Tenmile Lakes
Watershed Assessment

Produced by the Tenmile Lakes Basin Partnership

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Hydrology & Water Use
Eel and Clear Lakes provide water for the cities of Lakeside and Reedsport, respectively. Reedsport is situated north of the Tenmile basin, and redirects water from the Clear Lake basin to the Umpqua river. Annual rainfall varies from sixty five inches in the coastal regions to upwards of 100 inches near the eastern watershed boundary. Most rainfall occurs between October and April, but it is rare for a month to go by without some rain. The lakes are fed by numerous tributaries that take the form of long arms reaching back into the tributary valleys, which reflects the origin of the lakes, namely, a series of drowned river valleys.
As with most of Oregon, water rights are overextended, i.e., there isn't enough water to go around based on the number of rights and the amount of flowing water.

Fish & Fish Habitat

Due to various human activities, the once prolific Coho producing Tenmile Lakes complex has lost its crown as the most productive coastal spawning grounds in Oregon. Introduced predatory warm water fish have made the lakes inhospitable to salmonids, removing the overflow area for nomad fry. Ditched waterways in agricultural areas have reduced spawing habitat and increased turbidity while allowing more light to reach the water's surface, leading to increased temperatures.

Riparian Conditions & Wetlands

Wetlands have been converted to fields and home sites, buried by roads and railroads, and starved of water in the dry summer months by channelization. Riparian areas have remained mostly healthy in the eastern third of the watershed, which is mostly Elliott State Forest, while agricultural areas and lake front riparian zones have suffered from clearing activities. Large woody debris recruitment lags in all areas of the watershed as a result of logging activity and land clearing for farms and home sites. Unexpectedly, solar loading is less of a problem than we had assumed in the agricultural areas. Most streams were ditched on the south sides of their resident valleys, and therefore receive topographic shading from the abutting hillslopes. The ditching itself also affords some cushion for temperature swings, as the higher banks and lower width to depth ratio limit the amount of water surface area available to solar heating.

Sediment Sources

The background rate of mass wasting in the coast range is much higher than elsewhere in the state, due primarily to high annual rainfall, steep topography, and intense storm events that occasionally produce large quantities of rain in relatively short periods of time. Roads, un-vegetated rangeland, downcutting due to channelization, and logging activity add to the background rate of landslides, streambank erosion, and surface erosion. According to the Tenmile Lake Nutrient Study (J.M. Eilers, et al), the Sediment Accumulation Rate (SAR) has increased fourfold over historical rates (pg 83). Sedimentation also occurs within the lakes as a result of biological activity, e.g.,

Channel Modification

The common practice of ditching streams in agricultural areas has had several consequences. Progressive down cutting of alluvial deposits within and upstream of agricultural areas, and the disappearance of wetlands and moisture tolerant plant communities formerly located within agricultural areas. Whereas in the past, the low gradient stream deltas were populated by willow, ash (possibly), poplar, alder, cherry, and other now extirpated species, the deltas now are typically utilized as hay fields and forage for cattle.

Water Quality

The most pressing concerns with water in the basin are water quality within the lakes themselves and elevated stream temperatures during the summer months. The cyanobacteria Microcystis presents a health and public relations problem when water levels drop and temperatures go up. Most spawning grounds had acceptable temperatures based on monitoring studies in 2001 and earlier, but solar loading in agricultural areas may contribute to overall lake warming.

Watershed Condition

Conditions in the watershed are dire in some respects, such as aquatic weeds and exotic fish, and acceptable if not good in others, such as spawning habitat in the Elliott State Forest.

Monitoring

The Tenmile Lakes' Basin Partnership (TLBP) has numerous monitoring programs, including stream temperature, riparian planting progress, and microcystis testing.

Chapter 1

Introduction

Purpose and Extent

The goals of this watershed assessment are to characterize conditions within the Tenmile Lakes basin, and to provide a roadmap for restoration activities geared towards improving salmonid habitat and water quality. Existing information will be gathered and integrated with data collected by the Tenmile Lakes Basin Partnership (TLBP).

As Oregon Watershed Enhancement Board (OWEB) assessments are meant to be large scale screenings of watershed processes, the wide range of subjects is meant to indicate areas that need more attention. Of primary concern is the explanation of complex watershed processes for the benefit of watershed council members, the general public, and natural resource managers involved in the enhancement and management of the Tenmile Lakes basin. Ultimately, increased understanding of watershed dynamics and land use practices, along with community involvement will lead to a Tenmile Lakes Watershed which will maintain and improve all beneficial uses.

Geographical Setting

The Tenmile Lakes basin is situated on the southwest coast of Oregon, in northern Coos and western Douglas Counties, and encompasses approximately 98 square miles of lakes, river valleys, and ocean dunes. Tenmile Creek drains all streams in the basin directly to the Pacific Ocean, seven miles to the south of the Umpqua River.

The City of Lakeside lies near the outlet of South Tenmile Lake, and is the only incorporated area in the watershed.

Ecoregion

Oregon is divided up into ecoregions based on climate, geology, physiography, vegetation, soils, land use, wildlife, and hydrology. Each ecoregion is shaped by and functions through its unique combination of natural variables. Familiarity with the characteristics of an ecoregion permits a greater understanding of that ecoregion. The Tenmile basin has stretches of coastal lowlands, coastal uplands, and mid-coastal sedimentary.

Coastal lowlands occupy the coastal fringe of most of Oregon, and are characterized by sand dunes and low terraces, low gradient streams and shallow coastal lakes, tidal marshes and estuaries. Shore pines, Sitka spruce, salal, and various native and introduced shrubs are common. Rainfall runs sixty to eighty five inches a year, and snow is rare but not unknown.

Coastal uplands extend inland from the lowlands, are wetter (up to twice as much rain), steeper, and are more prone to landslides and erosion than the lowlands they drain into.

Mid-coastal sedimentary regions occur higher up in the watershed, and include some of the steepest and wettest terrain in the Tenmile basin. See map 1.3.

Population

Lakeside is the main population center in the Tenmile Basin, with approximately 1800 residents. Outside city limits there are numerous rural residences, numbering perhaps close to a thousand homes. About half of these homes are concentrated along the shores of North and South Tenmile Lakes. The rest are scattered around the watershed and the area surrounding Saunders Lake.

Climate and Topography

The Tenmile Basin shares many traits of coastal Oregon, mainly the influence of the Pacific Ocean and seasonal wind patterns. The ocean acts as a moderator, allowing neither very cold nor very hot conditions to persist for long. Winters tend to be mild, with temperatures in the thirty to sixty degree (Fº) range, and winds predominantly out of the southwest. Northwest winds dominate summer weather on the coast, leading to conditions that are in some ways less favorable than during the winter. Ocean water temperatures, for example, tend to be significantly colder during the summer due to upwelling in the ocean caused by the northwest winds. The mean air temperature in July is 59Fº, and it never seems to vary by more than a few degrees.

Inland a few miles, however, is an entirely different story. In the lee of ridges, out of the relentless NW winds, temperatures may reach the mid 90's occasionally, and night time temperatures can dip lower than those on the coast. Lakeside is also rarely plagued by the coastal summer fog. Slopes are steeper here, and rainfall more substantial. This is where agricultural areas are located, tucked away in the valley bottoms, in between steep slopes of timber land.

The summer months are usually very dry, with an average of 4.4 inches for June, July, August, and September. July is the driest month, averaging only 0.31 inches of precipitation. The winter months bring prodigious amounts of rain, with on average 30.5 inches coming down in November, December, and January. [i]

The topography of the Tenmile Lakes watershed ranges from the wind blown sand dunes near the ocean, to very steep headwaters in the east.

Elevations run from sea level to 1818' at Dean Mountain at the eastern boundary of the watershed.

Geology

The forty mile stretch of sand dunes from Coos Bay to Heceta Head, just north of Florence, is the largest system of sand dunes in North America[ii]. While not as free to migrate as in the past, the dunes that front the Tenmile watershed are still extensive. In his book, Cycles of Rock and Water, geologist Kenneth A. Brown gives a great history of the dunes,

> "Geologists have no clear idea as to how old the dunes are. While they talk with certainty about the trajectories of continents and the beginnings of ancient seas, the dunes are so recent and active that there is no clear consensus of opinion regarding their age. Dunes have existed here and there around the world for several hundred million years. On the Oregon coast they may have appeared as early as the Pleistocene some 1.8 million years ago at the start of the ice age.
>
> As the earth's climate began to cool, ice spread out of the Arctic into North America, at times reaching as far south as Kansas. At its peak, so much water was locked up in ice that sea level was more than three hundred feet lower than it is today. Off the coast of Oregon that large drop exposed wide stretches of the continental shelf—a sandy plain covered with the eroded rocks and sands of the ancestral Klamath Mountains. Evidence from such diverse sources as the orientation of bedding layers in ancient dunes in the deserts of eastern Oregon, and the wind-blown ash deposits of ancient volcanoes like Mount Mazama, which blew apart several thousand years ago to create what is now Crater Lake in southern Oregon, suggests that the region was swept by the same seasonal wind patterns that shape the dunes today. With a broad continental shelf exposed offshore, those winds would have blown sand toward shore, building up a wide sheet of dunes.
>
> When the glaciers melted and sea level began to rise, again encroaching waves would have pushed sand farther inland, driving dunes in front of them like the blade of a plow. Later when sea level dropped as the climate cooled and the glaciers advanced, those dunes would have been left high and dry as both the waves and the beach headed back out to sea. With their supply of new sand cut off, the dunes would have slowly given way to plants—a steady succession of grasses, shrubs, and trees that led gradually back to a rich coastal forest. A few thousand years later when the glaciers began to melt again the cycle started anew. Over the past two million years sea level has risen and fallen more than a dozen times.
>
> Geologists believe that the most recent episode of dune building began some seventeen thousand years ago, about the time that the first humans were making their way across the continent-sized land bridge that once linked Asia to North America. That building reached a peak here some six thousand years ago—although there have been several smaller advances and retreats since then. At one time the dunes reached much farther inland than they do today. The rolling forested hills that lie between the dunes and the Coast Ranges today are, like the tree islands, the remains of those ancient dunes."[iii]

Inland, alternating layers of thin siltstone and thick sandstone have been uplifted and eroded to give the basin its present appearance, i.e., mountainous and deeply incised. The generally accepted theory regarding the lakes is this: At some point, following the local retreat of the glaciers eighteen thousand years ago, sea levels rose, and enough sand accumulated near the outlet of the basin to provide the right conditions for the creation of the lakes.

Vegetation

Two data sets exist which may help to characterize vegetation in the Tenmile watershed. Both are satellite based observations from several years ago; the Western Oregon Digital Imagery Project (WODIP) set was acquired through the Bureau of Land Management, while the Coastal Landscape Analysis and Modeling Study (CLAMS) data set was originally generated by researchers at OSU.[1]

Generally, vegetation within the watershed follows a gradient of size and abundance that increases with distance from the ocean. The dunes are not particularly hospitable to plant life, but with the introduction of European beach grass in the 1890's, and again in the 1930's, the dunes have stabilized in various locations, allowing succession to occur rapidly. Shore pine, willow, alder, sedges of every persuasion, American beach grass, wild strawberries, Scotch broom, beach pea and monkey flower all inhabit some parts of the dunes. Where the sand gives way to solid earth, sitka spruce, red alder, hemlock, Douglas fir, willow, Bitter cherry, Oregon crab apple, and Western red cedar vie for light and nutrients along the stream banks and upland slopes. Farther back towards the eastern terminus of the watershed, Douglas fir begins to predominate, both from preferred growing conditions and active planting by timber companies and the ESF.

While native terrestrial vegetation remains, at least at first glance, somewhat as it was in the past, North and South Tenmile Lakes have undergone fundamental changes of their plant communities. Brazilian elodea (Egeria densa) has become a nuisance in shallow areas of the lake, making it nearly impossible to navigate the shallow arms of the lakes. The microscopic denizens of the lakes have experienced a conversion from the once predominant zooplankton and diatoms to the less desirable (for salmon and humans) cyanobacteria.[iv]

GIS Data

For convenience and portability, most of the data gathered and collected over the course of this assessment has been stored in a digital format accessible through the GIS (Geographical Information System) computer program called ArcView. Data represented in this fashion are easily comparable with other data,

[1] CLAMS is a multi-disciplinary research effort sponsored cooperatively through OSU's College of Forestry, the USDA Forest Service Pacific Northwest Research Station, and the Oregon Department of Forestry. The project's main goal is to analyze the aggregate ecological, economic, and social consequences of forest policies of different land owners in the Coast Range.

more easily analyzed than paper versions, and far easier to update. Several of the GIS data sets used in this assessment are either experimental in nature, or of such large scale that their usefulness is limited. Such cases are noted in Table 1.1, where all of the larger data sets are listed.

Layer	**Resolution / Scale**	**Source**	**Notes**
Aerial photographs	one meter	SSCGIS	Digital Ortho Quads
Aquatic weeds	1:24,000	TLBP	Incomplete, but with new information
Channel habitat types	1:24,000	TLBP	
Culvert/Road surveys	1:24,000	TLBP	
24 Hour rainfall Debris Flow threshold		DOGAMI	Experimental, provided with no guarantees
Debris flow potential		ODF	Based on slope
Habitat structures	1:24,000	TLBP	
Land use		TLBP	
Ownership	1:24,000	TLBP	
Purple Martin nesting boxes	1:24,000	TLBP	
Riparian vegetation	1:24,000	TLBP	
Riparian shade	1:24,000	TLBP	
Roads		ODF	Modified and added to by TLBP
Salmonid distribution		SSCIGS	Modified and added to by TLBP
Streams	1:24,000	ODF	Modified and added to by TLBP
Topographic maps	1:24,000	SSCIGS	
Water rights	1:24,000	OWRD	
Water temperature monitoring sites	1:24,000	TLBP	
Wetlands		NWI, Local wetlands inventory	
Vegetation		BLM	WODIP

Table 1.1 Data origins.

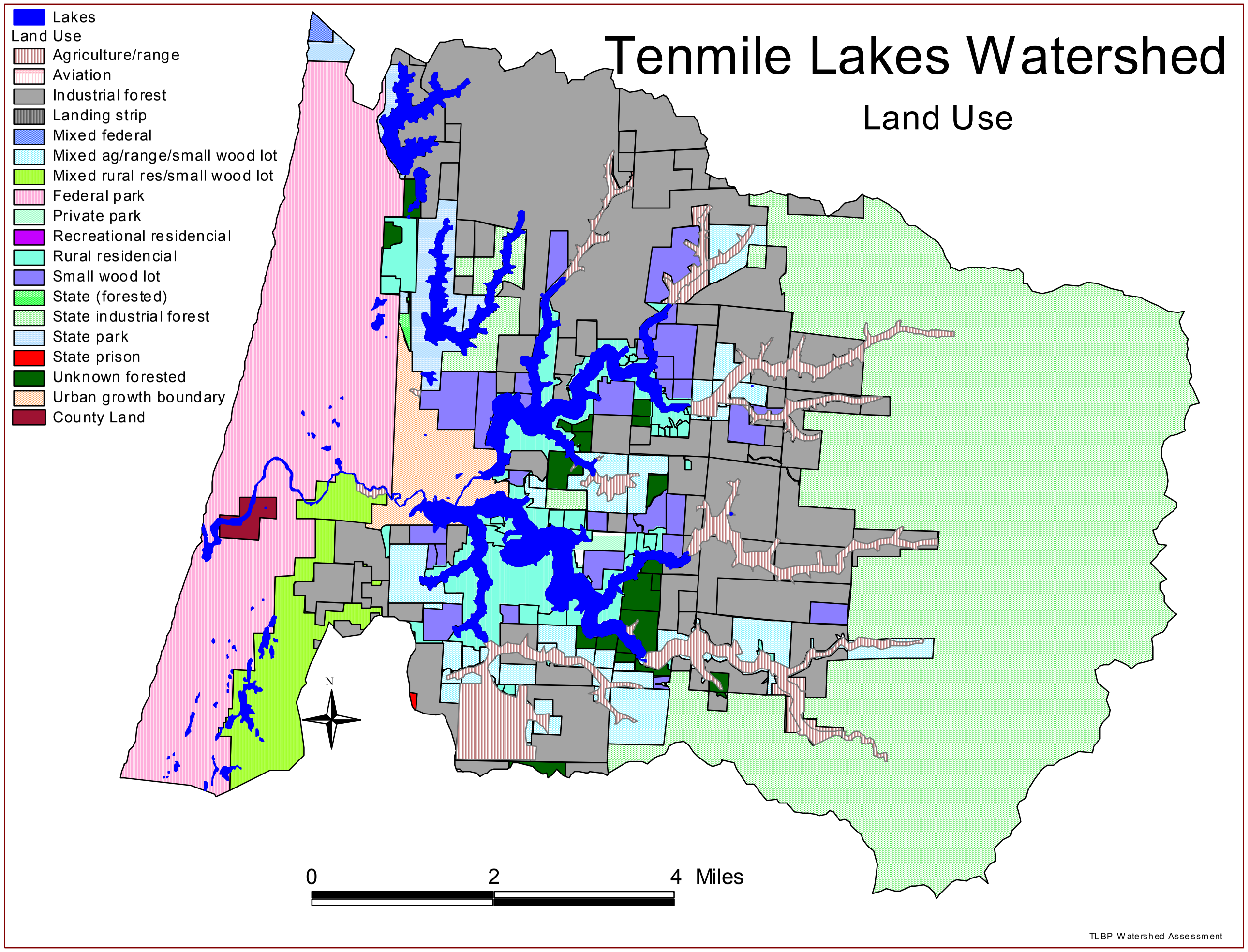
Land Use

Nearly the entire eastern third of the watershed is made up of state forest lands, namely the Elliott State Forest (ESF). Farther west, industrial timber lands are less contiguous than the ESF, yet still comprise the bulk of land ownership in the middle third of the watershed. Even farther west, the Oregon Dunes National Recreation area owns nearly all of the land from Highway 101 to the Pacific Ocean.

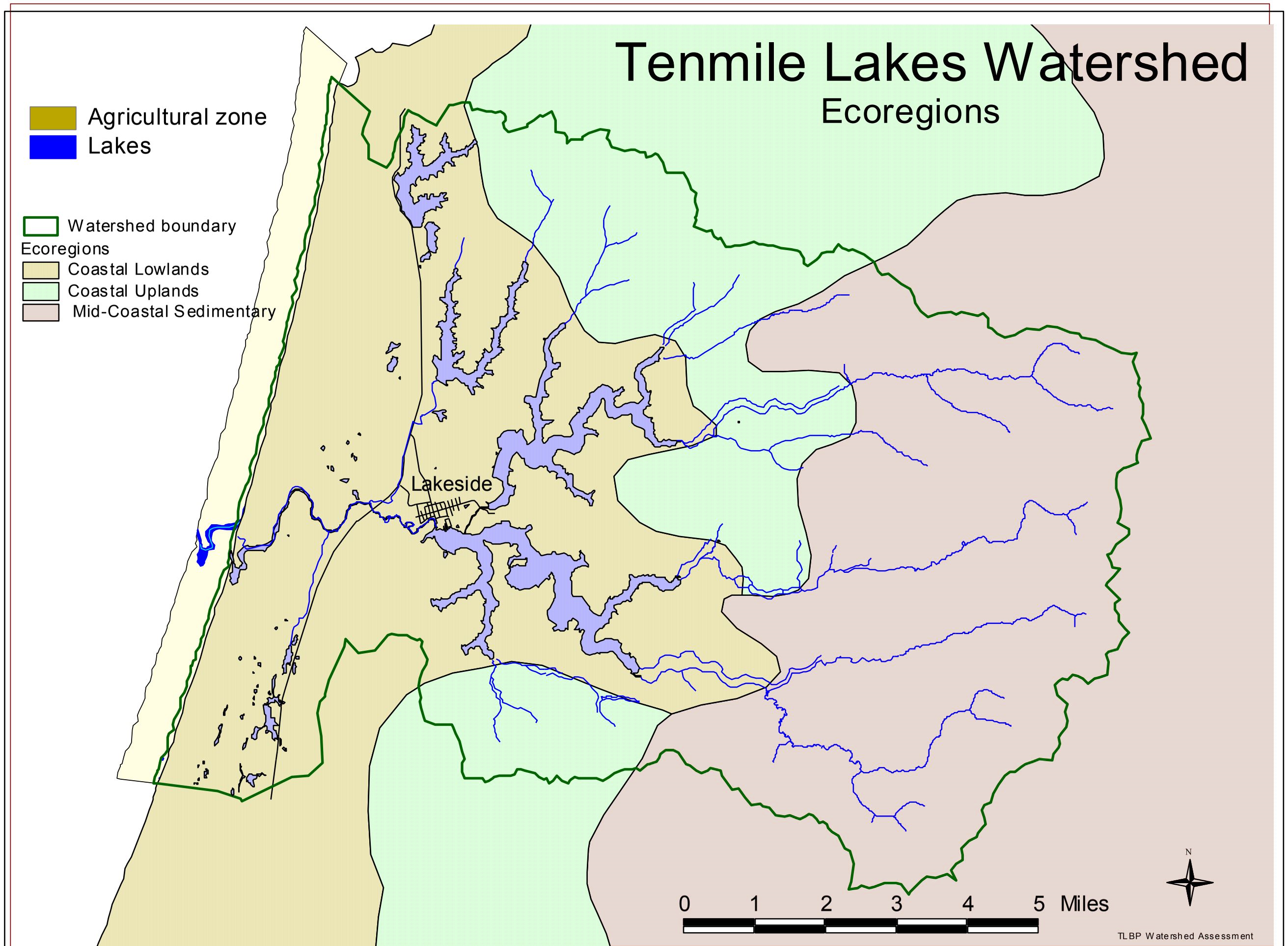
Ownership/Use	Acreage	% of total
Elliott State Forest	21504	34
Oregon Dunes NRA	8650	14
State Parks	790	1
State Lands	672	1
Industrial Forest	14837	24
County Lands within ODNRA	160	<1%
Rural residential, Small woodlot	4180	7
Agriculture	2650	4
Wetlands	1720	3
Lake surface area	2830	5
Urban	1442	2
Total watershed acreage	62777	

Table 1.2 Land use.

Overlapping land use, errors inherent in the mapping process, and uncertainty about certain land uses leads to land use acres not adding up to the total acres of the watershed as shown at the bottom of table 1.2. Percent of total watershed area for each land use is, nonetheless, a fair representation of what types of land uses are occurring in the area.



Map 1.1 Land use



Map 1.3.. Ecoregions. Oregon Geospatial Clearing house.

Map1.2 Agricultural areas

Chapter 2

Fish & Fish Habitat

Introduction

While the Tenmile basin was home to numerous species of fish prior to the appearance of European influence, geologic circumstance led to our lakes and streams being prime coho habitat. The generally small size of the lake tributaries and the lack of large spawning cobble make the area unproductive for Chinook salmon, and the abrupt nature of the side tributaries limits habitat for winter steelhead. Searun cutthroat and resident cutthroat were, and still are present, but not approaching the number of coho. In the recent ecological past, the Tenmile Lakes basin was extraordinarily hospitable to Coho salmon. According to the Oregon Department of Fish & Wildlife,

> "Historically, the Tenmile Basin has been an excellent producer of coho salmon and may have been the largest producer on the coast of Oregon. Incomplete commercial seine and gillnet records in ODFW files suggest runs up to 75,000 adults per year around the turn of the century… [and] nearly 73 million eggs were collected from coho salmon in the Tenmile Basin in the period from 1935 to 1946…These eggs were shipped to hatcheries all over Oregon."[v]

Evidently, the Tenmile basin was a very special place for Coho. The reason usually given for the high productivity of the basin is the secondary rearing capacity of the lakes. Once the carrying capacity of the streams was reached, "nomad" fry were able to survive in the lakes before heading out to sea. With the lakes acting as a safety net for those fry displaced from the streams, many more Coho were produced than possible in a lake-less stream system. Since the introduction of non-indigenous predatory fish and the subsequent loss of lake habitat, Coho production has fallen precipitously. From a high of perhaps seventy five thousand adults, recent escapement(the number of adults returning to spawn) numbers have been dismal by comparison, with escapements averaging 3,867 adults per year.[vi] Habitat degradation, fishing pressure, poaching, a change in the dominant forms of plankton in the lakes, and cyclic ocean conditions have all conspired to reduce Coho levels to all time lows.

Positive changes in coho habitat within the Tenmile Lakes basin are, however, still possible. For example, once identified, fish passage problems are easily dealt with. The solution to elevated stream temperatures is sometimes nothing more than judicious placement of riparian vegetation. Reduced summer rearing habitat and competition and predation due to non-native fish are additional problems that have answers, albeit with vastly differing complexity.

Critical Questions

Species	Native or Introduced	Year Introduced	Management

Coho salmon	Native[B,C]	-----	Population declined from >75,000 adults/year to about 4000.
Coho Salmon	Introduced	1968 1980's	930,000 smolts from native eggs and salvaged fry were introduced after the Lakes were treated with Rotenone. Smaller efforts in prior years.
Winter steelhead	Native & Hatchery	-----	Current population estimated at 20% of 19th century levels; currently stocked. Alsea & Coos River broodstock used in the past.
Cutthroat trout	Native[C]	-----	Historically abundant population; currently managed for wild stock
Rainbow trout	Introduced	1930's	Currently managed as a "put and take" fishery
Brown bullhead	Introduced[A]	1920's	High population was not impacted by a commercial fishery in 1952-53; not eradicated by rotenone; continued abundant population
Yellow perch	Introduced[A]	1930's	Affected but not eradicated by rotenone treatment. Still present and fished for. (M. Mader)
Bluegill	Introduced[A]	1960's	Currently most abundant fish in the lakes; attempt to eradicate the species in 1968 with rotenone was unsuccessful
------	-----	1968	Rotenone treatment to eradicate introduced species (Montgomery 1969)
Kokanee	Introduced into Eel Lake	1968	One time release. Status unknown. Source; Tenmile STEP group
Largemouth bass	Introduced	1971	Highly successful fishery. May have been earlier illegal introductions.
Hybrid bass Striped bass X White bass	Introduced	1982	Successful fishery discontinued after 1988 because of concerns for hybrids straying into other river systems. Still present in small #'s
Black crappie	Introduced[A]	1987	ODFW study showed presence in '87
Miscellaneous native species Eulachon Staghorn sculpin Threespine stickleback Green sturgeon Pacific lamprey Western brook lamprey Prickly sculpin Shiner perch			Populations unknown
Chinook	Introduced	1905 & 1980's	250,000 fall Chinook released in Tenmile Lake in 1905. Another 260,000 released in 1940. (Tenmile STEP).
A=Illegal introduction B=Federally listed C=State listed			

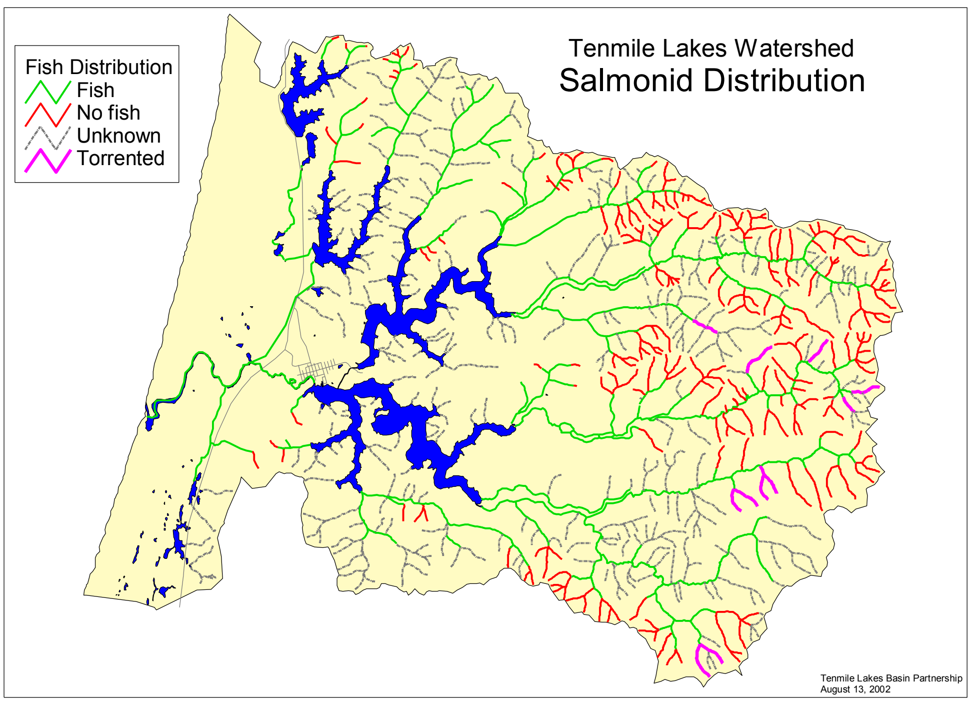
- What fish species are documented in the watershed? Are any of these currently state or federally listed as endangered or candidate species? Are there any fish species that historically occurred in the watershed which no longer occur there?

Table 2.1. Fisheries history of the Tenmile Lakes[vii]

Fish Presence

Prior to the introduction of exotic species of fish, the Tenmile Lakes teemed with numerous indigenous species of fish. Coho is perhaps the most familiar, but also green sturgeon, sculpin, winter steelhead, sea run cutthroat, resident cutthroat, pacific lamprey, and others. Beginning in the 1930's (at the latest), non-native fish were introduced with the hope of providing a year round fishery. Largemouth bass, crappie, bluegill, and brown bullhead are among the most common of the introduced species. Species present in the past and the present are listed in Table 2.1

➢ **What is the distribution, relative abundance, and population status of salmonid species in the watershed?**



Map 2.1. Salmonid distribution in the Tenmile basin. Combined ODFW & TLBP data.

The distribution of Salmonids in the basin has been investigated with electroshock techniques, by ODFW and TLBP. Typically, a two person crew walks a stream with a backpack device that sends enough of a current into a pool to "roll" any fish present. Electroshock protocol dictates that once the crew reaches a pool where no fish are found, a number of additional pools are shocked upstream in order to rule out further fish use. The map 2.1 is a snapshot of the presence of salmonids, typically with resident cutthroat residing highest up in each drainage. Conditions change gradually, and sometimes catastrophically with regards to distribution. Fault scarps may eventually produce impassable falls, debris flows can transform desirable spawning habitat into bedrock in a matter of minutes, and large scale logging can lead to changes in water temperature that render formerly habitable areas too warm to support salmonids. Reaches that have been affected by debris torrents are left unsurveyed for a period of five years in order to allow for recovery of populations in the stream.

Asking about the relative abundance of salmonids is asking for speculation. Creel surveys haven't been done recently, and electroshock distribution work does little except establish the upper extent of salmonid habitation. Coho are likely the most abundant salmonids in the watershed, followed by either resident cutthroat trout or steelhead. Sea run cutthroat are probably the least populous salmonids that were naturally present. It is entirely possible that Kokanee populate Eel lake at a very low level, and there are certainly, at times, many rainbow trout in the lakes.

Abundance relative to past counts is low. The familiar stories of spawning salmon so thick one could virtually walk across their backs to cross streams are now seen by some as exaggerations. This is what French fish biologist Daniel Pauly termed the "shifting baseline" theory. As each subsequent generation of fish biologists becomes accustomed to the present abundance of fish, runs that would have raised alarm bells in the past are seen as "normal." The same might be said of fishers who, unaware that two hundred years ago their hooks might have had trouble hitting water for all the fish, think five thousand coho coursing through Tenmile Creek is a good run.

Abundance of salmonids relative to warm water fish has not been quantified, although data collected by ODFW suggests populations of invasive fish are in the multiple hundreds of thousands, if not higher.

> "Based on the 1981 creel survey, when about 29,000 bass were caught, the population of largemouth bass larger than 8 inches probably exceeded 150,000 in Tenmile and North Tenmile Lakes."[viii]

As Bluegill are the most abundant fish in the lake, followed in uncertain order by Largemouth bass, Yellow perch, and various other non-native fish, it appears that adult salmon are significantly outnumbered by non-native fish populations. The implications of this native salmon/warm water predatory fish imbalance are not encouraging.

- **Which salmonid species are native to the watershed, and which have been introduced?**

Coho, cutthroat trout, sea run cutthroat, and winter steelhead are native, rainbow trout are introduced, there have been repeated attempts to establish Chinook salmon over the years, and there was a one time plant of Kokanee salmon into Eel Lake in 1968. Refer to Table 2.1.

- **Are there potential interactions between native and introduced species?**

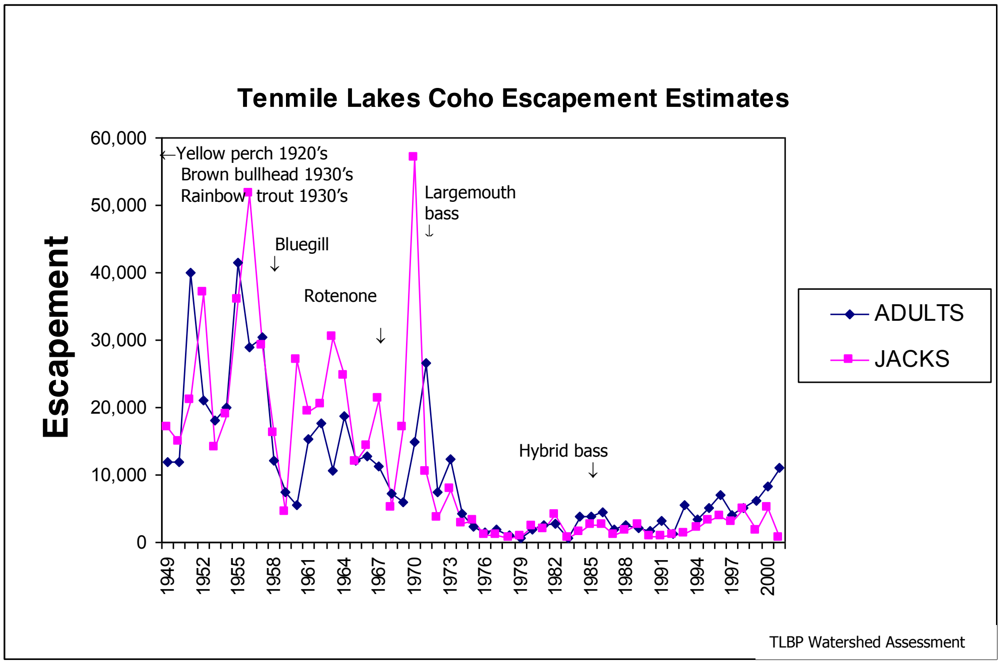


Figure 2.1. Estimated spawning run of adult and jack coho salmon in the Tenmile Lakes system. 1949-88.[ix]

It is safe to say that there *are* interactions between native and introduced species, although there is scant scientific evidence that the interactions are harmful to native species. The Oregon Game Commission planted Largemouth bass in 1971 hoping that the LMB would help control the Bluegill population, in addition to providing another fishery. The graph in figure 2.1 appears to show a correlation between the introduction of Largemouth bass in 1971 and a drastic and persistent drop in coho numbers. Whether the LB introduction *caused* the decline of coho is not discernable, nonetheless, the graph is suggestive. ODFW has conducted stomach content analysis of LMB in an attempt to determine whether LMB utilize coho as a food source, but the results were not clear. There are also Largemouth bass in Tenmile Creek, which would present another problem for ocean bound smolts,[x] namely, it may well be similar to the situation in the Lake Washington locks area in Seattle where one or two sea lions are able to devastate the run of salmon due to the bottle neck created by the locks.

In general, there are direct and indirect effects of competition, i.e., either the Largemouth bass eat coho, or they eat the coho's food. Introduced species may also affect the life cycle of natives by transmitting disease or by serving as a repository for a disease that would normally disappear in the absence of a host (All of the introduced species are year round residents of the lakes).

Comment [P1]: Given the high ratio of warm water fish to salmonids, the unknown timing of stomach content analysis, the scant number of stomachs analyzed, and the already low abundance of fry or smolt in the lakes at any given time, it's not surprising that ODFW didn't find many coho remains in the stomachs of LMB.

- **What is the condition of fish habitat in the watershed (by sub-basin) according to existing habitat data?**

	Refugia (pools)	Water temperatures	Spawning gravel	Large woody debris	Riparian[2]
Blacks Creek	Poor	Good	Poor	Poor	Fair
Wilkins Creek	Poor	Unknown	Fair	Poor	Good
Murphy Creek	Unknown	Good	Fair	Poor	Good
Big Creek	Unknown	Good	Good	Poor	Good
Alder Fork	Unknown	Good	Good	Unknown	Good
Noble Creek	Poor	Fair	Poor/Good	Poor	Good
Alder Gulch	Poor	Poor/Good	Poor/Unknown	Poor	Good
Benson Creek	Unknown	Poor/Good	Good	Unknown	Good
Roberts Creek	Unknown	Good	Good	Unknown	Good
Johnson Creek	Unknown	Good	Good	Unknown	Good
Hatchery Creek	Unknown	Unknown	Good	Unknown	Good
Robertson Creek	Unknown	Unknown	Unknown	Poor	Good
Adams Creek	Poor	Good	Poor/Unknown	Poor	Fair
Shutter Creek	Unknown	Unknown	Unknown	Unknown	Poor

Table 2.2. Fish habitat by sub-basin.

Assessment of habitat quality has been carried out by ODFW researchers who consider several variables thought to be important for salmonid health. The number of pools per mile, for example, is a figure gleaned from habitat surveys that gives some idea of the availability of hiding spots for salmon fry during a stressful time of year. Water temperature information lets us know if fish can survive during the long hot summer, regardless of the number of pools or the amount of large woody debris.

Comment [P2]: Kim Jones & Charlie Stein from Corvallis Research head up this project.

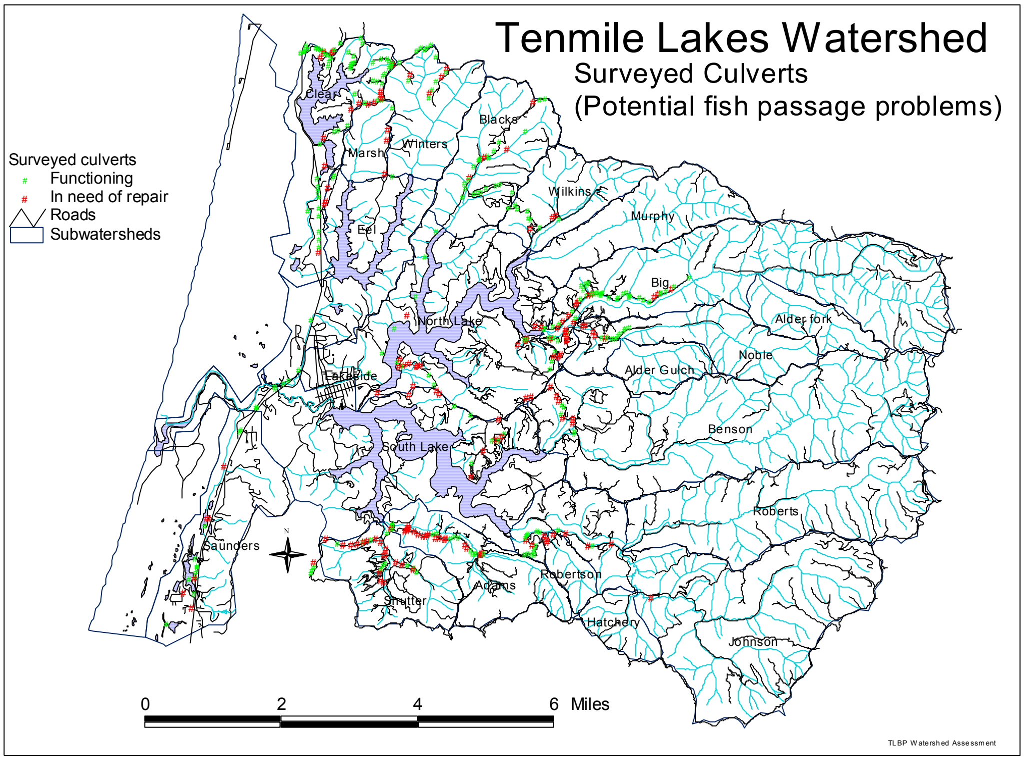
Habitat assessments are among the trickiest of parameters to quantify, and the results are good usually only until the next big storm event. Spawning gravel, for example, may be described quite differently by two different survey crews. One crew might say the gravel is embedded in sand while the other might say sand is only a minor component of the substrate mix. Accounting for these differences which, according to ODFW[xi], might vary by 15% between crews, leads to rather broad based categories for assessing habitat quality. Namely; poor, adequate, and good. Striving for any greater detail is not productive.

TLBP has carried out a temperature monitoring program for the last few years, and the results have been generally good, i.e., the streams in the Tenmile basin stay reasonably cool. Complete results are documented in the water quality component

TLBP has also interpreted riparian vegetation conditions from aerial photographs(see the chapter on riparian conditions), which relate to stream temperatures, large woody debris availability, sediment delivery, and other factors associated with habitat quality.

- **Where are potential barriers to fish migration?**

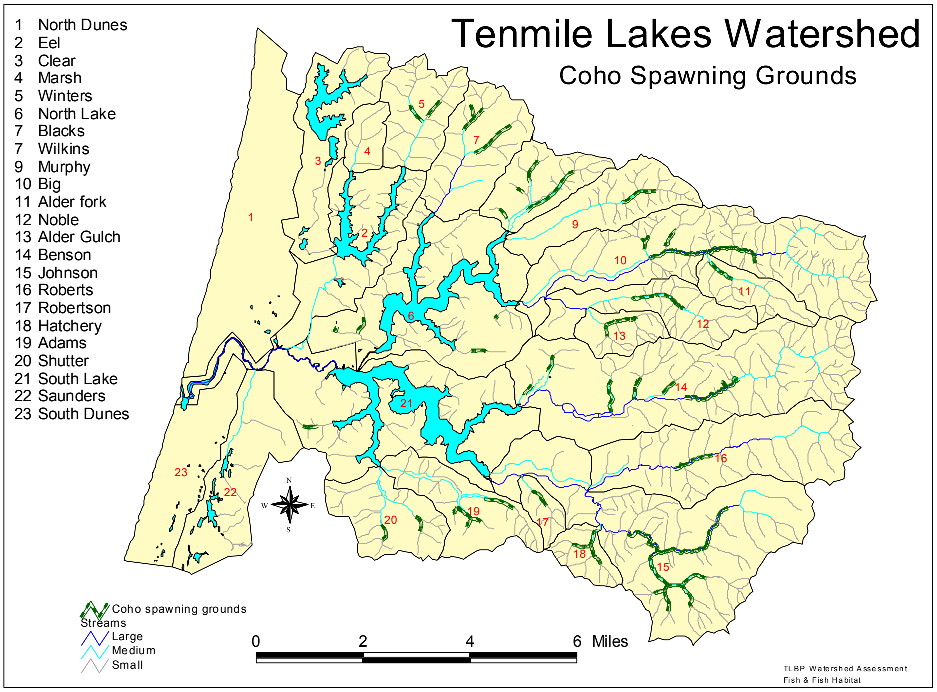
[2] Based on averaged shade values for entire subwatershed.



Map 2.2. Potential fish passage barriers. TLBP.

Fish passage problems range from numerous road crossings (culverts), three small dams, two man made waterfalls, one natural waterfall, and a train tunnel. The stream diversion for the train tunnel cuts off less than a mile of high gradient habitat, and the natural falls in Big Creek are likely only to affect Coho.

On an enforcement note, several sections of Tenmile Creek present fish passage problems of a human nature. The confluence of Eel Creek and Tenmile Creek is a narrow section of stream that attracts poachers(sometimes with channel spanning nets!) who may be making a significant dent in the population of returning spawners. No studies have been done, but with estimated numbers of spawners of only the low thousands, several score or even hundreds of poached salmon would be a blow to recovery efforts.



Map 2.3. Coho spawning grounds.

Species of Concern

Due to recent court activity, the legal distinction between wild Coho and hatchery Coho has been cast in doubt. Prior to 2002, however, The National Marine Fisheries Service had listed the Oregon coastal coho as an endangered species.

There is a debate regarding the value of hatchery reared versus wild fish that has reached the Federal court system and made a politically messy situation out of a genetically messy situation. The main argument advanced by the wild crowd is that salmonids that have populated a certain stream for multiple generations are well adapted to that particular stream. Introducing hatchery fish that are from another system that may be geographically far removed is unwise, they say, because the hatchery fish are ill-adapted to the idiosyncrasies of the local stream. The hatchery crowd would respond to this by noting that salmon naturally stray into other systems at varying rates. This is a good thing, they say, because otherwise streams that had been closed off by landslides or waterfalls for longer than the salmon breeding cycle would never be re-colonized. Hatchery bred fish are akin to the strays that occur naturally. There is truth to both arguments, but there are several things to consider. First, a genetic bottleneck, i.e., a condition where every organism in a population is virtually identical genetically, puts populations of animals at risk of becoming extinct via a nasty virus, or adverse environmental conditions. By way of example, the Irish potato famine might have been averted had the Irish grown a more diverse crop of potatoes, of which there are literally thousands of varieties. One farmer's crop would have gone bad, but his neighbor would still have had enough to survive. A genetically diverse population stands a better chance of surviving disease and changing environmental conditions. Secondly, while salmon stray, the closer the broodstock are geographically are to the stocked stream, the more likely they will possess at least some of the characteristics that allowed the original inhabitants of the stream to thrive. Alaskan Copper River Reds, for example, probably wouldn't do well in the Tenmile watershed.

The evolution of hatcheries however, has been towards more natural conditions and use of local broodstock. Eventually, there may be no basis for argument.

Life History

The life history of anadromous fish includes time in both fresh water streams and the ocean. Typically, the fresh water stage of life involves reproduction and early rearing, while the ocean stage is where fish mature and utilize the productive ocean habitat to bulk up and get ready for perpetuating their species.

The Tenmile Lakes are home to no fewer than seven species of anadromous fish, including two species of lamprey, Threespine stickleback, Green sturgeon, Coastal cutthroat trout, Steelhead salmon, and Coho salmon. it is unlikely that sturgeon breed within the Tenmile watershed, but they are occasionally found in the lakes.

The ability to migrate between fresh and salt water has been an effective reproductive strategy in the past, but that strategy has become a liability as humans have become ever more abundant. Loss of spawning and rearing habitat, the introduction of competitive fish species, commercial and sport fishing, and changing water temperature regimes have all made life much harder for our native fish.

Somewhat unique to the Tenmile system is the annual discontinued surface flow of the confluence of Tenmile Creek and the ocean. As flow levels drop, wind and waves conspire to build a berm of sand that prevents Tenmile Creek from emptying into the Pacific. A lagoon forms behind the berm until rising water levels and heavy surf erode the foredune in the fall. Perhaps because of this routine, Tenmile Coho tend to arrive late, and stay late.

Hatcheries, Stocking Programs, Illicit Introductions

Presently, no hatcheries exist within the basin.

Stocking programs currently exist for Rainbow trout and Steelhead. According to ODFW (R. Smith, pers. Comm), approximately 19,000 Rainbow trout are released at several sites in the basin. N. and S. Tenmile Lakes each receive 5800 fish, and Eel Lake gets 7500. Releases are normally in the spring (there were three releases in 2001), and occasionally in the fall. Approximately 16,000 Steelhead are acclimated and released each year in Eel Lake (1/3), and Saunders Creek (2/3). Currently native broodstock are used to stock the lakes. In the past, broodstock from the Alsea and Coos Rivers were used.

Illegal introductions of game fish have occurred on a regular basis over the years, but there is currently no mechanism for discovering new introductions other than information gleaned from fishers and others with eyewitness accounts. Drastic measures to eliminate exotic fish, such as rotenone, are doomed to failure due to persistent illicit introduction and re-introduction of fish not normally found in the area.

In 1968, after much concern about the introduced fish population, the Oregon Game Commission poisoned North and South Tenmile Lakes with rotenone, a highly effective chemical means of killing fish that doesn't persist in the environment like DDT or other synthetic pesticides. The treatment was effective for the short term, but reports soon surfaced of all of the usual suspects (Yellow perch, Bluegill, etc.). Rotenone is widely used by governmental agencies to eliminate invasive species and probably bears a closer look since its use will undoubtedly be advocated again here in the future. The Oregon Department of Wildlife wrote:

> "Rotenone is the most commonly used compound for treating lakes. It has been used in numerous lakes and reservoirs in Oregon with great success to remove unwanted fish species and restore traditional fisheries. Diamond Lake was treated in 1954 with rotenone and treatment was 100 percent successful. Biologists believe the treatment can be repeated to restore this highly productive fishery."[xii]

The prevailing belief amongst fisheries managers is that rotenone is the most cost effective method of treating lakes with invasive fish problems. ODFW is considering once again treating Diamond Lake with rotenone, but the Tenmile Lakes haven't drawn the kind of attention in the press as has Diamond Lake. There are still concerns regarding the safety of rotenone, but it does not appear to be anywhere near as toxic as some synthetic pesticides. The Pesticide Action Network has a good section on rotenone, including this:

> "Rotenone is a naturally occurring chemical with insecticidal, acaricidal (mite and spider-killing) and piscicidal (fish-killing) properties, obtained from the roots of several tropical and subtropical plant species belonging to the genus *Lonchocarpus* or *Derris*. It is a selective, non-specific insecticide, used in home gardens for insect control, for lice and tick control on pets, and for fish eradications as part of water body management. Both a contact and stomach poison to insects, it kills them slowly, but causes them to stop their feeding almost immediately. It exerts its toxic action by acting as a general inhibitor of cellular respiration."[xiii]

The primer on rotenone goes on to detail the half life of the substance in the soil (several days), its effects on humans (virtually non-existent in the concentrations used to kill fish), and the first time it was ever used (for thousands of years by South American natives to stun fish).

As an alternative treatment for invasive fish, the Oregon Game Commission(OGC) introduced Largemouth bass into the Tenmile basin in 1971 in the hope that they would find Bluegill and other warm water fish to be an attractive food source. The OGC also wanted to create a fishery for Largemouth bass. According to an ODFW report, "Tenmile and North Tenmile lakes have densities of largemouth bass that are higher than any other lake in Oregon." (Tenmile Basin Fish Management Plan, 1991, pg. 60). Bass fishing continues to draw fishers to the Tenmile Lakes, who in turn infuse cash into the local economy. Bluegill are still abundant.

Of possible interest in regards to water quality is the unexplained (as of 1991) early summer die off of Brown bullhead, a kind of catfish introduced illegally in 1930[3]. The Tenmile Basin Fish Management Plan speculates on several possible causes, including Columnaris bacteria, sedimentation, and a soft substrate. Microcystis is not mentioned, but may not have been in the general consciousness at the time.

In the past, there have been stocking efforts with Chinook salmon, 250,000 smolts were dumped into the Templeton Valley in the 30s or 40s. (M. Mader, pers.com)

Conclusions

Salmon habitat in the Tenmile watershed ranges from excellent to non-existent. Agricultural areas should remain the focus of habitat enhancement efforts, as this provides the greatest "bang for the buck" in the watershed. Protecting spawning grounds in low forest reaches will become increasingly important as pressure builds to either sell off the Elliott State Forest or log more intensively in order to solve state budgetary woes. And lake habitat is low on the priority list as warm water predatory fish remain an intractable problem, both biologically and politically. Removing invasive species of fish is technically unfeasible and politically unpopular, so they appear to be here to stay.

[3] Tenmile Basin Fish Management Plan. Abrams, et al. 1991. Pg 57.

Channel Habitat Types

A stream reach may be a raging cascade or a placid glide, it might be constrained on either bank by hillslopes, or free to meander through a wide valley. Classifying stream reaches by Channel Habitat Type (CHT) is a way to provide a uniform view of stream morphology across varied landscapes. Reaches are initially grouped together based on channel gradient and stream confinement, then divided further based on channel pattern and the width of the valley that the stream occupies.

The main reason for deciding what type of channel habitat a stream reach exhibits, is the subsequent ability to assign a sensitivity to change value to the reach. Habitat restoration work depends on a channel's affinity to change, and knowing what CHT's exist in the watershed is a start to identifying reaches where restoration work is best directed.

Critical Questions

- **What is the distribution of Channel Habitat Types throughout the watershed?**
  See map 2.4.

- **What is the location of CHTs that are likely to provide specific aquatic habitat features, as well as those areas which may be the most sensitive to changes in watershed condition?**
  Agricultural reaches and low forest reaches are the two areas most likely to respond well to habitat modifications. These reaches are grouped in the Low Agriculture, High Agriculture, and Low Forest TLBP categories.

Code	CHT Name	Gradient	Channel Confinement	Size	TLBP Type
ES	Small estuary	<1%	Unconfined to moderately confined	Small to medium	_
EL	Large estuary	<1%	Unconfined to moderately confined	Large	_
FP1	Low gradient large floodplain	<1%	Unconfined	Large	Wetland(WL)
FP2	Low gradient medium floodplain	<2%	Unconfined	Medium to large	Wetland(WL)
FP3	Low gradient small floodplain	<2%	Unconfined	Small to medium	Wetland(WL)
AF	Alluvial fan	1-5%	Variable	Small to medium	Variable
LM	Low gradient moderately confined	<2%	Moderately confined	Variable	Low Forest (LF)
LC	Low gradient confined	<2%	Confined	Variable	Low Forest (LF)
MM	Moderate gradient moderately confined	2-4%	Moderately confined	Variable	Low Forest (LF)
MC	Moderate gradient confined	2-4%	Confined	Variable	Low Forest (LF)
MH	Moderate gradient headwater	1-6%	Confined	Small	High Forest (HF)
MV	Moderately steep narrow valley	3-10%	Confined	Small to medium	Low or High Forest
BC	Bedrock canyon	1->20%	Confined	Variable	Variable
SV	Steep narrow valley	8-16%	Confined	Small	High Forest (HF)
VH	Very steep headwater	>16%	Confined	Small	High Forest (HF)

Table 2.3. Channel Habitat Types and associated parameters (WPN 1999). Refer to the Watershed Assessment Manual for a more complete description of channel habitat types

A stream segment will follow a certain disturbance regime based on its own particular channel morphology. The combination of stream bed gradient, bed material, channel sinuosity, stream side vegetation, and other factors will determine the specific response to peak flows. In other words, parts of streams react differently than others to high flows. Bedrock reacts very little to floods, whereas floodplains and moderately constrained sections of stream show significant changes when exposed to high water. In order to conserve funds and effort then, it would be helpful to identify stream reaches that will react favorably to restoration efforts.

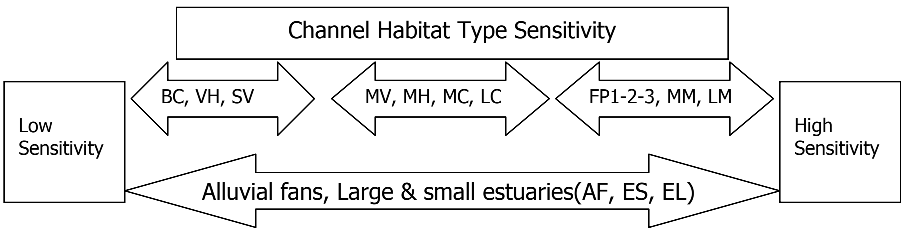


Figure 2.2. CHT sensitivity (WPN 1999)

	Channel Sensitivity											
	High					Moderate					Low	
CHT	FP1	FP2	FP3	LM	MM	AF	LC	MC	MH	MV	SV	VH
TLBP Type	WL	WL	WL	LF	LF	----	LF	LF	HF	HF	HF	HF
Stream miles	4.2	31.6	6.3	8.1	3	1.2	5	11.8	0.3	13.8	19	10.9
Percent of total stream miles for each CHT	4%	27%	5%	7%	3%	1%	4%	10%	0%	12%	16%	9%

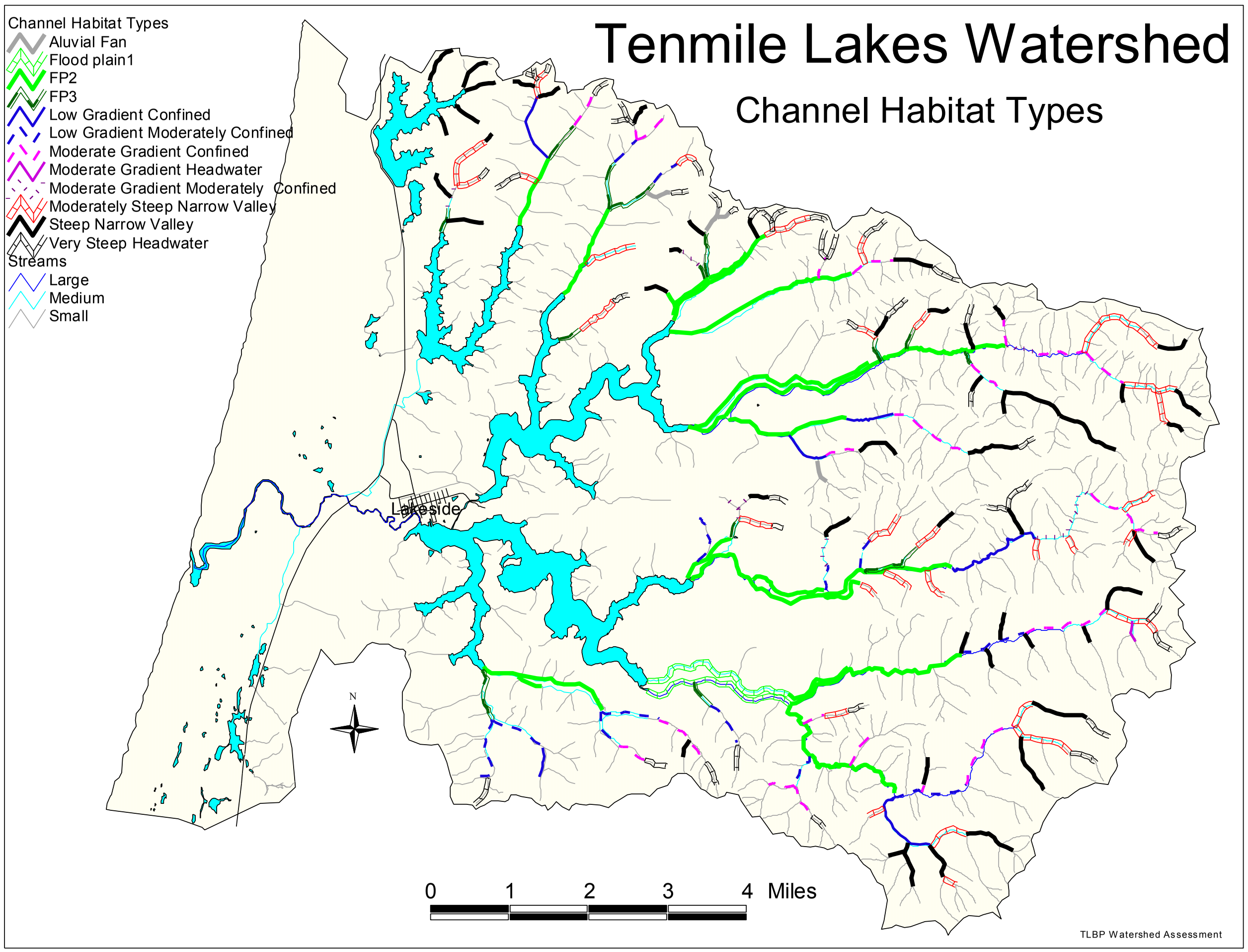
Table 2.4. A breakdown by CHT, sensitivity, and percentage of stream miles represented by each CHT. TLBP.

In the Tenmile watershed, medium sized floodplains (FP2) account for over a quarter of the characterized habitat types, and together with all floodplains, account for over a third of the main streams in the watershed. Most of these stream segments occur low in the watershed, are privately owned, and are now used as agricultural land.

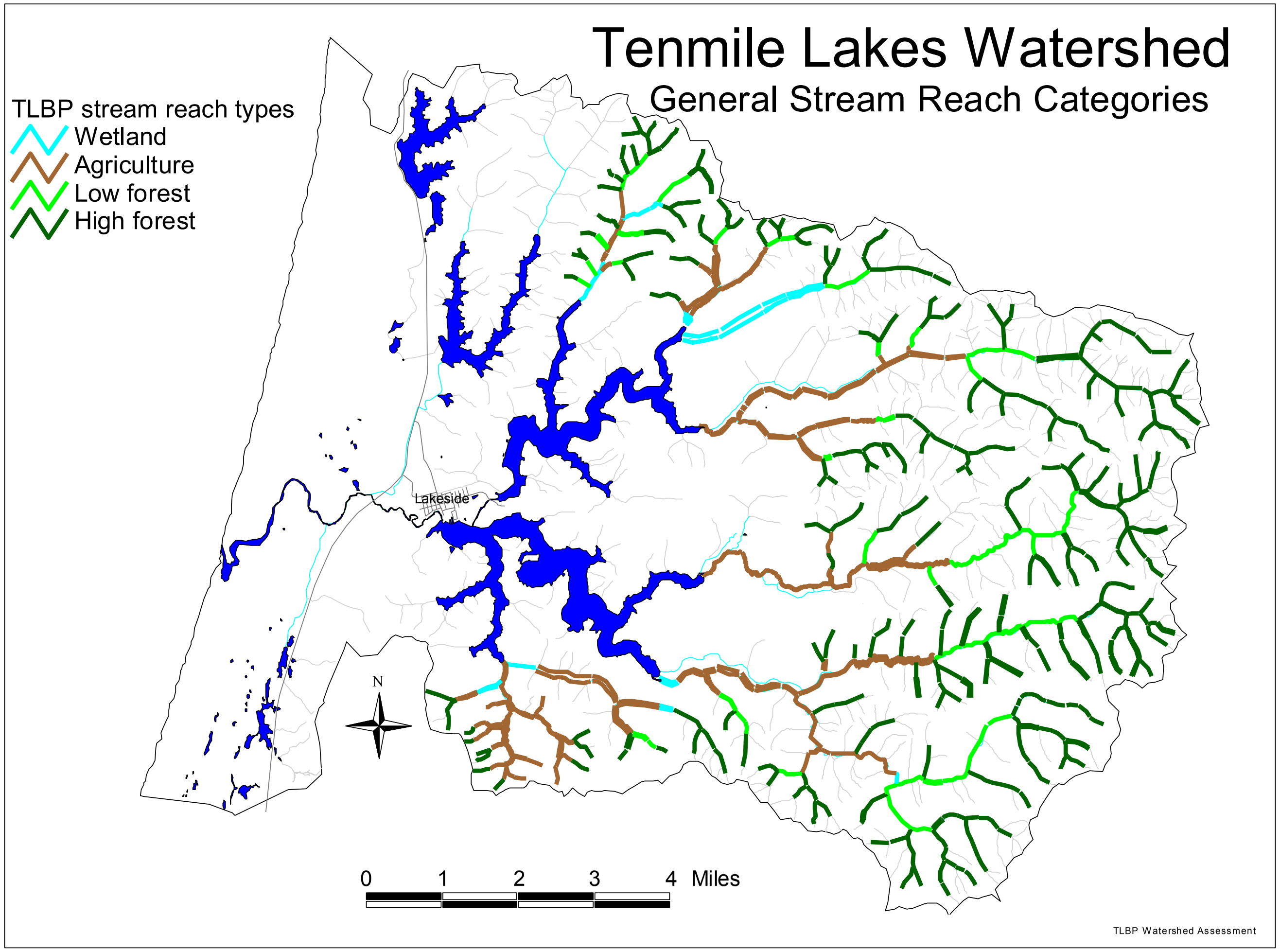
At the other end of the geomorphological spectrum are the steep valleys and headwaters (SV & VH), which are typically dry in the summer, and much less responsive to land management changes and restoration efforts.

Of greatest importance to salmonids are those habitat types which are useful in various stages of their lives. Streams in the Tenmile basin follow a common basic morphology; a low gradient section that formerly meandered through wetland, but now is typically ditched on one side of the valley or both; a higher gradient section through the beginning of the conifer dominated, narrower valley floors; and finally an abrupt gradient change leads into steep headwaters. Spawning usually takes place in the moderate gradient sections, and summer rearing takes place in both the moderate gradient reaches and the low gradient reaches closer to the lakes.

In an effort to simplify the descriptions of habitat types, we came up with a scaled down version that seemed to fit the Tenmile basin well. The TLBP system is geared more towards an awareness of land uses and locally prevalent channel types.



Map 2.4. Channel Habitat Type in the Tenmile basin



Map 2.5. Stream reach categories.

Table 2.5. Tenmile Basin Partnership channel habitat types.

TLBP Type	Gradient	Responsiveness	Channel Habitat Types	Temporal
Wetland	<1%	Low	FP1,2,3	Past land use
Agriculture	1-2%	High	FP, LM, MM, LC, MC,	Present land use
Low forest	2-5%	Moderate	LM, MM, LC, MC	Present land use
High forest	>5%	Low	SV, VH, MV, MH	Present land use

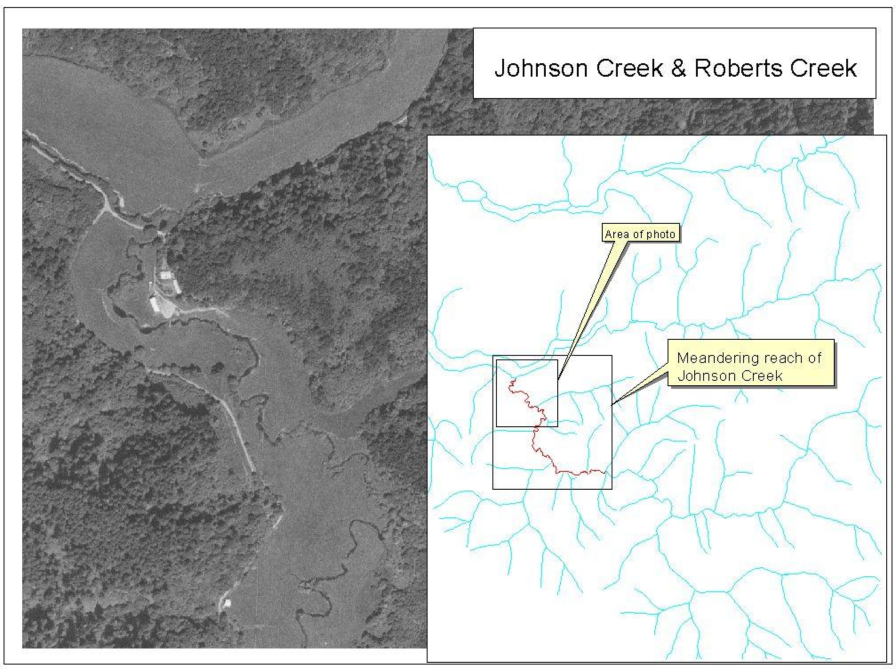
Comment [P3]: This is a system based on our knowledge of the TM watershed and, as such, is specific to TM and may not correspond directly to the OWEB CHT classification system.

Figure 2.3. Johnson Creek delta, classified as a flood plain. Note Skunk cabbage at about 9 o'clock (surveyor is pointing at a temperature monitor site). This area is usually under water during the winter due to lake influence. Banks here are somewhat vegetatively stabilized, but are still prone to erosion due to livestock use.

Channel Modifications

Stream channels have been ditched for agricultural purposes, re-routed for convenience, dammed for increased storage capacity, and re-graded to accommodate a railroad. Virtually every drainage in the watershed has been ditched as part of agricultural use. Clear, Eel, and Tenmile Creeks have all either been re-routed or straightened by highway and forest engineers. And Blacks Creek has a remarkably even, man-made gradient leading up to the railroad tunnel that punches through to Wind Creek in the Umpqua drainage.

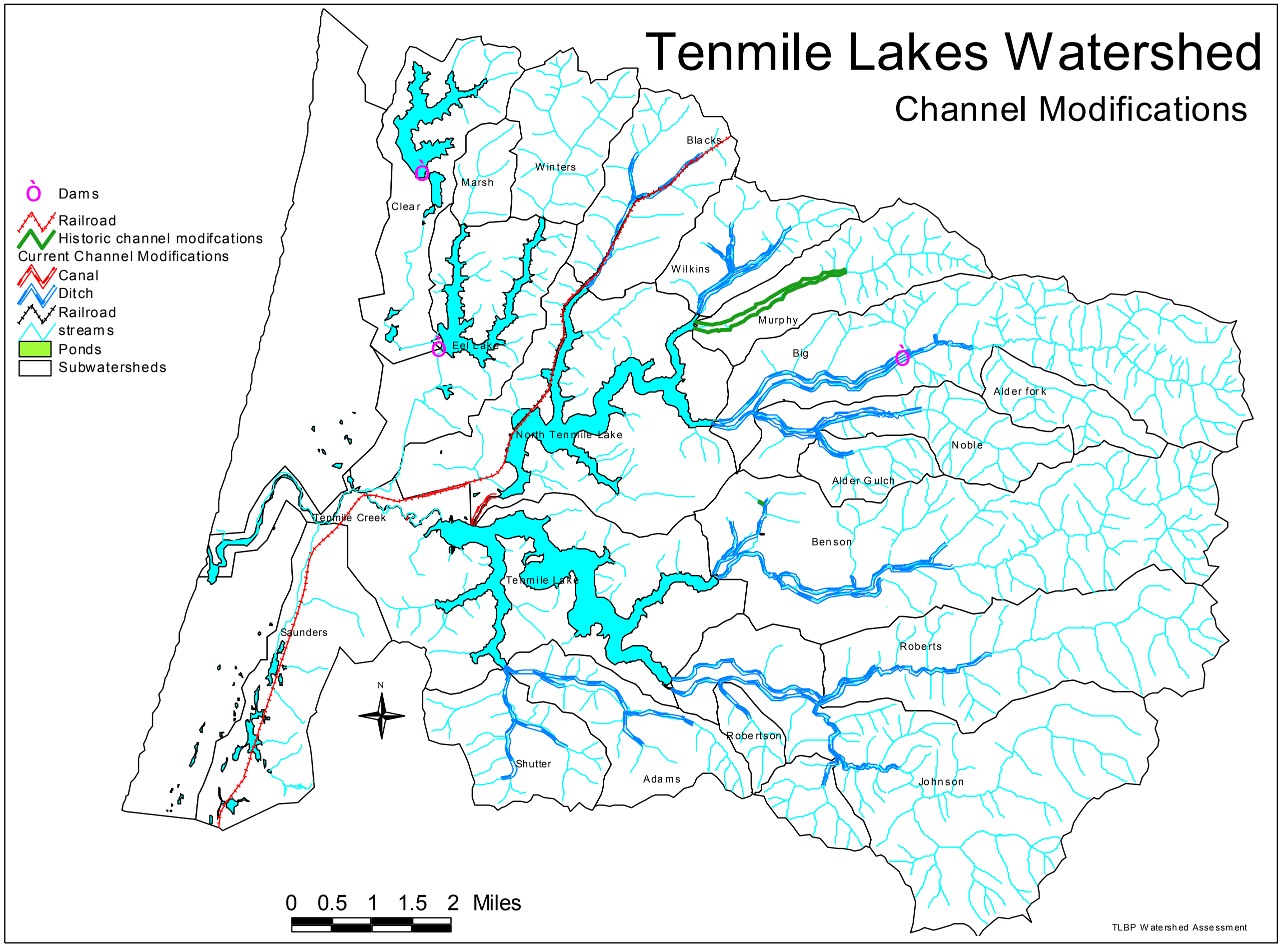
Straightening stream channels has the effect of increasing stream velocity, decreasing the time water spends in the stream channel, and reducing the amount of ground water recharge.



Map 2.5. Meandering reach of Johnson Creek, bottom, and straight ditched streambed of Roberts Creek, top.

Map 2.5 gives some idea of the difference between a meandering reach versus a ditched reach. The inset area of the map highlights the entire length of the meandering reach in Johnson Creek from the Elliott State Forest boundary to the confluence with Roberts Creek. The distance, as the crow flies, from the beginning to the end of the reach is 5683 feet. The estimated distance of the reach if it had been ditched against one side of the valley is 7072 feet. The measured distance from the digital orthoquad (photo), is 9676 feet. The natural condition of the creek, i.e., meandered, provides at least a 37% increase in stream length over ditched conditions. Additional stream length slows water velocity (which decreases erosion), allows for additional filtration of runoff by streamside vegetation, and increases the amount of time surface water has to infiltrate groundwater. This stretch of Johnson Creek is unique in the Tenmile watershed, as virtually all other agricultural reaches are ditched against hillslopes.

Map2.6 shows channel modifications in the watershed. Murphy Creek is slowly reverting to a braided channel system in the wetlands, but still shows signs of past management as an agricultural area.



Map 2.6. Channel modifications.

Chapter 3

Riparian Conditions & Wetlands

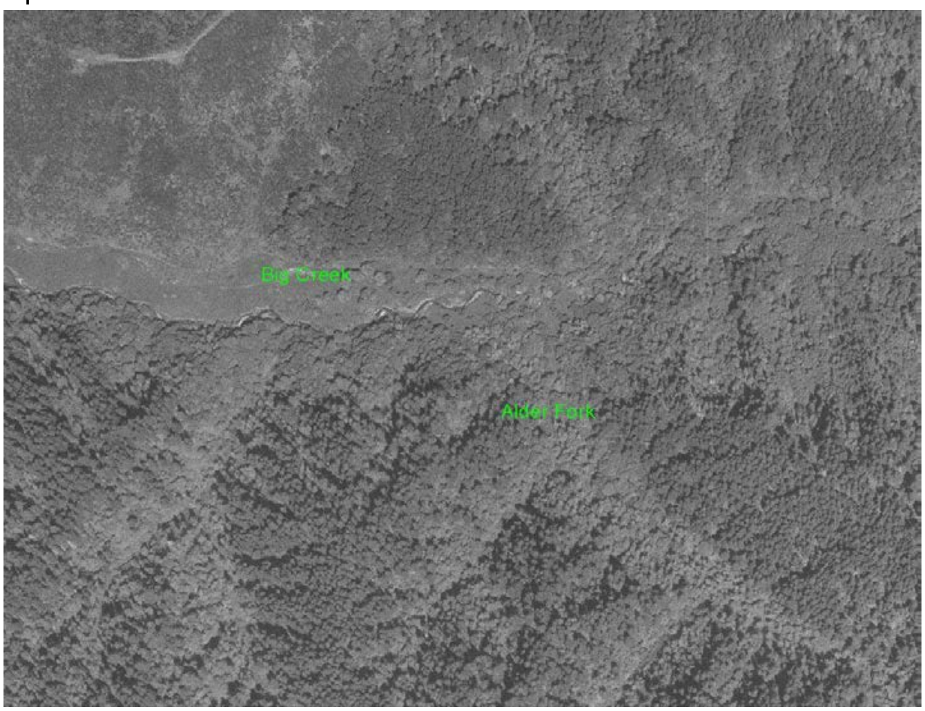


Figure 3.1. The confluence of Alder Fork with Big Creek.

Introduction

Riparian conditions, or the condition of the area immediately adjacent to a stream, generally within 100 feet, affect salmon and water quality in several different ways. Trees, shrubs and herbaceous plants provide shade, cover from predators, food (via insect populations), large woody debris for habitat structure, flood velocity control, stream bank stabilization, and filtering of overland water flow. Conditions vary due to land use (logging, road building, ornamental lawns, agriculture) and to natural phenomenon such as landslides, windthrow (storm wind damage), plant community succession, stream channel meandering, and fire. In what might be considered a natural condition, a stream would by no means always be completely shaded by a dense canopy of mature trees. A range of conditions from bare soil to old growth stands of conifer and hardwoods would exist. The aerial photo above shows a variety of conditions occurring within a short distance

For the purposes of this assessment, modern land use has been divided into several general categories. Wetlands, agricultural lands, low forest, and high forest do a good job of summarizing the land use of the Tenmile watershed. Wetlands are generally found near the lake and also in some upland sites. Agricultural lands occupy mostly former wetlands and some low forest. Low forest is upstream of the first break in gradient from the lowlands (from 2-5%), and high forest comprises the greater than 5% gradient reaches leading up to and including headwaters of streams.

The riparian zone information presented here is derived primarily from stereo aerial photographs & field observations.

Table 3.1. Current vs. potential conditions in each land use.

	Potential Conditions	Current Conditions
Wetlands	Extensive.	Sparse
Agricultural areas	Not present in the past.	Low impact agriculture.
Low forest	Dense riparian cover, with a diverse mix of hardwoods and conifers.	Intact low forest mostly confined to ESF.
High forest	Extensive conifer forests, with Douglas fir, Western hemlock, and Sitka spruce predominating.	Intact high forest mostly confined to ESF. Industrial high forest managed for short rotation tree farming.

Riparian areas may be grouped into four general reach categories in order to better understand current conditions: wetlands, agriculture, low forest, and high forest.

Critical Questions for riparian areas

- What are the current conditions of riparian areas in the watershed? (Parameters include: Riparian width, vegetation types, veg density, stream shading, and the continuity of the riparian zone due to roads, buildings, and other land uses).

Current Conditions

Wetlands

Figure 3.2. Blacks Creek wetland.

Long discounted as "swamps," or mosquito infested quagmires, wetlands have undergone an image rehabilitation in most public agencies. Rather than fetid reservoirs of disease worthy only of fill, wetlands provide habitat for wildlife and perform several valuable services, including water filtration, sediment abatement, and water storage and ground water recharge. That being said, most of Tenmile's wetlands were long ago converted to agricultural use. What remains are lacustrine,(lake front) wetlands, and areas in several arms where wetlands have made a comeback due to the removal of grazing pressure. Murphy Creek, which hasn't had livestock for the last twenty years, is the best example of passive re-emergence of a wetland. From the confluence of Murphy Creek with North Tenmile Lake and upstream for approximately two miles, a functioning wetland consisting mostly of Reed canary grass has taken over what was formerly grazing land. Reed canary grass can't be used as an obligate wetland species, such as Skunk cabbage, since it will grow outside of what is normally considered wetland, but its presence does indicate the possibility of wetland geomorphology. The fact that Tenmile wetlands are populated with an introduced species of vegetation is the main difference between current conditions and those present in the past. A walk through seven foot tall Reed canary grass in Murphy Creek appears at first to be a tour of a monoculture wetland. Upon closer examination, however, there are native wetland species making a living amongst the much more prevalent introduced grass.

Maps 3.1 & 3.2 show the National Wetland Inventory maps for our watershed. These maps were derived from aerial photographs and topographic maps, and do not reflect actual land usage. In other words, what the US Fish & Wildlife Service classifies as a wetland, may in reality be rangeland, cropland, or a recreational vehicle park. These maps are better viewed as representing the original extent of wetlands.

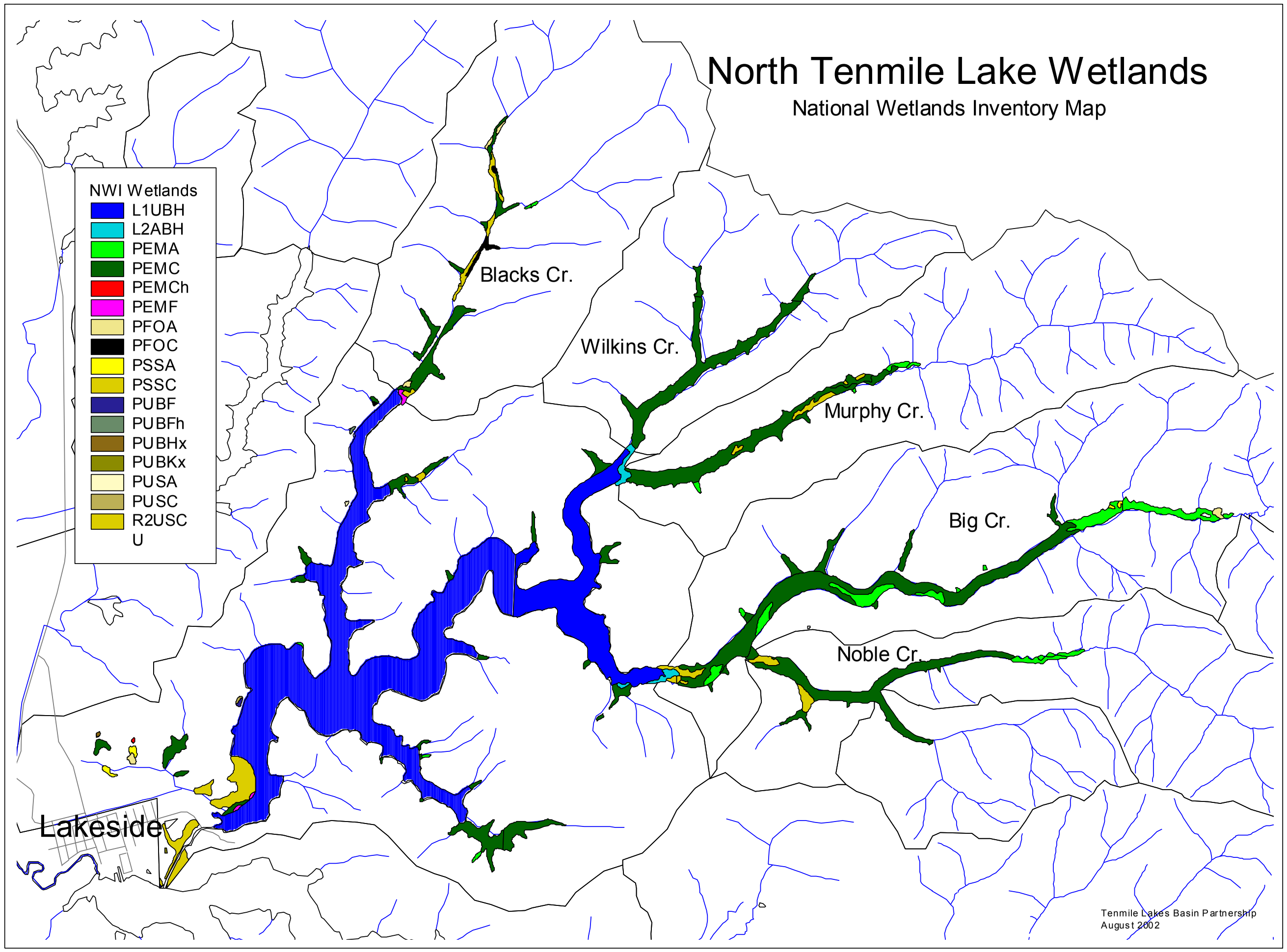
Map 3.3 shows the present distribution of wetlands, based mainly on our personal knowledge of land use in the basin, and the presence of obligate wetland species such as skunk cabbage.

Figure 3.3 shows the mouth of Benson Creek under flood conditions. Note the line of vegetation marking the ditched channel of King Gulch (center, foreground).

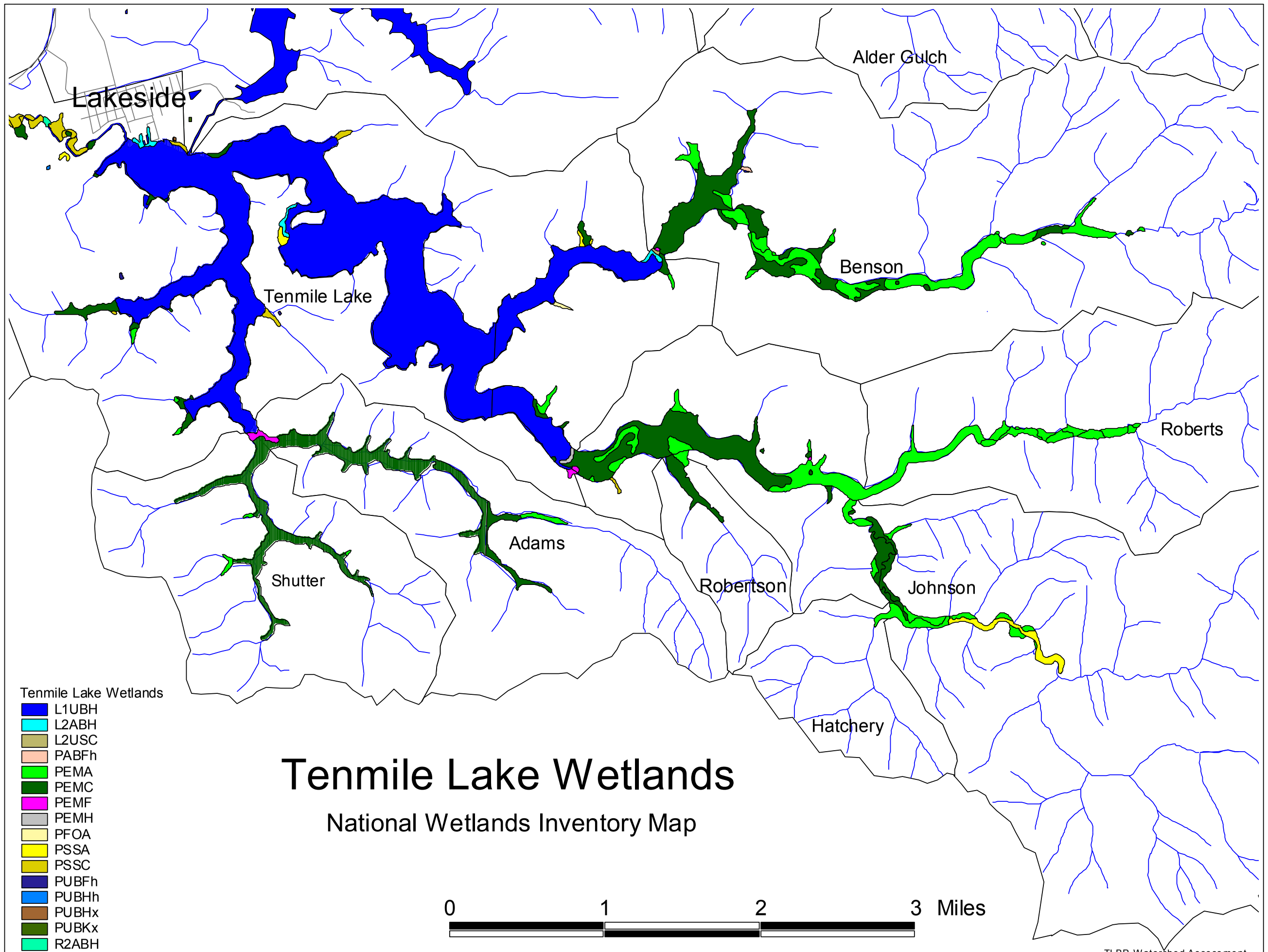
Figure 3.3. Benson Creek rangeland merging into wetland.

Benson Creek is ditched to the far left in the picture. The line of willow in the distance is an indication of the wetlands between the lake and field. While the area in the photo is considered a wetland by the USFW Service, the Army Corps of Engineers would disagree, citing lack of characteristic wetland vegetation, and possibly the lack of function as a wetland. The photo shows what, on the map, is described as PEMC, or palustrine (freshwater) emergent (the vegetation breaches the surface of the water, seasonally flooded (what the "C" in PEMC stands for). Despite conditions after heavy rains, when it's dry, this is prime Tenmile Lakes pasture.

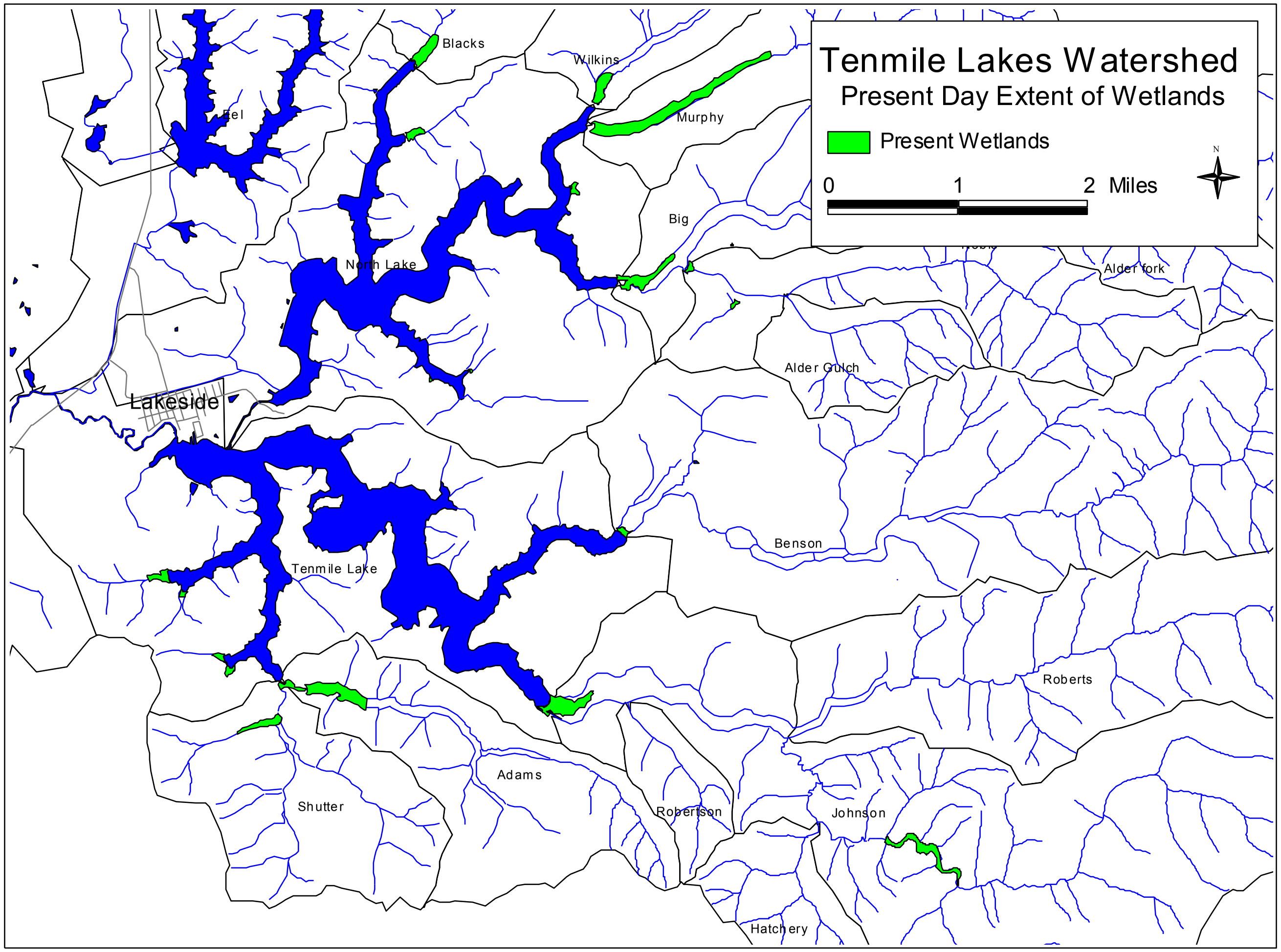
Another thing to note about the picture, is that the ditch in the center will rapidly drain the field once the lake level has dropped, limiting the amount of seasonal flooding this area experiences.



Map 3.1. North Tenmile Lake wetlands.



Map 3.2. South Tenmile Lake wetlands.



Map 3.3. Present day extent of wetlands.

Map 3.3 is a rough estimate of remaining wetlands in the stream deltas in the arms of the lakes. Wetlands delineation, of the detailed variety used by the ACOE, was not an option for TLBP due to time constraints and a lack of technical expertise. Our method was fairly straight forward, consisting of the following: If the land had livestock, we called it agricultural land. If the land had no livestock, and skunk cabbage was present, we called it wetland. Our goal was to provide a realistic assessment of the actual conditions, not an acre by acre account of wetland potential. There are areas within designated agricultural areas that have characteristics of functioning wetlands, but it is probably more instructive to leave a distinct boundary between wetlands and agricultural areas.

Lakefront wetlands were an area that we gave scant consideration to, not because they aren't important, but again because of limited time and resources. In short, when there are homes abutting the lake, lakefront wetlands are often reduced in area due to lawns, docks, and boat houses. Invasive aquatic species such as Brazilian elodea have adversely affected the native complement of aquatic plants, although the effect on lakefront wetland function is unknown.

The area presently occupied by the City of Lakeside was most likely a patchwork of wetlands and hummocks(very small hills). In some cases drainage of rain water is still a problem, as evidenced by figure 3.4. In most cases, however, wetlands were filled to provide needed space for housing and businesses. The placement of the City of Lakeside was due to the unique geography of the area. A broad, relatively flat area exists in the area where Eel Creek, North Tenmile Lake, and Tenmile Lake come together.

Figure 3.4. Low lying land in Lakeside.

Agriculture

Agriculture in the Tenmile watershed takes place largely in the narrow river valley bottoms formed by sediment deposition at the lake-stream boundary. Once sediment that has been carried downstream by relatively fast moving streams encounters the still waters of a lake, it settles out of the water and is deposited as new ground. Many thousands of years have passed since the dunes closed off what used to be an embayment of the ocean (see geologic history of the area in introduction), plenty of time to build up extensive alluvial deposits that run for miles from lake to the high forest. Prior to European settlement, the river deltas began near the lakeshore as wetlands and graded into low forest with meandering stream channels. Wetland vegetation consisted of various sedges, rushes, willow, and possibly Oregon ash. Stream channels in these low reaches were braided and allowed for laminar (surface) flow during high water events. Low forest vegetation consisted of a mix of hardwoods, conifers, and an understory of salmonberry, various other shrubs, and sometimes Bitter cherry (*Prunus emarginata*) and crabapple (*Malus fusca*).

Figure 3.5. Cattle with unfettered access to stream.

Ranchers work towards keeping rangeland well drained, which involves ditching and managing water flow, consequently, present conditions in agricultural areas are significantly different from historical conditions. Rangelands in the Tenmile watershed are typically managed grasslands with ditches and diverted stream channels running alongside hillslopes on either side of long narrow valleys. Figure 3.5 shows a typical scene in rangeland, with grass occupying land that used to support low forest and wetland habitat. The cow in the stream offers some perspective on how deep the streams have become relative to present rangeland. Eroding streambanks, as in the photo, are also very common in agricultural areas. Headward erosion, livestock activity, and lack of anchoring vegetation all contribute to unstable streambanks in agricultural areas. Figure 3.6 shows Big Creek overflowing its banks after a heavy rainfall. The nearly vertical stream bank that has been flooded in the left

Figure 3.6. Big Creek overflows

side of this photo will become saturated with water and likely slough off into the stream when the flood waters recede. Some sediment deposition will occur in the field to the left, but due to the channelized flow and lack of riparian vegetation, most of the sediment in the floodwaters will make its way to the lake. Figure 3.7 is a photo of the confluence of Big Creek Arm and Carlson Arm after heavy rains. Notice the clear dark water coming out of Carlson Arm, and the brown, muddy water from Big Creek. Refer back to figure 3.6 and imagine what this stretch of stream might have looked like several hundred years ago. The stream probably meandered widely through the valley, bouncing off the valley walls and even reversing course occasionally. The valley bottom was so heavily vegetated that crossing from one side to the other would have been difficult. Willow, cherry, crab apple, and probably ash populated the bottom lands, while big leaf maple, Sitka spruce, hemlock, and myrtle occupied the slopes adjacent to the valley floor and high spots in the flats. The stream was likely very slow moving, with a low gradient, more prone to laying down sediments than removing them. The stream surface received a small fraction of the solar radiation that it does in some spots today, and the variety of habitat was much greater than present. Beaver were active in the system, and did their part to increase the residency time of flood waters by building and maintaining dams. Beaver dams also functioned as summertime rearing habitat for salmon fry, providing cover and deep water where there might otherwise have been none.

Figure 3.7 Confluence of Big Creek Arm and Carlson Arm.

If the assessment of agricultural zones sounds dismal, it should be pointed out that one of the unintended consequences of ditching streams on the south sides of river valleys is that incident solar radiation is reduced. In order to get exposure to the sun, homes in the settlement days were built on the north side of east-west running river valleys. The main stem streams were then directed along the southern boundary of the valleys where they gained shade from the topography and upslope vegetation. It is not uncommon to see a stream reach with nearly one hundred percent vegetative overhang even when there is nothing but grass on the field side of the stream. Big leaf maple, myrtle, and alder to a lesser extent have the ability to span streams with active channels of twenty to thirty feet, effectively making up for the lack of a riparian zone on the actively farmed side of the stream. Additionally, the downcutting action which leads to entrenched streams also leads to enhanced topographic shading. The "U" shaped stream cross section may not be "natural," but it does cut down on the amount of light reaching the stream surface.

Low Forest

Figure 3.8. Streamside hemlock in Benson Creek.

The low forest, where stream gradient begins to rise and the valley floor narrows, is where coho salmon spawn in the Tenmile watershed. If present conditions in our field verified streamside vegetation sites are any indication, the riparian cover in pre-European Tenmile basin streams could get incredibly dense. The streams in the Tenmile basin are typically narrow, owing to the tight geologic settings, and consequently are easily shrouded with overhanging vegetation. More often than not, Red alder is the most abundant tree found within one hundred feet of most of our streams. Alder are pioneering trees, and will colonize a disturbed area much faster than our native conifers. It is not unusual to find oneself walking through what amounts to a tunnel of alder formed over a stream, with virtually no direct light getting through to the forest floor. After about eighty years, the alder canopy begins to senesce, and holes open up allowing

other species to proliferate. Sitka spruce and hemlock are among the more moisture tolerant conifers, and grow quite well very close to the active channel of smaller streams. (Figure 3.8). Once the alder canopy thins out, more light gets to the water's surface, and more heating occurs. In the past, this situation was in some sort of equilibrium, with a recurring progression from debris flow and fire altered(denuded) riparian zones, to salmon berry thickets, to dense alder patches, to older stands of conifers and hardwoods.

Present day conditions are dictated by the same forces as in the past, as well as modern land usage. Most low forest reaches are fish bearing streams, which accords them some protection under the Forest Practices Act. The Elliott State Forest(ESF) operations are more conservative than most commercial operations, with harvest rotations of 160 to 240 years (figure 3.9) in those portions of the ESF that fall within the Tenmile watershed. The amount of riparian cover in low forest reaches roughly corresponds to the type of land use. Agricultural areas typically have the least amount of woody vegetation, industrial and small woodlot timber operations leave what is required by law (usually an amount of basal[the area of the cross section of a tree at breast height] area calculated using Oregon Forest Practice rules), and the ESF appears to leave more riparian vegetation than required by law. Exceptions are common, laws are not always observed, and Nature tends to throw wrenches into the works every year, but it's a good bet that the largest trees and the most extensive riparian zones will be on the Elliott State Forest.

Table 3.2 shows the stream miles of low forest in each of the main land use categories and the modeled shade for each land use. Of the original 22.5 miles of low forest, about 0.7 miles in Blacks Creek are now classified as wetland due to railroad re-grading of the stream bed.

Land Use Category	Low Forest Stream Miles	Average SHADOW shade for all Low Forest reaches
Elliott State Forest	15.8	80%
Industrial forest	4.0	62%
Agriculture	4.8	25%

Table 3.2. Break down of stream miles in the three main categories of land use. TLBP.

Comment [P4]: This table needs work, but the general idea is sound.

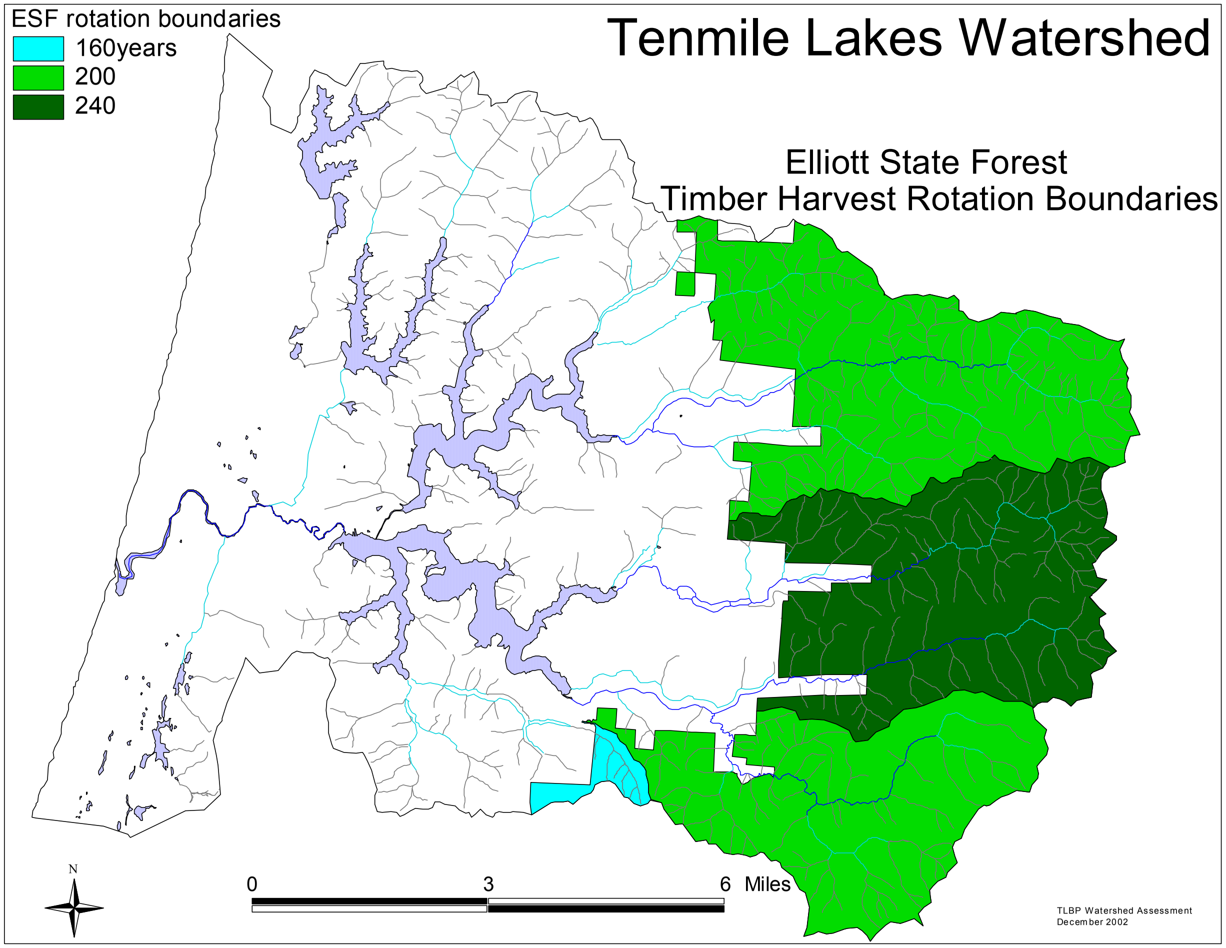


Figure 3.9. Timber harvest rotation boundaries in the Elliot State Forest.

High Forest

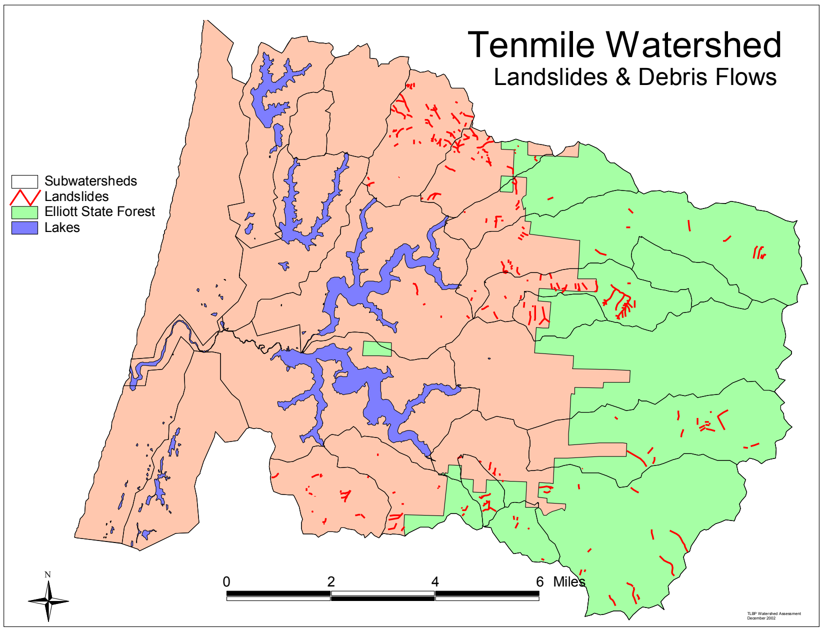
Although current riparian conditions in the high forest reaches are generally good, two or more conditions unique to high gradient reaches can contribute to either sparse or completely absent riparian zones. First, the steepness of the coast range, combined with a weak sandstone substrate in the Tenmile watershed, and high winter precipitation leads to a high rate of mass wasting. In other words, landslides and debris flows are common. A debris flow will do a remarkable job of scouring a streambed down to bedrock, removing all of the riparian vegetation in the process. Refer to the Sediment Sources chapter for a more detailed picture of landslides and debris flow risk. Secondly, high gradient streams are often unusable by fish, and the requirements for maintaining riparian vegetation are less stringent(Table 3.3).

Geographic Region	Management Prescription
Coast Range	None required
South Coast	Perennial channels where the upstream drainage area is >160 acres
Interior	Perennial channels where the upstream drainage area is >330 acres
Western Cascades	None required
Siskiyou	Perennial channels where the upstream drainage area is >580 acres

Table 3.3. Oregon Department of Forestry Forest Practices.

The Elliott State Forest Habitat Conservation Plan does provide for some management prescriptions that differ from ODF policy. Non-fish bearing streams which are intermittent, for example, are given a buffer zone of twenty five feet within which shrubs and forbs are left.

A mitigating factor for timber harvests and landslides is the ESF. See map 3.9 showing the rotation boundaries for the ESF. With rotation periods significantly longer than commercial outfits, trees (and other riparian vegetation) in the ESF simply stay on the ground longer. Long lived riparian zones tend to shade out invasive species such as Himalayan blackberries, which may provide some shade but not large woody debris necessary for habitat complexity. Road density in the ESF is lower than surrounding industrial timber lands, and the roads in the ESF are in the best condition of any non-paved roads in the watershed. Whether this correlates with lower rates of landslides is debatable, but of the 246 landslides noted from aerial photographs, 95 were wholly within or originating within the ESF.



Map 3.4. Landslides from aerial photographs.

With few exceptions, high forest reaches in the Tenmile watershed are dedicated to producing timber. This is part of a larger pattern of land ownership common in the coastal range, where the uplands belong to timber operators and the lowlands are either in agricultural production or are sited with homes. The Elliott State Forest, several corporate wood products outfits, and many small logging concerns operate within the watershed. In higher gradient reaches where fish use is not an issue, riparian zones are usually cut along with the rest of the sale. While this practice may not have a major effect on water temperatures since these areas are almost always dry during the hottest months, it is a departure from the historical successional pattern. Figure 3.10 shows another practice associated with industrial timber harvest, slash burning after a harvest. Given the expected return of fire in the coast range of between 200-400 years,

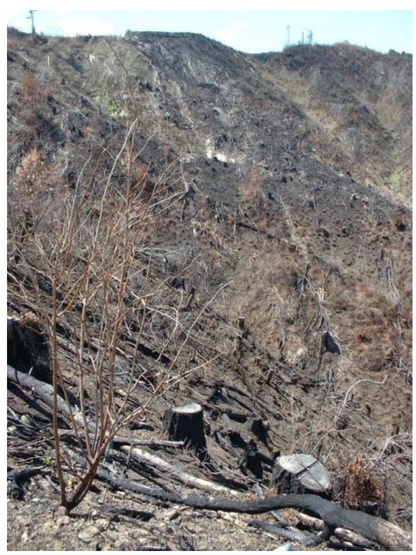


Figure 3.10. Burned unit, post harvest.

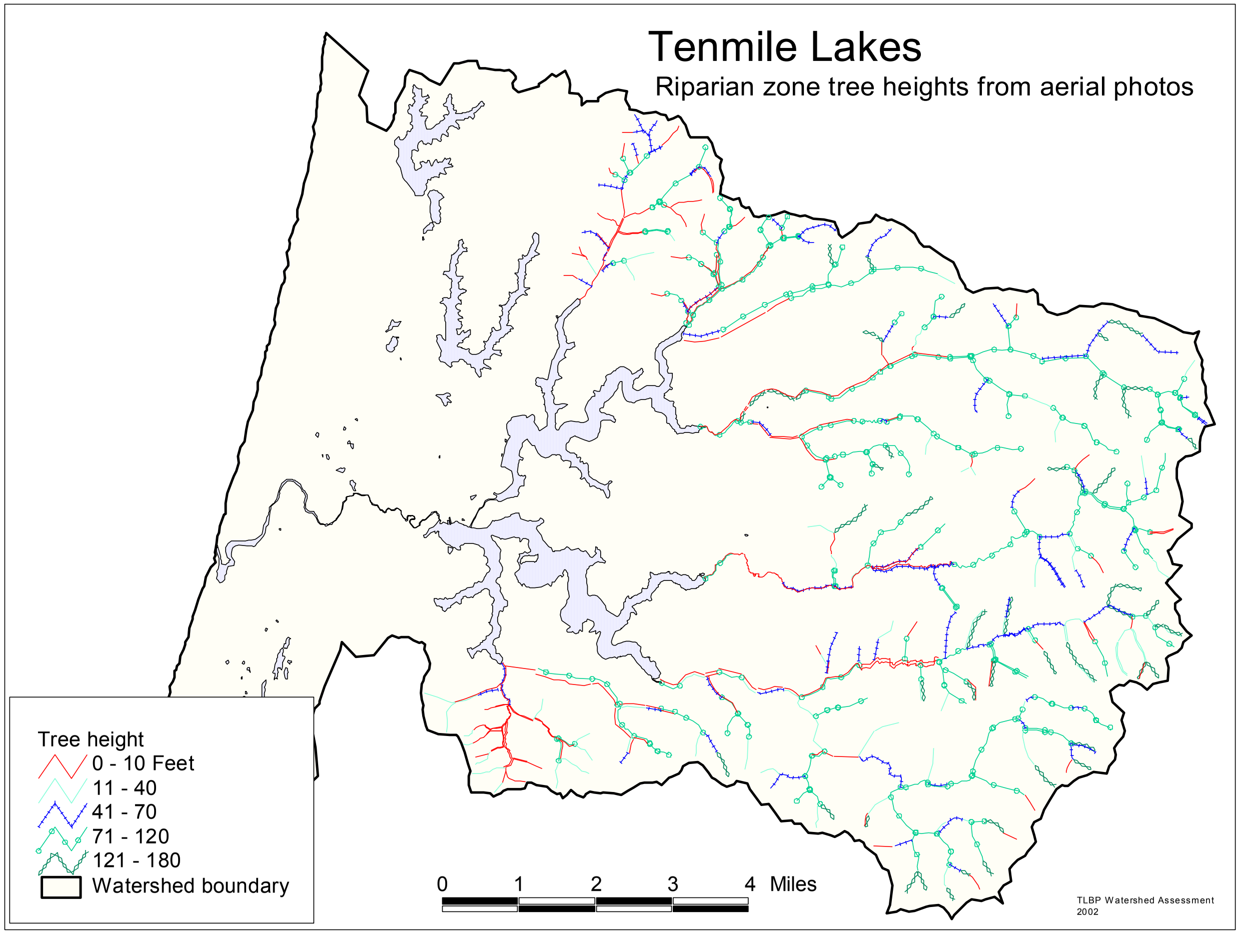
burning units on 40 to 60 year rotations makes fire a more common occurrence than in the past. Overall, the high forest reaches in the Tenmile watershed are the areas least affected by increased human presence.

Modeling Shade

Vegetation density and stream shading may be modeled to predict conditions in the future or, presumably, in the past.

Our aerial photo interpretation looked at several parameters, including; tree (or vegetation) height, vegetation type, shade density (in the form of crown density), overhang of stream surface by vegetation, width of the riparian zone, continuity of the riparian zone, the distance from the average tree line to the active channel of the stream, and the active channel width. On the ground checks of the accuracy of the information gathered from photos showed a strong correlation between estimated and actual vegetation heights, but a weak correlation between estimated active channel widths and actual active channel widths. Trees are easy to see in aerial photos, whereas stream channels are often obscured by vegetation and better estimated by their position in the drainage basin.

See, for example, map 3.5, which shows tree heights along streams in the Tenmile Lakes basin. This information in itself is interesting, but not terribly useful. We already know that agriculture requires treeless fields, and that industrial forests and state forests are in the business of growing trees. Seeing a map that reinforces that knowledge is no cause for surprise. When, however, we start adding up all of the variables, it becomes less obvious how a particular reach in a stream will react to different riparian conditions. This is where shade modeling becomes useful as a descriptive tool.



Map 3.5. Vegetation heights from stereo aerial photographs.

SHADOW output

In order to make a mathematically inclined subject easier to understand, we filtered our riparian aerial photo interpretation through a computer program called SHADOW. SHADOW is a stream temperature management program "developed as a 'front end' to Brown's (temperature) equations to aid the user in estimating the amount of unshaded stream and maximum stream temperature." (SHADOW model manual, pg1). Developed by Chris Park of the Siskiyou National Forest, SHADOW is used primarily to process aerial photo interpretation for riparian vegetation.

In short, after riparian conditions have been interpreted through aerial photos, there is an additional need to account for factors such as topography (hill shade), aspect (the direction in which the stream is oriented), and channel characteristics such as width, bank height, and distance of vegetation from the water. SHADOW is a convenient method of factoring in these variables. The user of the program supplies data such as the altitude and angle of the sun for the month of interest (August, by convention), active channel width of the stream, tree height, tree to channel distance, shade density (crown density), terrain slope, and stream orientation. The value kicked out by SHADOW when all is said and done, is simply "amount of stream un-shaded." The inverse of un-shaded stream is used to describe shade falling on a stretch of stream.

How does knowing the amount of shaded stream help the natural resource manager? By providing a method of prioritizing stream reaches based on the amount and type of shade they receive in the hottest months of the year. The SHADOW model takes into account two types of shade: shade overhang, the shade produced by vegetation directly overhanging the stream; and shade density, the shade produced by streamside vegetation set back from the stream. Some stream reaches, while lacking robust streamside vegetation, may still get a fair amount of shade due to their aspect. A stream that runs either north or south will be lined up with the sun at the hottest part of the day, from around 11am to 1pm, and will depend mostly on shade overhang to prevent sunlight from reaching the water's surface. If the riparian vegetation on this stream is, for example, mostly eighty foot Red alder, and the stream is narrow, then virtually no direct sunlight will penetrate the trees to reach the water. No direct solar radiation means little heating of the water by the sun (the most effective way to heat streams). A stream that runs either east or west, on the other hand, depends more on the density of riparian vegetation to filter out sunlight. Channel width is still important, since at some point of increasing width, no matter how tall the trees, some portion of the stream surface will always remain exposed to the sun. Back to why knowing how much shade a stream segment has helps a natural resource manager. Given the choice between planting a limited number of seedlings along two different streams, it would be useful to know what would benefit the stream most, shade density, or shade overhang. Planting a narrow strip of alder along an east-west stream wouldn't provide as much shade as a deeper planting of conifer. Conversely, a narrow strip of alder would provide a good deal of shade on a narrow, north-south stream.

The ability to use SHADOW as a predictive model is also valuable, since it's possible to run simulations of different types of vegetation to see how they affect shade values. Following are several figures showing present shade conditions, future shade conditions, shading vs. land use.

Future shade, or potential shade makes several assumptions that may or may not appeal to all land owners. Specifically, we felt that willows and Oregon ash would make a good planting mix in the wetland and former wetland reaches.   Willow tops out at about 40 to 50 feet, ash at about 80 feet. We also assumed that tree to channel distances would decrease, conifers would average 180 feet tall, shade density would range from 70 to 80%, and overhang would range from 50 to 80%.

All output from the SHADOW model is subject to variation in interpretation methods, outdating due to timber harvest, fire, etc., and revision based on input from outside sources.

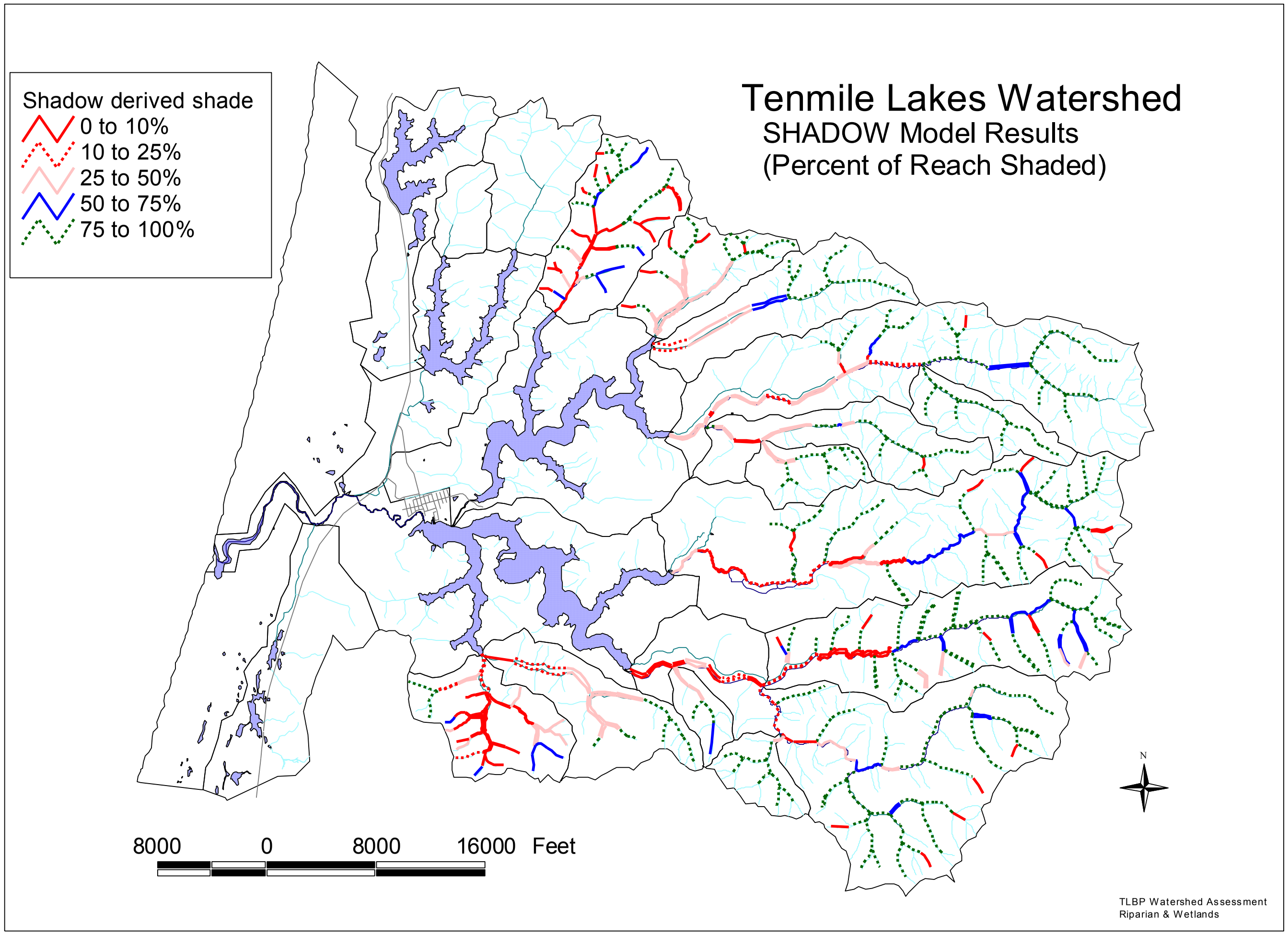
Shade in relation to land use shows the difference in cover between agricultural areas and forested areas. The map provides a visual affirmation of the obvious: where streamside vegetation is reduced, shade is also reduced. The Elliott State Forest occupies the eastern third of the watershed, and is managed in such a manner as to maintain a riparian buffer strip on all fish bearing streams. This has the effect of preserving shade and, consequently, shielding streams from the sun and therefore, solar heating. Agricultural lands, on the other hand, typically are cleared of native vegetation and planted with forage for cattle. The operative methodology in agriculture is maximizing the area devoted to crop land. This has the effect of reducing shade and increasing solar loading for streams in agricultural areas. This is the present state of the watershed at Tenmile Lakes.

At first glance the lowlands of Murphy Creek appear to be in the same condition as the agricultural lands, i.e., not much shade. Upon closer inspection, the lowlands of Murphy Creek are rather well shaded by Reed canary grass in a system that, while not entirely native, bears a striking resemblance to a functioning wetland. Since buying the land some twenty plus years ago, Roseburg lumber has been content to allow the lowlands to revert to a natural state. As a result, the channel in lower Murphy Creek has become braided and somewhat less incised than in the past. As aerial photo interpretation has limitations regarding the ability to discern tree (or grass) heights, the extent of shade provided by Canary grass in Murphy Creek, and range areas where the grass also grows, is not well accounted for in this analysis. Many of the lower reaches of agricultural areas, i.e., former wetlands, have significant riparian cover from Reed canary grass. The point has been made that, if shade is all one is after, grass and blackberries do a great job of shading small streams. This can be demonstrated with a device known as a "Solar Pathfinder." The Solar Pathfinder was originally designed as an aid to solar panel placement, but had found a secondary niche as a stream shade gauge. For example, Benson Creek is grazing land that looks wide open to the sun when seen from aerial photographs. On the ground, however, it turned out that the reach that looked as though it had zero shade from the air was well shaded by a deeply incised channel filled with grass (see figure 3.11). The solar pathfinder gave a shade reading of 69%, and would have been higher if we hadn't moved grass aside to place the device.

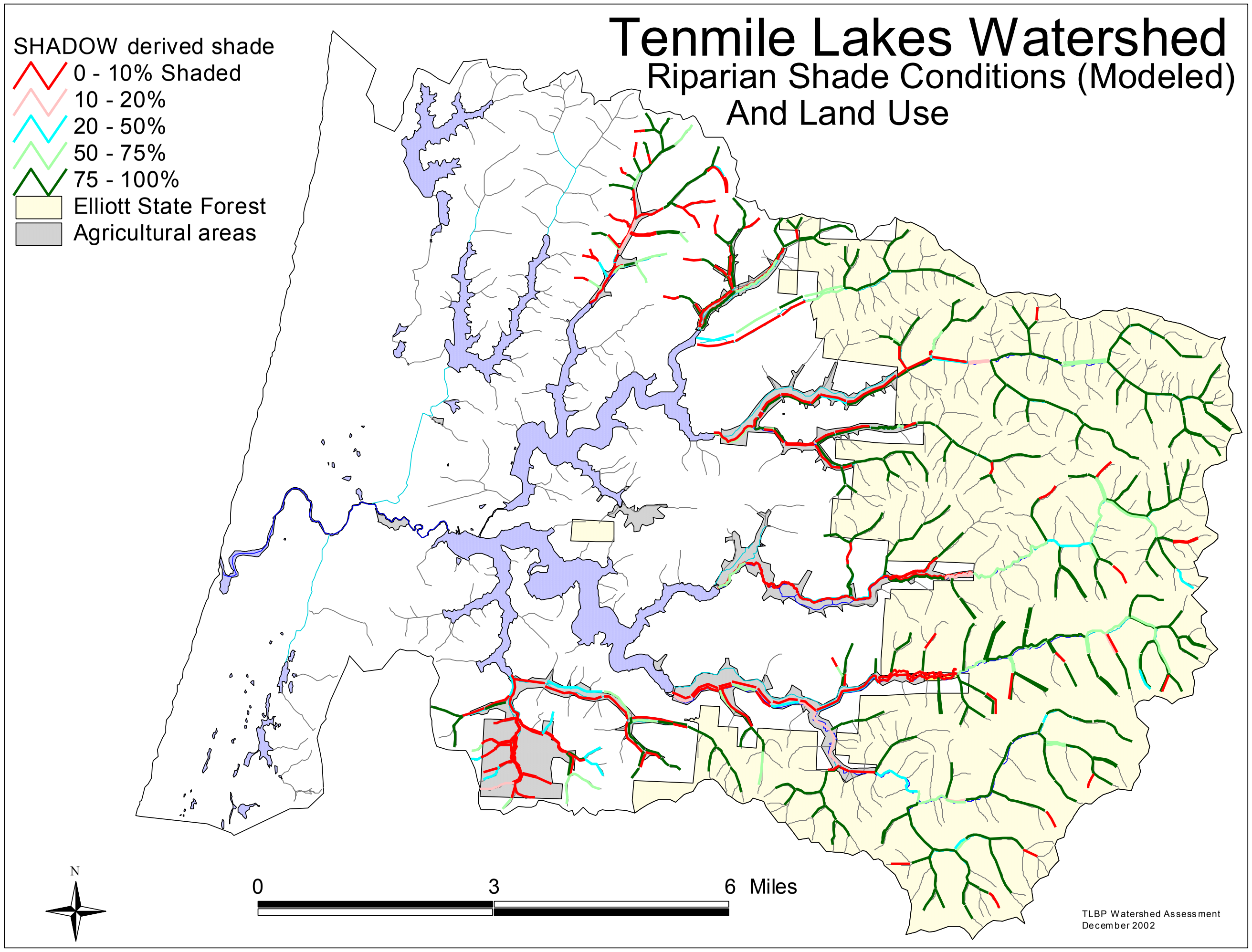
Depending on grass for shade may not be prudent, however, as summer drought can wither away grass shade when it is needed most. Nevertheless, future modeling runs should take into account seven foot tall canary grass simply because it does provide a fair amount of shade.

The Solar Pathfinder has been used as an independent check on the quality of the output from SHADOW by ground truthing a reach that has been interpreted through aerial photos. The technique the Oregon Department of Environmental Quality (DEQ) uses is to identify reaches in the watershed that are close to categories chosen to represent the shade conditions. A fifty percent shade reach, for example, is identified from aerial photos, then, once on the ground, three Solar Pathfinder readings are taken, from the beginning, middle, and end of the reach. These values are then averaged and taken to be the true shade value for the reach. The idea is to train the eye of the photo interpreter to recognize the actual conditions. Unfortunately, we had trouble locating enough standard sites with the correct orientations, that hadn't been cut over to get a good representative sample of shade categories. The SHADOW model relies on the aerial photo interpretation(API) for overhang and shade density values, so does not supply overhang or shade density as output, only total shade. Total shade for the aerial photo interpretation is not something that comes with the analysis. Shade density and overhang are estimated separately, with no estimate of total shade attempted. So...where is the value in comparing the different techniques? First, the comparison is JUST between the output from the SHADOW model and the Solar Pathfinder averages. This means we can compare total shade with total shade. Is there any utility in comparing the API values for overhang and shade density with Solar Pathfinder overhang and shade density? Possibly. But there are some caveats. First of all, the shade density measured by the Solar Pathfinder includes topographic shade, whereas the shade density measured in the API does not include topographic shade. The Solar Pathfinder looks at sunlight getting through the canopy to the dome, in contrast to the crown density estimate in the API. Therefore, the shade density from the Solar Pathfinder ought to always be higher than that of the API. The reason for mentioning this is only to point out that there is still some subjectivity involved in measuring shade.

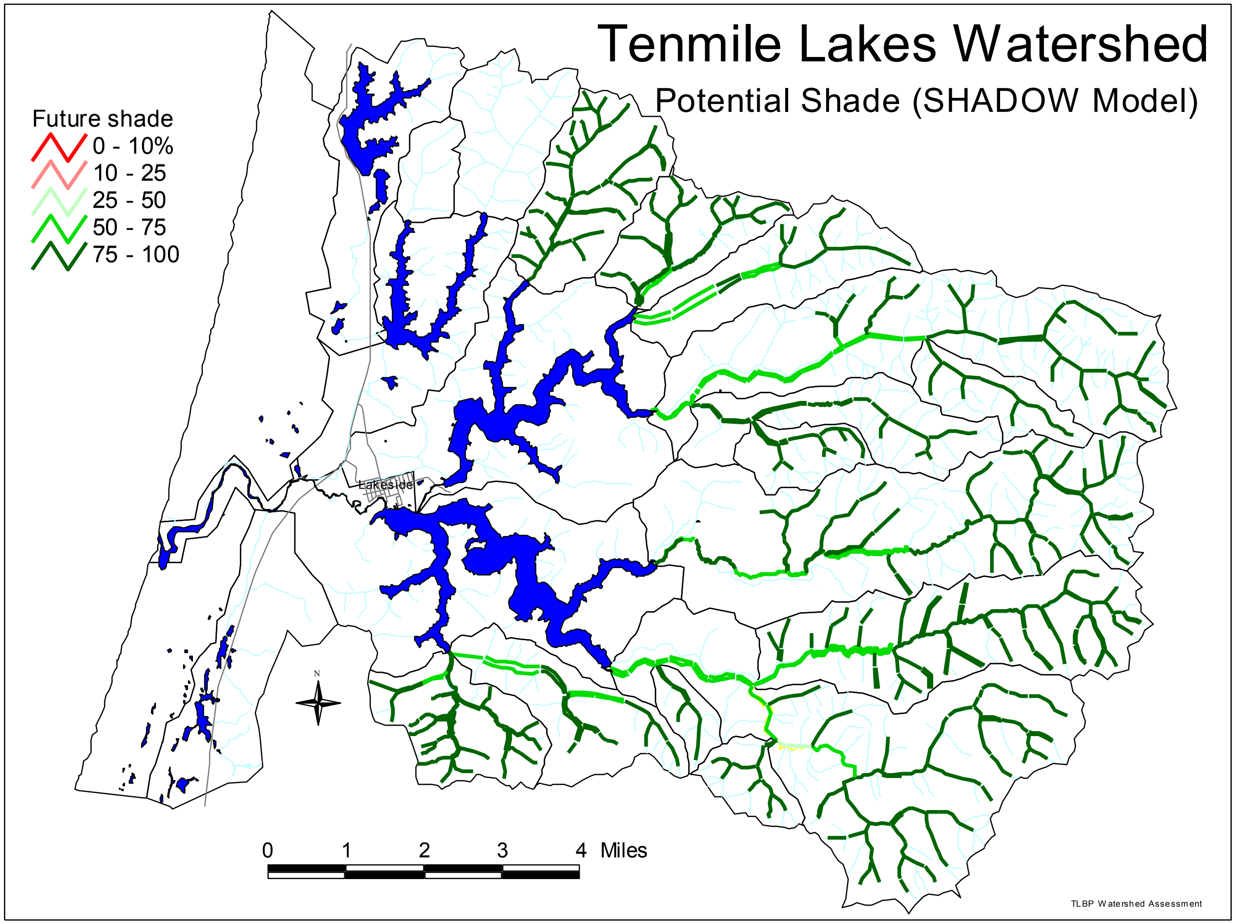
Figure 3.11. Solar pathfinder in Benson Creek.



Map 3.6. SHADOW derived shade values for current conditions.



Map 3.7. SHADOW derived shade values vs. land use.



Map 3.8. SHADOW model derived potential shade.

Wetlands

What is a wetland?
Why are wetlands important?
Where are wetlands located in Tenmile?
What are the restoration possibilities?

What is a wetland?

From the Federal Register(CE=Corps of Engineers):
"The following definition, diagnostic environmental characteristics, and technical approach comprise a guideline for the identification and delineation of wetlands:"

"a. Definition. The CE (Federal Register 1982) and the EPA (Federal Register 1980) jointly define wetlands as: Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

b. Diagnostic environmental characteristics. Wetlands have the following general diagnostic environmental characteristics:

(1) Vegetation. The prevalent vegetation consists of macrophytes that are typically adapted to areas having hydrologic and soil conditions described in a above. Hydrophytic species, due to morphological, physiological, and/or reproductive adaptation(s), have the ability to grow, effectively compete, reproduce, and/or persist in anaerobic soil conditions. Indicators of vegetation associated with wetlands 1 are listed in paragraph 35.

(2) Soil. Soils are present and have been classified as hydric, or they possess characteristics that are associated with reducing soil conditions. Indicators of soils developed under reducing conditions are listed in paragraphs 44 and 45.

(3) Hydrology. The area is inundated either permanently or periodically at mean water depths _6.6 ft, or the soil is saturated to the surface at some time during the growing season of the prevalent vegetation. Indicators of hydrologic conditions that occur in wet- 2 lands are listed in paragraph 49.

The five major kinds of wetlands are: 1) freshwater (or palustrine), 2) saltwater (or estuarine), 3) riverine, 4) lacustrine (or lakes and other deepwater habitats), and 5) marine wetlands.

Wetlands provide a multitude of ecological, economic and social benefits. They provide habitat for fish, wildlife and a variety of plants. Wetlands are nurseries for many saltwater and freshwater fishes and shellfish of commercial and recreational importance. Wetlands are also important landscape features because they hold and slowly release flood water and snow melt, recharge groundwater, act as filters to cleanse water of impurities, recycle nutrients, and provide recreation and wildlife viewing opportunities for millions of people." (From NRCS questions and answers).[xiv]

What makes a wetland depends on the federal agency providing the definition. The U.S. Fish & Wildlife Service has produced a series of maps identifying wetlands based on presence of any one of three criteria, while the Army Corps of Engineers has a somewhat stricter interpretation requiring the presence of a positive wetland indicator for each criterion (vegetation, soils, and hydrology).[xv] In other words an ACOE wetland will always be a USFW wetland, but the reverse is not necessarily true. The Oregon Division of State Lands has the Oregon Freshwater Wetland Assessment Methodology for non-professional assessment of wetlands. A more recent approach to characterizing wetlands is the hydrogeomorphic method:

> The HGM Approach is characterized and differentiated from other wetland assessment procedures in that it first classifies wetlands based on their ecological characteristics (i.e., landscape setting, water source, and hydrodynamics). Second, it uses reference to establish the range of functioning of the wetlands, and third, it uses a relative index of function, calibrated to reference wetlands, to assess wetland functions.[xvi]

Given the wide array of available information and methods for characterizing wetlands, several questions come to mind:

1. What is the basis for our interest in wetlands?
2. How can TLBP identify wetlands without highly trained wetlands delineators?
3. How does the main goal of enhancing watershed conditions for salmonids tie into our interest in wetlands?

The second question requires us to look at the difference between the ACOE and USFW methods. If we were going strictly by USFW criteria, we could use the NWI maps and be done with the identification almost immediately. The NWI maps are, in fact, a good estimate of the area covered by wetlands in the past. The same goes for the presence of hydric soils (map 3.9), which may be a good indicator of past wetland areas, but not for present day conditions. The trouble lies in the "either/or" methodology used by the USFW, i.e., either this parameter or that parameter may be present, and then we may call the area in question a wetland. Hydric soils occur because they are flooded for a good portion of the growing season(the portion of the year when soil temperatures are above biologic zero at 50 cm (19.7"))[xvii], which is year round on the coast of Oregon. That means we could call virtually all of the bottom lands in the Tenmile basin wetlands. If we look at hydrophytic plants, or those plants typically found in wetlands, we would have a different picture. Agricultural areas harbor few hydrophytic plants, as standing water has been given a direct route to the lakes via ditches and straightened channels. In other words, agricultural areas are no longer wetlands. There is also the question of wetland function. In Murphy Creek, the agricultural lands are long gone, replaced by what was around when the grazing pressure stopped, which happened to be reed canary grass(*Phalaris arundinacea*). If reed canary grass provides the same function as native wetlands, then it seems fair to call the nearly mile and a half of solid canary grass in Murphy Creek a wetland (DSL does point out, however, that reed canary grass grows both in wetlands and non-wetlands). This gets us back to the main question, "how shall we identify wetlands in the Tenmile basin?" What seems clear to us, is that if it functions as wetland, we should call it a wetland. Therefore, most of the river mouth area of Johnson Creek, for example, can't realistically be seen as wetlands. Cattle regularly gain access to the lake via well compacted soils, vegetation present is closely cropped grass, and the hydrology reflects the land use(ditched streams to facilitate water removal). What will probably end up being the best use of our time is to identify areas that function as wetlands, as evidenced by the presence of plants typically found in wetlands, and the sustained absence of range animals. How will identifying wetlands further us towards our goal of enhancing the environment for coho salmon?

Why are wetlands important?

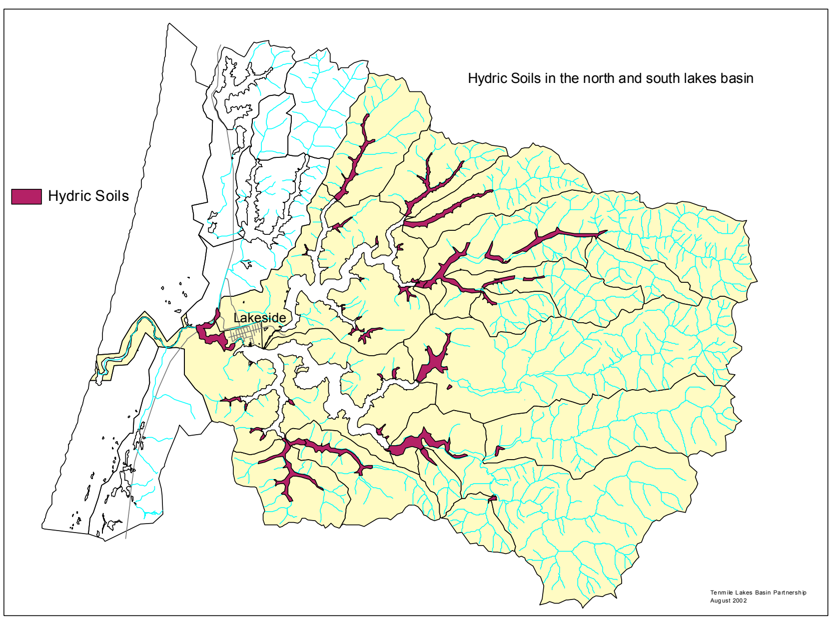
When wetlands are functioning properly, they perform a wide variety of "services" important to humans. Here is a succinct list of functions from the Oregon Division of State Lands:

- Hydrologic functions:
  - Water storage & delay
- Water quality functions:
  - Sediment stabilization & phosphorus retention
  - Nitrogen removal
  - Thermoregulation
- Biological functions:
  - Primary production
  - Fish habitat:
    - Anadromous fish habitat
    - Resident fish habitat
  - Wildlife habitat functions:
    - Amphibian habitat
    - Waterbird habitat
  - Support of characteristic native vegetation[xviii]

The value, to a farmer for example, of a particular wetland may then be tied into its function. Depressional wetlands occur in many agricultural areas in the Tenmile basin, and are sometimes seen as defects in an otherwise level, well drained field. When the function of those Depressional wetlands are considered and put into context, the case can be made that it's better to have low areas in one's field than not. For example, the water storage and delay that a Depressional wetland provides means that groundwater recharge is occurring, and when late September rolls around there may still be running water in the adjacent stream thanks to the groundwater.

Where are wetlands located in the Tenmile Watershed?

Refer back to maps 3.1 & 3.2 for the National Wetlands Inventory maps. Map 3.3 shows current wetlands locations in a very general sense, based on local knowledge.



Map 3.9. Extent of hydric soils in the Tenmile basin, an indicator for the presence of wetlands.

What are the restoration possibilities for wetlands?

Murphy Creek is a good example of what happens when agricultural practices cease and the land is left alone. Twenty years of allowing the bottomlands to go fallow, or revert to a natural state has led to the re-establishment of a functioning wetland in the first 1.5 miles of Murphy Creek. The Tenmile Lakes Nutrient Study pointed out that suspended solids, nutrient levels, and stream velocity were all lower in Murphy Creek than in Big or Benson Creeks (See the Sediment sources component).

Restoration possibilities are greatest in the larger creeks that house agricultural areas, such as Big Creek, Benson Creek, and Johnson and Roberts Creek. Several smaller drainage basins have either mostly intact wetlands or are taking on more characteristics of wetlands, such as Devore Arm, Blacks Creek, and the lower portions of Wilkins Creek, Adams creek, and West Shutter Creek.

Prior to undertaking wetlands restoration, it would be helpful to get a clear picture of which wetlands species are present in the watershed. TLBP has begun a study of aquatic bed plants which will document any changes in species composition and/or abundance

More time and effort is involved in characterizing wetlands in the Tenmile basin than has been available. A study of macrophytes in the lake would be a natural project to begin looking at wetlands in a more detailed way than has been possible here.

Chapter 4

Sediment Sources

Figure 4.1. Mass wasting as a result of heavy rains.

Introduction

Geologists are fond of calling continental rock, as in the North American Continent, scum. Scum, according to Webster's New World College Dictionary, is "the dross or refuse on top of molten metals." In other words, the rock we live on is made up light materials that remain near the surface of the planet rather than being continually recycled through plate tectonics like the basalt that makes up the ocean floors. For billions of years the continental rock we live on has battled with the sun, the wind, and the rain. And for billions of years, rock has always lost the battle.

While the pace of tectonic change in the northeast is relatively slow, change in the west is much faster by comparison. The Juan de Fuca plate is what affects us locally, as it is being subducted (drawn underneath) under the North American plate. As the sediments on top of the Juan de Fuca plate are compressed against the leading edge of the North American plate (think of the leading edge of a rug being crumpled and compressed by a large piece of furniture being moved), they gain thickness and vertical relief(height). Eventually, depending on the direction of local tectonics, sedimentary rocks may be brought above the oceans surface, or subducted deeply enough so that they become hot enough to change into metamorphic rock (rock that has re-crystallized due to high heat and pressure).[xix] On the coast of Oregon, we live on top of sediments that have been squeezed, stretched, crumpled, and folded into a complex suite of rocks and soils that give the area a unique look.

Given enough time, rock exposed to rain, wind, and temperature extremes will "weather" into smaller and smaller particles. Soil is the result of rock being weathered and re-deposited in a looser, less compact state. The result of weathering in a geologically complex area is a crazy quilt of soils each of which has its own peculiar characteristics. Some soils shed water faster than others, some host different plant communities, some make streams muddy when they erode, others are hardly noticeable when they are carried away in a flood. The Tenmile Lakes area has a decided lack of weather resistant rocks such as granite and basalt, and instead consists of mostly fragile sedimentary rock. In addition to a weak substrate, the Tenmile Lakes basin has very steep topography, with headwater slopes often exceeding angle measures of 45 degrees, or > 100% slope[4]. Add to this an average of sixty-five inches of rain a year(closer to 100 inches in the headwaters), mostly in the winter months, and it all adds up to unstable ground.

Source of Sediments

Sediment is derived from different sources, from the obvious such as landslides (mass wasting), to incredibly remote events such as Mongolian dust storms. Even living things leave behind their bodies in sufficient quantities to make commercial mining of the deposits viable(diatomaceous earth for example). Scientists call land derived sediments "lithogenous,"(or mineral) and biologically derived sediments "biogenous" (or organic). Biogenous sediments haven't been of much concern for Tenmile in the past, but as the lakes become warmer and richer in nutrients, algae, blue green algae, and invasive macrophytes(large aquatic plants) may become a more significant source of lake derived sediments.

[4] Slope is defined as rise over run. If a hill rises ten feet in elevation for every twenty feet of horizontal distance traveled, then slope = 10/20 = 0.5, or 50%.

In the meantime, however, lithogenous sources, or those from weathered rock, appear to be the most well represented in the Tenmile watershed. Landslides on steep slopes and erosion of low lying alluvial soils are the two main sources of sediment, and heavy rainfall and flooding are the two main agents of sediment delivery. The Oregon Department of Geology published a preliminary map(figure4.2) that predicted the amount of rainfall a particular region would need to receive in a twenty four hour period in order to cause landslides and debris flows. Although the map is not considered a rigorous management tool, it did prove to be approximately correct for the Tenmile watershed. In mid-December of 2002, an intense storm soaked the south coast, and dropped about five inches of rain in 24 hours in the Big Creek Arm of North Tenmile Lake. The result was scores of landslides and a muddy Tenmile Creek (something that rarely happens).

In general, the more rain, the more sediment gets delivered to streams. In 2001, J. Eilers completed a nutrient (sediment, phosphorus, & nitrogen) study for the Tenmile watershed. Part of the study looked at the relationship between the intensity of rainfall and the amount of suspended solids coming out of certain drainages. Eilers notes that:

> Stream water quality varied as a function of stream discharge in Big and Benson Creeks. Increased stream discharge resulted in increases in total suspended solids (TSS) and total phosphorus (TP; Figures 10 and 11). The largest increases in TSS and TP were associated with the greatest increases in flow. Pollutant concentrations varied not only as a function of stream discharge, but also varied in response to precipitation intensity, antecedent moisture conditions, position of the hydrograph (rising vs falling stage), and duration of the storm. Pollutant concentrations were generally greatest in high-intensity storms with rapidly rising hydrographs. As storms progressed, the pollutant concentrations generally declined, other factors being equal.[xx]

An analogy is hosing down a driveway. The amount of dirt and the time it takes to rid the driveway of it will depend upon the quantity and velocity of the hose water. A slow leak in the hose will wash away dust, while a pressure washer will actually remove bits of concrete. So an intense storm with high rainfall will move lots of sediment, especially in the early stages of the storm. Coastal Oregon has two seasons; wind and rain. Sixty percent of an average year's rain falls from November through February.[xxi] The rain tails off in the spring, and the wind takes over during the summer. Refer back to figure 4.2 and note that the Tenmile watershed is in a zone of five to six inches in twenty four hours to cause debris flows. Data from the Oregon Climate Service show that since 1961, there have only been two days in North Bend which exceeded five inches of rain in one calendar day; December 5th, 1981, and November 18th, 1996. Unofficially, on the 15th of December of 2002, John Kelsey reported over five inches of rain in one day on the Big Creek Arm of the North Lake.

The November 18th, 1996 storm dropped over thirteen inches of rain on the Weyerhauser gauge in the Coos River watershed in the same period of time recorded by the North Bend gauge. If we can assume[5] the same sort of additional rainfall in the headwaters of the Tenmile watershed, then three inches of rain in North Bend translates into over five inches of rain in the uplands of Tenmile. Since 1961, there have been twenty two days that exceeded three inches of rain in twenty four hours, which means that we can expect a three inch rain day about every two years. So every two years or so there will be enough rain somewhere in the watershed to cause a landslide. The days in which over five inches of rain fall are rare, but overwhelming when they happen. And, if the National Oceanic and Atmospheric Administration (NOAA) is correct that, "The frequency of extreme rainfall events has increased throughout much of the United States," (due to global warming), then we can expect more of those really wet days and, consequently, more frequent landslides.[xxii]

[5] This assumption can be documented. For example, the Tenmile Lakes Nutrient Study Phase II Report says, "Note that the precipitation at North Bend probably underestimates precipitation for Tenmile Lake watershed of two factors: (1) greater precipitation occurs near the proximity of the Umpqua River as shown by a 25% greater precipitation at Reedsport and (2) the orographic effects of the Coastal Range intercepts more precipitation as the systems move inland."(pg 63) The BLM also mentions this fundamental effect in regards to the East Fork of the Coquille River, "Most precipitation occurs as rainfall, ranging from 55 inches annually in the lower elevations, to more than 95 inches at the eastern end of the watershed near 3,200 ft. elevation (OSU 1993).Precipitation varies strongly with elevation. Precipitation is higher in the upper elevations of the drainage, declining from west to east for any given elevation. Aspect and drainage orientation to prevailing southwest winter winds also influence precipitation amounts. (East Fork Coquille Watershed Analysis, Bureau Of Land Management, Coos Bay District Myrtlewood Resource Area, First Iteration: May 2000.).

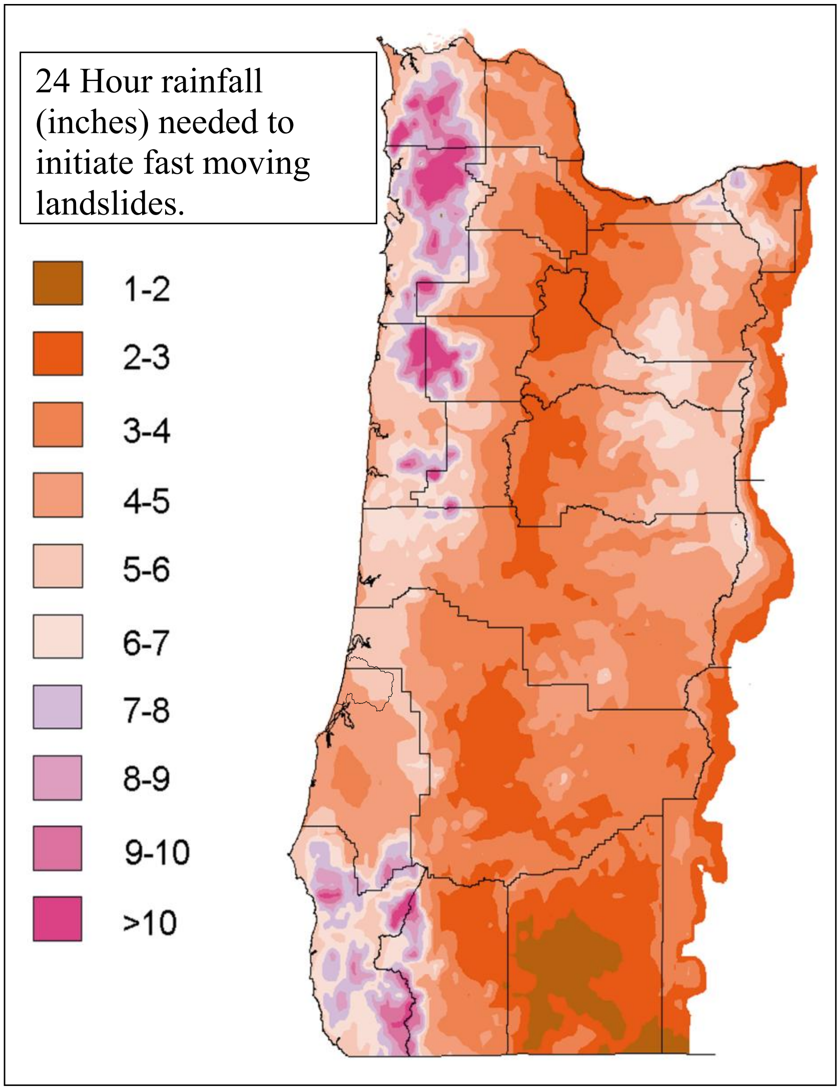


Figure 4.2. 24 hour rainfall needed to induce landslides. Oregon Department of Geology.[xxiii]

Measuring sediment transport

In order to gauge how much sediment is present in the water of a stream or lake, it is helpful to determine the amount of particulate matter in the water. One measure of suspended particulates is total suspended solids (TSS). TSS was originally meant to measure suspended solids in partially treated sewage, but has become common as a quality check for natural waters. Methods for measuring TSS vary, but typically a sample of water is drawn from the water body and sent to a laboratory where a sub-sample is run through a glass fiber filter, heated at slightly above the boiling temperature of water and, when dried, weighed and reported as milligrams of solids per liter of water.[6]

Solids may be organic or inorganic. Streams are likely to have more inorganic materials such as clay and sand(minerals), whereas lakes tend to have a higher proportion of organic constituents, i.e., algae and zooplankton. The time of year influences what types of suspended solids are highest. High stream flows in the fall and winter produce high mineral readings, while spring and summer see increased plankton growth in the lakes.

The Tenmile Lakes Nutrient Study found a wide variance of TSS values, with agricultural drainages and urban areas coming in high compared to drainages with functioning wetlands and either little or no agricultural activity and/or channelization.

Nutrients

Phosphorus(P) and nitrogen(N) are two key elements in watershed ecology when considering human impact on the environment. Both P & N are essential nutrients normally found in limited quantities and, as such, are bottlenecks to growth of organisms dependent on them. Phosphorus is present in soil as water insoluble phosphate rock. Nitrogen is abundant in the atmosphere, but is not readily available to plants that don't have nitrogen fixing bacteria living inside their roots. Red alder and salmon carcasses have been the historical sources of nitrogen in our watershed.

Man made phosphorus is introduced into the environment through septic systems and fertilizers, and remains in place under vegetated conditions, becoming mobile when soils are exposed and eroded. Timber harvest sites, construction sites, and eroding streambanks are sources of P.

Nitrogen can be introduced in several ways, including the decay of nitrogen fixing organisms, agricultural use of fertilizer, animal wastes, septic

---

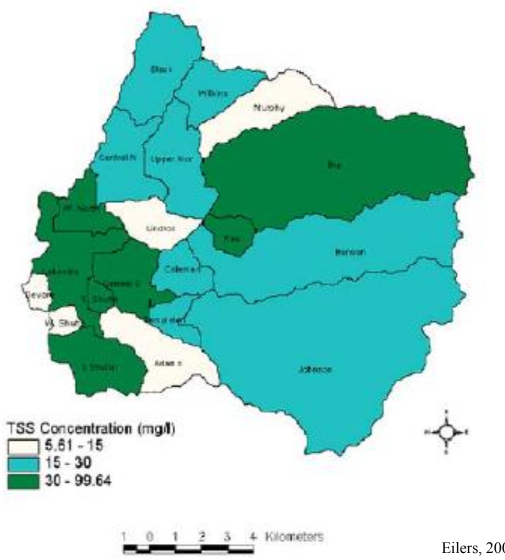
[6] Suspended Sediment Concentration (SSC) is considered to be a more reliable method for samples that have a higher percentage of large particulates. Comparability of Suspended-Sediment Concentration and Total Suspended Solids Data. By John R. Gray, G. Douglas Glysson, Lisa M. Turcios, and Gregory E. Schwarz Water-Resources Investigations Report 00-4191. U.S. Geological Survey. August, 2000.

systems, and atmospheric deposition(from fossil fuel combustion, bacterial volatilization of N in the form of nitrous oxide)[xxiv]. Once present in a form useful to algae and cyanobacteria, N helps drive population growth to levels unattainable prior to nutrient enrichment. Microcystis, for example, can't fix N and depends on metabolically available N in order to thrive.

Other elements are present and may act as nutrients, potassium(K) for example, but N & P are of the most concern.

Critical Questions

What are the current sediment sources in the watershed?



Eilers, 2002

Map 4.1. Total suspended solids concentration, Tenmile Lakes Nutrient Study SWAT modeling

Landslides in the uplands, stream bank erosion in the agricultural lands, roads, and lakefront development and septic systems.

Lakeside is, according to the results of sediment modeling, a source of suspended solids and nutrients

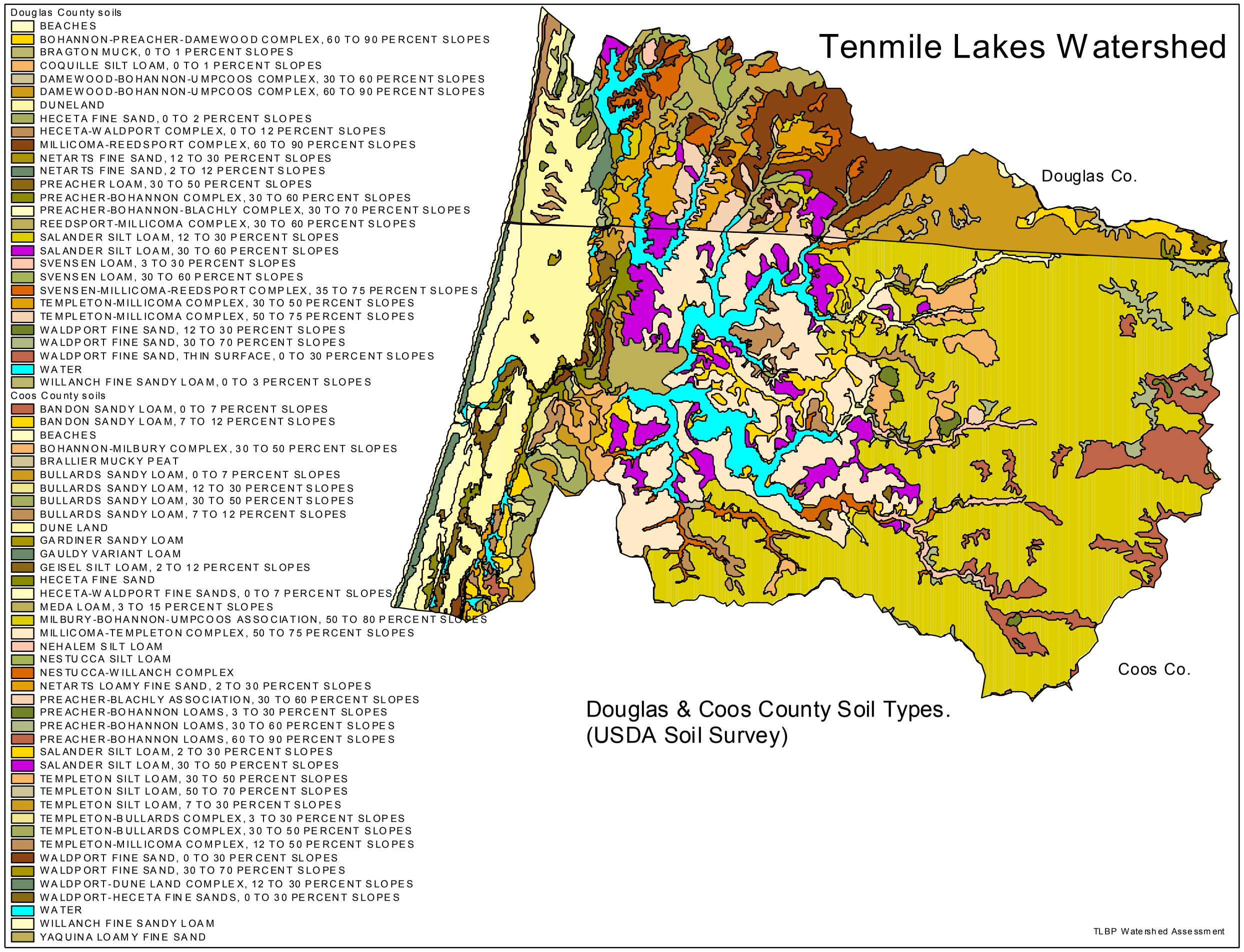
What are important future sources of sediment in the watershed?

Presumably the same as today, with perhaps more coming from rural development.

Which erosion problems are most severe and qualify as high priority for remedying conditions in the watershed?

Restoration opportunities are identified in the summary tables, which indicate locations where human caused sediment increases are most severe. Stabilizing stream banks in agricultural areas is likely to be the key to alleviating the chronic sources of sediment. Debris flows are frequent in the Tenmile basin, due primarily to the sedimentary rock and steep terrain, but there may be a correlation with timber harvests and roads.

Each of the following sections addresses the question of sediment sources and severity for the four main types of channel types found in the watershed; wetlands, agriculture, low forest, and high forest. Agriculture typically straddles both wetlands and low forest and shows characteristics of both.



Map 4.2. Soil types. USDA.

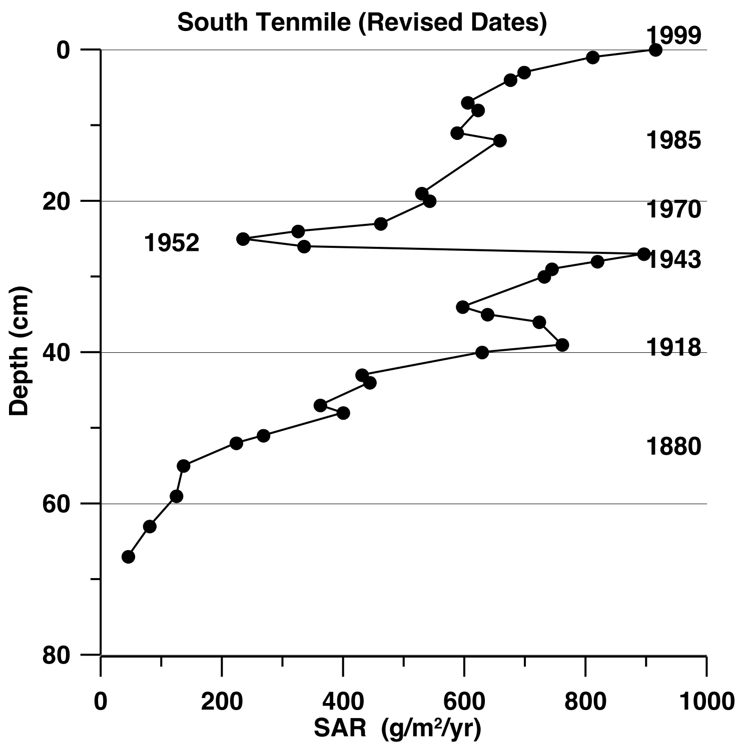
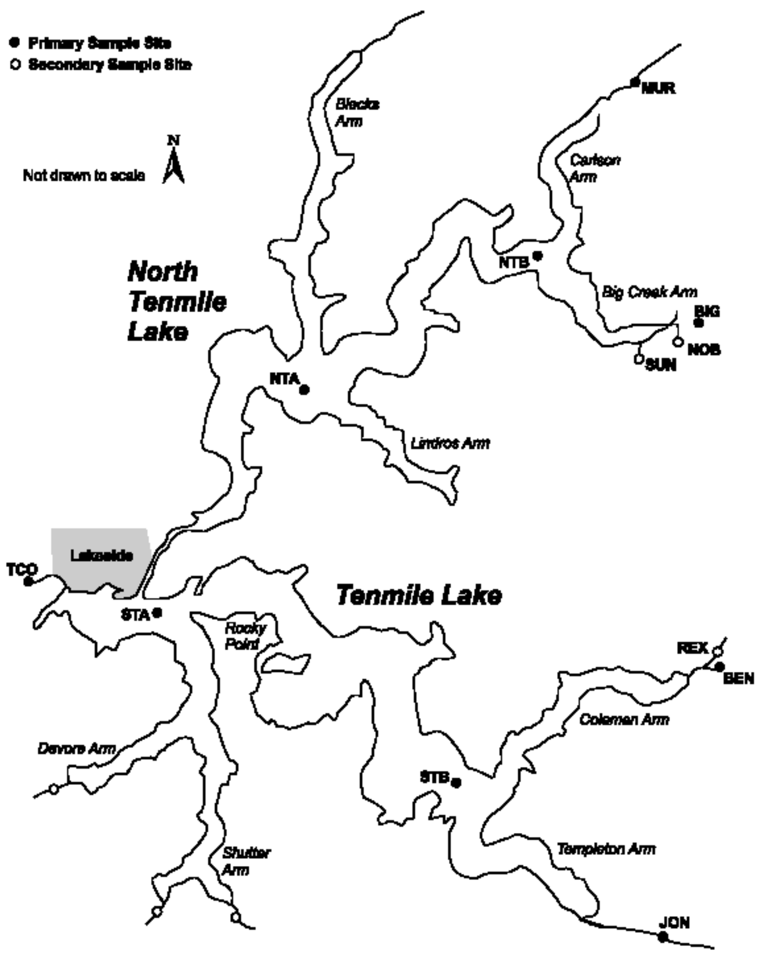


Figure 4.3. Sediment accumulation rate. J. Eilers et al.

Wetlands

With respect to sediment, wetlands function as traps rather than sources. In the arms of the lakes our wetlands are the advancing fronts of the stream deltas, forever inching out into the lake to create new land. As time goes on, the normal progression is from a highly productive, eutrophic lake to meadow to forest. In the absence of some drastic change in the local geomorphology, the lakes that define our watershed will disappear sometime in the distant future. The situation at the moment is that succession appears to be happening at a far faster rate than in the past. Figure 4.3 shows the sediment accumulation rate (SAR) calculated(by removing a cylindrical core of lake bed sediment and analyzing how certain elements varied vertically in the column) by J. Eilers for the Phase II Nutrient Study for the Tenmile Lakes, North and

South. It should be noted that the highest sediment accumulation rates were measured in the lakes not far from where the streams enter the lakes(see Map 4.3).



Map 4.3. Phases I and II water quality monitoring and coring sites, Tenmile Lakes watershed.

The following passage is from the Tenmile Lakes Nutrient Study, Phase II. References are made to study sites in North and South Tenmile Lakes, please refer back to map 4.3 to find each site.

Lake Sediment

The sediment core from the south lake (STA) was dated using 210Pb and analyzed for fossil diatoms, 15N, and cyanobacteria akinetes. The 210Pb provides estimates of the age of the sediments and therefore allows one to compute the sediment accumulation rate (SAR). Diatom taxa preserve well in lake sediments because the cell wall is composed of silica. Diatoms have specific environmental requirements and the type of species in the sediments provide considerable information about the historical water quality in the lake. Nitrogen-15 is a naturally-occurring isotope of nitrogen (atomic weight 14). A shift in the 15N/14N ratio can provide insight into shifts in major sources of nitrogen to the lake. In particular, an elevated ratio can be associated with high inputs of marine-derived N from anadromous fish. It also can be caused by a shift in the proportion of N-fixing phytoplankton that might occur if the relative amount of cyanobacteria had increased. Akinetes are structures found on N-fixing cyanobacteria that can be preserved in the sediments. An increase in akinetes might signal an increase in cyanobacteria.

a. Sediment Accumulation Rates

The SAR measured in the main basin of South Tenmile Lake shows an increase from about 100 g/m2/yr prior to settlement to a current value approaching 900 g/m2/yr (Figure 40). The core from the main basin in North Tenmile Lake shows a baseline SAR near 400 g/m2/yr increasing to a current rate of 800 g/m2/yr (Figure 41). The core from Lindross Arm is comparable to the main basin core in the north lake site, but the core from site NTB, Coleman Arm, exhibits a current SAR of about 1300 g/m2/yr (Figure 42). Thus, the minimum increase in SAR is about two-fold at NTA, increasing to maximum measured rates of four-fold baseline levels at NTB and possibly much greater at STA. The rates of phosphorus and nitrogen accumulation are greater than the increase in sediment because of the concomitant increase in the concentration of nutrients in the sediment (Eilers et al. 1996a). A comparison of the SAR in Tenmile Lake (STA) with Devils Lake, located further up the coast, shows some interesting parallels (Figure 43). The SAR in both lakes shows a pre-settlement SAR near 200 g/m2/yr and a major increase between 1910 to 1920, possibly as a consequence of early logging combined with a major storm event (Eilers et al. 1996). However, Devils Lake appeared to show a rapid recovery following the event, whereas Tenmile Lake experienced high SAR through the early 1950s at which point it decreased to near pre-development levels. Both lakes have since shown a return to high SAR as lakeshore development and high rates of timber harvest contributed to renewed rates of erosion. The sediment core samples collected under Phase II were processed by a different laboratory than in the previous sediment work by Eilers et al. (1996a). However, a comparison of the 210Pb activity measured previously in Phase I shows reasonably close agreement in overall levels of activity with those measured in Phase II (Figures 44 and 45). The STA core from Phase I exhibits a higher degree of apparent disturbance in the upper 20 cm of the core, but the two cores from NTA exhibit virtually the same pattern.[xxv]

The nutrient study points out that, " During this period, Big and Benson Creeks, which appear to be representative of most tributaries to the lake, delivered sediment and nutrients at a rate far greater than occurred in Murphy Creek. Loads, expressed on a per-hectare basis, show that sediment yields from Big and Benson Creeks are at least ten times greater than the yield from Murphy Creek (Tables 7-9). The loads of nitrogen and phosphorus from Big and Benson Creeks are at least three times those from Murphy Creek."[xxvi] Murphy Creek functions more or less as a wetland and tree farm. Big and Benson Creeks are working ranches with livestock, and Big Creek has a fair number of human inhabitants. Murphy Creek has had no permanent human presence for perhaps thirty years and has not had livestock for over twenty years, and it is beginning to resemble what we think of as a typical wetland, i.e., braided stream channels, wetland vegetation, and persistent seasonal flooding.

When floods hit Murphy Creek, the densely vegetated stream banks quickly overflow and disperse flood waters out over a floodplain covered with six foot high grass. The velocity of flood waters is drastically reduced, sediment is effectively filtered out of the water column, and stream banks are held in place by the extensive vegetation. In other words, intact wetlands generally don't contribute sediment to the system, they trap it. Soil scientists call this "aggradation."

Lake shore sources

Ringing the lakes from just above the water line to a water depth of about six feet are wetlands(lacustrine) that vary in composition from site to site, but generally have a mixture of emergent and submerged plants. While aquatic plants are a nuisance to people who must maintain docks, they perform much the same function as the wetlands in the arms of the lakes namely, filtration, nutrient uptake, and soil stabilization, plus they provide habitat for invertebrates(the base of the aquatic food web).

Sediment delivery directly to the lakes(not including streams) comes primarily through landslides and lakefront construction. Figures 4.4 and 4.5 show various instances of recent activity along the lakefront. While this area has not received much attention, those interested in the lake front point out that boat traffic in the lakes has an adverse affect on the shoreline. Waves created by boats are common in the summer and have a seemingly small but widespread ability to remove sediment from the lake front.

Figure 4.4. Landslide that has reached N. Lake.

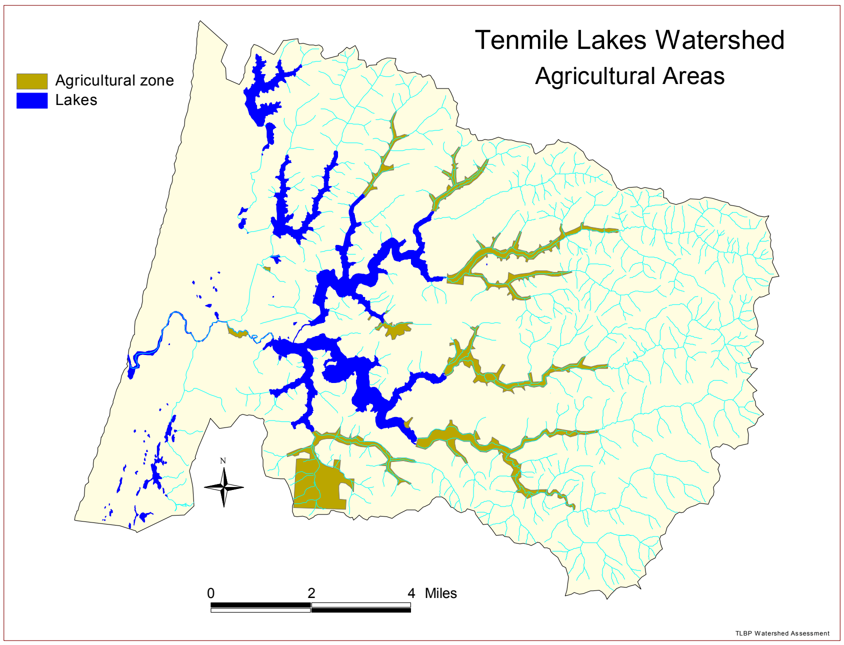
Figure 4.5. Surface erosion in a construction site. North Lake.

Figure 4.6 shows the effects of placing a septic system on a very steep slope. Not evident in the photo is the approximately 50% slope above the home. When a late December storm dumped eight inches of rain in thirty-six hours, the already saturated soil in the drain field gave way.

Figure 4.6. Catastrophic failure of slope and septic system.

Lake-fringe wetlands are subject to some of the same pressures as other wetlands: Over-sedimentation, filling for human purposes, and some unique pressures such as chemical and physical measures to control vegetative growth in the vicinity of docks. Invasive plant species are also a problem for native plant species, although there have been no studies(in the Tenmile watershed) comparing the functioning value of one species vs. another.

To reiterate, in regards to sediments, wetlands are typically where the sediment ends up. In the process of filtering and absorbing, the wetland community is essentially working itself out of a job. The higher the rate of sediment delivery to the wetlands, the faster they will begin to look like low forests.



Map 4.4. agriculture in the Tenmile basin.

Past agricultural activity in the Tenmile basin included dairies, along with a creamery in Lakeside, and crops such as potatoes, apples, and berries. Agriculture now consists mostly of pasture land and hay fields in the lowland areas of the river valleys. The one anomalous area is Shutter Creek, which resembles the rolling green hills of a New Zealand sheep farm. In fact, most of the Shutter Creek basin is devoted to sheep ranching. The rest of the uplands in the Tenmile basin are used as timber land and a few scattered home sites.

Having gone through a century plus long change in appearance and function, lowland areas in the Tenmile watershed now function as a ranches, pasture land, and hay fields rather than wetlands and forest. Erosion can be severe in these areas, especially where riparian vegetation is scarce and streams have been channelized. Figure 4.7 illustrates the tenuous nature of soil once it has been relieved of overlying vegetation and exposed to high velocity flood waters. Once the stream bank becomes saturated with water, it becomes heavy, the grains of soil begin to separate from each other under the influence of interstitial water (water between the grains) and failure becomes imminent. Bank failures of this type are common in our agricultural areas.

Stream reaches in agricultural areas that were either historically wetlands or low forest sediments are typically low gradient reaches and can act both as sediment sources and depositional areas. High flows that reach the lip of the flood plain are fast moving and tend to scour the banks and stream bed, with net erosion being the result.

Figure 4.7. Slumping stream bank after a flood.

Once a stream has breached its banks and covered the flood plain, water velocity is slower and suspended solids settle out of the water column. Farmers along rivers everywhere recognize this process as the source of their productive soils. The trick is to keep the rich soils that have accumulated over the millennia without having the farm inundated every winter. Most farmers and ranchers accomplish this by removing accumulated sediments from the stream and re-depositing them in the fields. Drainage way cleaning usually occurs once every three to five years.

Some local ranchers have had luck with a ditching blade when maintaining drainage ditches. A ditching blade produces a sloped bank, which can be seeded with grass, rather than a vertical bank that is much more prone to failing. Slightly more space is required to produce a sloped ditch bank, but the reduced loss of topsoil makes up for the added effort.

Agricultural contributions to sedimentation depend on the condition of the stream banks, the type of agricultural activity, and the density of livestock on the fields. The variety of agriculture now practiced in the Tenmile watershed is considered to be low impact because of the lack of tilling and the conversion of high infiltration soils to low infiltration soils. A concerted riparian planting effort would reduce the occurrence of situations pictured in figure 4.7 by allowing streamside vegetation to anchor soils exposed to bankfull flows.

Low Forest

Figure 4.8. Incised stream bed in low forest reach.

Low forest reaches are dynamic areas that change from year to year much more than either agricultural areas, wetlands, or the high forest (not taking into account debris flows and landslides). A pool tail out that provided spawning habitat one year may be next year's riffle, depending on how much water moves through the system. The net effect over the years however, has been soil gain due to the low stream gradient. Keep in mind that thousands of years ago, the main stem streams were most likely open water, yet to have undergone the successional process. A man made reservoir fills in much the same way—from the point where streams enter the body of water. What is now main stem low forest was previously wetland, and before that, part of the lake.

What has changed since European settlement is the velocity and time spent of water in agricultural areas. Drainage ditches and the clearing of extensive wetlands has led to water spending less time in agricultural areas(the desired effect), but also a change in the profile of the stream gradient. When ditches were first dug, the surface of the creeks fell relative to the former meandering path through wetlands. This had the effect of increasing the velocity of the stream in the low forest and, consequently, the rate of erosion. What might have formerly been a net depositional area became a net erosional area. The process is self-reinforcing, since a stream that begins to eat down into its sediments tends to become constrained in a channel, velocities increase, and bank erosion begins to occur more regularly.

This piece of the sediment puzzle merits further studies. Rates of bank erosion, net soil movement, bar(sand and cobble accumulations within the stream channel) migration, longitudinal profiles of the stream bed, and the changing degree of entrenchment would all be valuable bits of information. For now we have preliminary evidence that the low forest is a sediment source rather than a sink.

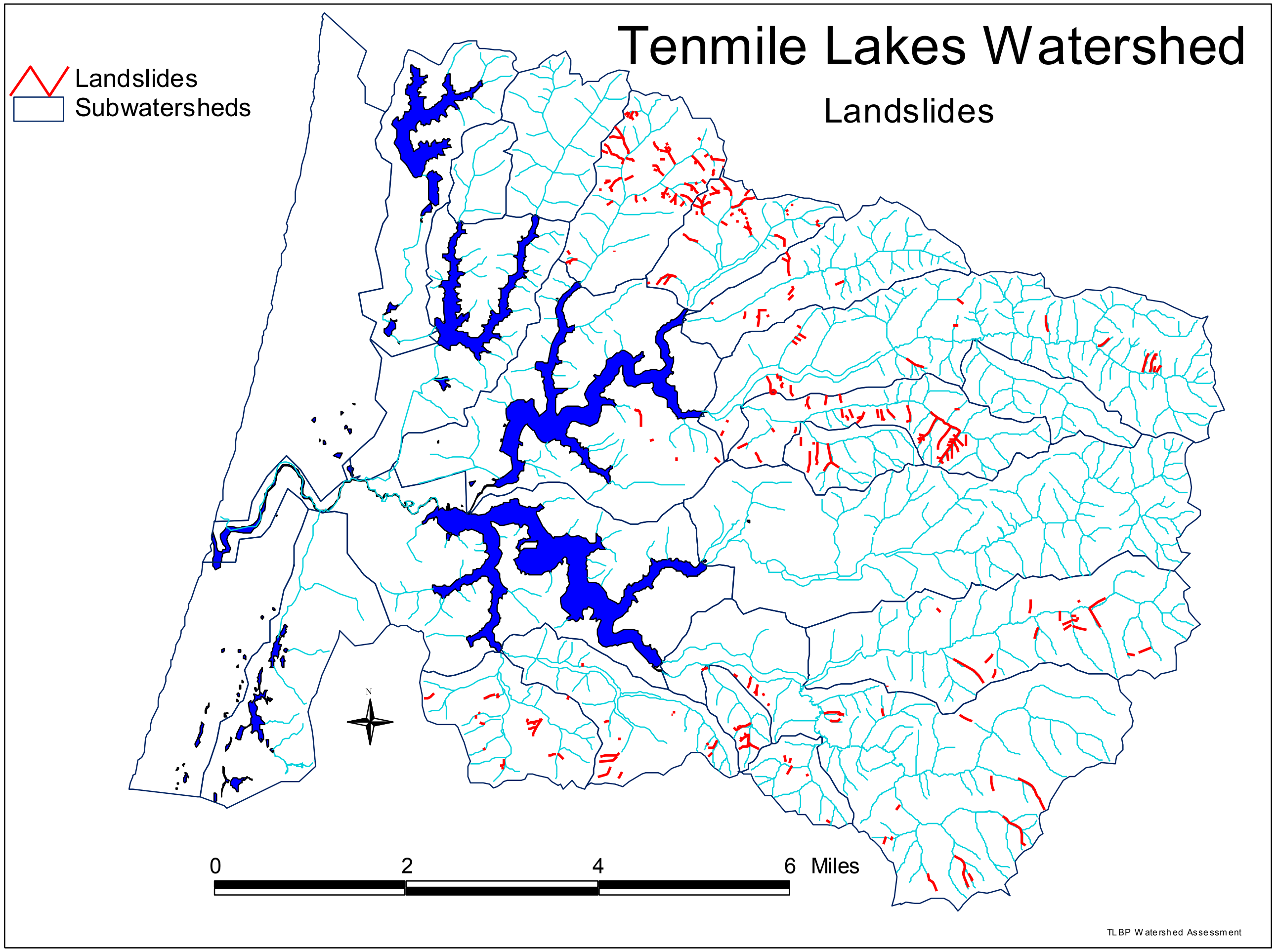
High Forest

The vast majority of landslides in the Tenmile watershed originate in the high forest, mainly due to orographic effects on rainfall and gravity's effect on steep slopes. That is to say, the higher the mountains, the more rain they collect; and the steeper the slope, the more likely soil is to succumb to gravity's pull once weighed down by intense winter rainfall.

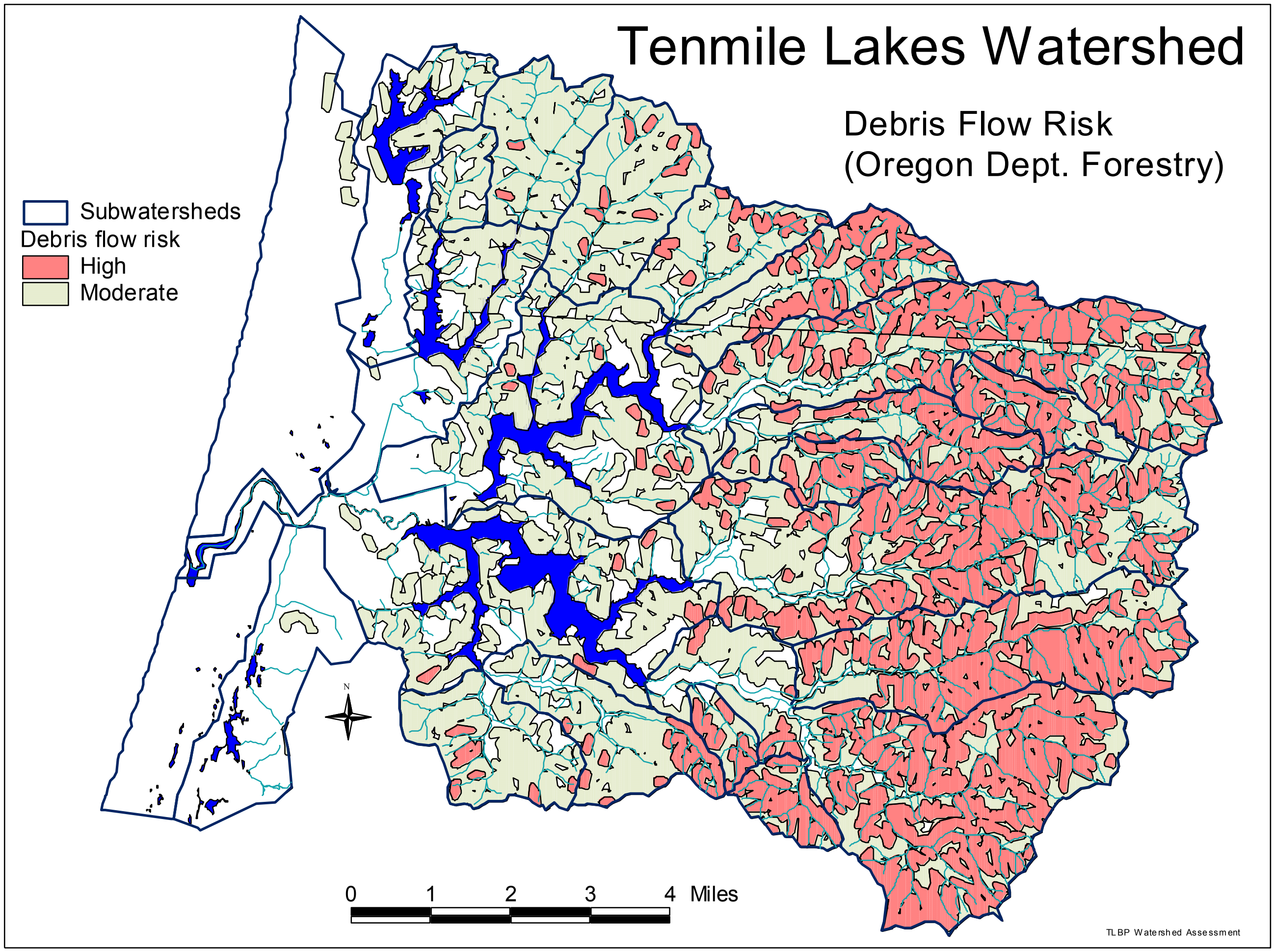
Map 4.5 shows the location of landslides visible in stereo aerial photographs from 1997 and 2001. There are caveats regarding aerial photo interpretation, including the inability to identify large slow moving slumps and surface erosion, the differential success in identifying slides in clear cuts versus stands of large trees, and in general the unlikely prospect of seeing any small scale slides or bank failures. Most of the slides noted in map 4.5 are debris flows originating in high slope headwaters.

The following excerpt from Oregon Geology makes the case for anthropogenic (human caused) slides:

> "Agricultural irrigation and forestry practices such as clear-cutting and stripping vegetation from naturally oversteepened slopes have been shown to be responsible for a spate of landslides. Highway construction on similar slope conditions awaits only the first good rain to provoke earth movement.
>
> During the floods of 1996, most of the 250 landslides in the Clackamas River watershed and 75 percent of the slides in the Mount Hood National Forest were in logged–over lands or those criss-crossed by dirt logging roads.
>
> Research on slides in relation to clear-0cutting in the Pacific Northwest over the past 30 years documents a direct causal relationship. A 1996 Forest Service study of 244 slides found 91 instances of mass movement on logged-over lands, 93 in association with roads, but only 59 in undisturbed forest. The combination of both logging and road-building increases slide frequency times over a twenty-year period when compared to undisturbed forested lands.
>
> Forestry regulations, modified in 1997, address only those logging or road-construction operations where there might be a risk to human life from landslides or debris flows, as opposed to considering the overall environmental picture.
>
> One characteristic of landslides is that virtually all unstable and movement-prone slopes can be recognized, so mass movement should not be totally unexpected. Tip-offs to incipient hazard-prone slopes include scarps, tilted and bent ("gunstocked") trees, wetlands and standing water, irregular and hummocky ground topography, and oversteepened slopes with a thick soil cover. The technology of spotting landslides by use of aerial photography has become so refined that NASA routinely recognizes and maps mass movement features on several of the planets in our solar system as well as on our own moon."[xxvii]



Map 4.5. Landslides from aerial photo interpretation.



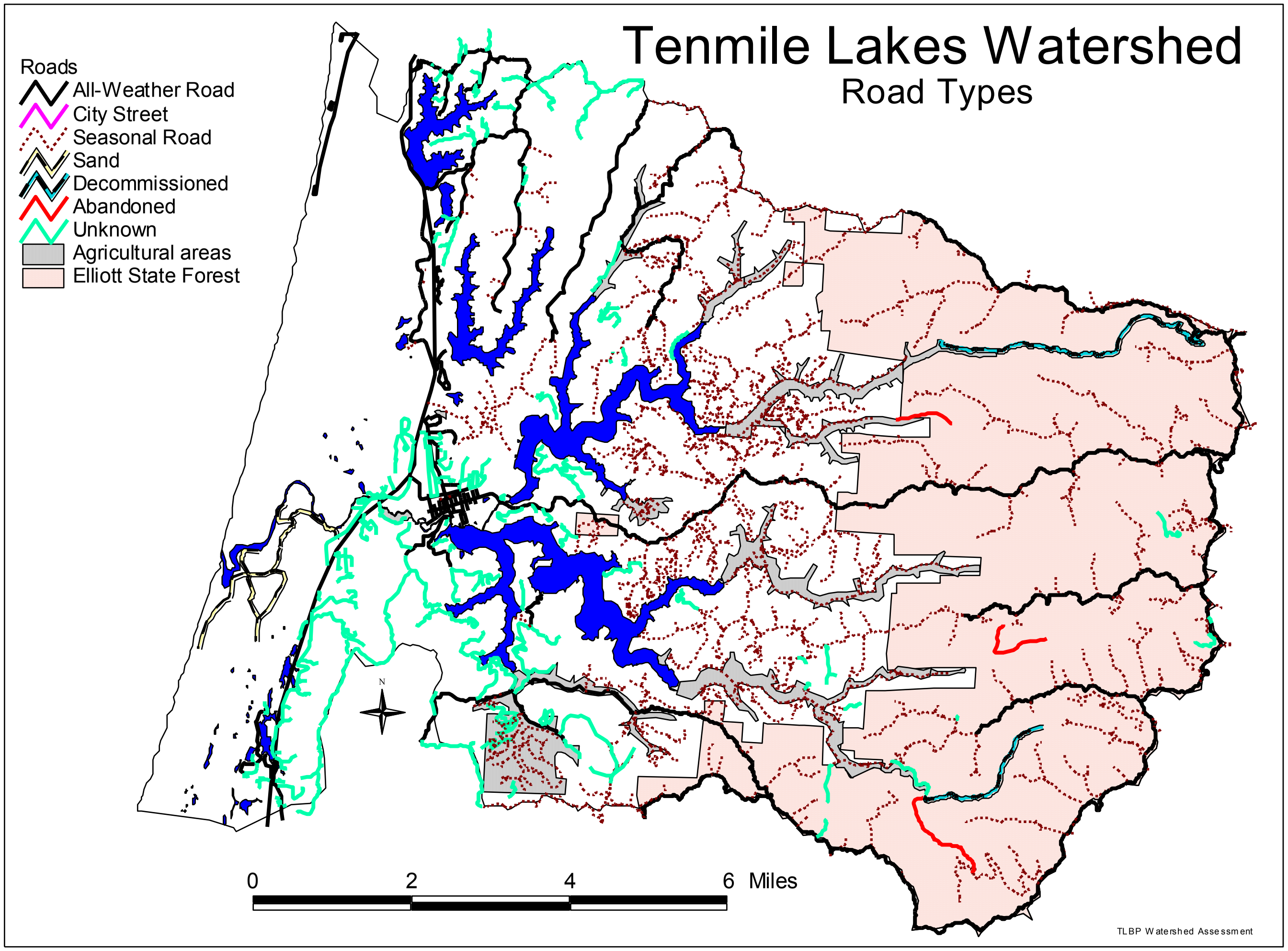
Map 4.6. Debris flow risk. Oregon Department of Forestry. Based on terrain slope.

Roads

Figure 4.9. Road related mass wasting.

When roads are either poorly constructed, poorly maintained, or both, significant amounts of sediment may originate from roadbeds. The material a road is surfaced with, distance from water, the slope of the terrain, and the amount of traffic all figure in how much sediment it will shed.

Map 4.7 shows the distribution and type of roads in the Tenmile watershed. All weather roads have either an asphalt surface, or gravel, like those found in the ESF. Heavily rocked and prepared with ditch relief culverts, roads on the Elliott State Forest are found mostly on ridge tops, are far from waterways, and contribute very little sediment directly to streams. Seasonal roads are roads that are either dirt or lightly rocked. Spur roads on the ESF, most of the private timber operators, agricultural access roads, and private residential access roads are often classified as seasonal roads. Roads classified as unknown are most likely seasonal, but have not been surveyed. Abandoned or decommissioned roads have been either deliberately taken out of service (this is a time consuming and technically involved process), or simply left to the forest to reclaim. A note on road construction; roads cut into hillslopes may be constructed with either a full or partial bench cut, i.e., either the road surface is entirely cut into the hillslope, or half is cut into the hillslope and half is made up of sidecast material from the cut. Full bench cuts are more stable, although when material removed from the road cut is cast downslope rather than removed from the site (end hauling), landslides are more likely to occur due to the extra weight of the spoils. End hauling is very expensive, however, and rarely done.



Map 4.7. Road type and distribution.

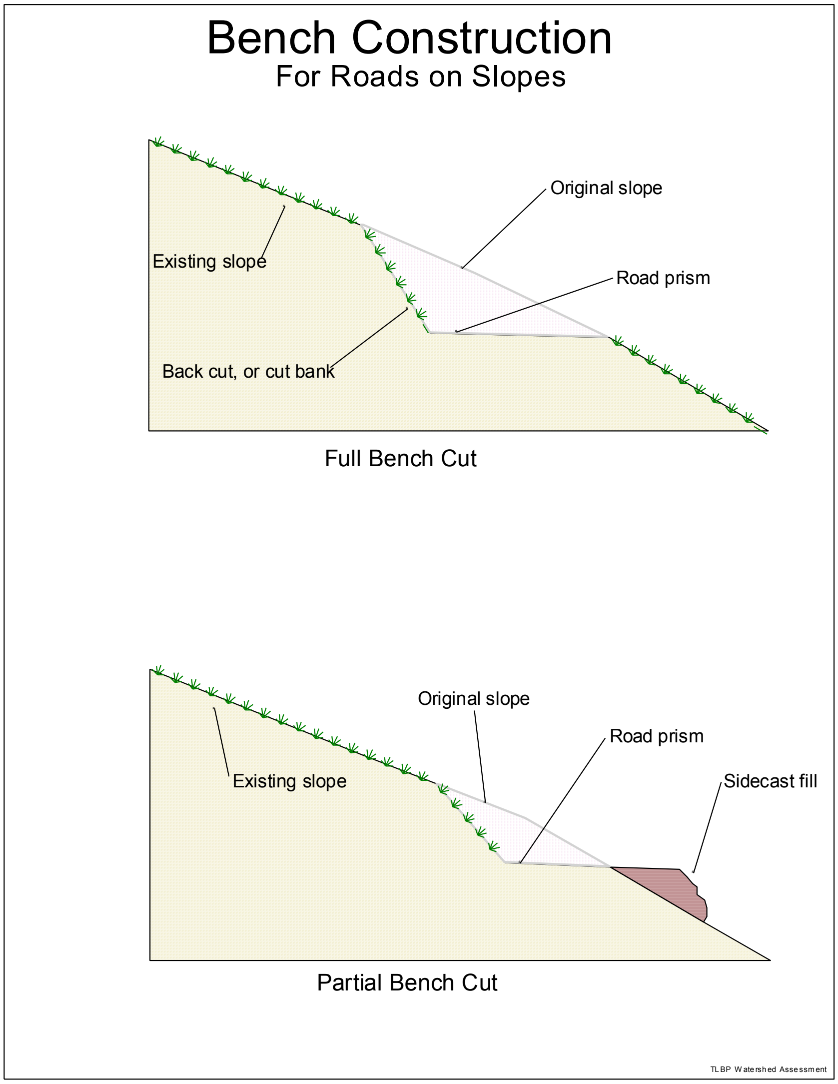


Figure 4.10. Road construction variations.

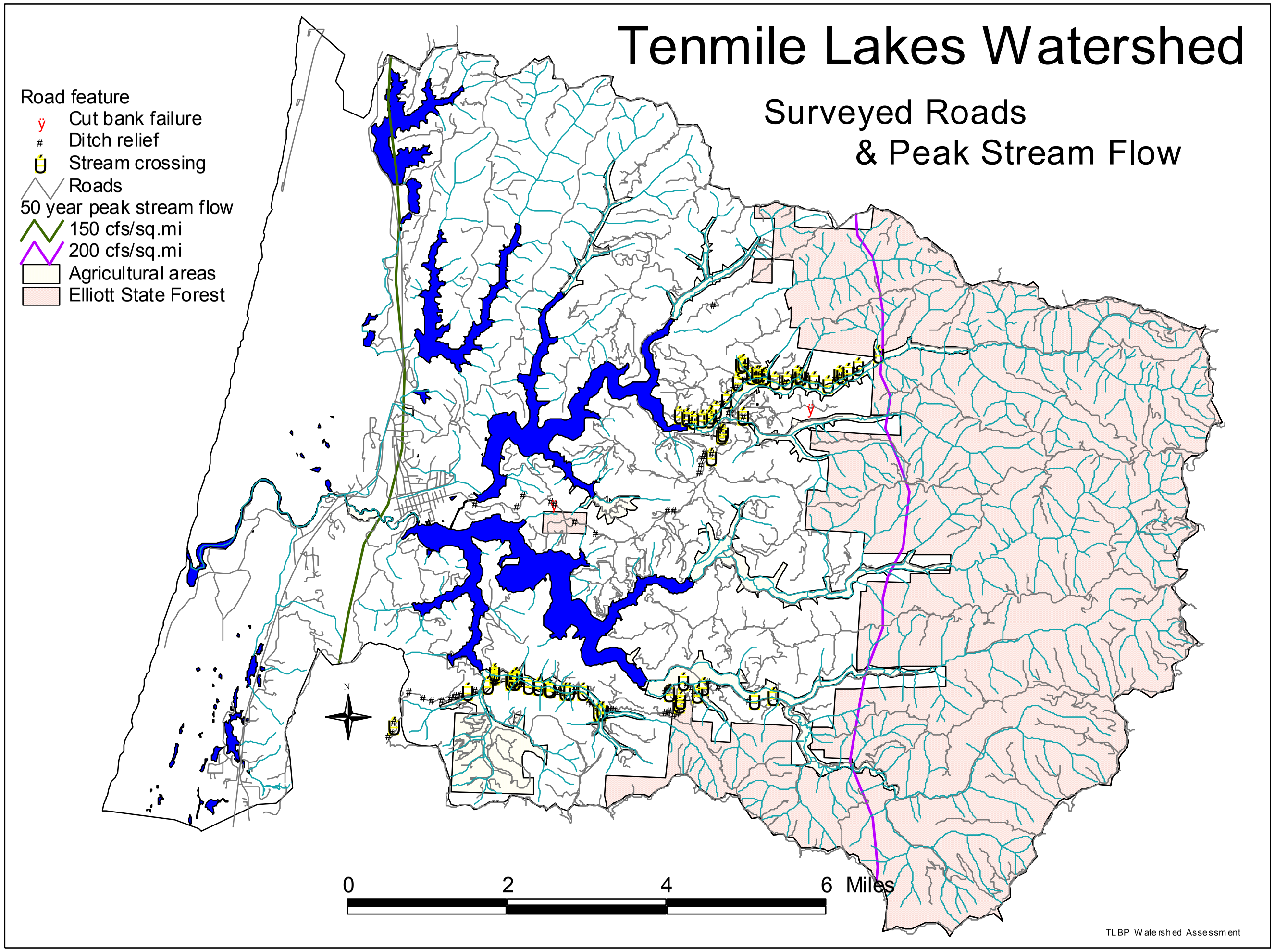
The diagram in Figure 4.10 is misleading in one respect: slope. The down hill side of many roads in the Tenmile watershed are incredibly steep, even vertical at times. The result is sometimes that the road fill gives out and initiates a larger slide below. The picture in figure 4.11 is an example of side cast failure. The softer side cast fill dirt under the road surface is easily undermined when exposed to running water, triggering slides on slopes that might otherwise not have given way.

Figure 4.11. Road related landslide, moving downstream.

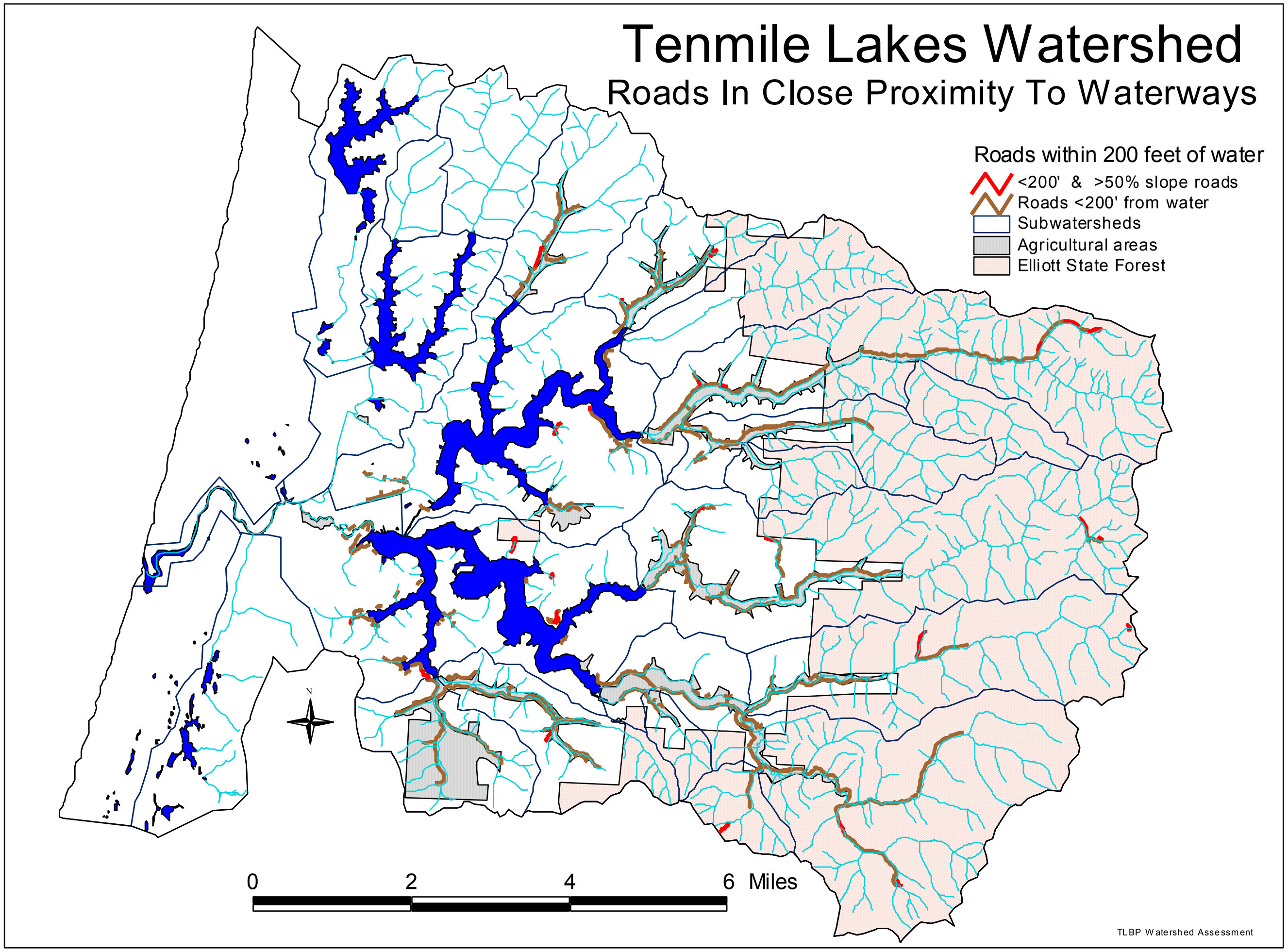
TLBP road surveys have concentrated on several aspects of sediment delivery, including cut bank failures, ditch relief culverts, and stream crossings. Cut bank failures are common, as the back cut of a bench cut road ends up being much steeper than the original slope and the lack of vegetation leaves the soil exposed to the elements. Ditch relief culverts are placed in order to relieve the upslope side of a road of accumulated water. Sometimes water bars accomplish the same goal by redirecting water over the surface of the road rather than under it. When a ditch relief becomes clogged by sediment, the risk of a larger road failure is increased due to the inability of the road to shed water efficiently. Stream crossings have the potential for causing the largest road failures and sediment delivery because of the tendency of culverts to clog and back up large quantities of water. Culverts are one of the prime suspects in fish passage problems, usually because of being undersized and/or poor maintenance. Culverts are, theoretically, sized for extreme storm events. In other words, a culvert should be oversized for forty-nine out of fifty winters. Most of the upland streams of the Tenmile watershed are capable of delivering over 200 cubic feet per second of flow per square mile of drainage area in a fifty year storm event. Many early culverts were undersized for the job.

Other indications of slope failure, such as road slumps, were noted when seen. Map 4.8 shows the locations of surveyed roads and the peak stream flow for fifty year storm events.

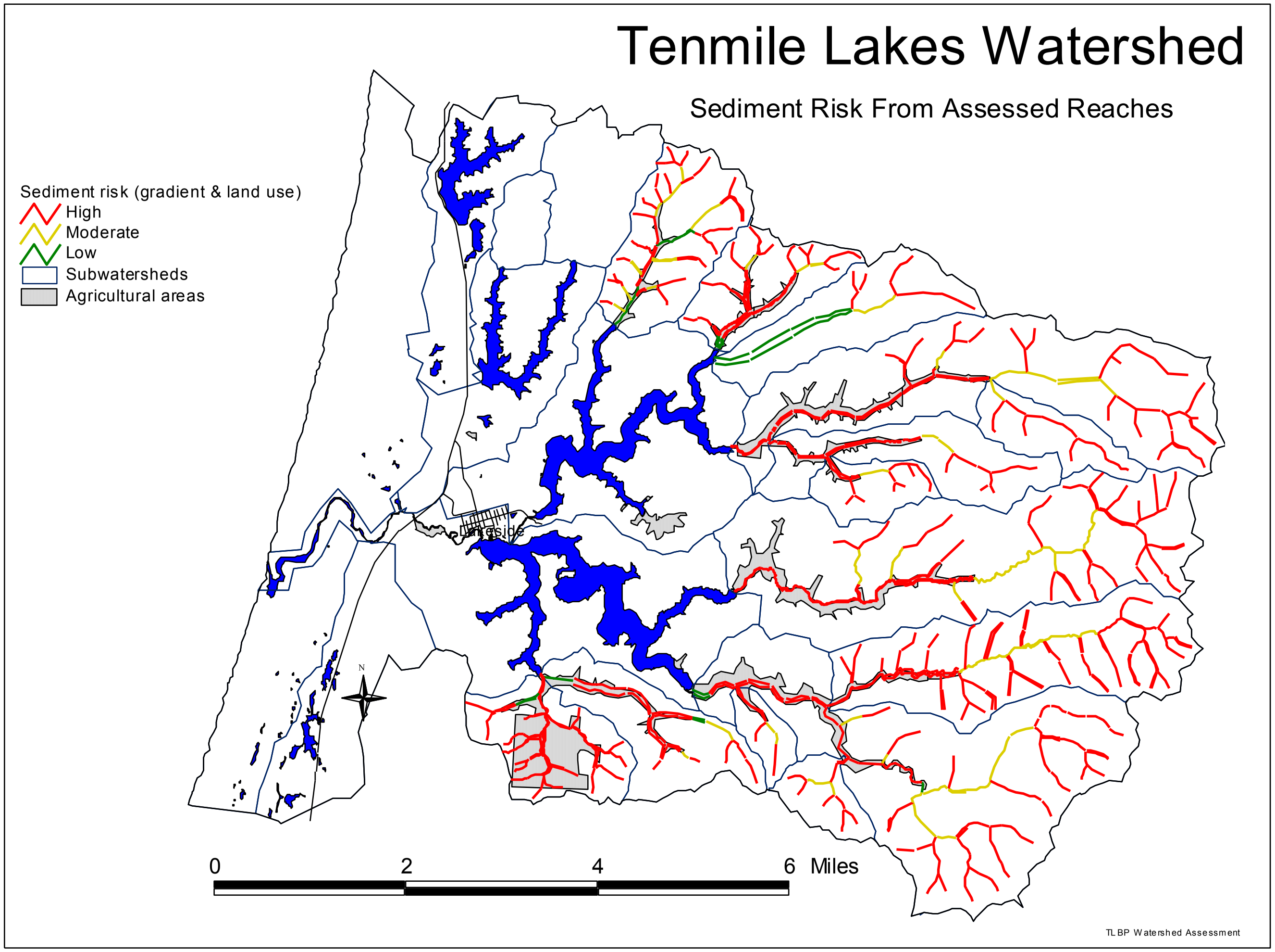
Conditions vary between locations, road types and usage. Abandoned roads and seasonal roads may be chronic sources of overland sediment delivery, while ridge top roads may be enhancing the occurrence of debris flows by channeling water flow into concentrated areas. More study is necessary, however, before assigning too much blame to roads for landslides and sediment delivery.



Map 4.8. Surveyed roads and 50 year peak stream flow boundaries.



Map 4.9. Roads near water.



Map 4.10. Sedimentation risk based on gradient and land use.

Chapter 5

Hydrology & Water Use

Hydrology

The Tenmile Lakes watershed receives approximately six to seven feet of precipitation over the course of a year, the vast majority as rain. For a 62,777 acre watershed, that's about 123 billion gallons[xxviii] of water a year that has to go somewhere after it has fallen to the ground. There is little upland storage of water during the winter, unlike the Cascade Range where the snowpack is an important reservoir of water for the summer months. This means that when rain falls here, there is a fast response by the streams and lakes to the incoming moisture. Think of the difference between a watershed made of solid granite with no vegetation versus a watershed where the ground acted like a sponge. The former would lose its water very quickly, the second as would have water long after the rain had stopped. The Tenmile watershed is closer to the first example, with the obvious exception of the lakes. Instead of snowpack, lakes in the watershed serve as storage areas for water. Eel and Clear Lakes act as reservoirs for the municipal water systems of both Lakeside and Reedsport, but the largest lakes, North and South Tenmile, are used as a domestic water supply only by lakefront residents without access to city water. Together, at average surface levels, North and South Tenmile Lakes hold about 12% of the yearly rainfall.

North and South Tenmile Lakes cover about 2000 acres, with South Tenmile Lake the larger of the two at 1190 acres.[7] The surface elevation of Tenmile Lake fluctuates seasonally, from a high of close to twenty feet mean sea level (MSL) to a low of about six feet MSL.[8] The average lake surface elevation has been considered to be nine feet (MSL), which is the surface elevation shown on the USGS Lakeside 7.5 minute series topographic map. Interestingly, the Trail Butte quad map was drawn at a higher lake level, showing the North Tenmile Lake at 13' MSL. Both North and South Tenmile Lakes are shallow, with mean depths of 14.75' and 16.33' MSL respectively. Interestingly, Eel Lake, which covers about 650 acres, is more than twice as deep as the Tenmile Lakes.[9] If the ratio for mean depth is approximately the same, then Eel Lake has

[7] There have been many estimates of lake surface area, this is based on a hand digitized polygon over a digital orthoquad photograph in ArcView GIS.
[8] Tenmile Lakes Limnological Survey. Systma.1995.
[9] Eel Lake's deepest spot is 19.8m, Tenmile Lake's is 8.2m. Tenmile Lakes Nutrient Study. Eilers. 2002. Pg 114.

approximately the same volume of water as North Tenmile Lake, despite having only 42% of the surface area of N. Lake.

Both Tenmile Lakes are dendritic, i.e., they have convoluted shorelines that deviate significantly from a perfectly round shape. The shape factor of N. Tenmile Lake is 5.1, and S. Tenmile has a factor of 4.9. The higher the shape factor, the more convoluted the shoreline.[10] In addition to making for a much longer shoreline, the numerous arms, embayments, and coves make for an array of microclimates in the lakes. During the summer it is common to have one arm of the lake clogged with aquatic plants while another arm is relatively free of plant growth.

Water spends less time in the watershed than in the past due to changes in the landscape since settlers arrived in the mid to late 1800's. Channelization in the lowlands made it possible to farm in the narrow valleys which had formerly been wetlands. In his discussion on nutrient sources, J. Eilers illustrates the point:

[10] S. Tenmile Lake, if perfectly round, for example, would have a shoreline of 25,522 feet. The actual shoreline of the lake is 123,708 feet. 123708/25522 = 4.9.

"The recovery of Tenmile Lake is linked not only to reduction of nutrient sources, such as septic tank loads, but also requires a restoration of more natural hydrologic flow paths. The generation of nutrients in the watershed is only harmful to the lake if the hydrologic flow paths exist to transport the sediment and nutrients. The development of agriculture in the Tenmile Lake watershed was made possible by channelization of virtually all major lowland valleys. Unlike many applications elsewhere, the channelization of this watershed was conducted by channelizing both sides of a valley. The result was a very efficient means of transporting runoff to allow the central portion of the valleys to remain as pasture. An illustration of the consequence of channelization in the watershed on stream morphometry is provided in Figure 70. Murphy Creek has a small channel that is easily exceeded during high precipitation events. As a consequence, much of the high flows are distributed across a large wetland at very low velocity. In contrast, flows in Benson Creek (and also Big and Johnson) are distributed in an enlarged channel designed to carry much greater stream discharge prior to exceeding capacity (Figure 70). Benson Creek at this location carries nearly three times the discharge of Murphy Creek on a unit-area basis.

The stream geometry of these streams at these sites is very different. Benson Creek has a width:depth (w:d.) ratio of about 2.5 compared to a value of about 1.2 for Murphy Creek. However, when the bank full capacity of Murphy Creek is exceeded, the w:d ratio greatly increases (≥ 300), which results in a huge increase in the wetted perimeter, a large increase in channel resistence, and very low effective stream velocities.

The higher discharges in the channelized streams such as Benson Creek lead to greater stream velocities because of shortening of stream lengths and the positive relationship between discharge and stream velocity for a given slope. The increase in the proportion of flow in the confined channels increases the stream power - hence its ability to do work. The greater stream power is indicated by the erosive capacity of a stream or its ability to transport an already entrained sediment load. This concept is illustrated in Figure 71, which shows that for a given particle size found in silt loam soils typical of some soils in the Tenmile watershed, the flows in the channel of Benson Creek (A) are actively eroding soils, whereas velocities in the overbank area of Murphy Creek (B) are only capable of transporting the small size material."[11]

[11] Tenmile Lakes Nutrient Study - Phase II Report November, 2002 Page 129. See the next page for the referenced figures.

In other words, water exits the watershed faster and moves more sediment than in the past. This affects groundwater recharge, above ground storage of water, and ultimately, through eutrophication and lake succession, the storage of water in the lakes.

There are no major dams in the watershed, although both Clear and Eel Lakes have small dams designed to maintain water levels. An interbasin water transfer occurs via the City of Reedsport's use of Clear Lake as a water supply. The Reedsport plant removes an average of 2100 gallons a minute(about 1.1 billion gallons a year) throughout the year.

There is a move afoot to exercise a water permit of 23.2 cfs to Tenmile Creek by the Coos Bay/North Bend Water Board, although there are still unresolved legal issues.[12]

The Coos Bay/North Bend Water Board also has a serried line of permits in the dunes beginning just south of Tenmile Creek extending beyond the southern boundary of the watershed. Those permits within the watershed boundary are not yet in use, but may be utilized at some point in the future depending on population growth and increased water need.

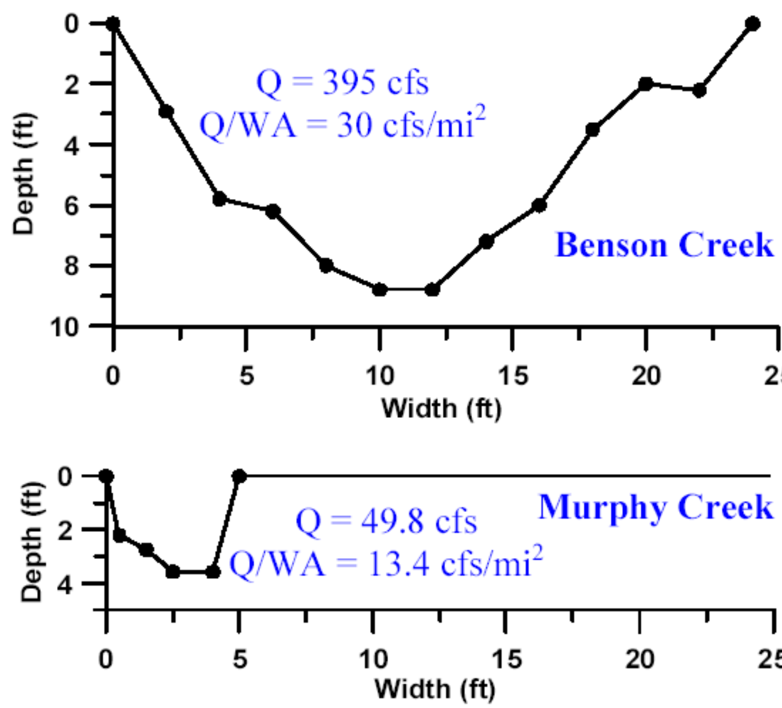


Figure 5.1. Stream channel cross sections for Benson Creek (top) and Murphy Creek (bottom) at the water quality monitoring sites. The stream discharge (Q, cfs) and discharge normalized per unit area (Q/WA, cfs/mi2) is shown for both sites at bank-full flows.[13]

[12] Permit # 53710. Located just east of Spinreel Park, T23S, R13W, SW¼ SW¼ .

[13] Tenmile Lakes Nutrient Study - Phase II Report November, 2002. Pg 131.

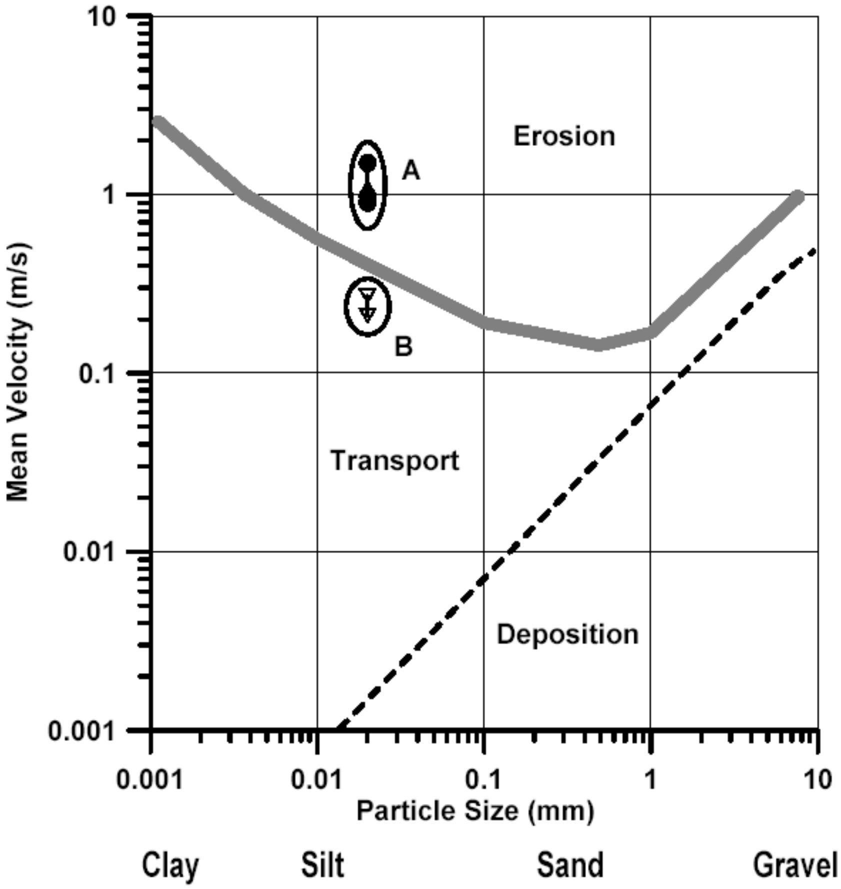


Figure 5.2. A Hulstrom plot showing the relationship to particle size transport as a function of stream velocity. The stream velocities measured during a storm event in the channel of Murphy Creek (A) are contrasted with the measured velocity in the over-bank region (B).[14]

[14] Tenmile Lakes Nutrient Study - Phase II Report November, 2002. Pg 132.

Critical questions:

What land uses are present in the Tenmile Lakes watershed?

Urban: About two percent of the watershed. Lakeside is a small city with only about half of its streets paved. The main assumption is that paved areas are "impervious" to water infiltration, so the more paved land the less groundwater recharge, and the higher the peak flows.

Agricultural: About 2650 acres, or about four percent of the watershed. Most of the agriculture in the Tenmile Watershed is geared towards hay and rangeland and is not irrigated.

Timber management: About 36,000 acres as industrial management (57%), and another 5000+ acres of either small woodlots or unknown forested lands(8%).

Urban area in the watershed is considered low risk for enhancing peak flows. As a small city situated near the outlet of Tenmile Lake, Lakeside's pavement has virtually no effect on peak flows.

Agriculture is at low risk for enhancing peak flows. The screening process looks for areas that used to be high infiltration soils that are now altered to allow more runoff of rain. Hayfields and rangeland are not regarded as heavy agricultural usage.

Forestry is at low risk for enhancing peak flows. Rain on snow events (ROSE's) are the main concern as a peak flow enhancer. The coast range does not accumulate enough snow to produce ROSE's of any significance. The Cascades typically experience this phenomenon either in the fall or spring.

What is the flood history of the Tenmile Lakes watershed?

Periodically, conditions conspire to cause flooding in the Tenmile watershed. Heavy rain over several days when the ground is already saturated will very quickly flood low lying agricultural areas adjacent to the lakes. This is, however, a common occurrence during Winter. Major floods, above a lake level of about eighteen feet when a significant portion of the City of Lakeside would be under water, are rare. Map 5.1 shows the flood prone areas in Lakeside.

Lakeside has rarely been mentioned in accounts of flooding damage on the south coast of Oregon. A search of primary sources[15] of flooding accounts for the 1955 and 1964 floods yielded not a single mention of Lakeside or the Tenmile watershed. Reedsport, to the north, has suffered repeatedly due to its proximity to the confluence of the Umpqua and Smith Rivers and Schofield Creek. The cities of Coos Bay and North Bend have, for the most part, been witness to flood damage in surrounding areas while being spared inundation due to their relatively high elevations. Coquille and Myrtle Point, and the coastal cities of Gold Beach and Brookings are situated on large rivers subject to flooding. A history of flooding in the Tenmile Basin does not exist in a single source, but it is reasonable to interpolate based on coast wide events.

[15] The World and Coos Bay Times newspapers.

Dan Carpenter, a hydrologist at the Bureau of Land Management in North Bend, constructed a flood history for a watershed assessment of the East Fork Coquille River from historical records and modeling based on eighty years of gauge history.

"During November of 1861, there was a significant rain-on-snow event accompanied by strong, warm, southerly winds in southwest Oregon (Wooldridge 1971).

In February of 1890, an intense and prolonged rain and major flood occurred in southwest Oregon. There are various observations of this event on area coastal streams in the historic literature. The flood magnitude and return interval is unknown. Much slide activity was reported.

On November 1, 1924, an estimated peak discharge of approximately 22,400 cfs occurred in the East Fork Coquille watershed. The return period probability for this flood, based on the record is near 14 years.

On December 26, 1955, there was an estimated instantaneous discharge of approximately 20,500 cfs in the East Fork Coquille watershed. The return period probability for this flood, based on the record is near 9 years. However, a six-day period from December 21-26 had similar high flow.

On December 22, 1964, a maximum discharge of 38,800 cfs is estimated for the East Fork Coquille watershed. The return period probability for this flood, based on the record is in excess of 100 years. This equals 289 cfs/mi2, which is close to three times higher than the maximum equivalent area runoff for coastal watersheds to the north, but similar to coastal watersheds arising in the Siskiyous to the south. This was a rain-on-snow event.

On January 17, 1971, there was an estimated instantaneous discharge of approximately 22,800 cfs in the East Fork Coquille watershed. The return period probability for this flood, based on the record is near 15 years.

On January 15, 1974, there was an estimated instantaneous discharge of approximately 24,400 cfs in the East Fork Coquille watershed. The return period probability for this flood, based on the record is near 21 years.

On November 18, 1996, there was an estimated instantaneous discharge of approximately 30,500 cfs in the East Fork Coquille watershed. The return period probability for this flood, based on the record is near 70 years."[16]

[16] East Fork Coquille Watershed Analysis, May 2002. Appendix C, Flood History.

These events were widespread on the southwest coast of Oregon, with local topography and proximity to rivers determining the perceived severity of the floods.

In 1953, there was an estimated lake level of 19.87ft MSL[17], the highest level on record. Subsequent high water events came in 1964, 1970, 1986, 1995 and 1996. There has been some discussion regarding the importance of tides in influencing floods in the watershed. Figures 5.3 and 5.4 show two high water events with different outcomes.

The Christmas flood of 1955 was preceded by a four day rainfall of 7.13[18] inches, which wreaked havoc from the Umpqua River to the Rogue River, and had an unknown effect on Lakeside.

The pre-Christmas flood of December 1964 is considered to be the largest known flood on the southwest coast of Oregon, but was a rain on snow event combined with high tides (the Tenmile watershed receives far less snow than the Coquille watershed). This quote, from the December 23rd, 1964, World newspaper, sums up Reedsport's unfortunate flood history, "Several buildings were also seen floating down the Umpqua today." From the same page, the Rogue River was said to have been, "…one foot to 1 ½ feet above the level of the 1955 flood." Again, no mention of trouble in Lakeside.

The November 1996 storm dropped over eleven inches of rain in five days, but most damage in the watershed was in the uplands in the form of landslides.

Recently, in mid-December of 2002, five inches of rain in twenty four hours on top of several days of less intense rain led to scores of slides in the uplands and a lake level of approximately 17.5 feet.

Sadly, the USGS gauge operated only from late 1957 to early 1976, catching only two extreme events (1964, 1970). The 1970 high flow event recorded 3230 cfs, the highest reading in the twenty year life of the gauge. Interestingly, rainfall averaged an inch a day for nineteen days prior to the high reading. This was not considered a major flood for the surrounding areas, but the fact the lakes serve as de facto reservoirs may influence flood response.

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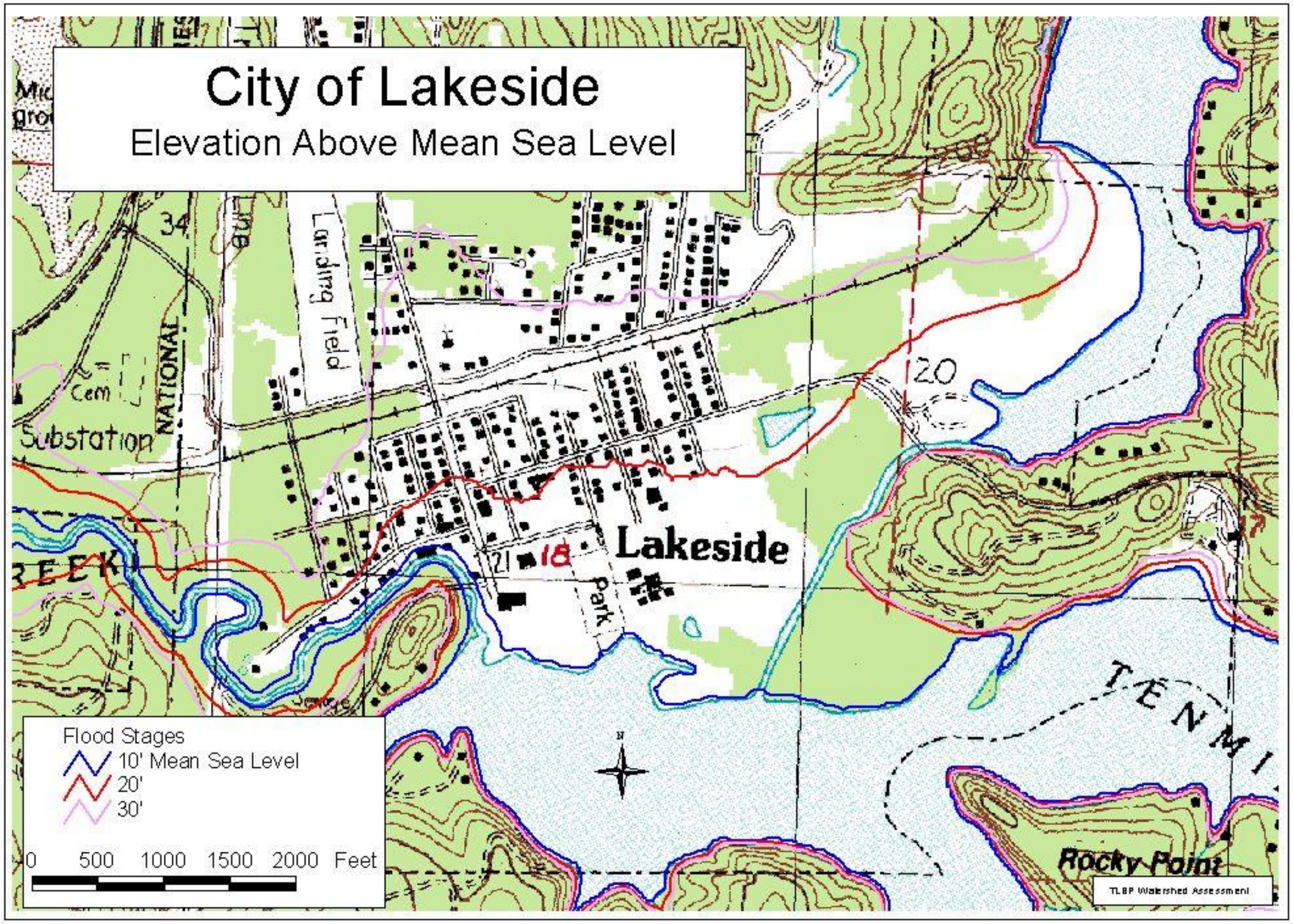
[17] USGS, from Tenmile Lakes Limnological Survey. Pg 1.

[18] Coos Bay Times, for the week of 12/19/55.



Map 5.1. Areas prone to flooding in the vicinity of the City of Lakeside.

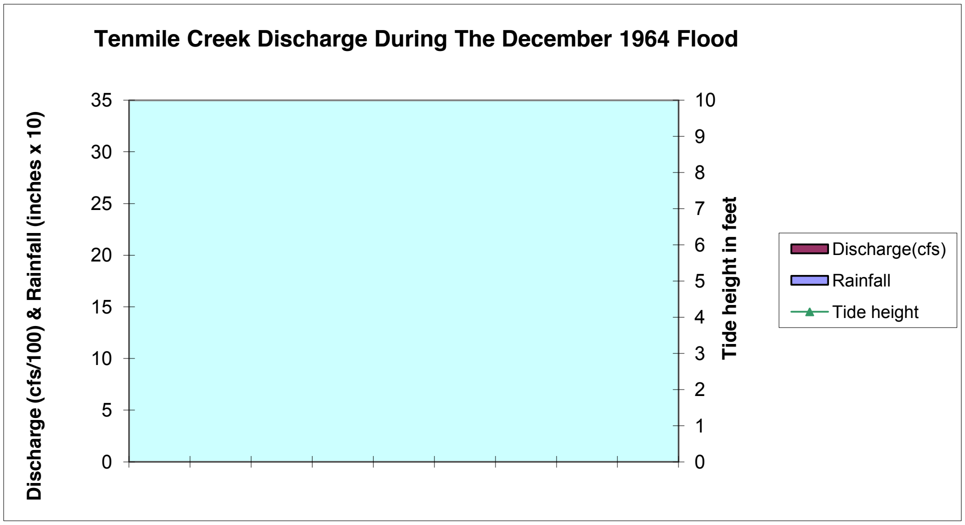


Figure 5.3. Tides, rainfall, and Tenmile Creek discharge in cubic feet per second. Divide rainfall by 10 to get true accumulation in inches.

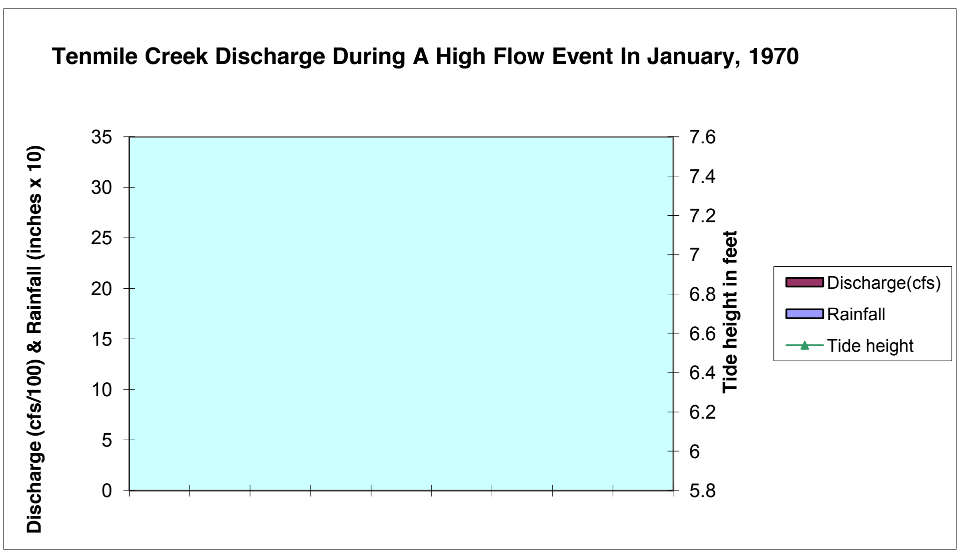


Figure 5.4. Tides, rainfall, and Tenmile Creek discharge. Divide rainfall by 10 to get true accumulation in inches.

Water Use

While peak flows are a concern for some, low flows are probably given more thought in the Tenmile Watershed. Ultimately, the most important question regarding water is, "will it be there when it is needed?" Salmon need clean cool water. Ranchers need sufficient water to grow hay and keep their livestock happy during the summer. Plants need water to survive. And residents of the watershed need water for domestic purposes. Most of the six feet of rain that falls in the course of a year (86%) comes between October and the end of April. That leaves the rest of the year with not much rain. August and September, which account for five percent of the yearly total of rain, present fish, livestock, and homeowners with the same problem: Not enough water when it's really needed. Under current water law, water rights are assigned priority based on seniority. Junior rights are always shut off prior to senior rights. As with most of the rest of Oregon, water rights in the Tenmile Lakes watershed are over allocated.

Critical questions

What are the beneficial uses of water in the Tenmile Watershed?

- Domestic water use
- Recreation: Fishing, boating, swimming.
- Fish habitat
- Agricultural use. Mostly for watering livestock.

Water rights

Water use is governed by the Water Code, which revolves around water permits and rights. Water permits and rights are granted by the Oregon Water Resources Department (WRD), and follow a gradient of seniority from senior to junior. Water laws in Oregon adhere to the principle of "prior appropriation." In other words, when water supplies dwindle, the oldest water right is the last to be turned off. When the senior right exceeds the amount of water in the stream, it is legal to remove whatever water remains for irrigation, cattle watering, or domestic use.

Water permits and rights are, except in the case of municipalities, perishable. If a right goes unused for five consecutive years, it is technically legally forfeited, and may be cancelled by the WRD. Water rights, but not permits, are attached to the land where they were established. When a property is sold, the water right goes with it.

Uses that are exempt from permitting requirements are, for surface water, stock watering, fire control, forest management, and rainwater collection. For groundwater, no permit is required for stock watering, lawn and garden watering of less than half an acre, and domestic water uses not exceeding 15,000 gallons a day.[19]

The State of Oregon holds water rights for fish habitat to ensure minimal flows for aquatic life. Even these rights are subject to prior appropriation, however.

[19] Water Resources Department Infosheet Number 2, June 1998. Verbally re-confirmed by watermaster's office March '03.

The following set of tables summarizes the state of water availability in the Tenmile watershed. Table 5.1 is essentially the average amount of natural stream flow minus the existing water rights, all in cubic feet per second. 50% exceedance level refers the probability that the stream will be running higher or lower than normal. A wet year for example might be considered a 25% exceedance, when a dry year would be a 95% exceedance (95% of the time the stream will be carrying more water than at present). The obvious point to be drawn from table 1 is that far more water has been allocated than can be taken out of the system. Whether water use is close to what has been allocated is not known, but short of installing water meters on every pump there is no practical method of ascertaining true water use. In September, usually the driest month of the year in the streambed, less water has been allocated because there is less water available. A deficit of 5.3 cfs in September would not appear to be as bad as a deficit of 38.9 cfs in January, until we look at stream flow. The lowest fifty flows for a twenty year record of readings were all in late August and September. Numerous 2.5 cfs flows have been measured during these low flows, but there are accounts of Tenmile Creek experiencing either no flow, or backwards flow. This may have been due to flow coming in from Eel Creek, which is just downstream of where the USGS gauge was placed. The highest flow on record is 3230 cfs on January 17th, 1970 (this would be the 0% exceedance level for the period during which the gauge operated).

Table 5.1. Water availability in cubic feet per second at the 50% exceedance streamflow.

Water Availability Basins	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tenmile	-38.9	-38.9	-38.9	-38.9	-38.9	-39.4	-18	-7.3	-5.3	-6.28	-38.9	-38.9

Table 5.2 shows the percentage of stream flow diverted as consumptive use. Consumptive use is use that is considered to be more or less lost to the original source. Generally, anything over 10% consumptive use is a red flag for aquatic habitat purposes.

Table 5.2. Consumptive Use as a Percentage of 50% Exceedance Streamflow.

Water Availability Basins	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tenmile	6.43	6.12	8.38	11.79	22.62	47.07	48.52	39.67	38.41	32.54	23.72	7.33

Table 5.3 is a summary of available water by month, along with average stream flows for each month.

Table 5.3. Water availability at an exceedance level of 50%.

Month	Natural stream flow	CU + Storage Prior to 1/1/1993	Net Min. flow prior to 1/1/93	CU + Storage after 1/1/1993	Net Min. flow now	Instream water rights	Net water available
Jan	605	0	605	38.9	566.1	605	-38.9
Feb	636	0	636	38.9	597.1	636	-38.9
Mar	464	0	464	38.9	425.1	464	-38.9
Apr	330	0	330	38.9	291.1	330	-38.9
May	172	0	172	38.9	133.1	172	-38.9
Jun	83.7	0.5	83.2	38.9	44.3	83.7	-39.4
Jul	37.1	0.6	36.5	17.4	19.1	37.1	-18
Aug	18.4	0.5	17.9	6.8	11.1	18.4	-7.3
Sep	13.8	0.3	13.5	5	8.5	13.8	-5.3
Oct	19.3	0.2	19.1	6.08	13.02	19.3	-6.28
Nov	164	0	164	38.9	125.1	164	-38.9
Dec	531	0	531	38.9	492.1	531	-38.9

The break on 1/1/93 is related to a hold over of water for "human consumption," for residents of the lakes without access to municipal water. Water use for human consumption does not mean domestic use (house plus irrigation for ½ acre and lawn, or 15,000 gallons a day), but a much smaller amount deemed necessary in order to be able to live in a home. This water is still available to permit seekers as of March, 2003, but is slated to disappear soon.[20]

Domestic use

Water used for domestic purposes in the Tenmile Watershed comes from two sources. Municipal water is drawn from Eel Lake, treated, and distributed via city water mains. Rural areas use either well water, springs, or water drawn directly from a lake. Technically, a well is a point of appropriation, while a point of diversion refers to where surface water, a lake or stream, is being redirected. Estimates vary by agency, but up to half of all surface diversions present in the watershed are not associated with a permit.

The primary concern stakeholders have about domestic water use is water quality. A summary of issues is presented here, although a more detailed discussion on water quality can be found in the Water Quality component.

Water is an excellent solvent, which means that virtually any substance will dissolve in water to a certain extent. Problems arise when toxic substances or organisms are present in water in concentrations sufficient to injure human health. Disease causing organisms, such as certain bacteria, viruses, and protozoans may occur in water sources either chronically or acutely, but are normally easy to remove by filtration or kill with various water treatment methods. Biotoxins, substances that are

[20] Watermaster, Lloyd VanGordon, personal communication.

produced by living organisms, are one class of toxin. Heavy metals, pesticides, herbicides, petroleum byproducts, and other synthetic compounds produced by humans and introduced into the environment either by plan or by accident are another. One problem with some water treatment methods is the unintended production of volatile organic compounds (VOCs). Trihalomethanes (THMs) are a class of VOCs that are created when organic material present in source water is exposed to chlorine. While THMs are regulated by the federal government and are not present in large quantities in Lakeside's water, they do make it possible, in a crude way, to gauge the amount of organic material in the lakes. Each year, water districts send out water quality reports that detail the chemistry of tap water. Table 5.4 shows the varying amounts of THMs from three different districts.

Table 5.4. Trihalomethanes in municipal water.

Water District	Source	THMs
Lakeside	Eel Lake	24 ppb
Reedsport	Clear Lake	4 ppb
Coos Bay	Pony Creek res.	28 ppb

Each district has a different method of treating water, which affects the quantities of THMs produced. Lakeside treats with chlorine gas, Reedsport with a combination of ozone and liquid chlorine (for residual disinfection in mains), and Coos Bay/North Bend with chloramine. Chloramine is a combination of chlorine and ammonia that is not as reactive as pure chlorine and shouldn't produce, given the same amount of organic material present, as many THMs. This is not a scientific comparison by any means, but it's notable that Clear Lake is the deepest, most remote water source of the three and it has the lowest THM concentration.

The overall quality of drinking water in our area is excellent, as the Lakeside Water District points out, "Two of the last five years, we have been awarded 'The Best Tasting Surface Water in Oregon' award." By way of comparison, the City of San Francisco, California, had an average THM concentration of 82ppb in 2002.[21] The federal standard is 80ppb.

Recreational use

Recreational use is considered a beneficial use of water, and is therefore recognized under the law and given certain protections. Generally, however, recreational use of the Tenmile Lakes is not dependent on minimum flows and is more appropriately discussed in the Water Quality section.

Fish habitat

In 1987, the Instream Water Rights Act (IWRA)(ORS 537.348) recognized instream flows as a beneficial use of water. Prior to the IWRA, any water left in a

[21] San Francisco Water Quality Report, 2002. http://sfwater.org/detail.cfm/MSC_ID/51/MTO_ID/63/MC_ID/10/C_ID/718/holdSession/1

stream was considered to not being put to a beneficial use, and was available for water permit seekers. As a result, state agencies were allowed to apply for instream water rights in order to maintain minimum flows for the benefit of aquatic organisms. In practice, this worked only if no big users of water were on any particular stream, as the state's rights were junior to most rights.

The disincentive to conserve water was addressed with the Conserved Water Program (CWP)(ORS 537.455) in 1987. Before the passage of the CWP, the operating principle of water law was, "use it or lose it." As the Oregon Water Trust explains,

> "The 1987 Oregon legislature amended the state's water laws to provide incentives for the first time for water rights holders to conserve water resources by making more efficient use of water. The Conserved Water Program makes it possible for a water user who voluntarily conserves water to retain control over a portion of the saved water. The water user has several options for reallocation of 75% of the saved water, including using it to irrigate additional lands, leasing or selling the water, or dedicating the water to instream use. In exchange for granting the water user the right to reallocate a portion of the saved water, 25% of the conserved water is allocated under the law to the state as an instream water right. To the extent that OWT contributes resources to a conserved water project, we encourage alternatives that increase instream flow to the extent feasible."[22]

The Oregon Water Trust has adopted a somewhat controversial strategy of buying, leasing, accepting as a donation, or otherwise procuring water rights, preferably senior, in order to convert the rights from consumptive use to instream use. This strategy functions well when there are water rights owners who are willing to part with their rights either temporarily or permanently. An example might be a rancher who plans on staying on his land but no longer expects to use the full allocation of water attached to his land.

Figure 9 shows points of diversion, some of which are active, while others are, for lack of a better description, placeholders. The dense line of dots in the dunes to the south of Tenmile Creek, for example, represents water rights for the Coos Bay/North Bend Water board. Presently there is no water being withdrawn from the area, but the rights remain intact based on perceived future need. Something else worth noting is that illegal uses do not show up on the map. The instream rights shown as purple lines are reach based rights established by the state after the Instream Water Rights Act of 1987. Point based instream rights are depicted by the blue points. Both are meant to provide sufficient flow to maintain healthy aquatic habitat. Figure 10 shows the flow restoration priority for subbasins in the Tenmile watershed. Big Creek and Johnson Creek are classified as highest priority.

In the case of the Tenmile watershed, very little irrigation occurs for farming, and livestock watering is a small fraction of what it was in the glory days of Tenmile Dairy production. Consumptive use is predominantly domestic use, and with continued development of the area the proportion of domestic use to other uses will only grow. Opportunities for flow restoration may lie within other restoration activities such as riparian and habitat complexity enhancement, via increased shade and an increased number of pools.

[22] The Oregon Water Trust. (http://www.owt.org/)

Agricultural use

Irrigation is the big use of water in the West, but very little use of water for growing crops occurs in the Tenmile watershed. Dry grazing is the preferred method for raising livestock in the area.

One benefit to the farmer or rancher deriving from the change in water law in 1987, is that rights may now be leased for instream use as a way to preserve rights without spreading water over fields every five years. Prior law penalized non-use of water rights, threatening to cancel water rights that were not exercised for five consecutive years. Most water right holders do not use the full amount of the right, but the prospect of having the right taken away due to non-use is sufficient cause to deny access to private property for gauging purposes. As a practical matter, water rights are rarely cancelled, as it is nearly impossible to prove non-use for five consecutive years.

Agricultural use of legally controlled water in the Tenmile watershed is not an issue at this time.

Conclusions

Changes in demographics in the area have changed the way water is used, reducing agricultural use and increasing domestic use. All available home sites on the lakes are by no means filled, and new construction occurs at a steady rate, increasing the demand for domestic water.

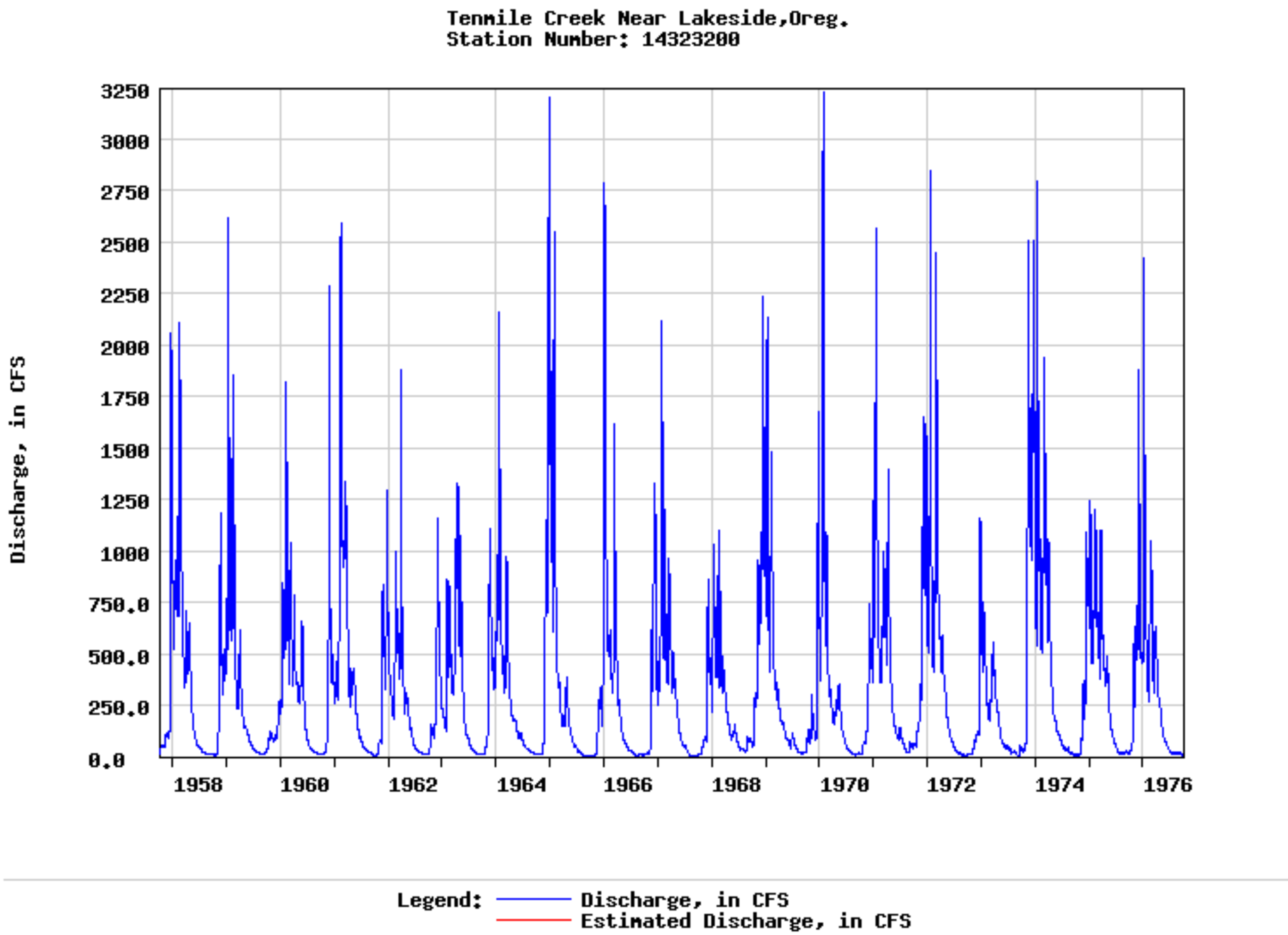


Figure 5.5. Hydrograph for Tenmile Creek.

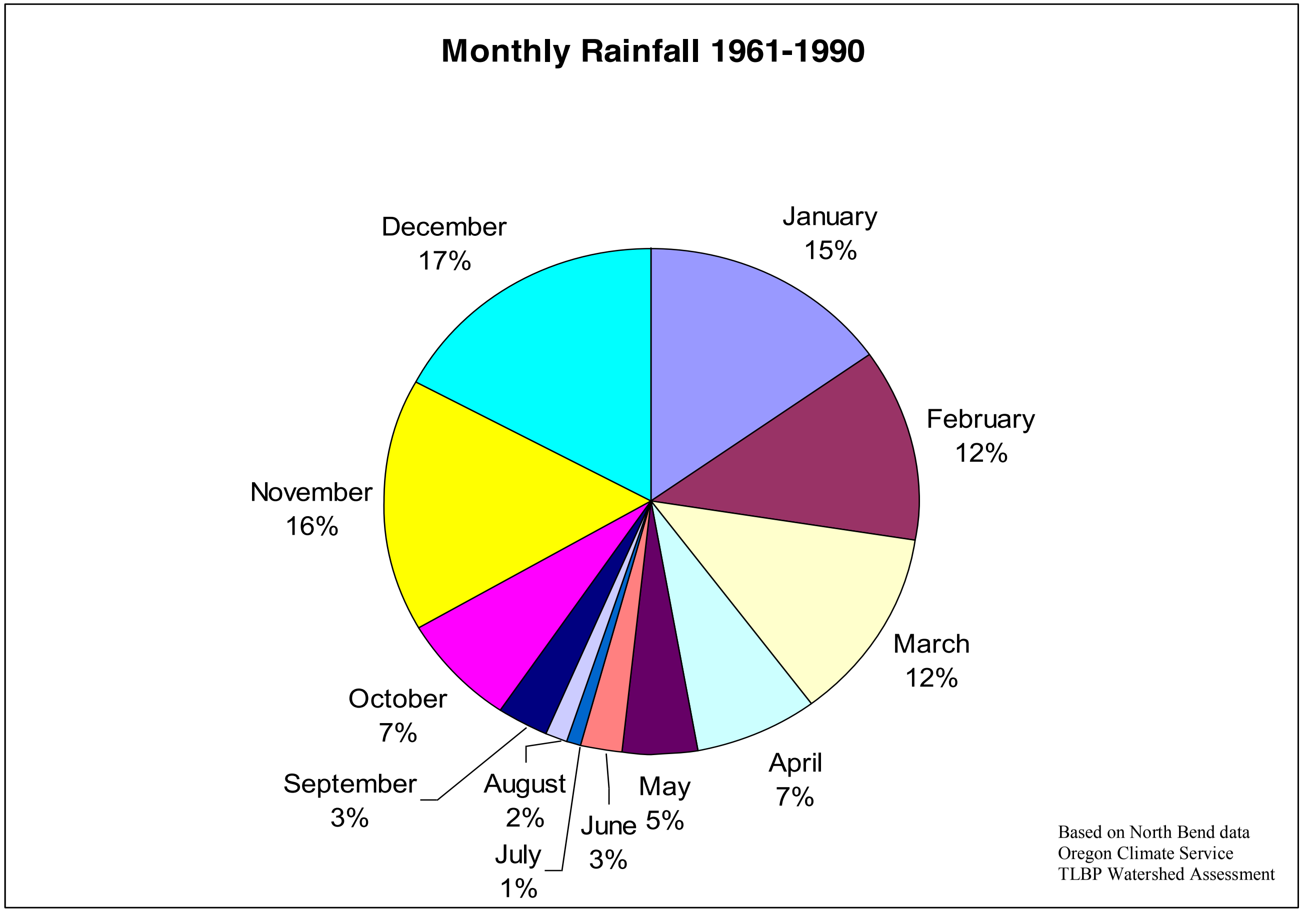
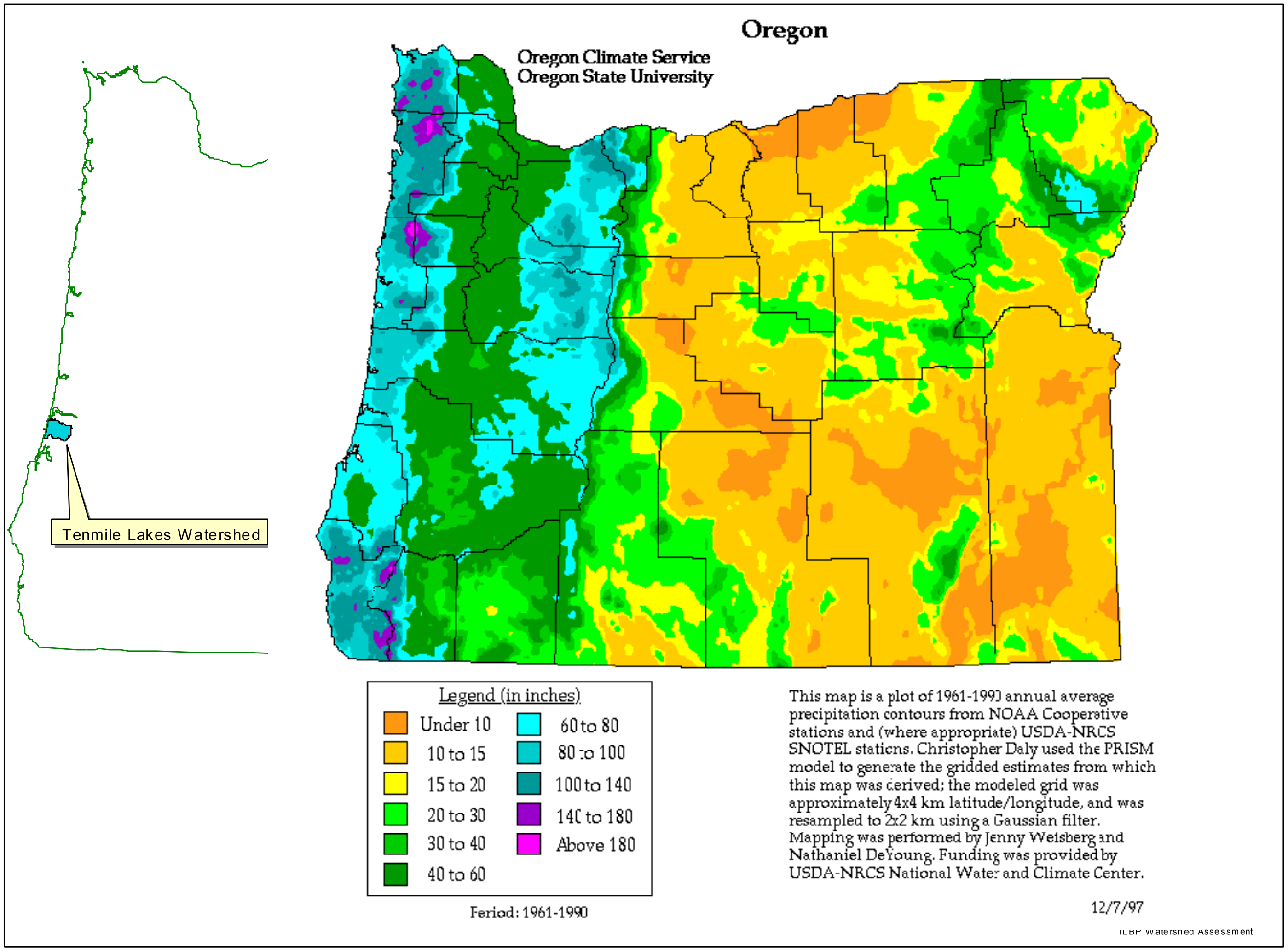
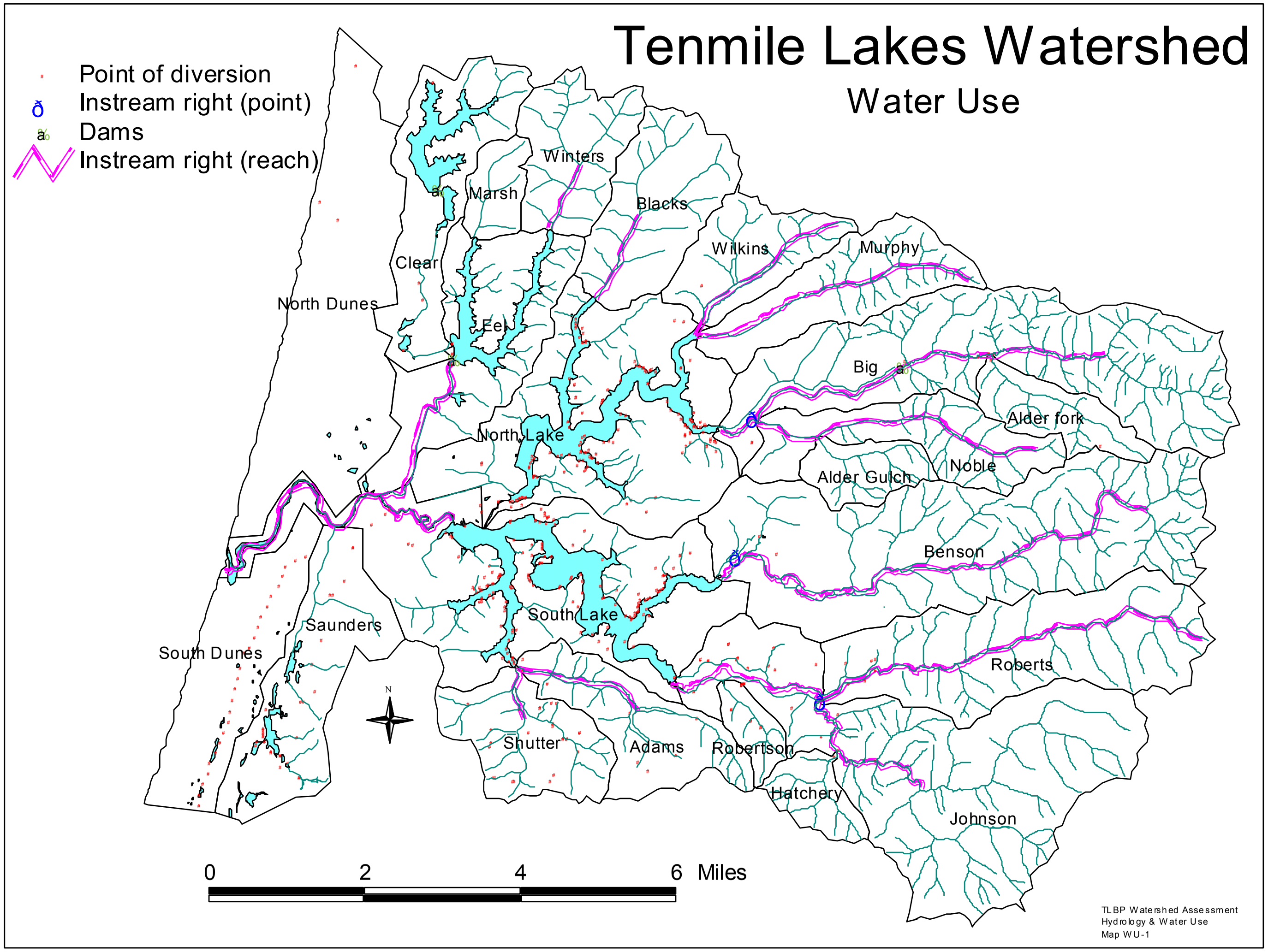


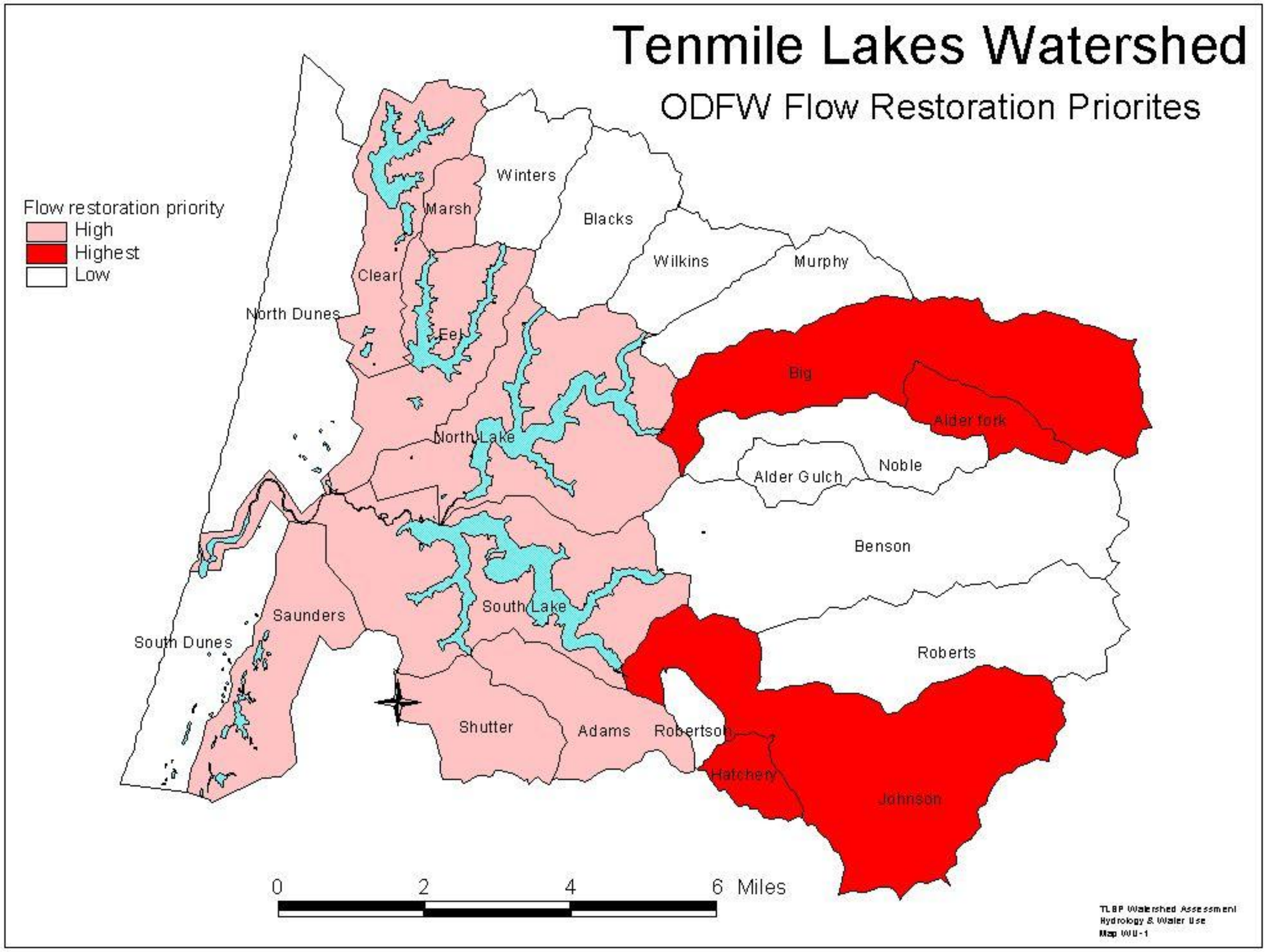
Figure 5.6. Rainfall, by month. Based on North Bend gauge.



Map 5.2. Statewide rainfall.



Map 5.3. Water use.



Map 5.4. Summer flow restoration priorities for anadromous salmonid recovery.

Chapter 6

Water Quality

"When the well's dry, we know the worth of water"
Benjamin Franklin

Introduction

In an effort to pare down what could be a colossal undertaking, the advice of the Oregon Watershed Enhancement Board is to identify which of seven beneficial uses are most relevant to the Tenmile Lakes community. The full list includes aesthetic quality, a scenic lake or roaring river for example; Fishing; Domestic water supply; Resident fish and aquatic life; Salmonid fish rearing(this is what the Tenmile Lakes used to have a tremendous capacity for); Salmonid fish spawning; and Water contact recreation. Of these seven, the following are most relevant to the Tenmile watershed:

- Salmonid spawning and rearing
- Aesthetic quality of the lakes
- Water contact recreation
- Domestic water supply

Each beneficial use, in turn, has an associated suite of water quality issues. Salmonid spawning and rearing, for example, require high dissolved oxygen for gravel bound eggs, low water temperature to reduce thermal stress on young salmon, low turbidity to avoid smothering eggs, and fewer stands of Brazilian elodea for warm water predatory fish to hide in.

Beneficial use	Water temperature	Algal blooms	Nutrients (N & P)	Invasive aquatic plants	Turbidity	Dissolved oxygen
Salmon spawning and rearing	x			x	x	x
Aesthetic quality		x	x	x	x	
Water contact recreation		x		x		
Domestic water supply		x	x	x	x	

Table 6.1. Beneficial uses of water in the Tenmile watershed.

Water Quality Parameters	Historical level	A problem in Tenmile?	Reason for imbalance
Water temperature	Lower	At times	Reduced shade
Dissolved oxygen	Presumably higher than the present	Under low wind, summer conditions	Decomposing organic material
pH	Probably lower	Eel Lake has high readings	Aquatic plant photosynthesis
Nitrogen	Low	Yes	Fertilizers, septic systems
Phosphorus	Low	Yes	Fertilizers, septic systems
Chemical contaminants	Zero	Unknown	Dumping, urban runoff,
Turbidity	Presumably lower than the present	Yes	Sediments, algal blooms.
Biological toxins	Unknown	Yes	Algal blooms,

Table 6.2. Water quality parameters.

Salmon spawning and rearing

Water Temperatures

It is generally believed that salmon are well suited to colder temperatures, and that the warmer the water, the more likely they are to suffer adverse effects. Water temperatures in the 70-80ºF range can bring about the death of salmonids in a matter of hours. Sub-lethal temperatures(mid to upper 60's Fº) cause chronic problems that lead to lowered survival rates rather than killing fish outright. The Oregon Water Quality Standards[23] state that a seven day moving average shall not exceed 64ºF, unless provided for in an approved temperature management plan. 55ºF is the maximum allowable temperature when Salmon are spawning, incubating as eggs, and emerging as fry. For the last several years we have monitored stream temperatures using devices placed directly into the water for several months during the summer and early fall.

Map 6.1 shows the placement of temperature loggers, primarily Vemco minilogs but also several Hobo Stowaways for the sampling season of 2002. We had good results in most sites, but there were several sites that went dry, and one minilog that was either lost or stolen. Low stream flows present a technical difficulty when choosing sites for temperature loggers. Ideally, a logger would be placed in a fast moving stream segment in order to take advantage of the mixing action. A pool, for example, may have flow for most of the year, but the difference between the temperature at the top of the pool and at the bottom can be significant. When at all possible, we placed loggers in areas where temperature stratification was at a minimum. Where experience told us the stream would go dry, we elected to place loggers in the thalweg of pools we hoped would survive the summer. Figure 6.1 shows what the Oregon Department of Environmental Quality considers proper logger placement. The

[23] OAR 34-41

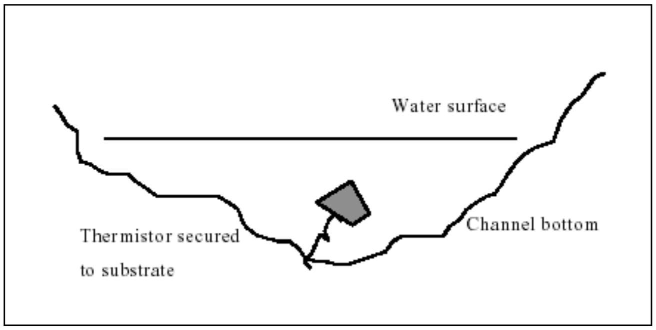


Figure 6.1. Thermistor placement.

overriding concern is that the logger not be in contact with the substrate of the stream, nor placed such that temperature stratification would provide an inaccurate picture of stream temperatures.

What we have found over the last few years is that when loggers are easily identifiable, they become the target of jokers and thieves. One logger that had been tied off to a large root wad with monofilament was replaced with an empty beer can. We never found the logger. Dale Webber of Vemco suggests fixing the loggers to the streambed with a metal pipe with a hole drilled into the tip so that the logger might be tied off to the pipe with the thermistor(the part that actually takes the temperature) facing up

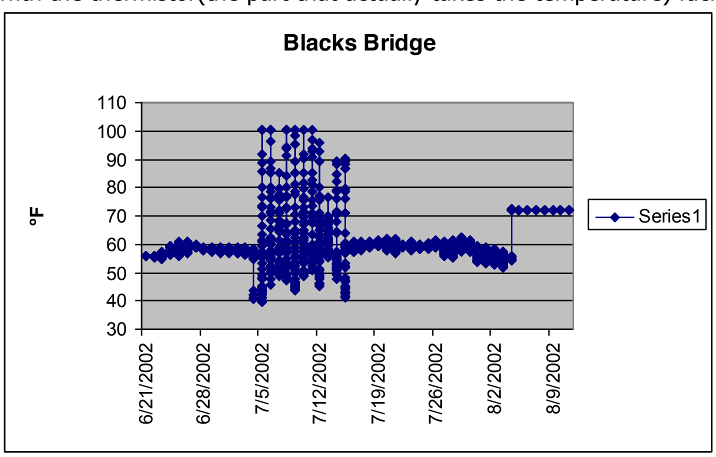


Figure 6.2. A graph of temperature data for an agricultural stream reach.

into the center of the stream. Last year(2002) we opted for trying to place the loggers so that they would be extremely difficult to see, hoping to reduce the chance of data loss due to pranksters. This turned out to be a less than effective strategy for two reasons. First, we still lost a very well hidden logger to a determined seeker or a lucky beaver(the line was cut). Secondly, a freshet in the early summer left at least one logger high and dry after a period of high flow. There is also evidence that cattle dragged a logger out of the stream on at least on occasion. When a logger goes dry, it is almost always very apparent when the data are graphed. Figure 6.2, for example, shows a fairly steady temperature regime until the 5th of July when, presumably, the cattle flipped the device up onto the bank.

The wild swings in temperature from the 5th through about the 15th are typical of diurnal air temperatures with no shade. In fact the thermistor of this particular device was separate from the logger, and black in color, which explains why the maximum temperatures were in the 100's. In the eyes of DEQ, this presents a problem. If an audit had been performed on the 4th and the 16th, then the rest of the data set would be considered usable, with only the center section of data rejected. Without knowing exactly when the logger became dry, there is no way to know where to save data, and where to eliminate data. This data set becomes anecdotal, rather than irrefutable evidence that Blacks Creek never got above 64ºF. The portions of the data set that were bracketed with field audits are usable, but there is not a continuous record of water temperatures. We can look at the period between the 5th and the 15th and say with some certainty that the logger was dry, but we cannot say that the water temperatures weren't significantly higher than the rest of the study period. The data analysis for the 2002 study is not available yet, but Table 6.1 summarizes information from the 2001 season.

Figure 6.3 shows Johnson Creek temperatures at the junction of the right and left forks, upstream of the Elliott State Forest boundary. The trend in temperatures moves downwards into the spawning season, suggesting that by late fall, water temperatures will be sufficiently cold for salmonids to spawn successfully. A winter temperature monitoring effort is desirable, but runs the risk of losing many more loggers.

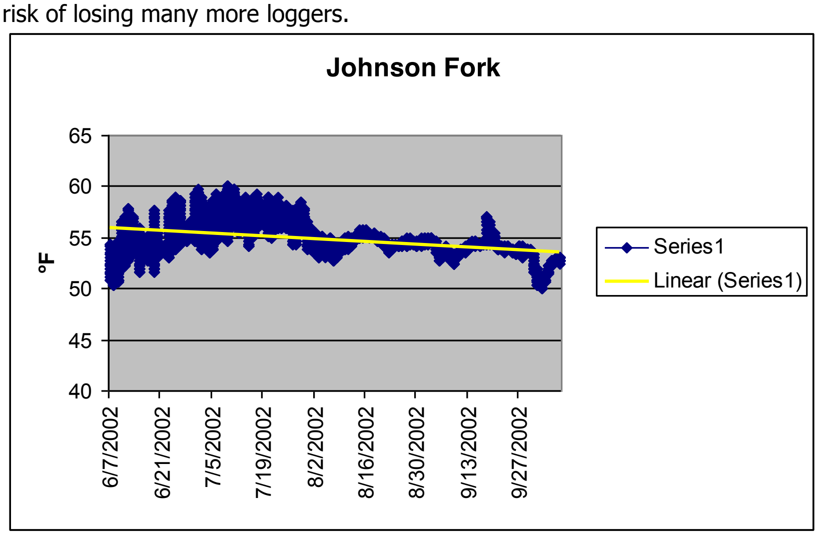
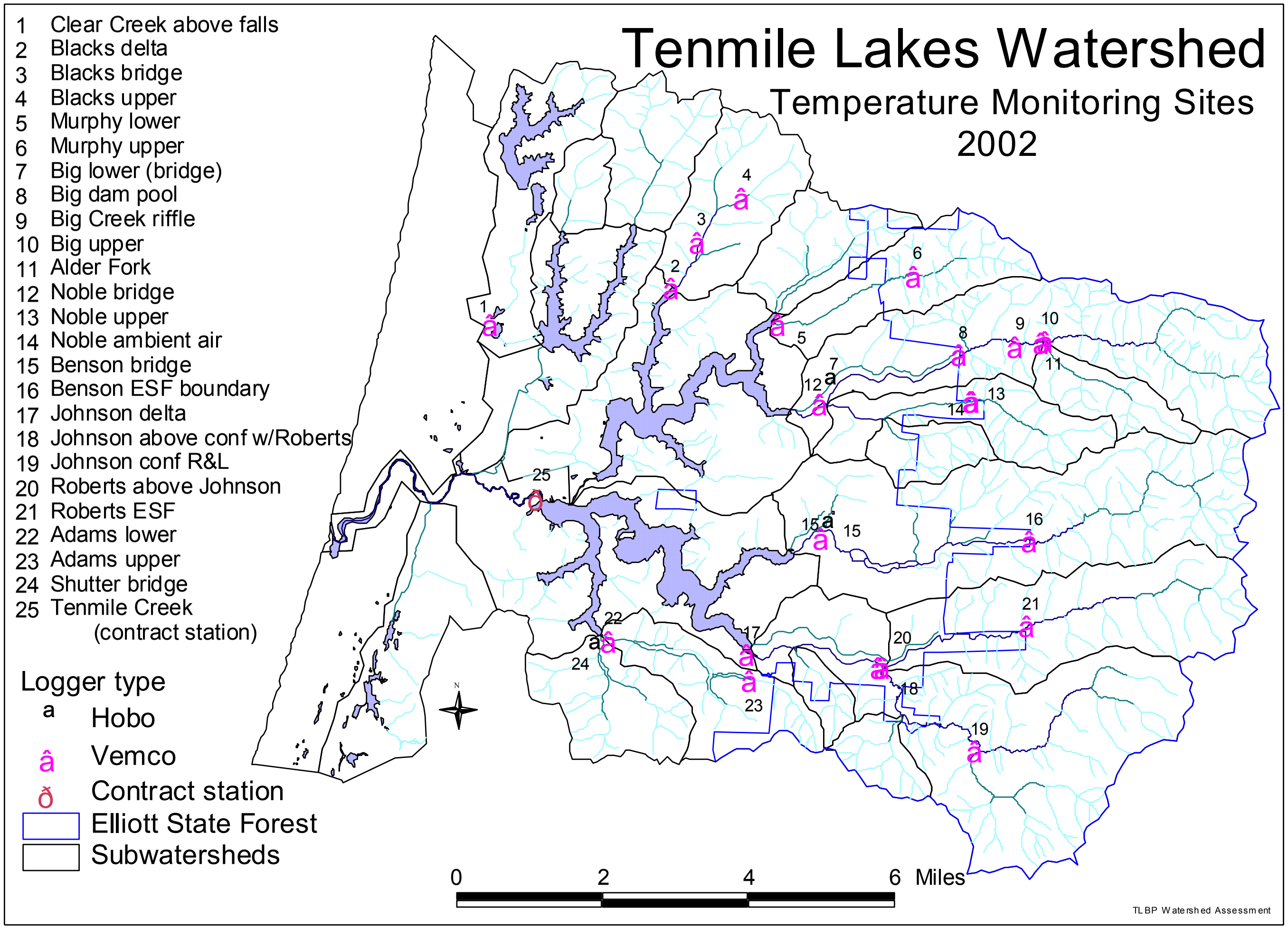


Figure 6.3. 2002 graph of temperatures at the fork of left and right Johnson Creek. Note direction of trend line (linear regression) as it gets closer to spawning season.



Map 6.1. Temperature monitoring sites. Summer/Fall 2002.

Summary Data

Site Name	Lat	Long	Start Date	Stop date	Seasonal Maximum Date	Seasonal Maximum Value	Seasonal Minimum Date	Seasonal Minimum Value	Seasonal Max ΔT Date	Seasonal Max ΔT Value	7-Day averages Date	7-Day averages Maximum	7-Day averages Minimum	7-Day averages Δ T
Murphy Creek lower	43	124	06/02/01	10/02/01	08/07/01	64.4	09/30/01	48.2	06/19/01	5.4	08/08/01	62.6	58.2	4.4
Murphy Creek upper	43	124	06/02/01	10/10/01	08/07/01	62.6	10/10/01	46.4	07/21/01	7.2	08/09/01	60.8	56.9	3.9
Big Creek Bridge	43	124	06/03/01	10/01/01	08/07/01	66.2	09/30/01	50.0	07/07/01	7.2	07/10/01	64.9	60.0	4.9
Big Creek Dam Pool	43	124	06/02/01	10/01/01	08/11/01	68.0	06/15/01	50.0	06/13/01	12.6	08/10/01	67.2	64.7	2.6
Big Creek upper	43	124	06/02/01	10/01/01	08/07/01	66.2	06/04/01	48.2	08/05/01	7.2	08/08/01	63.9	59.0	4.9
Alder Fork	43	124	06/02/01	10/01/01	07/24/01	60.8	06/18/01	48.2	07/08/01	9.0	07/11/01	60.5	54.6	5.9
Noble lower	43	124	06/02/01	10/01/01	09/30/01	93.2	09/30/01	41.0	09/30/01	52.2	09/28/01	79.3	44.9	34.5
Noble middle	43	124	06/02/01	10/01/01	08/11/01	68.0	09/21/01	46.4	07/08/01	14.4	08/09/01	67.0	59.3	7.7
Noble upper	43	124	06/02/01	10/01/01	07/02/01	68.0	09/30/01	50.0	07/01/01	16.2	07/04/01	65.2	54.9	10.3
Noble Ambient Air	43	124	07/06/01	10/01/01	09/08/01	77.0	09/28/01	39.2	09/30/01	34.2	08/08/01	69.8	52.6	17.2
Alder Gulch, lower	43	124	06/02/01	09/13/01	08/31/01	69.8	06/25/01	48.2	09/13/01	14.4	08/09/01	67.7	60.0	7.7
Alder Gulch, upper	43	124	06/02/01	10/01/01	09/18/01	57.2	09/30/01	48.2	09/21/01	5.4	08/21/01	55.7	53.3	2.3
Benson June	43	124	06/02/01	06/30/01	06/21/01	66.2	06/04/01	51.2	06/06/01	9.6	06/19/01	63.5	56.0	7.5
Benson July	43	124	07/04/01	08/07/01	08/07/01	69.6	07/21/01	55.9	07/26/01	9.5	07/25/01	67.5	59.8	7.7
Benson September	43	124	09/06/01	10/01/01	09/14/01	64.4	09/29/01	50.3	09/08/01	10.5	09/11/01	63.5	57.0	6.5
Johnson lower June	43	124	06/02/01	06/30/01	06/21/01	67.0	06/06/01	52.5	06/06/01	8.4	06/20/01	64.6	59.2	5.4
Johnson lower July	43	124	07/06/01	08/08/01	08/07/01	72.6	07/31/01	60.4	07/31/01	6.9	07/25/01	70.1	64.5	5.6
Johnson lower August	43	124	08/10/01	08/31/01	08/11/01	71.1	08/25/01	61.2	08/24/01	6.4	08/28/01	68.1	63.7	4.3
Johnson lower September	43	124	09/06/01	10/01/01	09/14/01	66.7	09/30/01	55.0	09/08/01	5.2	09/14/01	65.7	62.2	3.5
Johnson upper June	43	124	06/02/01	06/30/01	06/07/01	62.1	06/04/01	48.9	06/07/01	11.0	06/09/01	59.4	51.9	7.5
Johnson upper July	43	124	07/06/01	08/08/01	08/07/01	67.6	07/08/01	53.9	07/27/01	5.7	07/25/01	65.3	60.2	5.1
Johnson upper August	43	124	08/10/01	09/04/01	08/11/01	66.1	08/23/01	57.0	08/23/01	5.1	08/13/01	63.6	61.2	2.4
Johnson upper September	43	124	09/06/01	10/01/01	09/14/01	61.8	09/30/01	51.7	09/07/01	3.4	09/14/01	60.9	58.5	2.4
Johnson RFork June	43	124	06/02/01	06/30/01	06/21/01	58.1	06/04/01	48.6	06/13/01	6.7	06/19/01	56.5	51.6	4.9
Johnson RFork July	43	124	07/06/01	08/08/01	07/09/01	58.7	07/21/01	53.1	07/07/01	5.3	07/09/01	58.1	54.1	4.0
Johnson RFork August	43	124	08/10/01	09/04/01	08/24/01	59.2	09/03/01	54.2	08/24/01	3.9	08/21/01	57.8	55.6	2.2
Johnson RFork September	43	124	09/06/01	10/01/01	09/13/01	57.3	09/29/01	50.8	09/29/01	4.5	09/15/01	56.8	55.4	1.4
Johnson LFork June	43	124	06/02/01	06/30/01	06/20/01	58.7	06/04/01	49.7	06/19/01	7.0	06/18/01	57.5	51.2	6.3
Johnson LFork July	43	124	07/06/01	08/08/01	07/09/01	59.8	07/31/01	52.0	07/08/01	7.0	07/10/01	59.3	53.3	6.0
Johnson LFork August	43	124	08/10/01	09/04/01	08/27/01	58.1	08/16/01	52.8	08/25/01	4.5	08/27/01	57.8	54.7	3.2
Johnson LFork September	43	124	09/06/01	10/01/01	09/24/01	55.0	09/29/01	49.7	09/30/01	3.3	09/15/01	54.5	53.6	0.8
Adams upper June	43	124	06/02/01	06/30/01	06/29/01	55.3	06/18/01	48.0	06/18/01	5.3	06/27/01	53.9	51.3	2.6
Adams upper July	43	124	07/06/01	08/08/01	08/07/01	57.9	07/26/01	50.6	07/26/01	5.0	08/05/01	56.8	54.0	2.8
Adams upper August	43	124	08/10/01	09/04/01	08/18/01	62.7	08/17/01	49.4	08/19/01	11.2	08/19/01	59.8	51.8	8.0
Adams upper September	43	124	09/06/01	10/01/01	09/14/01	56.7	09/21/01	48.1	09/08/01	5.9	09/15/01	56.1	53.9	2.2
Adams lower June	43	124	06/02/01	06/30/01	06/21/01	65.3	06/06/01	52.2	06/06/01	9.0	06/20/01	61.9	57.9	4.0
Adams lower July	43	124	07/06/01	08/08/01	08/07/01	71.1	07/07/01	58.4	08/01/01	6.6	08/05/01	68.6	64.2	4.4
Adams lower August	43	124	08/10/01	09/04/01	08/10/01	67.9	08/23/01	58.9	08/17/01	6.3	08/29/01	66.3	62.9	3.4
Adams lower September	43	124	09/06/01	10/01/01	09/14/01	63.8	09/30/01	53.6	09/07/01	4.8	09/15/01	62.6	60.1	2.5

Table 6.3. Output from the TEMPTURE (DEQ) macro.

Site Name	Days > 55 F	Days > 64 F	Days > 70 F	Hours > 55 F	Hours > 64 F	Hours > 70 F	Warmest day of 7-day max Date	Maximum	Minimum	Agency
Murphy Creek lower	114	1	0	2311.0	4.0	0.0	08/07/01	64.4	60.8	TLBP
Murphy Creek upper	101	0	0	1859.0	0.0	0.0	08/07/01	62.6	59.0	TLBP
Big Creek Bridge	116	33	0	2673.0	196.0	0.0	07/09/01	66.2	60.8	TLBP
Big Creek Dam Pool	118	62	0	2648.0	751.0	0.0	08/07/01	68.0	64.4	TLBP
Big Creek upper	115	4	0	2411.0	23.0	0.0	08/07/01	66.2	60.8	TLBP
Alder Fork	104	0	0	1873.0	0.0	0.0	07/08/01	60.8	51.8	TLBP
Noble lower	121	78	18	2501.0	489.0	27.0	09/30/01	93.2	41.0	TLBP
Noble middle	121	44	0	2472.0	225.0	0.0	08/06/01	68.0	59.0	TLBP
Noble upper	68	20	0	1251.0	83.0	0.0	07/02/01	68.0	53.6	TLBP
Noble Ambient Air	88	72	8	1480.0	407.0	16.0	08/09/01	75.2	51.8	TLBP
Alder Gulch, lower	98	43	0	1846.0	279.0	0.0	08/07/01	69.8	62.6	TLBP
Alder Gulch, upper	18	0	0	244.0	0.0	0.0	08/22/01	57.2	53.6	TLBP
Benson June	28	4	0	553.0	22.0	0.0	06/20/01	66.2	57.6	TLBP
Benson July	35	26	0	839.0	186.0	0.0	07/24/01	69.6	62.1	TLBP
Benson September	26	2	0	507.0	3.0	0.0	09/14/01	64.4	58.7	TLBP
Johnson lower June	29	6	0	616.0	52.0	0.0	06/21/01	67.0	61.8	TLBP
Johnson lower July	34	34	6	815.0	612.0	34.0	07/24/01	72.0	65.8	TLBP
Johnson lower August	22	21	2	527.0	370.0	6.0	08/31/01	69.0	65.3	TLBP
Johnson lower September	26	11	0	623.0	61.0	0.0	09/14/01	66.7	62.7	TLBP
Johnson upper June	26	0	0	293.0	0.0	0.0	06/07/01	62.1	51.1	TLBP
Johnson upper July	34	11	0	769.0	79.0	0.0	07/24/01	67.0	61.5	TLBP
Johnson upper August	26	6	0	623.0	39.0	0.0	08/11/01	66.1	62.1	TLBP
Johnson upper September	24	0	0	495.0	0.0	0.0	09/14/01	61.8	59.2	TLBP
Johnson RFork June	18	0	0	100.0	0.0	0.0	06/21/01	58.1	53.3	TLBP
Johnson RFork July	34	0	0	566.0	0.0	0.0	07/06/01	58.7	53.3	TLBP
Johnson RFork August	26	0	0	606.0	0.0	0.0	08/24/01	59.2	55.3	TLBP
Johnson RFork September	23	0	0	319.0	0.0	0.0	09/13/01	57.3	55.9	TLBP
Johnson LFork June	19	0	0	130.0	0.0	0.0	06/20/01	58.7	52.0	TLBP
Johnson LFork July	18	0	0	177.0	0.0	0.0	07/09/01	59.8	53.6	TLBP
Johnson LFork August	10	0	0	195.0	0.0	0.0	08/24/01	58.1	53.6	TLBP
Johnson LFork September	2	0	0	4.0	0.0	0.0	09/16/01	54.7	53.9	TLBP
Adams upper June	3	0	0	12.0	0.0	0.0	06/29/01	55.3	51.7	TLBP
Adams upper July	32	0	0	260.0	0.0	0.0	08/07/01	57.9	55.1	TLBP
Adams upper August	26	0	0	398.0	0.0	0.0	08/18/01	62.7	53.6	TLBP
Adams upper September	16	0	0	131.0	0.0	0.0	09/14/01	56.7	54.5	TLBP
Adams lower June	29	1	0	603.0	2.0	0.0	06/21/01	65.3	60.1	TLBP
Adams lower July	34	32	2	815.0	439.0	6.0	08/07/01	71.1	66.4	TLBP
Adams lower August	26	22	0	623.0	283.0	0.0	08/31/01	67.3	64.1	TLBP
Adams lower September	26	0	0	601.0	0.0	0.0	09/14/01	63.8	60.6	TLBP

Table 6.3. TEMPTURE (DEQ) macro output, continued.

Aesthetic quality of the lakes

Admittedly not the lakes, but the mouth of Tenmile Creek provides aesthetic benefits as well.

Factors that affect lake aesthetics include:

- Turbidity
- Algal blooms
- Invasive aquatic plants

Turbidity is a measure of the clarity of water, which is clouded by both inorganic and organic suspended particles. A classic test of water clarity is the Secchi disk, a flat circular piece of metal painted black and white which is lowered into the water attached to a rope. When the disk is nearly at the point of no longer being visible, the depth is recorded as the Secchi depth. The greater the Secchi depth, the clearer the water. Some famously clear lakes, Tahoe for example, had(prior to lakefront development) Secchi depth readings exceeding 100 feet.[xxix] Whether winter or summer, the Tenmile Lakes have low Secchi disk readings, ranging from a couple of feet to a maximum of about fifteen feet. winter readings are affected by soil particles flushed out of the uplands by heavy rains, while summer readings are hindered by phytoplankton, zooplankton, and flotsam from macrophytes(large aquatic plants). Figure 6.4 shows the variations in Secchi disk readings over the course of a year. High water clarity days in the winter result from periods of dry weather, calm conditions and a lack of sunlight to produce algal blooms. High Secchi disk readings in the summer are rare, but may be associated with extended cloudy periods.

Past efforts to monitor lake clarity have had results similar to Eilers, et al in 2001. Data from 1982 and 1989[xxx] show Secchi readings from about three to fourteen feet. An outlier among the data is a reading of about twenty feet from September of 1989.

Other measures of turbidity, such as a laboratory method that gauges light refracted from a sample of lake water, have not been included in any analyses. Measuring Total Suspended Solids (TSS) provides an actual measure of the weight of solids suspended in a sample, and while the two methods are not directly comparable, they both provide a measure of water clarity. Secchi depths are mostly used in lakes, TSS may be used both in streams and lakes. Figure 6.5 is a graph of TSS during the same period as figure 6.4. Both graphs are from the Tenmile Lakes Nutrient Study, 2002, Eilers, et al.

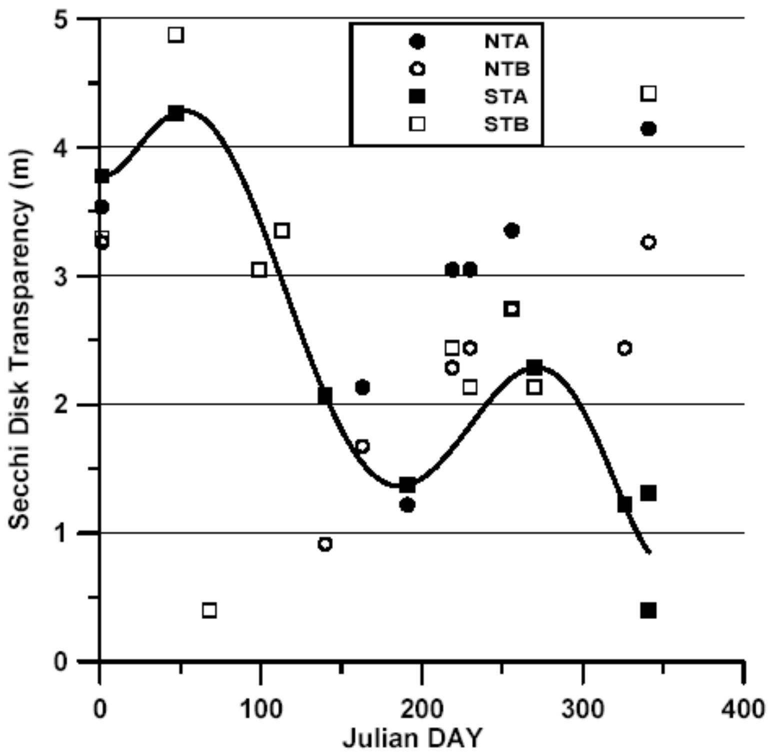


Figure 6.4. Secchi disk transparency (m) for the four sites on North and South Tenmile Lakes. Julian day 1 would be January 1st.[xxxi]

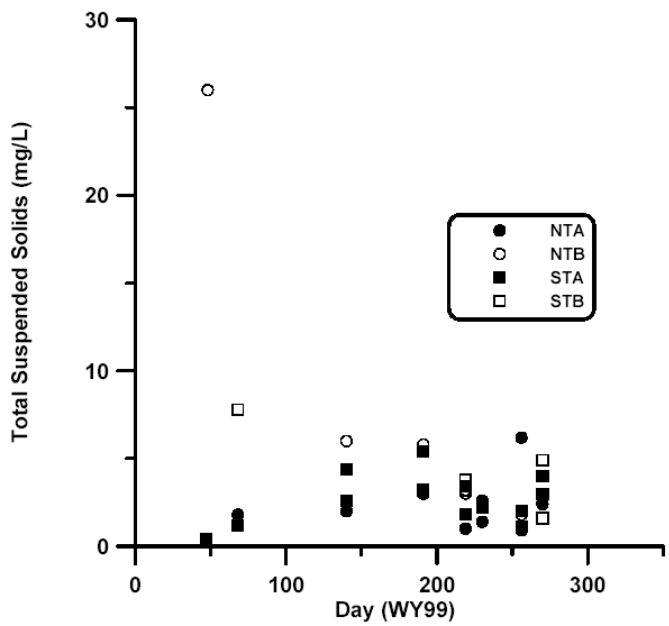
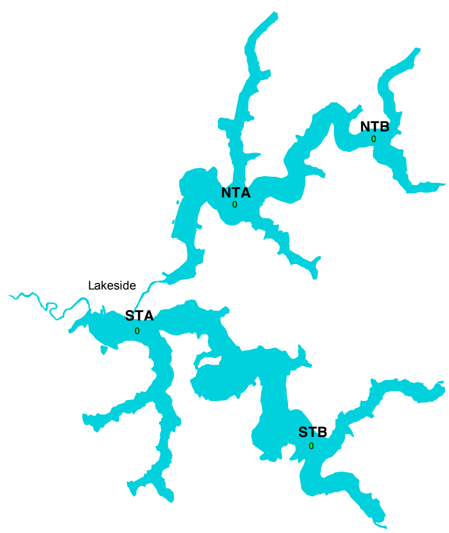
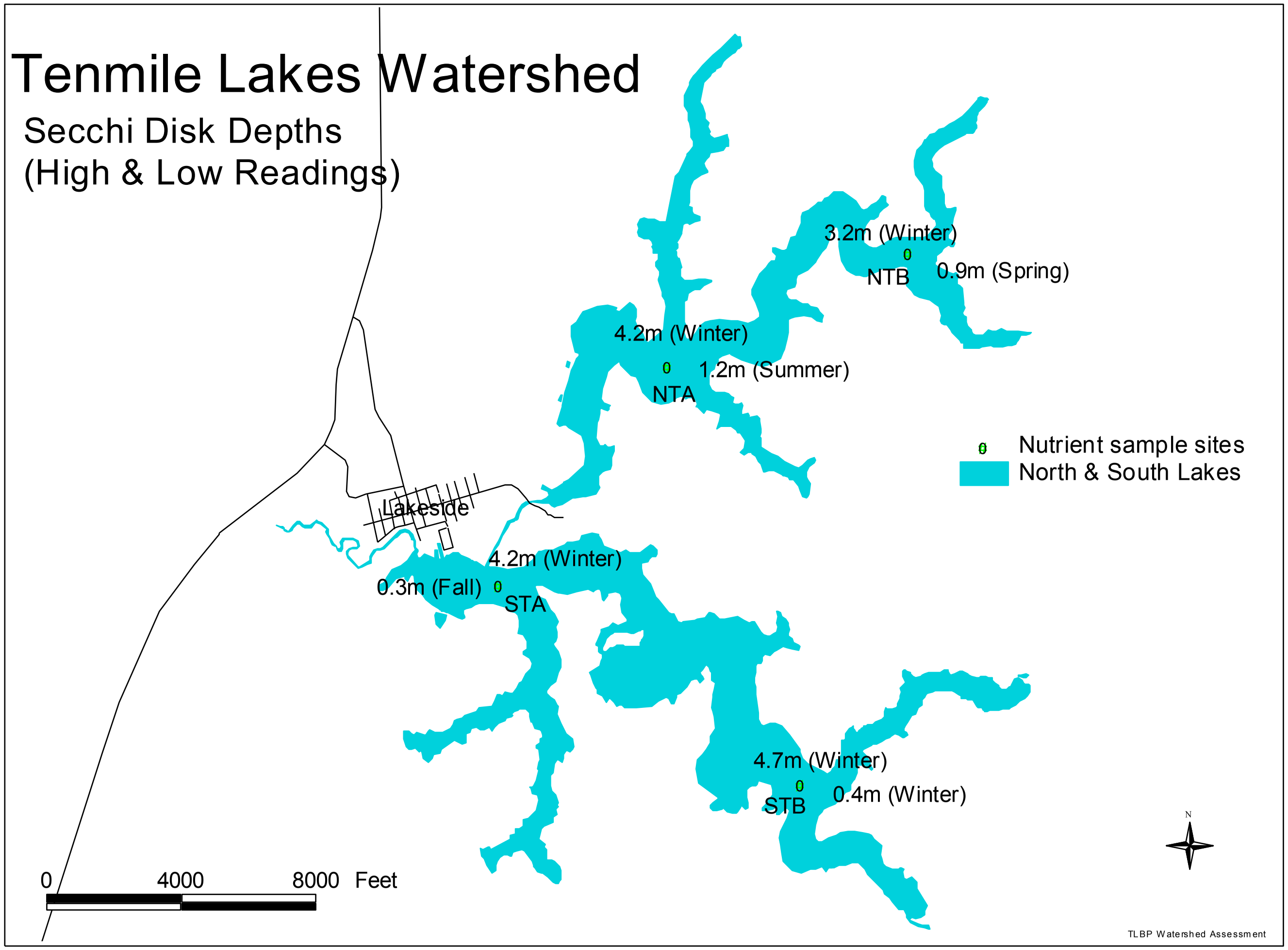


Figure 6.5. Total Suspended Solids (TSS milligrams/Liter) vs. water year. Day one would be October 1st.





Map 6.2. Secchi disk readings.

Algal blooms

Algae, diatoms, cyanobacteria, and other aquatic organisms may all undergo explosive growth periods, creating problems such as discolored water, high toxin concentrations, disagreeable odors caused by rotting organic material, and drastically reduced dissolved oxygen levels.

Studies over the years have had similar results measuring indicators such as chlorophyll a, which occurs in cyanobacteria as well as algae and other photosynthesizing organisms.

Table 6.4. Chlorophyll "a" concentrations.

Study	Highest Chlorophyll a concentration.	Date	Range
Eilers	152 ug/L	11 Sept 1999	Approx. 2 to 152ug/L
Systma	41.7 ug/L	18 July 1994	4.7 to 41.7ug/L
Aquatic Analysts	18.6 ug/L	24 September 1989	11.9 to 18.6ug/L

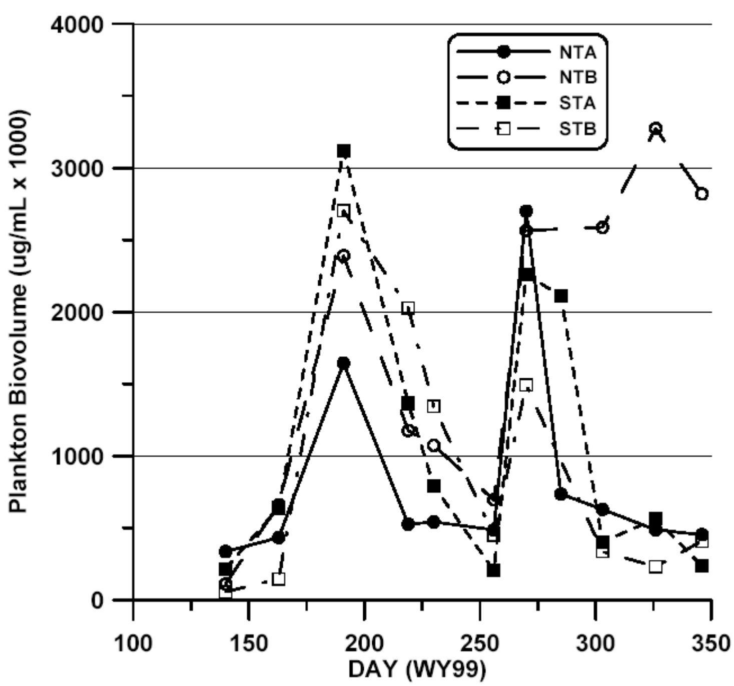


Figure 6.6. Phytoplankton volume in North and South Tenmile Lakes. Eilers, 1999.

When conditions are right, a large bloom can shade out plants beneath the lake surface, depriving them of light. In the absence of light, plants consume oxygen rather than produce it, leading to low dissolved oxygen levels near the bottom of the lake. If the lake temperatures are too high for fish to stay near the surface, conditions become ripe for a die-off. There are no records of significant die-offs in the Tenmile Lakes, which isn't surprising given the ability of the summer winds to turn over the shallow waters.

Preventing blooms is best accomplished by reducing the nutrient level of the lakes, i.e., reducing septic inputs, fertilizer loads, and urban runoff.

Invasive aquatic plants

The aesthetic quality of the lakes has been adversely affected by the presence of excessive aquatic plant growth, especially non-native plants. There has been no comprehensive survey of macrophytes(large aquatic plants) in the Tenmile Lakes, but The Tenmile Lakes Limnological Survey reports the following:

> "The Tenmile Lakes contain a diverse macrophyte community…Brazilian elodea (*Egeria densa*) was the dominant macrophyte. Brazilian elodea was most abundant at depths less than 16 ft. Coontail (*Ceratophyllum demersum*) was commonly abundant near the bottom at depths between 16 and 20 ft… Big- leaf pondweed (*Potomogeton amplifolius*) exhibited dramatic seasonality in abundance; it was common and formed dense stands, particularly in Templeton and Carlson Arms in July, but was rare in August. Other macrophytes present included: *Potomogeton natans*, *Elodea canadensis*, *Callitriche palustris*, *Lemna* spp., *Brasenia schreberi*, *Nuphar* spp., *Nympheae odorata*, *Myriophyllum hippuroides*, *Potomogeton praelongus*, *Potomogeton richardsonii*, and *Myriophyllum aquaticum*. Because of the seasonality of native species and the patchy distribution of macrophytes, complete description of the macrophyte community in the Tenmile Lakes would require a year round sampling program at more stations in the lakes."[24]

Invasive aquatic plants have generated debate surrounding methods of removal, including introducing grass carp, dyeing the lake with light absorbing pigments to prevent the plants from photosynthesizing, application of herbicides, and full scale weed harvesting by mechanical means. TLBP has begun an annual aquatic weed survey using photo documentation and species identification in an attempt to monitor the advance of various troublesome species such as Egeria densa, and Eurasian milfoil. The problem is severe during the summer and occasionally curtails boat traffic in the arms of the lake due to the density of plant material.

Preventing excessive macrophyte growth involves some of the same measures as with algae, namely reducing nutrient inputs to the lakes.

[24] Tenmile Lakes Limnological Survey. Mark Systma, Portland State University. March 1995. Pg. 9.

Domestic water supply & water contact recreation

Water used for domestic use or recreation have sufficiently similar concerns to warrant being presented together. Both uses rely on water that is safe for drinking and skin contact. Any water skier knows that, eventually, some lake water will end up being ingested via the mouth or injected via the nose (if you're lucky). Fishers may be concerned about bioaccumulation of toxins in the fish they catch. And residents who use lake water for drinking obviously have much more exposure to septic byproducts, biotoxins, heavy metals, and synthetic chemicals than the casual lake user.

While toxic algae has been in the news in recent years, there are other things to worry about when considering whether or not to drink from or swim in a lake. Viral, bacterial, and protozoic illnesses caused by human pathogens has historically been the most likely consequence of drinking un-sanitized water. Several infamous water borne illnesses are cholera, typhoid, and cryptosporidiosis. The Centers for Disease Control and Prevention has this to offer:

> "[Bacterial waterborne illnesses include] a range of syndromes, including acute dehydrating diarrhea (cholera), prolonged febrile illness with abdominal symptoms (typhoid fever), acute bloody diarrhea (dysentery), and chronic diarrhea (Brainerd diarrhea)." And, for other parasites, "*Cryptosporidiosis* (krip-toe-spo-rid-e-o-sis), is a diarrheal disease caused by a microscopic parasite, *Cryptosporidium parvum*. It can live in the intestine of humans and animals and is passed in the stool of an infected person or animal. Both the disease and the parasite are also known as "Crypto." The parasite is protected by an outer shell that allows it to survive outside the body for long periods of time and makes it very resistant to chlorine disinfection. During the past two decades, Crypto has become recognized as one of the most common causes of waterborne disease (drinking and recreational) in humans in the United States. The parasite is found in every region of the United States and throughout the world. Crypto may be contracted by swallowing recreational water contaminated with Crypto. Recreational water is water in swimming pools, hot tubs, jacuzzis, fountains, lakes, rivers, springs, ponds, or streams that can be contaminated with sewage or feces from humans or animals. Note: Crypto is chlorine resistant and can live for days in pools."[25]

Giardiasis is a disease known to many hikers caused by the protozoan *Giardia lamblia*. Giardia and crypto have the distinction of being extraordinarily hard to kill when in their cyst states, which makes it easy to make it past either inadequate or faulty water treatment systems. Synthetic chemicals introduced into the lake either by lakefront residents unhappy with aquatic plants clogging their docks, illegal dumping, urban runoff, or through other means have the potential to harm domestic users of lake water with either acute or chronic problems ranging from queasiness to cancer. Additives to gasoline percolate into the soil and groundwater, herbicides and pesticides do the same, and heavy metals found in fertilizers find their way into the lakes via lawns and gardens. There have been no studies specifically to test for synthetic chemicals in the Tenmile Lakes, but the Lakeside Water District puts out a water quality sheet once a year that addresses any problems with the water supply.The City of Lakeside gets its water from Eel Lake which, according to J. Eilers, has much better

[25] CDC. (http://www.cdc.gov/ncidod/dpd/parasites/cryptosporidiosis/factsht_cryptosporidiosis.htm)

water quality than the Tenmile Lakes.[26] Even municipally treated water may have problems, ironically, because of the actual treatment (see table 5.4). Trihalomethanes are volatile organic compounds that form as a result of organic material coming into contact with chlorine. The higher the organically derived turbidity, the higher the trihalomethanes. Most of the contaminants mentioned here are easily dealt with by employing an activated carbon filtration stage during water treatment. This is typically done at the site of water use (the home) as it is an expensive process not cost effective for most municipal systems.

Biotoxins are commonplace in the natural world. Trees produce toxins to ward off insects, animals make poisons to deter predators, and microorganisms produce some highly toxic compounds not to poison humans, rather to better compete with other microorganisms. The best known (in our area) of these microorganisms are *Microcystis aeruginosa* and *Anabaena spp.*, both types of cyanobacteria, the oldest known organisms on Earth. The earliest fossils known, the stromatolites(dome-like rocks) from Western Australia, are thought to be 3.5 billion years old and were produced by cyanobacteria.[xxxii] Twenty years ago, botanists were starting to realize that "blue-green algae"(now cyanobacteria) were much less like algae than bacteria. Today cyanobacteria are recognized as one of the largest groups of bacteria on the planet, responsible for everything from the early oxygen atmosphere to much of the oil deposits laid down billions of years before dinosaurs existed.[xxxiii]

Microcystis and Anabaena are present and, at times, abundant in the Tenmile Lakes. This presents a problem to humans and other animals due to the chemicals produced by certain species and strains of cyanobacteria. Organisms in the genus Anabaena produce anatoxins, microcystins, and saxitoxins. Microcystis aeruginosa produces microcystins. Anatoxins are neurotoxins that affect the nervous system by interfering with the neurotransmitters acetylcholine and cholinesterase. Microcystins are hepatotoxins that disrupt blood flow in the liver[27] and may interfere with other cellular processes.[28] Saxitoxins are also neurotoxins, but are found more often in Australian strains of Anabaena. Lethal doses of these cyanobacterial toxins vary from as little as ten millionths of a gram per kilogram(10ug/kg) of body weight(680ug for a 150lb(68kg) person) for the saxitoxins, 50ug/kg for microcystins, to 250ug/kg for the less toxic strains of Anabaena.[29,30] By way of comparison, a grain of table salt weighs about fifty micrograms.(A microgram=ug=one one millionth of a gram).

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[26] The comparison of total phosphorus, chlorophyll *a*, and Secchi disk transparency shows that Eel Lake exhibits much better water quality than Tenmile Lake… The striking differences in water quality between the two lakes suggests that water quality in Tenmile Lake could be improved by dealing with some of the watershed and in-lake sources of nutrients.

[27] By causing leaks in capillaries in the liver. Lakewise newsletter, December 1998.

[28] Cyanobacteria website. http://www-cyanosite.bio.purdue.edu/cyanotox/toxins/ppase.html

[29] Toxic cyanobacteria website. http://www-cyanosite.bio.purdue.edu/cyanotox/toxiccyanos.html

[30] "These hepatotoxins, called microcystins, are produced by several cyanobacteria taxa including *Microcystis, Anabaena, Nodularia, Oscillatoria,* all represented in the plankton of various lakes in NH. Microcystins are potent offenders and comprise a chemically-related family of slow acting, cyclic, heptapeptides, which produce internal bleeding in liver tissues of vertebrate animals.The reported LD50 for microcystin in mammals is 50 µg/Kg body weight. Microcystins alter intracellular microfilament structure (Yoshizawa, *et al.* 1990), inhibit protein phosphatase activity (PP1 and PP2a) (Honkanen, *et al*, 1991) and promote tumor growth (Falconer, 1991). They have been implicated in the poisoning of humans, cattle, sheep, waterfowl, dogs and salmonid fishes (Galey, *et al* 1987;Watanabe, *et al,* 1996). The impact of human exposure to *Microcystis* is noted in health reports from water supplies in Australia, Brazil, Canada and from Harare, Zimbabwe, where blooms have been linked to seasonal outbreaks of gastroenteritis in children (Zillberg, 1996). Microcystins have recently been related to the deaths of reared Atlantic salmon, the anomaly called net-pen liver disease (NLD), in British Columbia, Canada and Washington

Testing in the Tenmile Lakes watershed has concentrated on Microcystis and microcystin mostly due to public awareness and state agency interest. It has been pointed out that it would be prudent to test also for the presence of anatoxins as well as microcystins. As funding becomes available, more testing will be conducted. For now, the results of sampling during the Tenmile Lakes Nutrient Study are instructive.

> Supplemental to the overall watershed and lake study, additional lake sampling was conducted specifically to assess the dynamics of the potentially toxic blue-green alga, *Microcystis aeruginosa*. This species produces potent hepatotoxins (known as microcystins) that are capable of harmful effects to animals and humans (Chorus and Bartram 1999). A toxic bloom of *M. aeruginosa* was first documented in Tenmile Lakes in September of 1997, prompting the Oregon Department of Health to issue a health advisory recommending that the lake not be used for drinking water and that contact recreation be avoided (Kann and Gilroy 1998). The goal of this supplemental sampling, in partnership with the Tenmile Lakes Basin Partnership, was to specifically target *M. aeruginosa* to better understand conditions favorable for growth, bloom formation, and toxin production.
> The *Microcystis* sampling and microcystin analysis indicated that the organism and its toxin were present at levels to be considered a human health concern (Table 6). *M. aeruginosa* was present at low levels at the time of the first sample trip on July 21, 2000 (Figures 37 and 38), with the highest microcystin values (ELSIA µg L-1) encountered at stations N11 and S8 (Figure 40). These values were ~2X the World Health Organization (WHO) guidance level for drinking water (1 ppb or 1 µg L-1; Falconer et al. 1999).[xxxiv]

The Oregon Department of Health has issued health advisories in the past due to unacceptable levels of microcystin, first in 1997, then in 1999. The issue is politically charged however, given the question of financial responsibility and uncertainty regarding treatment options.

The World Health Organization sounds a cautionary note on cyanobacterial toxins, but notes that related acute illnesses are rare,

> "Outbreaks of human poisoning attributed to toxic cyanobacteria have been reported in Australia, following exposure of individuals to contaminated drinking water, and in the UK, where army recruits were exposed while swimming and canoeing. However, the only known human fatalities associated with cyanobacteria and their toxins occurred in Caruaru, Brazil, where exposure through renal dialysis led to the death of over 50 patients. Fortunately, such severe acute effects on human health appear to be rare, but little is known of the scale and nature of either long-term effects (such as tumour promotion and liver damage) or milder short-term effects, such as contact irritation."[31]

Table 6.5 shows the results of testing from the Tenmile Lakes Nutrient Study for Microcystis and microcystin. The organism, Microcystis, and the toxin it produces, microcystin, are not always found together, and the amount of toxin isn't necessarily related to an obvious bloom of cyanobacteria.

State (Anderson, *et al*, 1993)." From a grant proposal to the USGS by James F. Haney & Miyoshi IkawaDept. of Zoology, University of New Hampshire. http://water.usgs.gov/wrri/98grants/NewHampshire.html

[31] World Health Organization. http://www.who.int/water_sanitation_health/Water_quality/CYAN.html

Microcystis aeruginosa colony abundance, biomass, and microcystin toxin concentration in North and South Tenmile Lakes, July 21-September 4, 2000.

		Microcystis Abundance					Biomass (GALD X Colony #)				Microcystin	
STATION	DATE	*M. aeruginosa* Colonies (no./L)	N & S Col. mean	North Col. Mean	South Col. mean	GALD* (um)	Biomass Estimate	N and S Bio. Mean	North Bio. Mean	South Bio. Mean	ELISA (µg/g)	ELISA (µg/L)
N11	21-Jul	333				540	180077				63.30	2.03
N16 (NTA)	21-Jul	133				264	35241				26.70	1.17
S3	21-Jul	133				358	47662				25.60	1.05
S8 (STA)	21-Jul	600	300	233	367	477	285905	137221	107659	166783	57.50	2.30
N16 (NTA)	10-Aug	333				451	150185				1.01	0.04
NTB	10-Aug	67				480	31997				0.80	0.03
S8 (STA)	10-Aug	333				538	179382				1.14	0.04
STB	10-Aug	133	217	200	233	318	42396	100990	91091	110889	1.11	0.04
N11	21-Aug	133				170	22598					
N16 (NTA)	21-Aug	0				.	0					
S3	21-Aug	133				244	32530					
S8 (STA)	21-Aug	800	267	67	467	220	175816	57736	11299	104173		
N11	4-Sep	1200				365	437490				6.72	0.52
N16 (NTA)	4-Sep	533				388	206646					
S3	4-Sep	200				309	61860				16.52	0.59
S8 (STA)	4-Sep	67	500	867	133	190	12665	179665	322068	37263	7.06	0.49

* GALD = greatest axial linear dimension.

Table 6.5. Microcystis testing. Tenmile Lakes Nutrient Study. Eilers, et al, 2002.

Invasive Aquatic Plants

The aquatic plant community has changed over the years as introduced species of plants have become abundant. Chief among these invasive plants is *Egeria densa*, or Brazilian elodea. Anyone who has tended an aquarium should know what *E. densa* looks like; a long stalk with whorls of small thin leaves. *E. densa* begins to proliferate in the spring and, by the time mid-summer rolls around, is present as a dense mat of impenetrable vegetation that renders the ends of the arms of the lakes unnavigable.

Both North and South Tenmile Lakes are on the state's 303(d) list of impaired waters for weeds and toxic algae, while Eel Lake is listed for high pH during the summer (photosynthesis will reduce the pH of water by increasing H^+ ion concentrations). The proposed 2002 list recently submitted to the Federal government lists the same lakes for the same conditions.

Problems associated with invasive aquatic plants are mainly due to either their decay and subsequent increase of the biological oxygen demand (BOD), the ecological effects of the wholesale displacement of the aquatic plant community, and the nuisance factor associated with plant beds that are dense enough to stop a boat dead in the water.

TLBP has been active in seeking methods of invasive plant control, documenting the presence of aquatic plant species, and facilitating the cooperation of various state and county agencies in order to increase public awareness of the problem and implement solutions. By the fall of 2003, TLBP should have two years worth of aquatic plant bed surveys, enough to start analyzing spatial and species composition changes.

References

[i] Soil Survey of Coos County, US Dept. of Agriculture. Pg 182.
[ii] Kenneth Brown, Cycles of Rock and Water, p168.
[iii] Kenneth Brown, Cycles of Rock and Water, p186-187.
[iv] Eilers, et al, Tenmile Lake Nutrient Study, Phase 1, 1/2001, pg
[v] R. Abrams, et al, Tenmile Fish Management Plan, 1991, p26.
[vi] ibid, pg-27.
[vii] Griffiths & Yeoman 1941, and Abrams 1991, via J. Eilers' nutrient study 2001, for TLBP, with modifications.
[viii] R. Abrams, et al, Tenmile Fish Management Plan, 1991, p62.
[ix] Graph created with data from R. Abrams, et al, Tenmile Fish Management Plan, 1991, p26. figure 2 , and data from ODFW Corvallis Research, with notes added to show certain events.
[x] M. Mader. (pers. Com.)
[xi] Charlie Stein, pers.com.
[xii] ODFW Diamond Lake webpage. http://www.dfw.state.or.us/ODFWhtml/InfoCntrFish/Diamondlake/DiamondLake.html
[xiii] http://www.pan-uk.org/pestnews/Actives/rotenone.htm Pesticide Action Network website. A good primer on rotenone.
[xiv] http://www.nwi.fws.gov/bha/SandT/SandTQandA.html, see also: http://www.wetlands.com/coe/87manp2a.htm
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[xvii] USDA-NRCS Soil survey division website. http://www.statlab.iastate.edu/soils/hydric/intro.html
[xviii] Guidebook for Hydrogeomorphic (HGM)—based Assessment of Oregon Wetland and Riparian Sites: Statewide Classification and Profiles. Pg 55.
[xix] Paraphrased from Plummer & McGeary. Physical Geology, second edition.
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[xxi] Oregon State Climate Service. 1971-2000.
[xxii] http://yosemite.epa.gov/oar/globalwarming.nsf/content/Climate.html. NOAA.
[xxiii] 24-hour rainfall intensity that is likely to initiate fast-moving landslides. Published in "Oregon Geology," volume 62, number 2, March/April 2000. Thomas J. Wiley, principle.
[xxiv] Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen. Issues in Ecology. #3.1998.
[xxv] Tenmile Lakes Nutrient Study, Phase II Report. November 2002. J. Eilers et al.
[xxvi] ibid. Pg 114.
[xxvii] Oregon Geology, volume 61, number 6, November/December 1999. Elizabeth L. Orr and William N. Orr, Dept. of Geological Sciences, University of Oregon, Eugene.
[xxviii] One acre foot = 43560 cubic feet of water. One cubic foot = 7.481 gallons of water. 62777 acres * 43560 cubic feet * 7.481 gallons * 6 feet of rain = 122,743,734,862 gallons. A recent contract in Arizona called for one party to pay $17.42 per acre foot of water, so our yearly rainfall is worth at least 6.5 million dollars in Arizona. An equivalent amount of Evian spring water would sell for, by the liter, 460 billon dollars.
[xxix] Lake Tahoe Optical Model. Theodore J. Swift [*] , John E. Reuter [*] , Jennifer Coker [§] , Geoffrey Schladow[§] and Charles R. Goldman [*] Tahoe Research Group and [§] Dept. Civil & Environmental Engineering, University of California, Davis, CA 95616

[xxx] Citizen Lake Watch Program, cited in the Tenmile Lake Water Quality Report. Aquatic Analysts, March 15, 1990.
[xxxi] Tenmile Lakes Nutrient Study, Phase II Report. November 2002. J. Eilers et al. Pg 48.
[xxxii] University of California at Berkeley Cyanobacteria website. http://www.ucmp.berkeley.edu/bacteria/cyanofr.html
[xxxiii] ibid.
[xxxiv] Tenmile Lakes Nutrient Study, Phase II Report. November 2002. J. Eilers et al. Pg 66.