Road or Trail
- Streams and Rivers

LANDUSE CATEGORIES

- Dry Cropland
- Forest
- Irrigated Cropland (Hay)
- Irrigated Cropland (Orchard)
- Irrigated Cropland (Small Grains)
- Mined Areas
- Non-Irrigated Cropland (Pasture/Hay)
- Open Water
- Range
- Urban Areas

NOTE: The information portrayed on this map is meant for general planning purposes only rather than decisions on the use of specific tracts of land.

ALL BOUNDARIES ARE APPROXIMATE.

USDA
USDA Natural Resources Conservation Service
Washington State Office, Spokane
in cooperation with the
Okanogan Conservation District, April 1999

OKANOGAN RIVER BASIN LANDUSE ATLAS
MAP 4: NORTHERN AREA

OKANOGAN COUNTY, WASHINGTON

LEGEND

- Subwatershed Boundaries
- Primary Road
- Secondary Road
- Other Road or Trail
- Streams and Rivers

LANDUSE CATEGORIES

- Dry Cropland
- Forest
- Irrigated Cropland (Hay)
- Irrigated Cropland (Orchard)
- Irrigated Cropland (Small Grains)
- Mined Areas
- Non-Irrigated Cropland (Pasture/Hay)
- Open Water
- Range
- Urban Areas

NOTE: The information portrayed on this map is meant for general planning purposes only rather than decisions on the use of specific tracts of land.

ALL BOUNDARIES ARE APPROXIMATE.

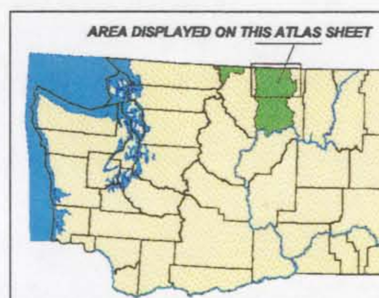
SCALE 1:250000

5 0 5 Miles

UNIVERSAL TRANSVERSE MERCATOR PROJECTION ZONE 11

SUB-WATERSHED LIST

A - Okanogan Interfluve
B- Nine Mile Creek
C - Tonasket Creek
D- Mosquito Creek
E- Antoine Creek
F - Siwash Creek
G - Bonaparte Creek
H- Chewiliken Creek
I- Tunk Creek
J - Wanacut Creek
K - Omak Creek
L - Chiliwist creek
M- Loup Loup Creek
N - Tallant Creek
O- Salmon Creek
P - Johnson Creek
Q - Sinlahekin River
R - Aeneas Creek
S - Spectacle Lake/Whitestone Lake
T - Similkameen River
X1 - Omak Lake
X2 - Duley Lakes/Joseph Flats
X3 - Fish Lake Basin
X4 - North Fork Pine Creek
X5 - Aeneas Lake
X6 - Wannacut Lake
X7 - Swamp Creek
X8 - East WRIA



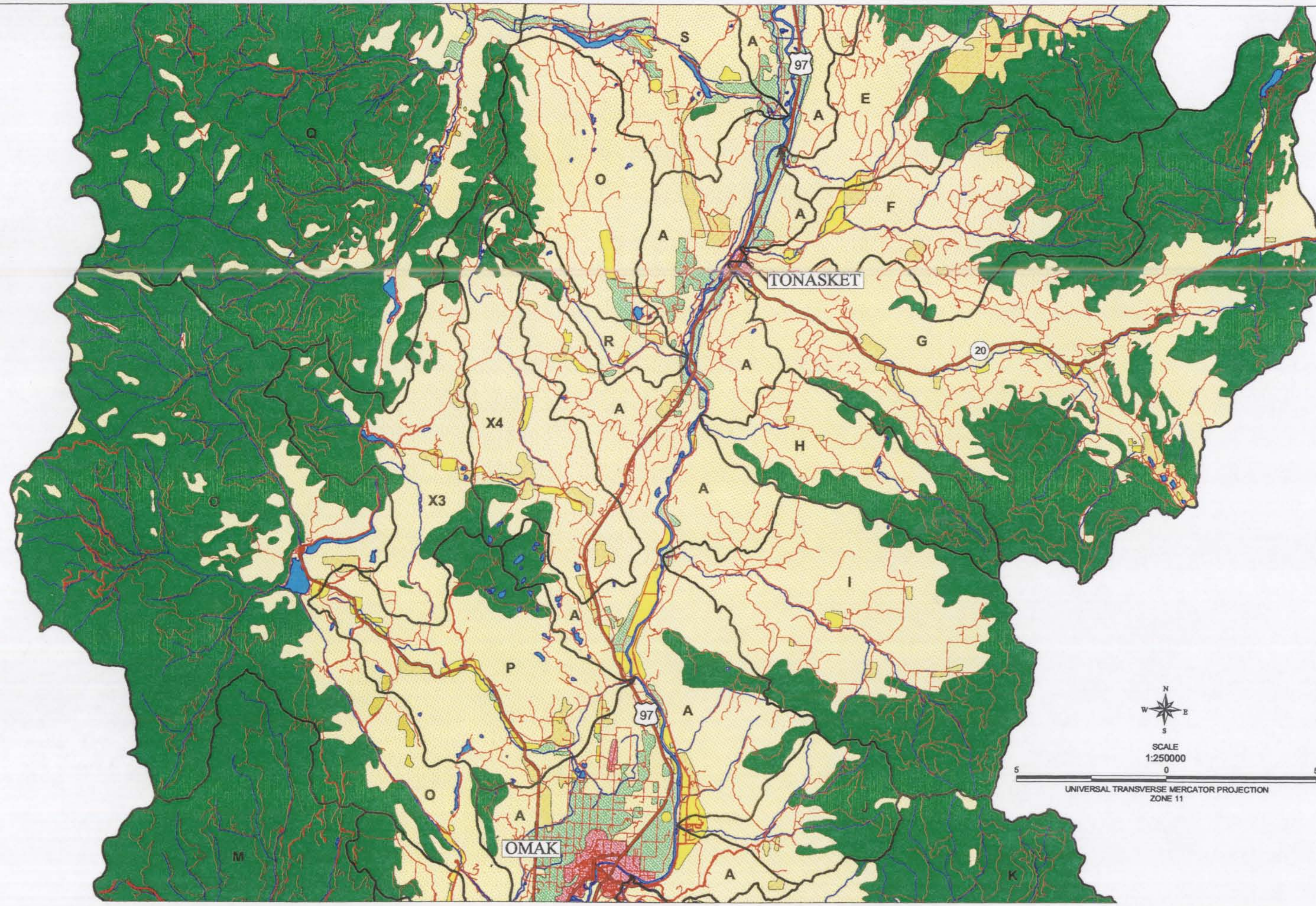
RIVER BASIN LOCATION MAP
Okanogan County, Washington

SOURCES: The base data shown on this map was compiled to meet a scale accuracy of 1:100,000. The sub-watershed areas are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. The "X" designations associated with some subwatershed numbers indicate areas that do not contribute sediment to the Okanogan River. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from the Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

USDA Natural Resources Conservation Service
Washington State Office, Spokane
in cooperation with the
Okanogan Conservation District, April 1999

OKANOGAN RIVER BASIN LANDUSE ATLAS
MAP 5: CENTRAL AREA

OKANOGAN COUNTY, WASHINGTON



LEGEND

- Subwatershed Boundaries
- Primary Road
- Secondary Road
- Other Road or Trail
- Streams and Rivers

LANDUSE CATEGORIES

- Dry Cropland
- Forest
- Irrigated Cropland (Hay)
- Irrigated Cropland (Orchard)
- Irrigated Cropland (Small Grains)
- Mined Areas
- Non-Irrigated Cropland (Pasture/Hay)
- Open Water
- Range
- Urban Areas

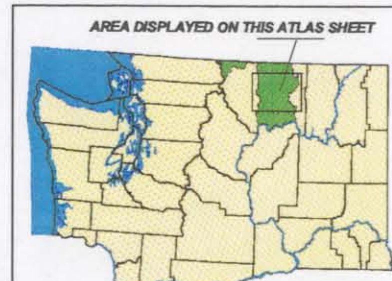
NOTE: The information portrayed on this map is meant for general planning purposes only rather than decisions on the use of specific tracts of land.

ALL BOUNDARIES ARE APPROXIMATE.

SOURCES: The base data shown on this map was compiled to meet a scale accuracy of 1:100,000. The sub-watershed areas are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. The "X" designations associated with some subwatershed numbers indicate areas that do not contribute sediment to the Okanogan River. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from the Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

SUB-WATERSHED LIST

- A - Okanogan Interfluve
- B- Nine Mile Creek
- C - Tonasket Creek
- D- Mosquito Creek
- E- Antoine Creek
- F - Siwash Creek
- G - Bonaparte Creek
- H- Chewiliken Creek
- I- Tunk Creek
- J - Wanacut Creek
- K - Omak Creek
- L - Chiliwist creek
- M- Loup Loup Creek
- N - Tallant Creek
- O- Salmon Creek
- P - Johnson Creek
- Q - Sinlahekin River
- R - Aeneas Creek
- S - Spectacle Lake/Whitestone Lake
- T - Similkameen River
- X1 - Omak Lake
- X2 - Duley Lakes/Joseph Flats
- X3 - Fish Lake Basin
- X4 - North Fork Pine Creek
- X5 - Aeneas Lake
- X6 - Wannacut Lake
- X7 - Swamp Creek
- X8 - East WRIA

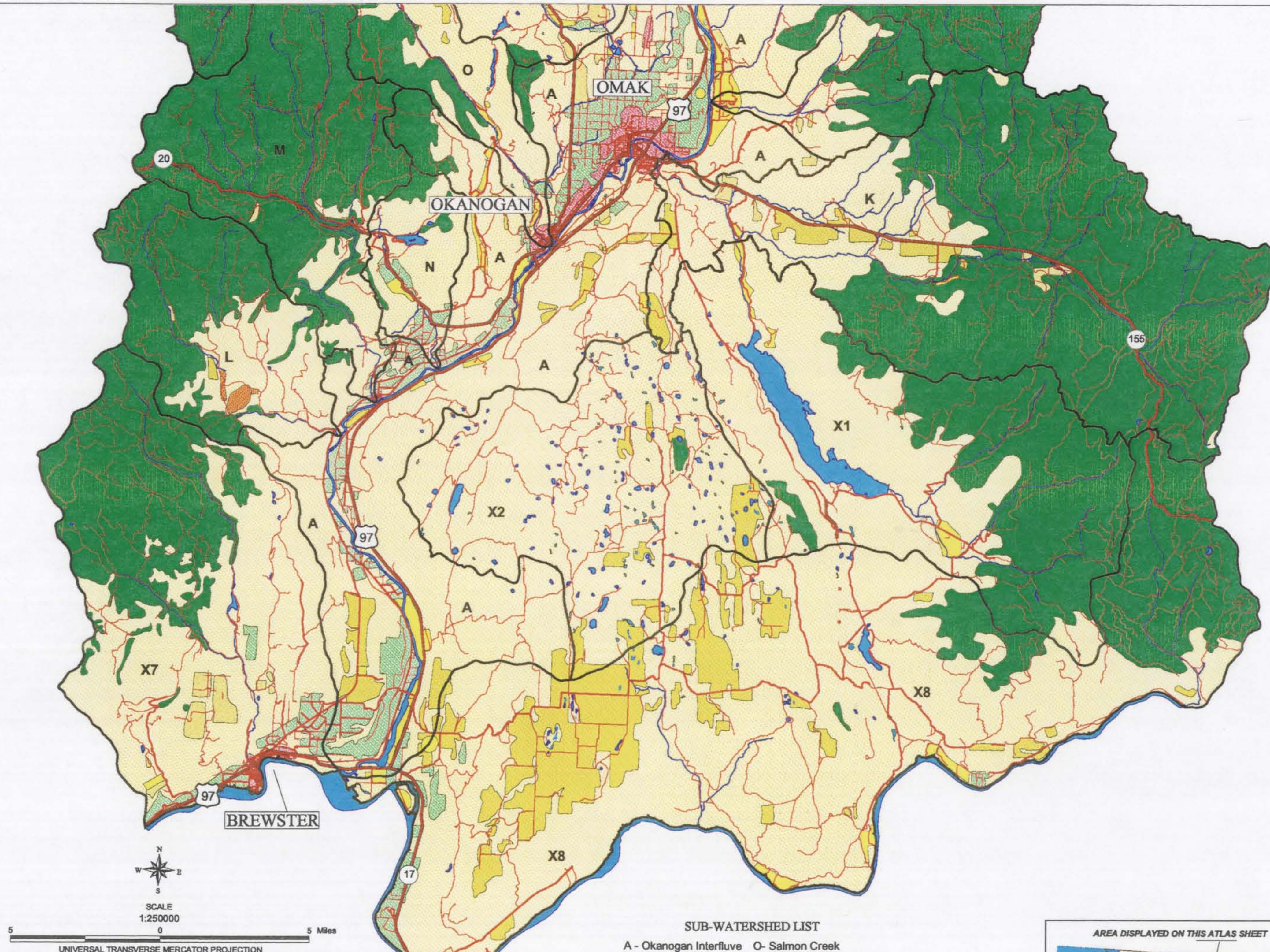


RIVER BASIN LOCATION MAP
Okanogan County, Washington

USDA Natural Resources Conservation Service
Washington State Office, Spokane
in cooperation with the
Okanogan Conservation District, April 1999

OKANOGAN RIVER BASIN
LANDUSE ATLAS
MAP 6: SOUTHERN AREA

OKANOGAN COUNTY, WASHINGTON



LEGEND

- Subwatershed Boundaries
- Primary Road
- Secondary Road
- Other Road or Trail
- Streams and Rivers

LANDUSE CATEGORIES

- Dry Cropland
- Forest
- Irrigated Cropland (Hay)
- Irrigated Cropland (Orchard)
- Irrigated Cropland (Small Grains)
- Mined Areas
- Non-Irrigated Cropland (Pasture/Hay)
- Open Water
- Range
- Urban Areas

NOTE: The information portrayed on this map is meant for general planning purposes only rather than decisions on the use of specific tracts of land.

ALL BOUNDARIES ARE APPROXIMATE.

SUB-WATERSHED LIST

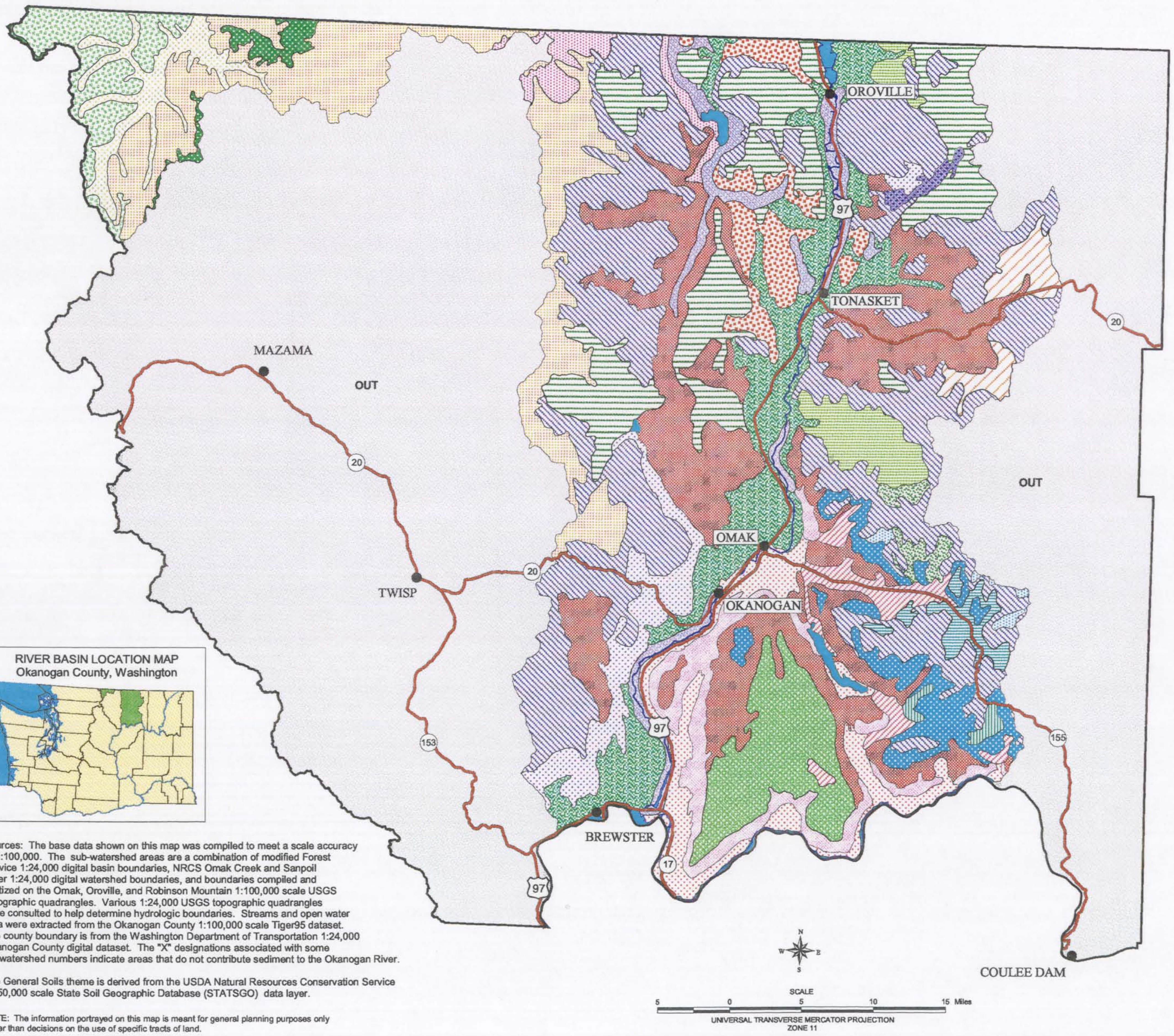
A - Okanogan Interfluve	O- Salmon Creek
B- Nine Mile Creek	P - Johnson Creek
C - Tonasket Creek	Q - Sinlahekin River
D- Mosquito Creek	R - Aeneas Creek
E- Antoine Creek	S - Spectacle Lake/Whitestone Lake
F - Siwash Creek	T - Similkameen River
G - Bonaparte Creek	X1 - Omak Lake
H- Chewiliken Creek	X2 - Duley Lakes/Joseph Flats
I- Tunk Creek	X3 - Fish Lake Basin
J - Wanacut Creek	X4 - North Fork Pine Creek
K - Omak Creek	X5 - Aeneas Lake
L - Chiliwist creek	X6 - Wannacut Lake
M- Loup Loup Creek	X7 - Swamp Creek
N - Tallant Creek	X8 - East WRIA

RIVER BASIN LOCATION MAP
Okanogan County, Washington

SOURCES: The base data shown on this map was compiled to meet a scale accuracy of 1:100,000. The sub-watershed areas are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. The "X" designations associated with some subwatershed numbers indicate areas that do not contribute sediment to the Okanogan River. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The roads information was compiled from the Washington Department of Natural Resources 1:24,000 township level Data96 dataset. The Landuse/Landcover information was delineated by NRCS and Conservation District personnel onto USGS 1:100,000 quadrangles. Categories were photointerpreted using 1990 NRCS 1:12,000 black and white NAPP aerial photography, and digitized at the NRCS State Office at 1:100,000 scale.

USDA
USDA Natural Resources Conservation Service
Washington State Office, Spokane
in cooperation with the
Okanogan Conservation District, April 1999

OKANOGAN RIVER BASIN
General Soils
MAP 7
OKANOGAN COUNTY, WASHINGTON



LEGEND

- Okanogan County Boundary
- Major Roads
- Okanogan County (outside study area)
- Okanogan River Mainstem

STATSGO GENERAL SOIL DESCRIPTIONS

WA001	WA141
WA084	WA148
WA100	WA151
WA115	WA243
WA119	WA299
WA132	WA325
WA133	WA328
WA134	WA341
WA136	WA342
WA137	WA343
WA138	WA345
WA139	WA346
	WA349

NOTE: See the STATSGO General Soils Key on the following page for a description of the components found in the general soil units listed above.

Sources: The base data shown on this map was compiled to meet a scale accuracy of 1:100,000. The sub-watershed areas are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The "X" designations associated with some subwatershed numbers indicate areas that do not contribute sediment to the Okanogan River.

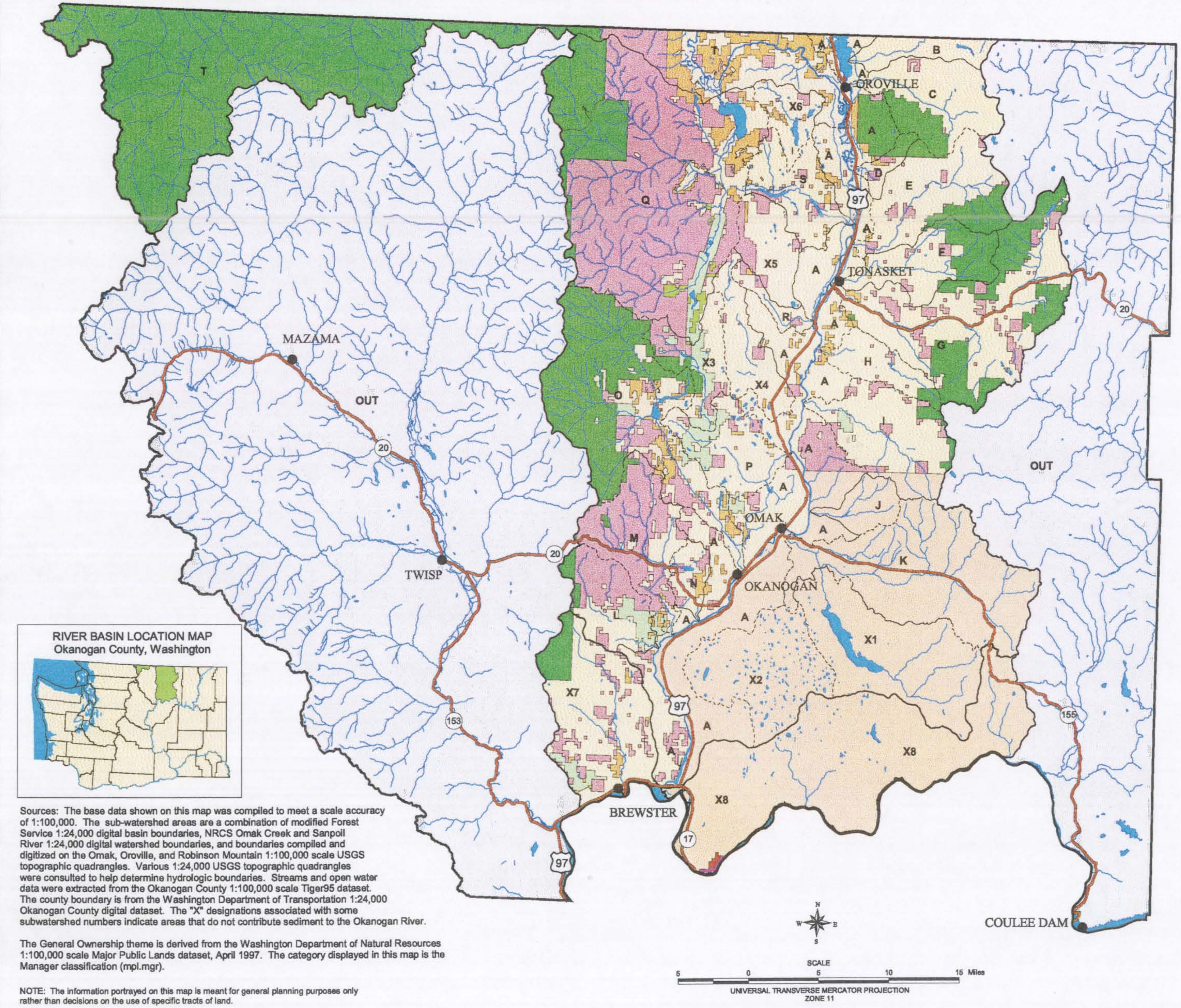
The General Soils theme is derived from the USDA Natural Resources Conservation Service 1:250,000 scale State Soil Geographic Database (STATSGO) data layer.

NOTE: The information portrayed on this map is meant for general planning purposes only rather than decisions on the use of specific tracts of land.

ALL BOUNDARIES ARE APPROXIMATE.

USDA Natural Resources Conservation Service
Washington State Office, Spokane
in cooperation with the
Okanogan Conservation District, April 1999

OKANOGAN RIVER BASIN
General Ownership
MAP 8
OKANOGAN COUNTY, WASHINGTON



LEGEND

- Towns
- State Routes
- U.S. Routes
- Major Roads
- Streams and Rivers
- Okanogan River Basin Boundary
- Subwatershed Boundaries
- Okanogan County Boundary
- Open Water

GENERAL OWNERSHIP CATEGORIES

- Private Lands
- US Forest Service
- US Fish and Wildlife Service
- US Bureau of Land Management
- US Department of Defense
- Washington State Department of Fish and Wildlife
- Washington State Department of Parks and Recreation
- Washington Department of Natural Resources
- Colville Indian Reservation

SUB-WATERSHED LIST

A - Okanogan Interfluve	O- Salmon Creek
B- Nine Mile Creek	P - Johnson Creek
C - Tonasket Creek	Q - Sinlahekin River
D- Mosquito Creek	R - Aeneas Creek
E- Antoine Creek	S - Spectacle Lake/Whitestone Lake
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G - Bonaparte Creek	X1 - Omak Lake
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I- Tunk Creek	X3 - Fish Lake Basin
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K - Omak Creek	X5 - Aeneas Lake
L - Chiliwist creek	X6 - Wannacut Lake
M- Loup Loup Creek	X7 - Swamp Creek
N - Tallant Creek	X8 - East WRIA

Sources: The base data shown on this map was compiled to meet a scale accuracy of 1:100,000. The sub-watershed areas are a combination of modified Forest Service 1:24,000 digital basin boundaries, NRCS Omak Creek and Sanpoil River 1:24,000 digital watershed boundaries, and boundaries compiled and digitized on the Omak, Oroville, and Robinson Mountain 1:100,000 scale USGS topographic quadrangles. Various 1:24,000 USGS topographic quadrangles were consulted to help determine hydrologic boundaries. Streams and open water data were extracted from the Okanogan County 1:100,000 scale Tiger95 dataset. The county boundary is from the Washington Department of Transportation 1:24,000 Okanogan County digital dataset. The "X" designations associated with some subwatershed numbers indicate areas that do not contribute sediment to the Okanogan River.

The General Ownership theme is derived from the Washington Department of Natural Resources 1:100,000 scale Major Public Lands dataset, April 1997. The category displayed in this map is the Manager classification (mpl.mgr).

NOTE: The information portrayed on this map is meant for general planning purposes only rather than decisions on the use of specific tracts of land.

ALL BOUNDARIES ARE APPROXIMATE.

USDA Natural Resources Conservation Service
Washington State Office, Spokane
in cooperation with the
Okanogan Conservation District, April 1999

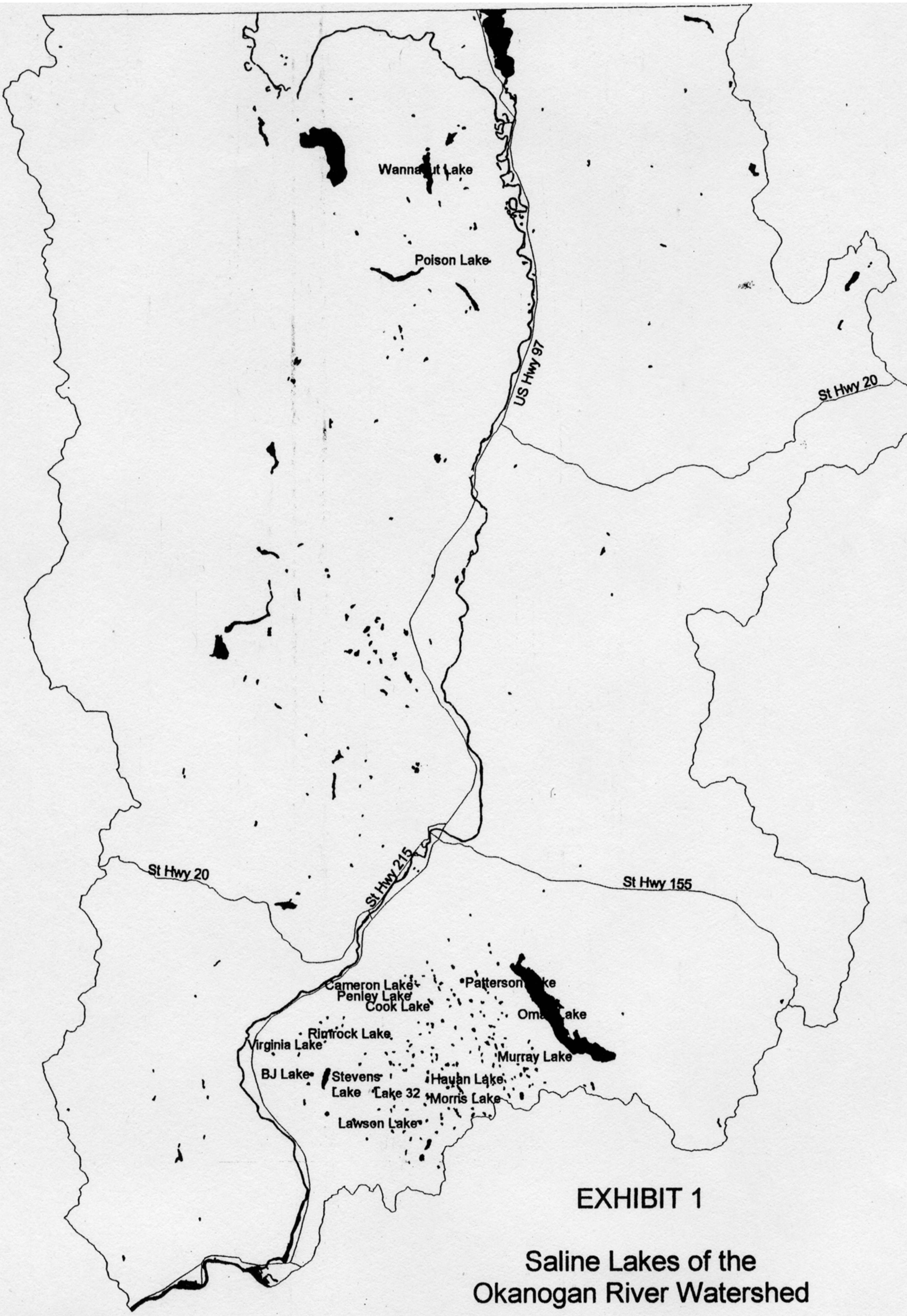

EXHIBIT 1

Saline Lakes of the Okanogan River Watershed

Other saline lakes identified but not on any maps include: Salt, Deposit No. 13, Deposit No. 16, Bitter and Lenton Flat.

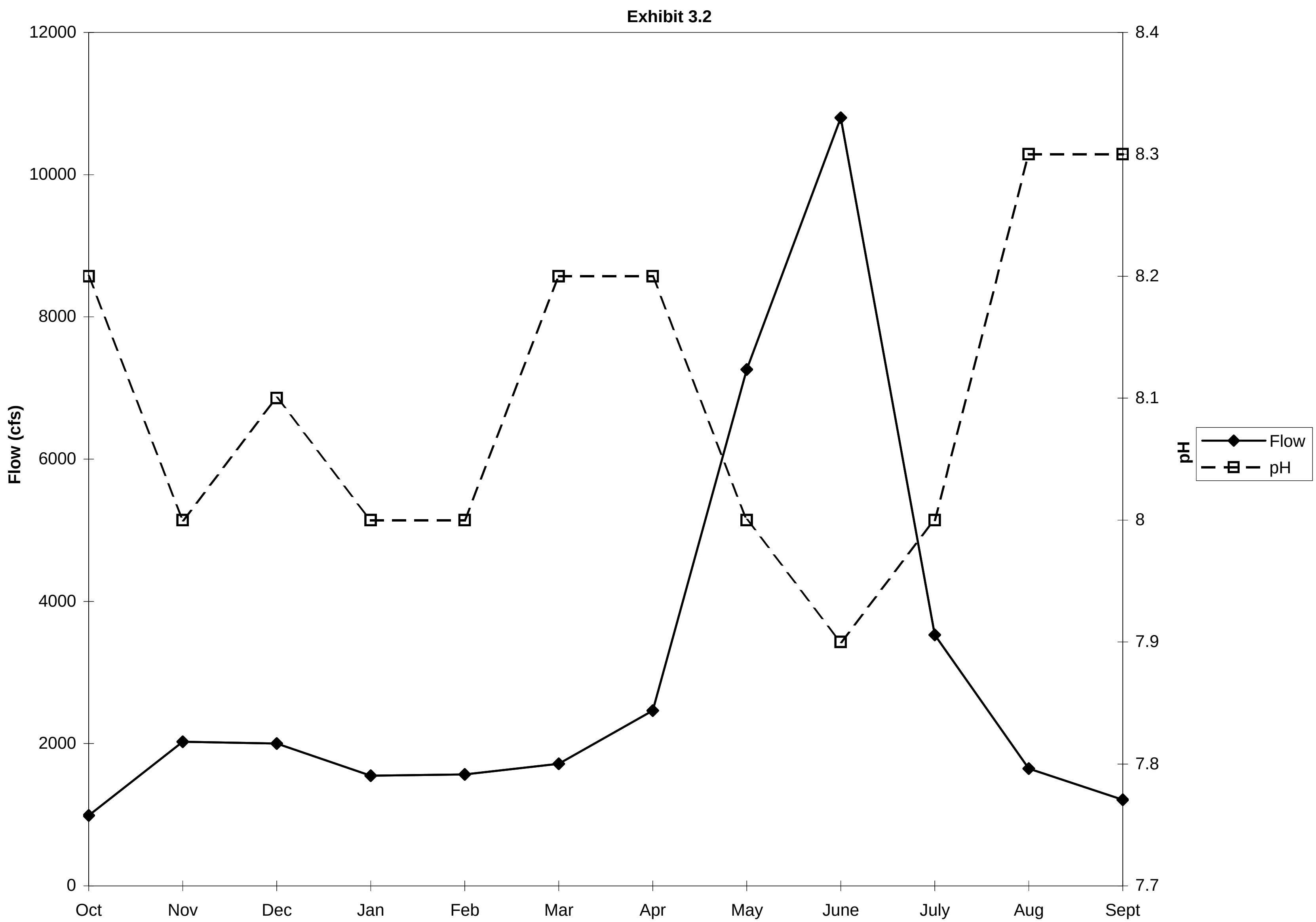

Exhibit 2 Okanogan R. at Malott Avg. Flow & pH vs. Month

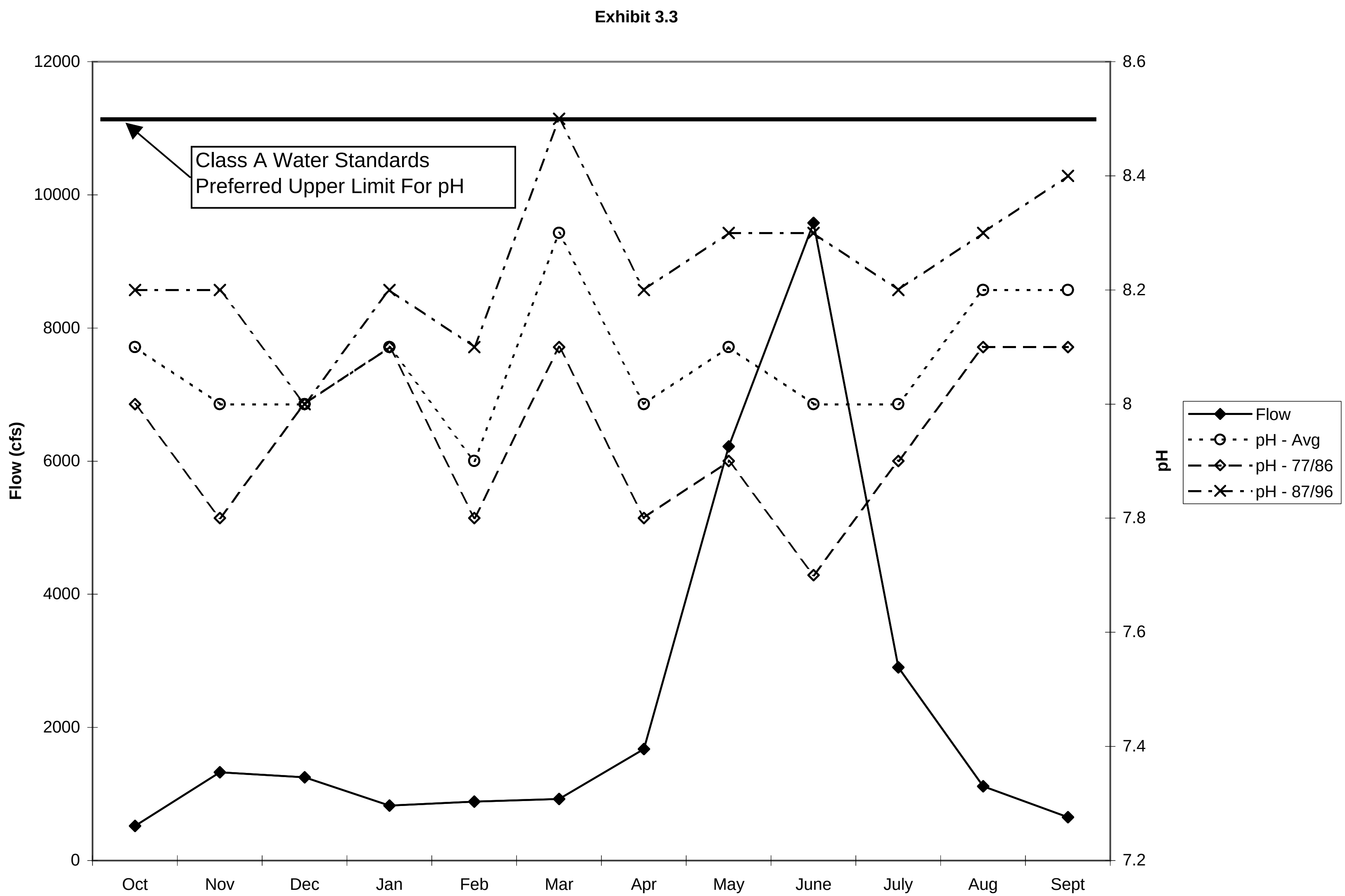

Exhibit 3 Similkameen R. at Oroville Avg. Flow & pH vs. Month

Exhibit 3.4

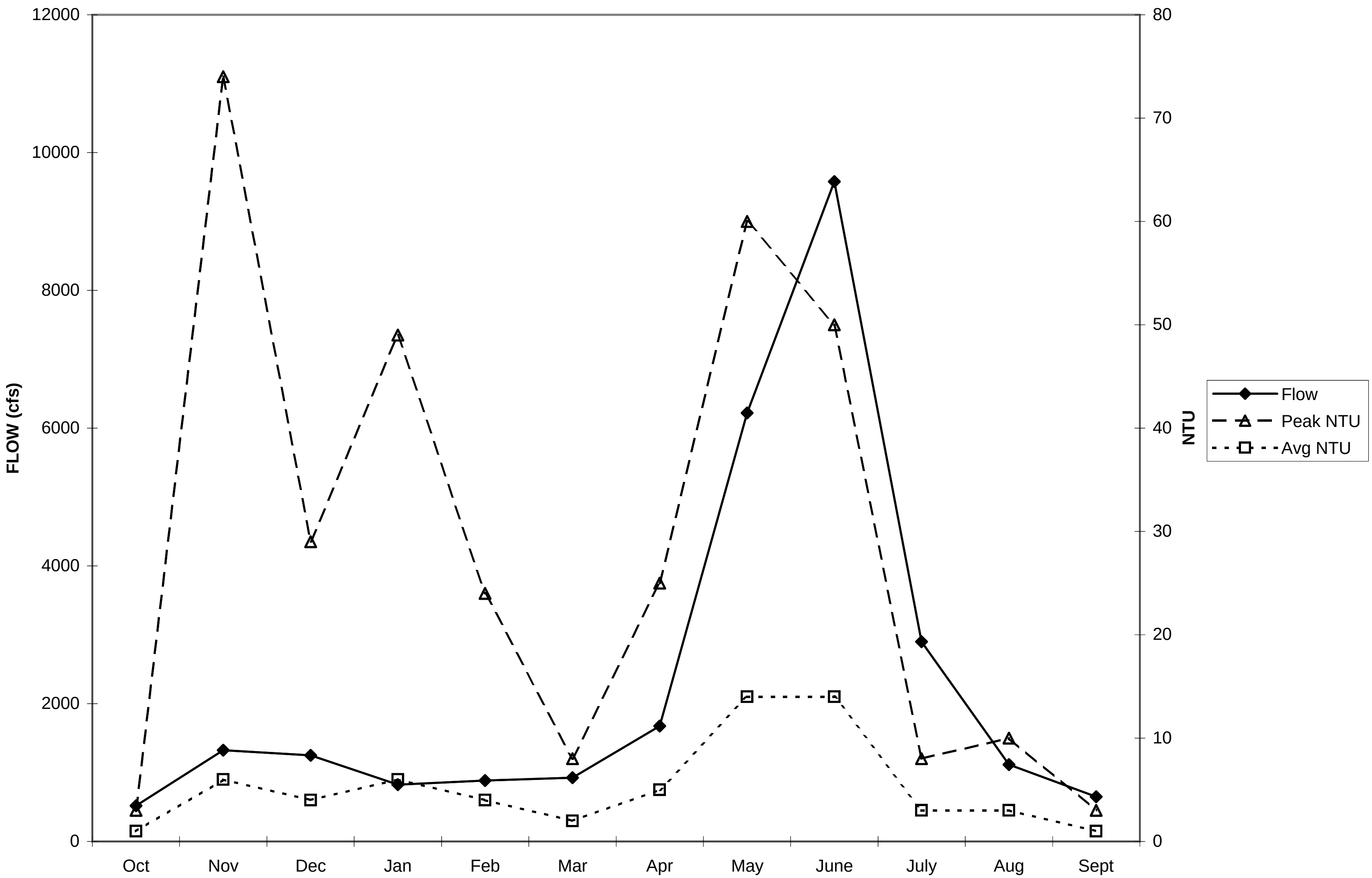

Exhibit 4 Similkameen R. at Oroville Avg. Flow & Turbidity vs. Month

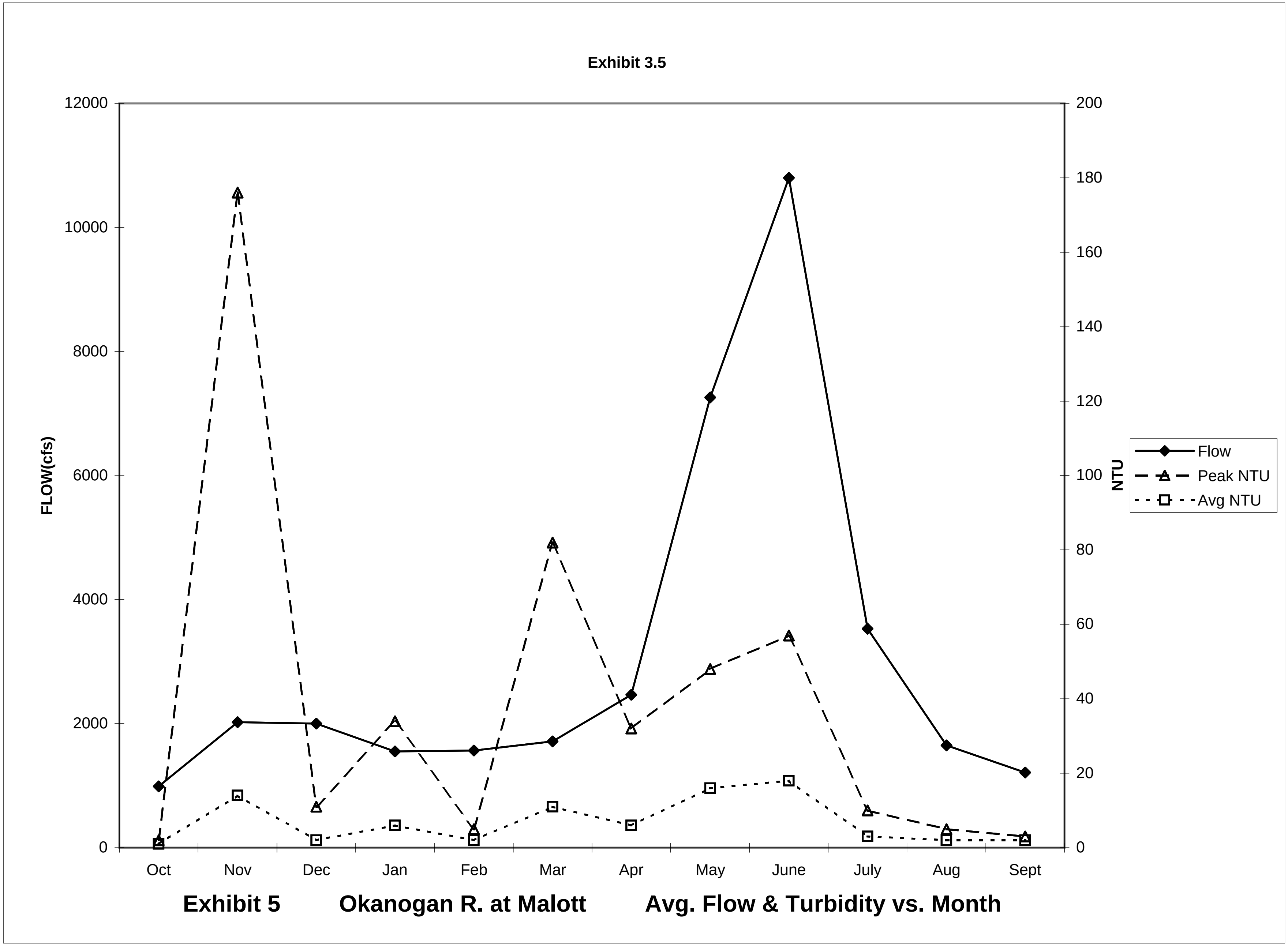

Exhibit 3.5
12000
10000
8000
6000
4000
2000
0
FLOW(cfs)
200
180
160
140
120
100
80
60
40
20
0
NTU
Flow
Peak NTU
Avg NTU
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Exhibit 5 Okanogan R. at Malott Avg. Flow & Turbidity vs. Month

Exhibit 3.6

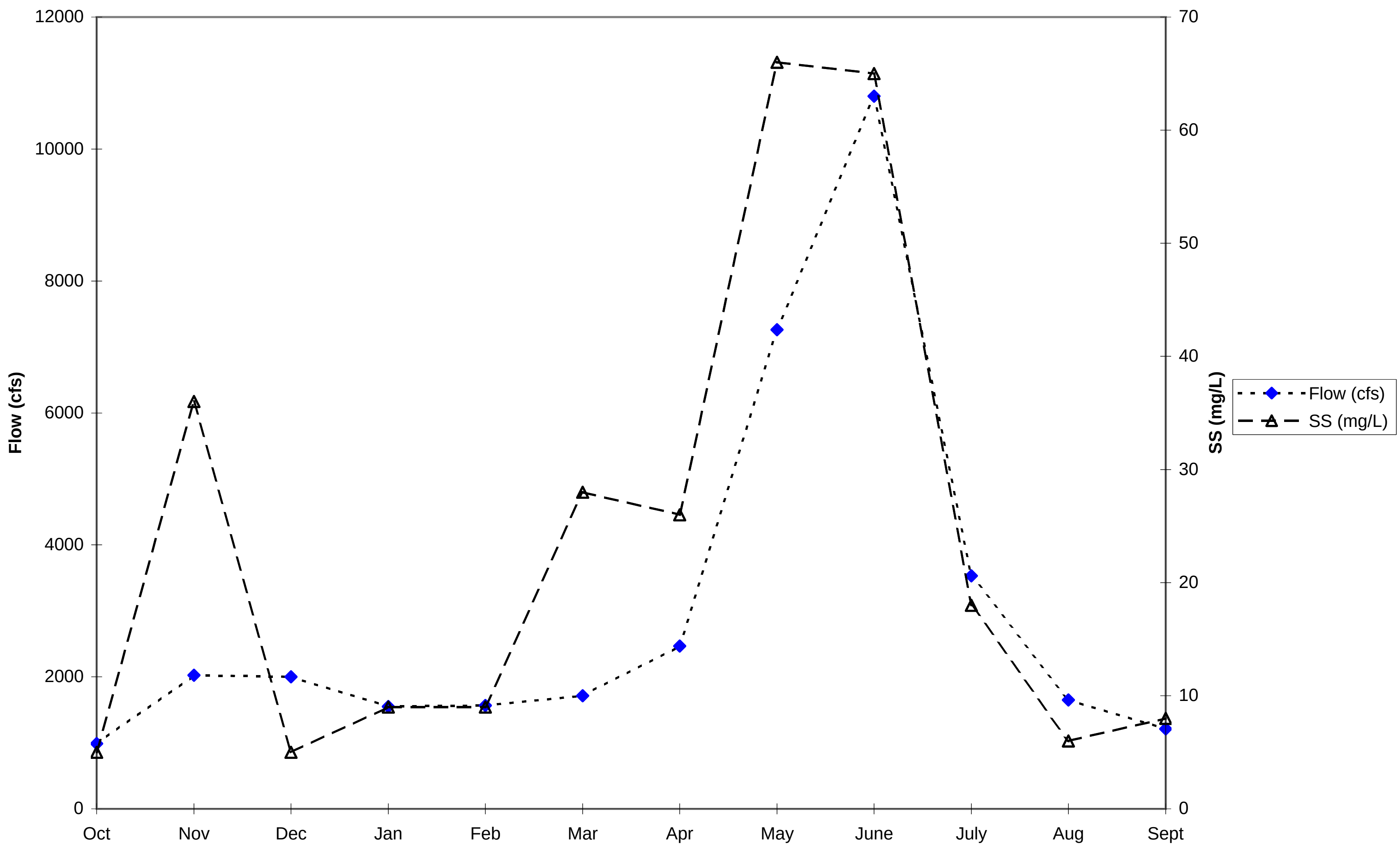

Exhibit 6 Similkameen R. at Oroville Avg. Flow and Sus. Sed. vs. Month

Exhibit 3.7

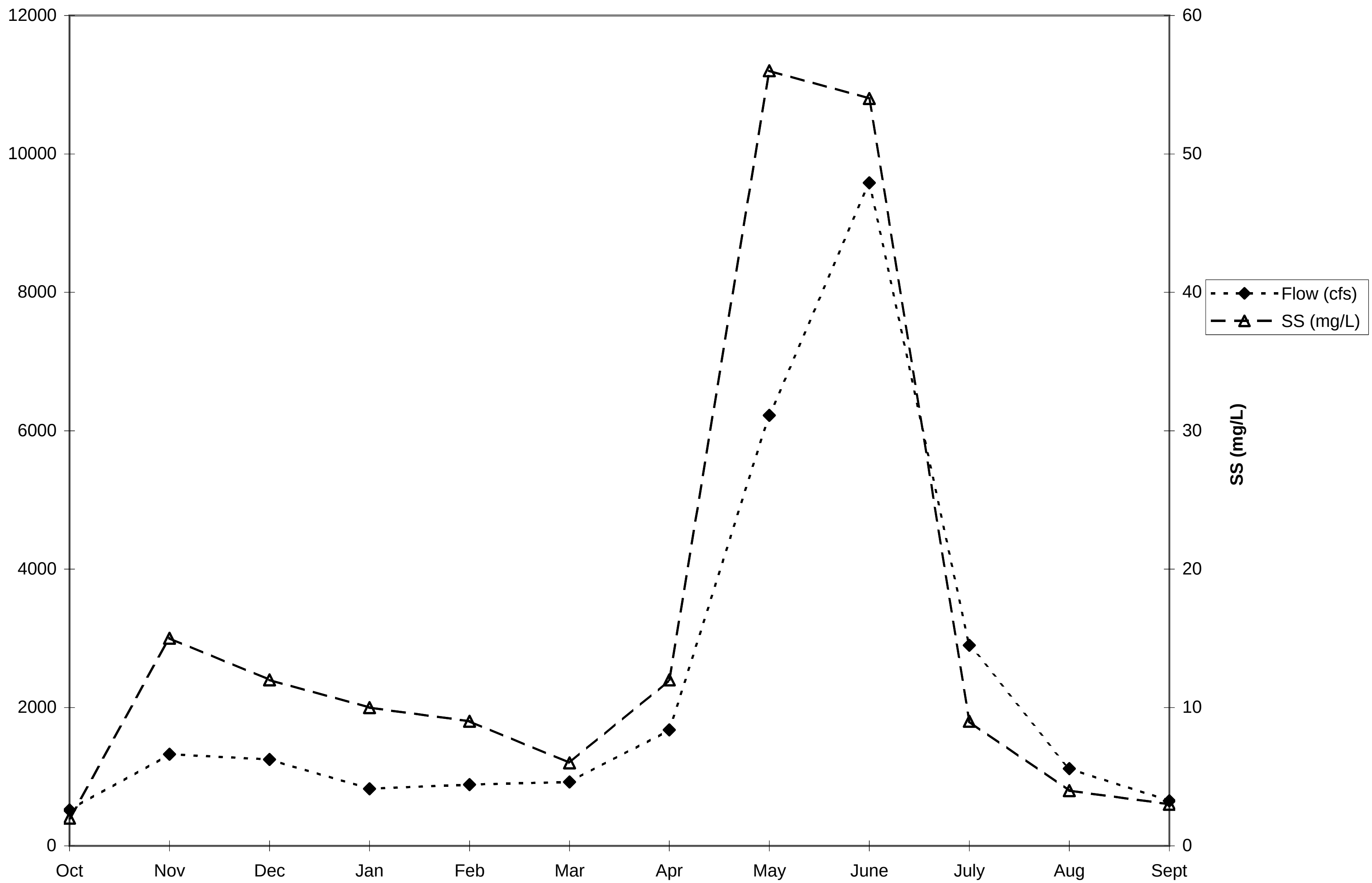

Exhibit 7 Okanogan R. at Malott Avg. Flow and Sus. Sed. vs. Month

3/11/98

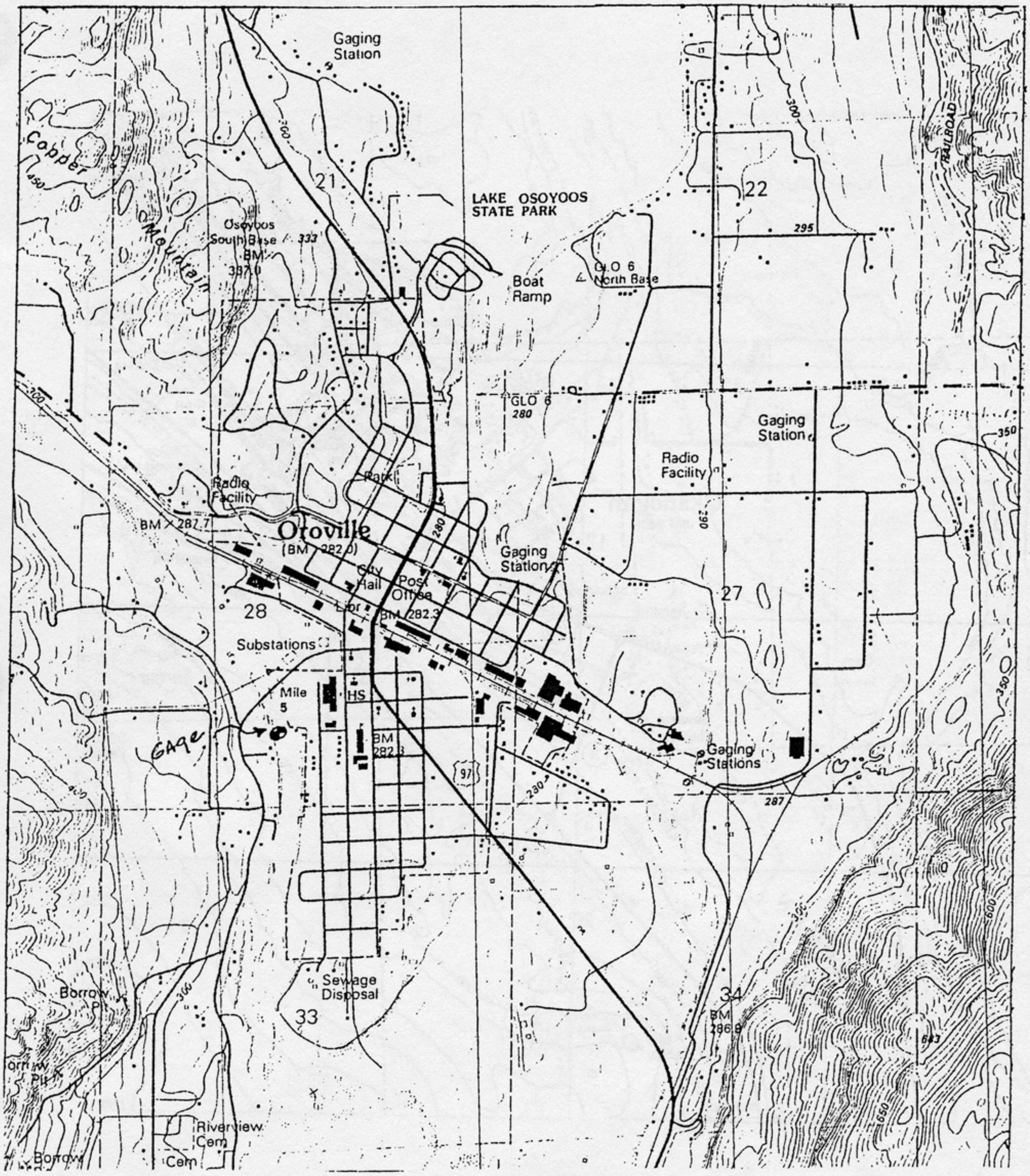

Exhibit 8

Okanogan River Gaging Station at Oroville, WA (USGS Gage #12439500)
Similkameen River Gaging Station at Oroville, WA (Washington DOE Station)

3/11/98

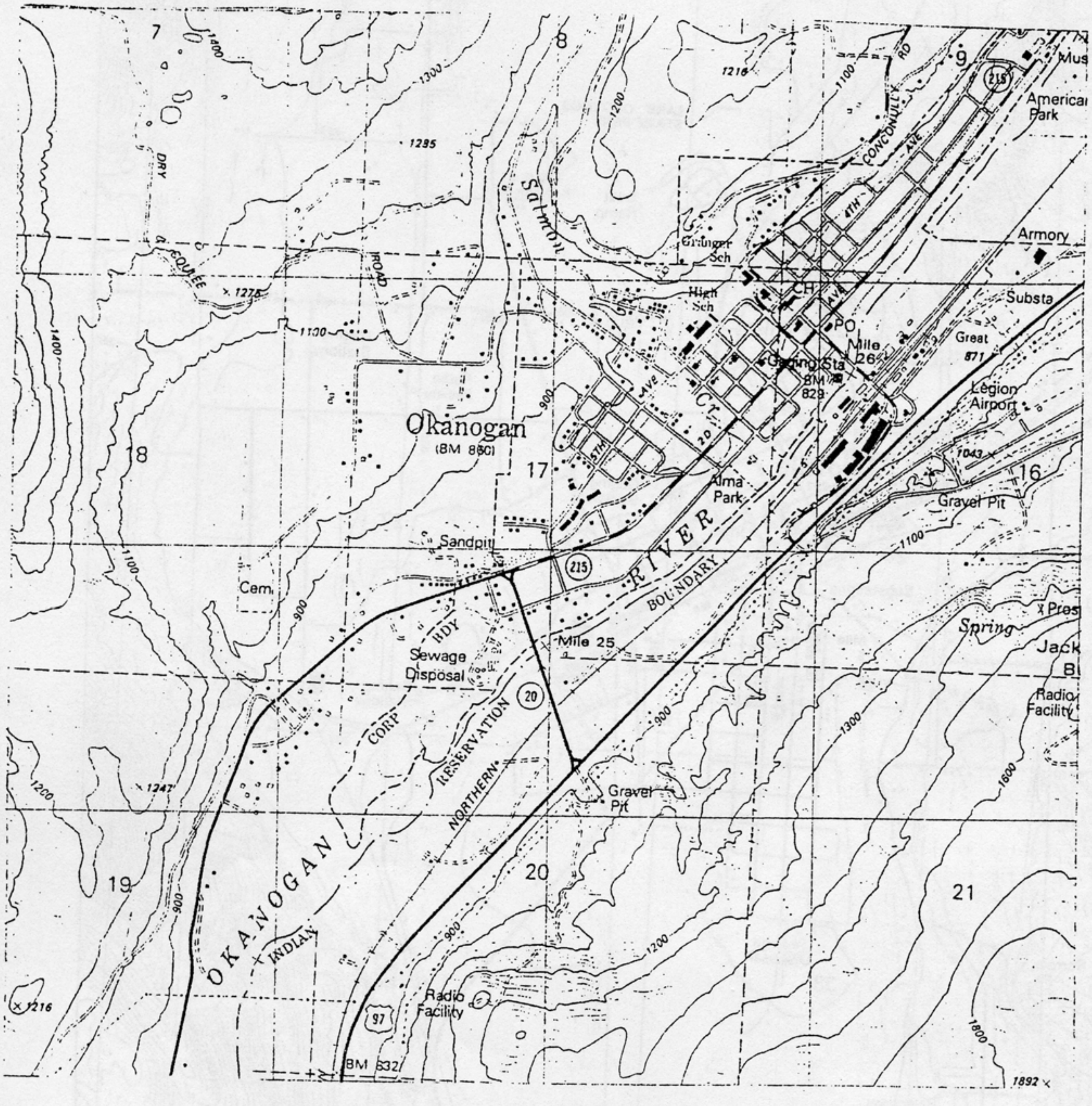

Exhibit 9

Okanogan River Gaging Station at Okanogan, WA (Washington DOE Station)

3/11/98

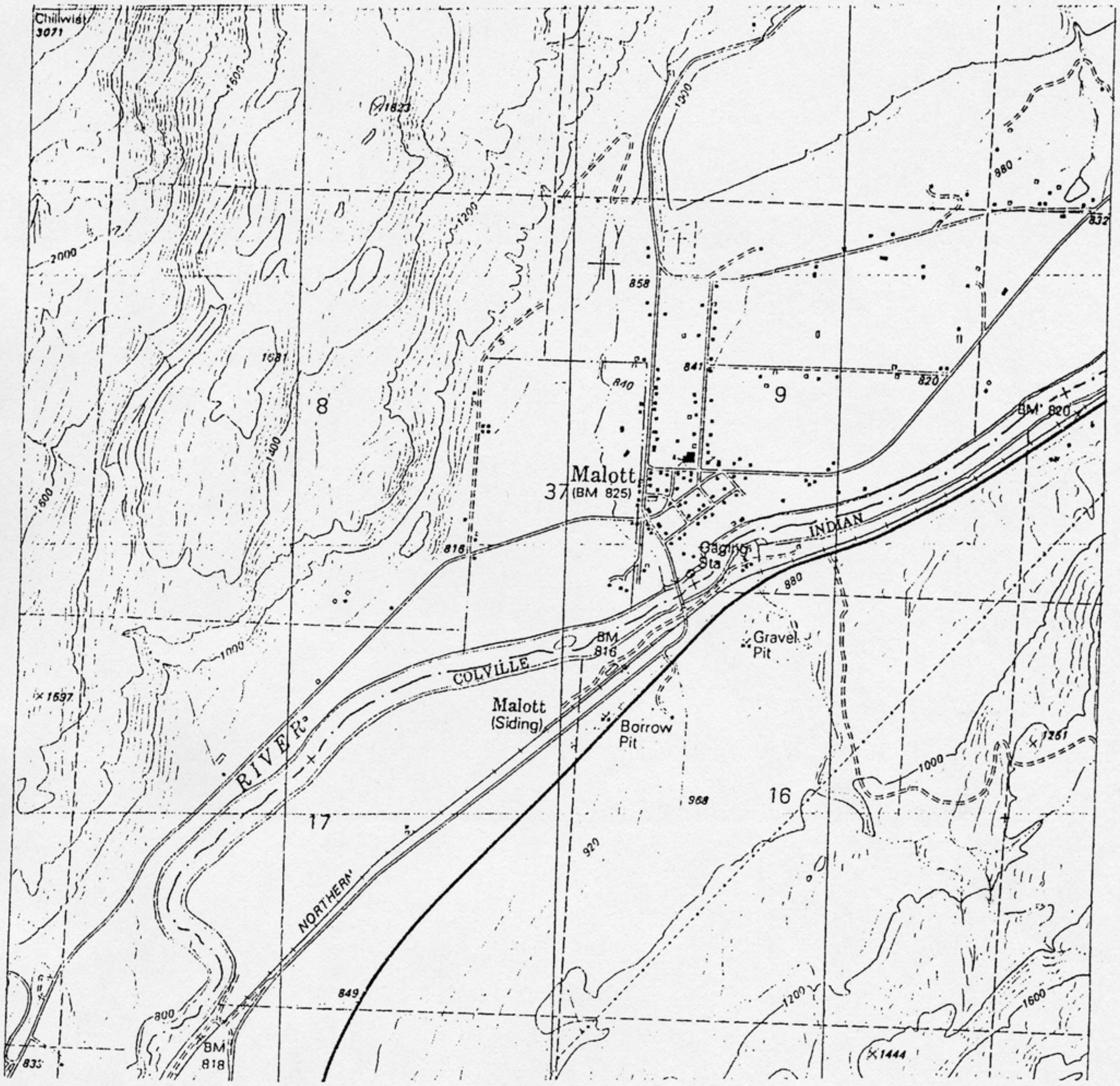

Exhibit 10

Okanogan River Gaging Station at Malott, WA (USGS Gage #12447200)

Irrigation Districts in the Okanogan Watershed

	Aeneas Lake	Alta Vista	Brewster Flat	Helensdale	Okanogan
Acres Supplied	1,400	40	2,832	NR	5,032
Delivery System Length - Pipe	4 miles	1 mile	28 miles	2 miles	50 miles
Delivery System Length -Canal	zero	zero	zero	zero	7.6 miles
Water Entering Delivery System*	11.1 cfs	1.0 cfs	60 cfs @ full demand	NR	15,000 ac/ft/yr
Number of Irrigators	24	300	106	NR	524
How Dependable is Delivery System	8	NR	9	NR	10
How Many Feet of Canal is Lined	NA	NA	NA	NR	7.6mi relined in 1987
Feet of Canal has Excessive Seepage	NA	NA	NA	NR	zero
Source of Water for System	NR	NR	Columbia River	Loup Loup Cr. & Okanogan R.	Salmon Cr. & Okanogan R.
	Whitestone	**Oroville-Tonasket**	**Pleasant Valley**	**Black Bear**	**Total**
Acres Supplied	3,001	10,300	2,000	105	24,710 acres
Delivery System Length - Pipe	16 miles	110 miles	3 miles	zero	210 miles
Delivery System Length -Canal	14 miles	10 miles	3 miles	2.5 miles	37.1 miles
Water Entering Delivery System*	45 cfs @ full demand	41,200 ac/ft/yr	17 cfs @ full demand	2 cfs	
Number of Irrigators	96	800	18	20	
How Dependable is Delivery System	NR	8.5	10	6	
How Many Feet of Canal is Lined	All	5 miles	800' in 4' dia. pipe	zero	
Feet of Canal has Excessive Seepage	Insignificant	1.5 miles	very little	0.6 mile	
Source of Water for System	Toats Coulee Creek	Similkameen R., Lake Osoyoos, Okanogan R.	Leader Lk. & Loup Loup Cr.	Sinlahekin Cr.	

NOTE: This Information obtained from a 1988 Survey Conducted by the Okanogan Conservation District
NA = Not Applicatable
NR = No Response
*All Systems do not have same common denominator. Variable missing from some system information is time at this cfs.

Exhibit 3.6

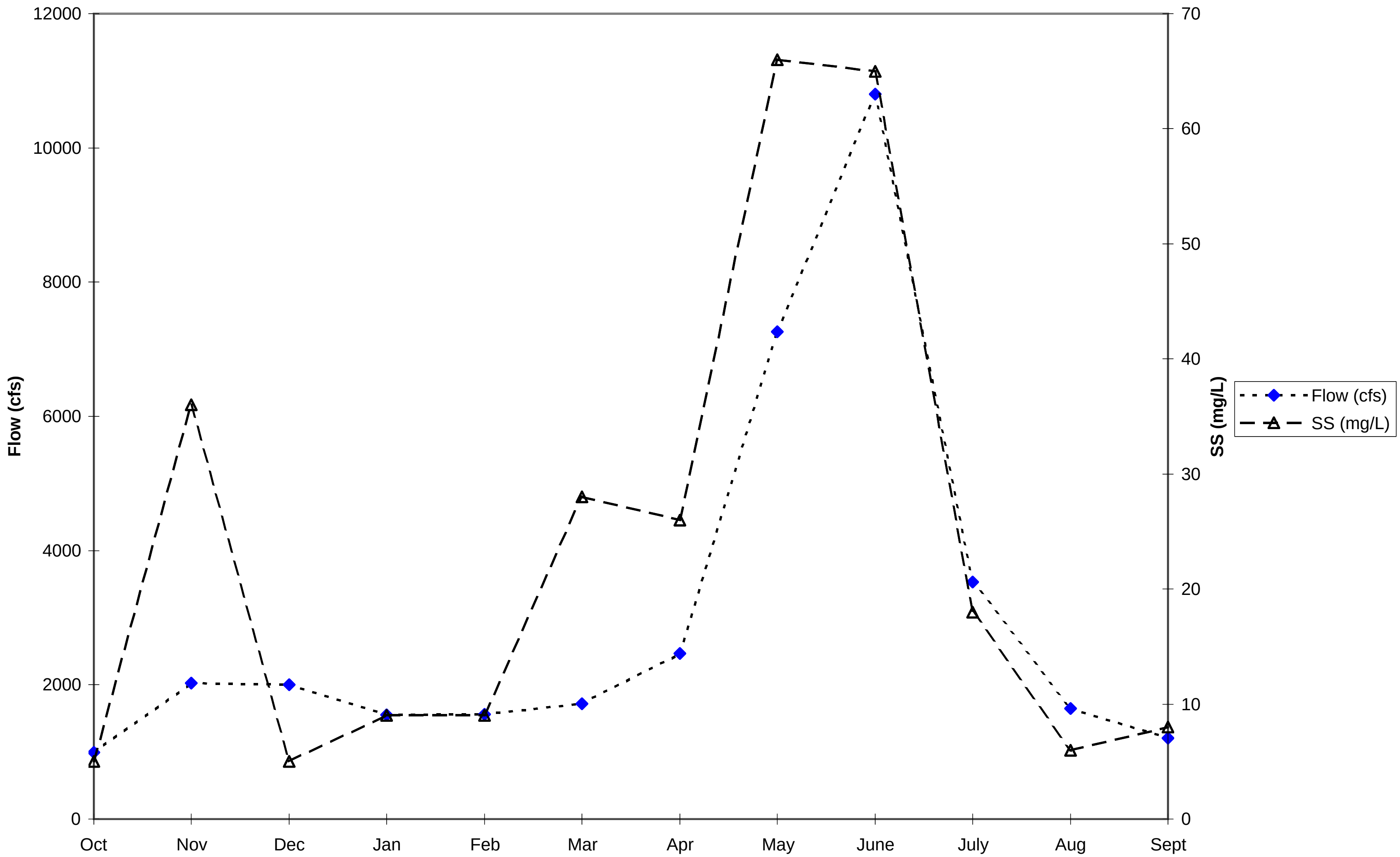

Exhibit 6 Similkameen R. at Oroville Avg. Flow and Sus. Sed. vs. Month

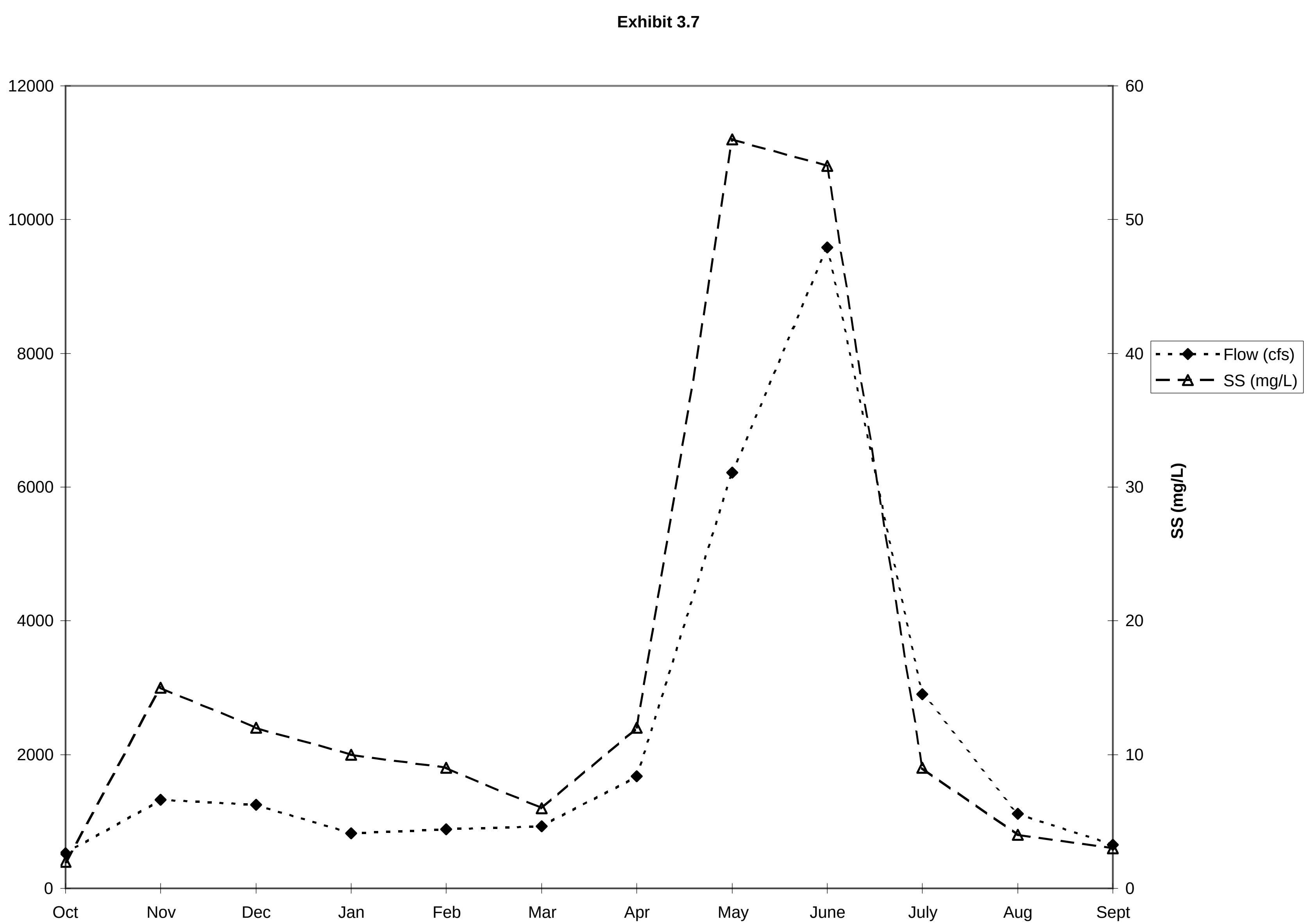

Exhibit 7 Okanogan R. at Malott Avg. Flow and Sus. Sed. vs. Month

1028991

RECEIVED OCT 2 8 1999

CTN

E. Walt Smith, Mayor
2 North Ash
(509) 826-1170
P.O. Box 72
Omak, WA 98841
Fax: 509-826-6531
trishb@televar.com

City of Omak

In the Heart of the Okanogan

State of Washington

October 27, 1999

Mr. Craig T. Nelson
1251 South 2nd Avenue, Room 101
Okanogan, WA 98840

Dear Mr. Nelson:

Received your draft Okanogan Watershed Plan. Our comments involve the very last item TS6 relative to the implementation of a comprehensive management plan.

We have five different discharges presently, and they are tested. Presently, all parking lots, including offices and small areas, etc., are required to have a plan to dispose of the water on site with wells, etc. Also, we collect a fee for storm water from each business to pay for improvements and handling of wastewater. Amount is so small it will take a while to accrue sufficient funds to handle the high costs of alternatives. Any developments are required to treat wastewater on site.

Our concerns are depending on the requirements this could be very costly. We certainly realize wastewater affects our water quality.

Sincerely yours,

CITY OF OMAK

E. Walt Smith
Mayor

EWS/nld

City of Tonasket
P.O. Box 487 ◆ Tonasket, WA 98855 509 / 486-2132 • Fax 486-1831

RECEIVED DEC 1 6 1999

December 7, 1999

Okanogan Conservation District
Craig Nelson, District Manager
1251 S. Second Ave., Room 101
Okanogan, WA 98840

Re: Watershed Plan Action Item

Dear Craig,

This letter is intended to acknowledge the action item for which the cities have been designated as lead entity. We assert that the City of Tonasket should be the responsible entity in regards to any plans developed for the City.

We cannot at this time identify an implementation schedule for the development of a storm water management plan as we are in the midst of seeking funding for a complete replacement of our wastewater treatment facility. However, we will investigate the scope of such a project in the year 2000 and plan accordingly. Meanwhile, our planning director and building official are aware of the potential for contamination of surface waters and will continue to work diligently to ensure that all storm water is treated on site in new development.

Sincerely,

David T. Caddy Sr.

David T. Caddy, Mayor
City of Tonasket

RECEIVED DEC 0 9 1999

City of Oroville

Clerk's Office, P.O. Box 2200, Oroville, Washington, 98844, (509) 476-2926 FAX (509) 476-9067

December 7, 1999

Okanogan Conservation District
Craig Nelson, District Manager
1251 S. Second Ave., Room 101
Okanogan, WA 98840

Re: Watershed Plan Action Item

Dear Craig,

We apologize for the late reply regarding the cities' lead entity designation for Action Item TS6. We cannot locate the specific request for our concurrence with this action item but our Stakeholder Advisory Member, Chris Branch, has advised us of its content.

As mentioned in the plan, the City of Oroville already does a great deal to reduce storm water impacts through various means; however, we concur that a general plan regarding our future management of storm water is necessary. We also agree that each individual city should be responsible for developing and implementing their own plans.

While we cannot at this time identify an implementation schedule for the action item we will consider the costs and work to identify funding sources over the next year. In the meantime, we believe that we can begin to collect and organize background data that will be used in a storm water management plan (e.g., estimated flow data, maps of existing and planned system, discharge points). Additionally, we will continue to implement development standards that minimize or eliminate runoff to surface waters.

Sincerely,

Jimmie Dale Walker

Jimmie Dale Walker, Mayor
City of Oroville

RECEIVED FEB 0 9 2000

CITY OF OKANOGAN
OKANOGAN, WASHINGTON 98840
120 N. 3rd Ave. • P.O. Box 752

February 7, 2000

Okanogan Conservation District
ATTN: Craig Nelson
1251 South Second Avenue, Room 101
Okanogan, WA 98840

Dear Mr. Nelson:

The City of Okanogan would like to state its concurrence with the portion of the Okanogan Watershed Management Plan that deals with the City. The City will address the issues as time and money allows.

If you have any questions, please feel free to call me.

Sincerely,

Ella Schreckengost
Mayor

Pc: Norm Butler, Public Works Supt.

PHONE (509) 422-3600 • FAX (509) 422-0747 • E-MAIL okanogan@northcascades.net
Supt. Office (509) 422-0717 • City Shop (509) 422-3902 • Wastewater Treatment Plant (509) 422-0000
Fire Dept. (509) 422-5757 • Bldg. Official (509) 422-3600