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Boise Cascade Corporation

Onion Creek Watershed Analysis

Prepared For:

Boise Cascade Corporation

110 South Boise Ave.
Kettle Falls, Washington 99141

In Cooperation With:

Washington Department of Natural Resources
Washington Department of Ecology
Stevens County Conservation District
Vaagen Brothers Lumber, Inc.
Arden Tree Farm
Inland Empire Paper
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Richard LeCaire, Fisheries Biologist, Confederated Tribes of the Colville Reservation

Bill Swartz, Geologist

Don Barron, Soils Scientist

Residents of Onion Creek

Boise Cascade Corporation

Onion Creek Watershed Analysis

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Form 1. Assessment Team Information Form
WAU: Onion Creek

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Assessment Team Leader	Mary Raines	1661 E. 56th St. Bellingham WA 98226	Work/Fax 360 398-9603	
Administrator	Domoni Glass	Boise Cascade One Jefferson Sq., PO Box 50 Boise ID 83728	W 208 384-6670 Fx 208 384-7699	
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Surface Erosion	Kathy Vanderwal Dubé	Harza Northwest, Inc. 2353 130th Ave. NE, Suite 200 Bellevue WA 98009	W 206 882-2455 Fx 206 883-7555	2
Hydrology	Joanne Greenberg, P.E.	Hydrologic Services Co. 1903 Broadway Bellingham WA 98225	W 360 743-1445 Fx	2
Riparian Function	Kent Doughty	CES, Inc. 1111 N. Forest St. Bellingham WA 98225	W 360 671-1150 Fx 360 671-1152	2
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Stream Channels	Mary Raines	1661 E. 56th St. Bellingham WA 98226	Work/Fax 360 398-9603	2
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Observers	Alan Henning David Roberts	U.S. Environmental Protection Agency, Region 10 Wash. Dept. of Ecology	W 206 553-8293 W 360 407-6414	

Form 1. Prescription Team Information Form
WAU: Onion Creek

Name	Address	Phone/Fax	Certification
Dave Weeman, Forester Prescription Team Leader	Boise Cascade Corp. 110 S. Boise Ave. Kettle Falls WA 99141	W 509/738-3255 Fx 509/738-3292	
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Maurice Williamson Forester	Maurice Williamson, ACF Consulting Forestry and Vaagen Brothers Lumber, Inc. 270 S. Main Colville WA 99114	W 509/684-8550 Fx 509/684-2008	
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Observers			
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Richard LeCaire	Confederated Tribes of the Colville Reservation, Nespelem WA 99155	509/634-8845	

Form 5. Watershed Characteristics

Watershed Administrative Unit:	**Onion Creek**

Drainage System: Columbia River

Location: T39N T38N R40E R39E

Basin Area: 47,360 acres

Climate: Transitional between maritime and continental
Mean Annual Precip: 22 inches

Elevation Range: 1,290 to 5,775 feet

Geology: Approximately 50% of the WAU is overlain with unconsolidated glacial sediments (till, outwash, lacustrine). Bedrock includes folded and faulted Paleozoic sedimentary and metasedimentary rock on sideslopes and ridges of foothills and Mesozoic granitic rock on footslopes and sideslopes of foothils.

Stream Density (mi/mi^2): 1.9 Road Density (mi/mi^2): 3.75

Vegetation: Valley bottoms and lower elevations: Western red cedar, western hemlock, some Englemann spruce. Drier hillslopes and higher elevations: Douglas fir, grand fir, western larch, lodgepole pine, Englemann spruce.
Agricultural: Mainly pasture land.

Land Use: Approximately 52% forestry. Other land uses include some agriculture, ranching, rural residential, several open pit quarries, the Van Stone Mine (lead/zinc), and several minor mining claims.

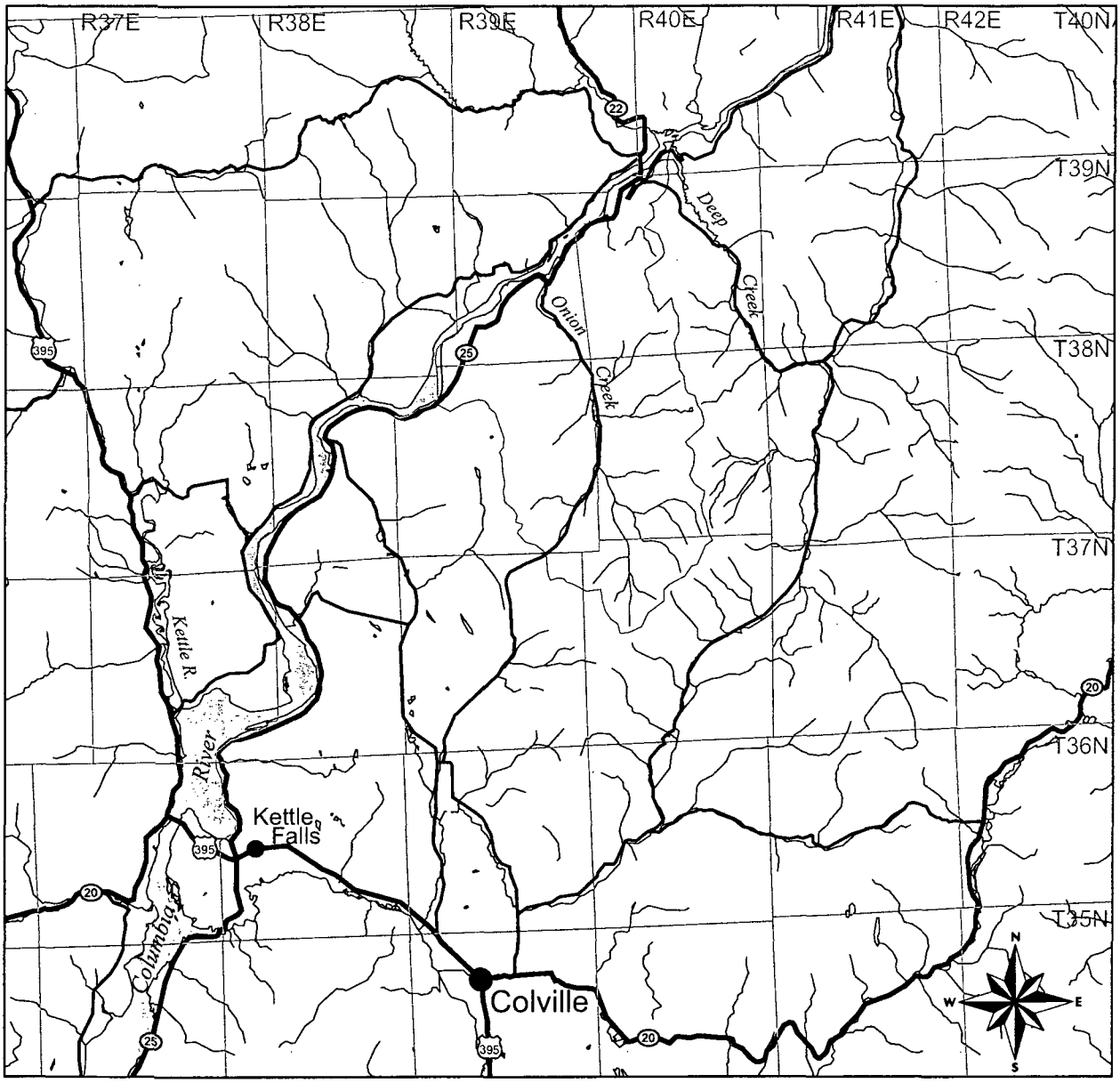
Land Owners:

Boise Cascade Corp.	10,777 acres	Arden Tree Farm	580 acres
Vaagen Brothers Lumber	4,346 acres	Marvin Bergmann	303 acres
Wash. State Trust Lands	4,271 acres	Inland Empire Paper	214 acres
USDA Forest Service	1,729 acres	Maurice Williamson	170 acres
Bureau of Land Mgmt.	1,716 acres		
Small private ownership	23,054 acres		

Water Supplies: No public water supplies

Major Public Capital Improvements: Onion-Clugston Creek Road, Onion Creek School, City of Northport, State Highway 25, Widow Hawk Road. Water supplies to the Onion Creek School and Northport are provided by wells.

Fisheries Resources: Brook trout *Salvelinus fontinalis* and rainbow trout *Oncorhynchus mykiss* are found throughout the drainage. Salmonid species that have been observed in the past in small numbers in the lower mile of Onion Creek below the barrier falls include: Kokanee salmon *Oncorhynchus nerka*, bull trout *Salvelinus confluentus*, cutthroat trout *Oncorhynchus clarkii*.

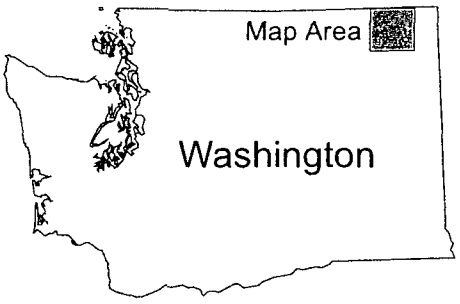


Scale 1:350,000

0 5 10 15

Statute Miles

Map projection: State Plane Washington South
Created on February 27, 1997



Onion Creek
Watershed Analysis

Figure 1. Onion Creek WAU Location Map

Onion Creek watershed
State or U. S. highway
County road
Stream

Boise Cascade Corporation

Onion Creek
Watershed Analysis

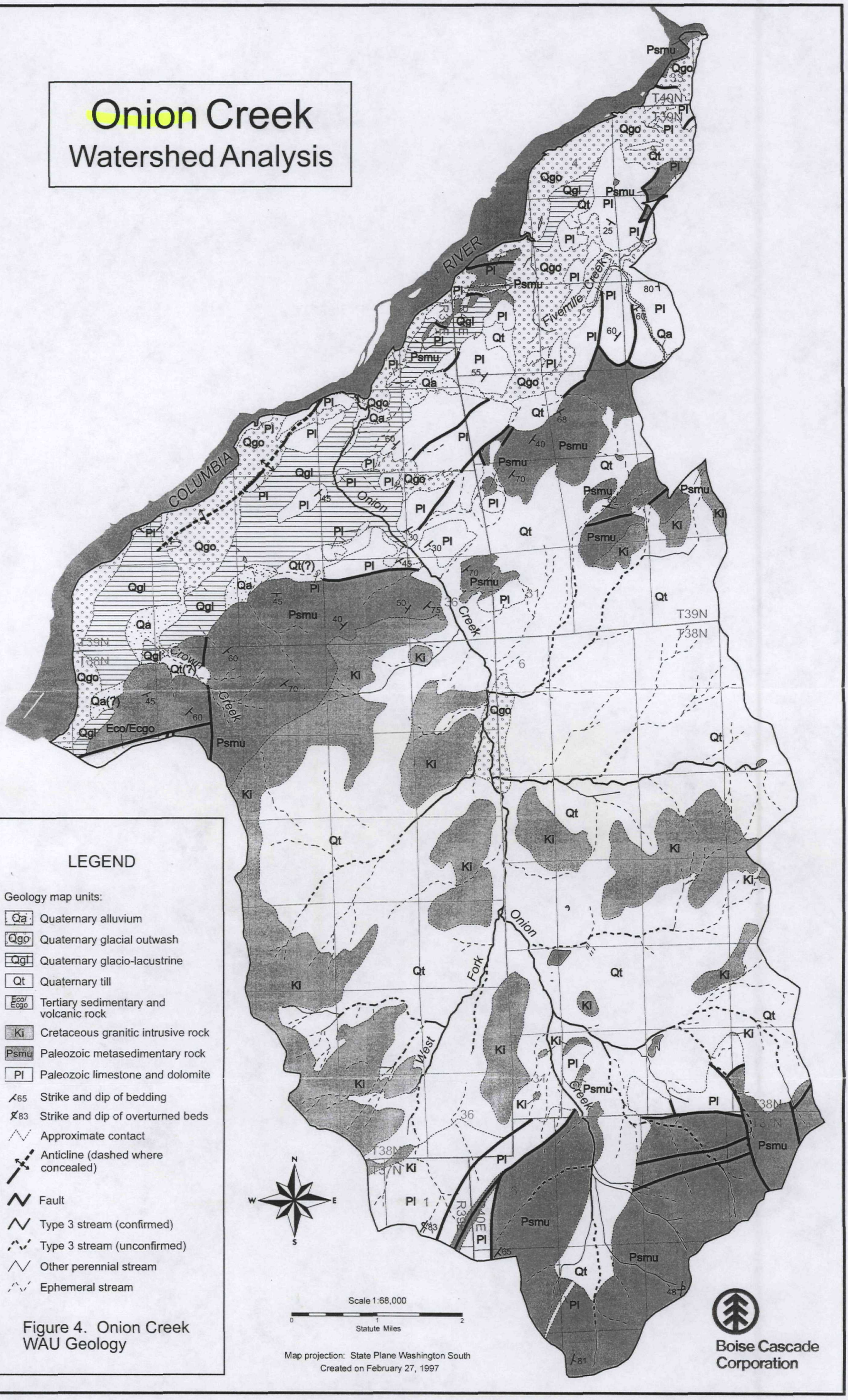
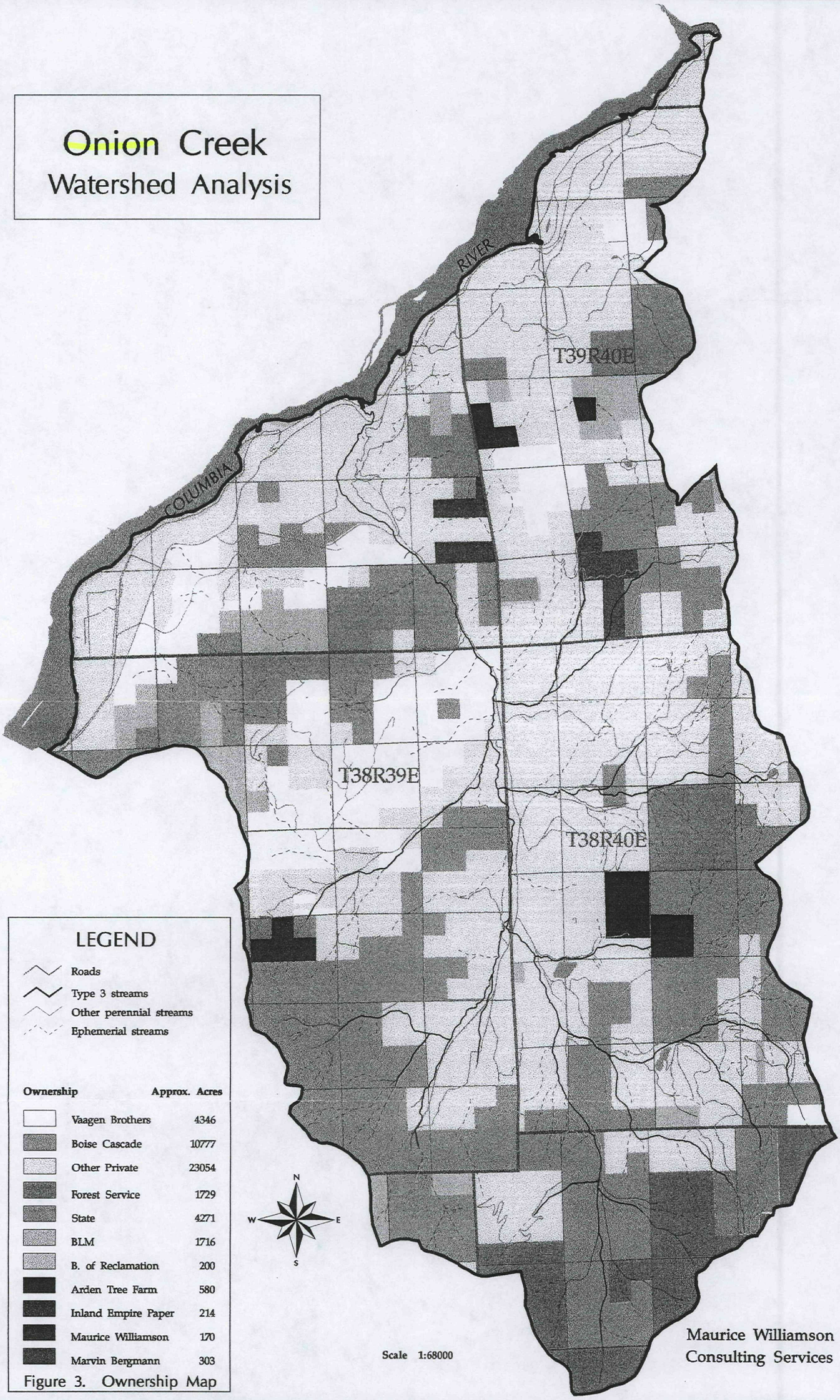


Figure 4. Onion Creek WAU Geology

Onion Creek
Watershed Analysis



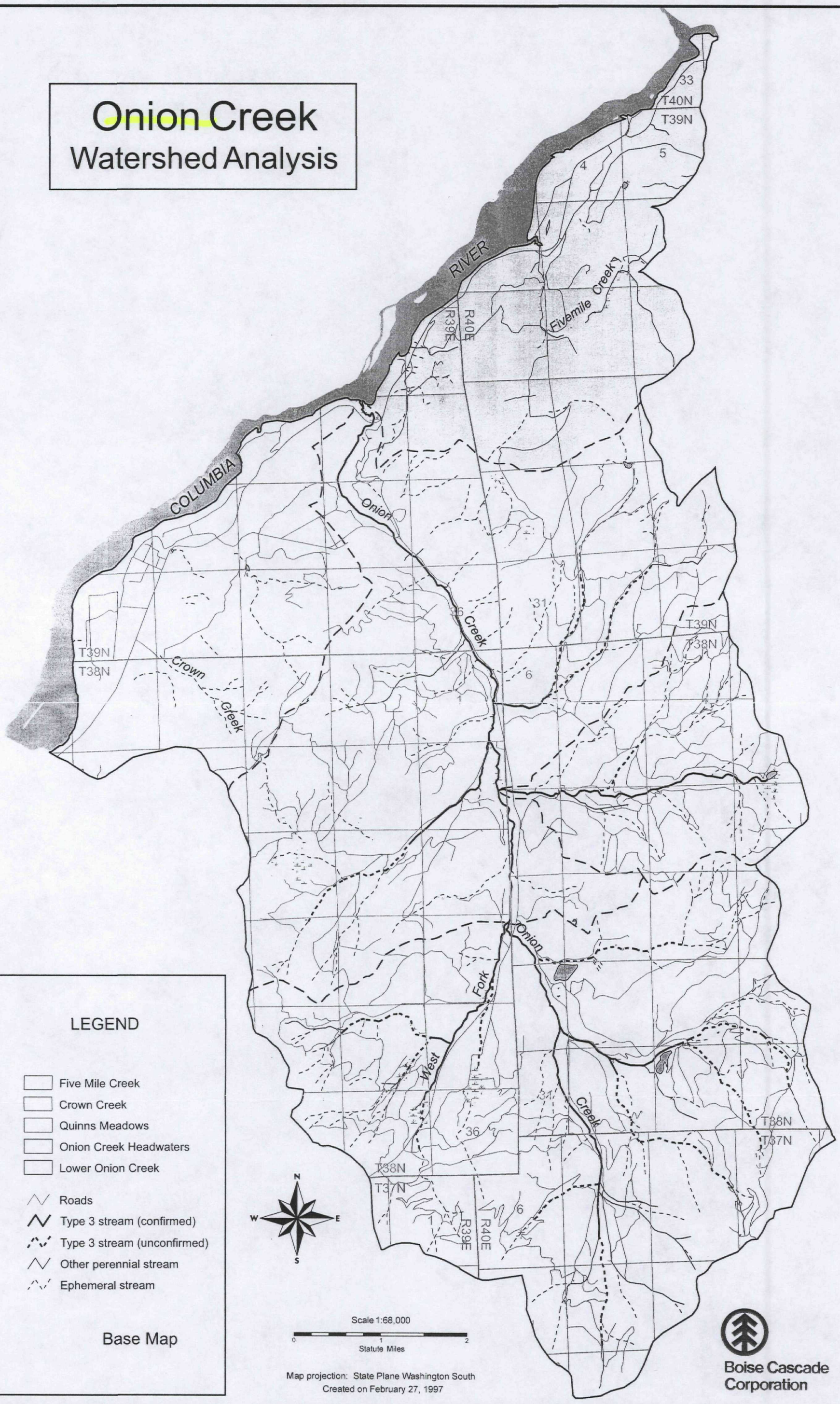
LEGEND

- Roads
- Type 3 streams
- Other perennial streams
- Ephemerial streams

Ownership	Approx. Acres
Vaagen Brothers	4346
Boise Cascade	10777
Other Private	23054
Forest Service	1729
State	4271
BLM	1716
B. of Reclamation	200
Arden Tree Farm	580
Inland Empire Paper	214
Maurice Williamson	170
Marvin Bergmann	303

Figure 3. Ownership Map

Onion Creek
Watershed Analysis



LEGEND

- Five Mile Creek
- Crown Creek
- Quinns Meadows
- Onion Creek Headwaters
- Lower Onion Creek
- Roads
- Type 3 stream (confirmed)
- Type 3 stream (unconfirmed)
- Other perennial stream
- Ephemeral stream

Base Map

Scale 1:68,000

0 1 2

Statute Miles

Map projection: State Plane Washington South

Created on February 27, 1997

Boise Cascade Corporation

5.0 ONION CREEK CAUSAL MECHANISM REPORTS and PRESCRIPTIONS

Introduction

Causal Mechanism Reports are the final products of the scientific assessment and represent the critical findings of the watershed analysis. The linkages between existing or potential resource conditions and land management activities are summarized in these reports. From the Causal Mechanism Reports, the managers team writes prescriptions for forestry operations above or in addition to standard forest practices to specifically address the resource situations described.

Onion Creek WAU Causal Mechanism Reports have been reorganized from the standard format to accommodate use by non-forestry participants. The reader will find the individual Causal Mechanism Reports clustered around an expanded discussion of the resource situation to which they have been linked. Organizing the "causes" around the resource "effect" has the benefit of explaining only once and in more detail the exact nature of the problem, in addition to ordering the relative importance or contribution of each activity to the situation. Because both forestry and nonforestry land use activities contribute to resource situations, separate Causal Mechanism Reports have been developed for each where possible. Regulators of the prescriptions might also find this format useful as a reference to understanding the intent of the prescriptions and degree to which forest practices may effect or correct the situation.

The following resource-limiting situations have been identified:

Causal Mechanism Reports 1.	Fish passage barriers
Causal Mechanism Reports 2.	Stream channelization
Causal Mechanism Reports 3.	Riparian shade and LWD conditions
Causal Mechanism Reports 4.	Substrate embeddedness and lack of sorted spawning gravel

In addition, a discussion has been developed to communicate nonforestry-related water quality situations where data indicate the need for further study.

CAUSAL MECHANISM REPORT and PRESCRIPTIONS 1

Fish Passage Barriers

Resource Situation:

Road crossings on fish bearing streams are known or potential barriers to fish passage (see map CMR-1). Thirty-three road crossings were identified by the surface erosion analyst as crossing Type 3 streams. Ten of these crossings were visited during field work to verify fish passage: seven crossings provided adequate fish passage and three were impassable. Fish passage on the remaining 23 crossings has not been determined.

Eight of the road crossings not field checked are on known fish bearing streams and 15 are on streams designated as potentially fish bearing under the new Forest Practices Board emergency rule for Type 3 streams. Two of the known barriers are in areas designated as potentially fish bearing under the new emergency rule.

Objective:

All culverts should be passable to fish in fish-bearing waters.

Contributing Activities:

	Known Barriers	Unchecked Crossings
Culverts under forest roads	2	9
Culverts under county/private roads	1	7
Culverts under joint forest/private use	0	7

1.1 Causal Mechanism Report for Forest Practices Related Fish Passage Barriers

Resource Sensitive Area(s): Map CMR-1

- Known fish barrier culverts at forest road crossings on segments 506 and 602.
- Undetermined fish barrier culverts at forest road crossings on segments 205 (2), 305, 311 (2), 507, 510, 512, 803.
- Undetermined fish barrier culverts at joint forest/private use road crossing on segments 202 (2), 204, **501**, **701**, **801**, 803 (*high priority culverts in bold*).

Triggering Mechanisms:

Culvert installations prevent fish passage. Exact condition preventing passage at each culvert needs to be assessed.

Rule Call	Resource Vulnerability	Delivered Hazard
Standard Rules	Low if not fish bearing	Low if not fish bearing
Prevent or Avoid	Moderate in upper tributaries	High for fish bearing
Prevent or Avoid	High in lower tributaries	High for fish bearing

Additional Comments:

Refer to WAC 222-24-040 specifications on culvert placement in fish streams.

The quality and quantity of habitat available to fish in areas designated as potentially fish bearing is unknown. Many of these streams were designated as potentially fish bearing under the new emergency rule after completion of field work for this analysis. Fish presence or absence should be verified in these areas prior to implementing extensive culvert replacement.

Culverts at the lower end of the tributary drainages in fish bearing waters potentially block access to large portions of the watershed. The unchecked crossings in segments 201, 301, 501, 701, and 801 potentially block the largest areas of the most usable habitat and should be the highest priority for checking and replacement if needed.

The presence of water impoundments may also impede fish passage (segments 301 and 311, may be more). Before undertaking extensive culvert replacement work, streams should also be checked for additional non-road related fish passage barriers.

1.1 Prescriptions for Forest Practices Related Fish Passage Barriers

Prescriptions:

Justification for Prescriptions:

Voluntary Action:

1.2 Causal Mechanism Report for Non-Forest Practices-Related Fish Passage Barriers

Resource Sensitive Area(s): Map CMR-1

- Known fish barrier culverts at county road crossings on segment **401**.
- Undetermined fish barrier culverts at private road crossings on segments **201**, **301**, 507 (2), 510, **701**, and 706 (*high priority culverts in bold*).
- Undetermined fish barrier culverts at joint forest/private use road crossing on segments 202 (2), 204, **501**, **701**, **801**, 803 (*high priority culverts in bold*).

Triggering Mechanisms:

Culvert installations prevent fish passage. Exact condition preventing passage at each culvert needs to be assessed.

Rule Call	Resource Vulnerability	Delivered Hazard
None, non-forestry	Low if not fish bearing	Low if not fish bearing
None, non-forestry	Moderate in upper tributaries	High for fish bearing
None, non-forestry	High in lower tributaries	High for fish bearing

Additional Comments:

Refer to WAC 222-24-040 specifications on culvert placement in fish streams.

The quality and quantity of habitat available to fish in areas designated as potentially fish bearing is unknown. Many of these streams were designated as potentially fish bearing under the new Forest Practices Board emergency rule after completion of field work for this analysis. Fish presence or absence should be verified in these areas prior to implementing extensive culvert replacement.

Culverts at the lower end of the tributary drainages in fish bearing waters potentially block access to large portions of the watershed. The unchecked crossings in segments 201, 301, 501, 701, and 801 potentially block the largest areas of the most usable habitat and should be the highest priority for checking and replacement if needed.

The presence of water impoundments may also impede fish passage (segment 301, may be more). Before undertaking extensive culvert replacement work, streams should also be checked for additional non-road related fish passage barriers.

CAUSAL MECHANISM REPORT 2

Non-Forest Practices-Related Stream Channelization

Resource Situation:

Channelization of Onion Creek in segment 2 has eliminated the channel complexity and pools necessary for suitable fish habitat. Channelization is a legacy problem from earlier agricultural improvements. The modified riparian zone has produced alders and shrubs that currently provide inadequate shade and no functional wood in the stream. These alterations have greatly reduced the spawning and rearing habitat for kokanee, rainbow, and adfluvial cutthroat trout. Habitat in segment 2 is the only portion of Onion Creek accessible to adfluvial species.

Objective:

To increase and improve the quality of available spawning habitat for kokanee and rearing and spawning habitat for rainbow and adfluvial cutthroat trout in segment 2.

Contributing Activities:

- Earlier bank channelization and armoring and current agricultural activities affect approximately 2,500 feet of stream upstream of the highway crossing.
- Channelization immediately above and below the highway concrete box culvert affects approximately 400 feet of stream.

Resource Sensitive Area(s):

Segment 2 of Onion Creek from approximately 2,700 feet above to 200 feet below the highway.

Triggering Mechanisms:

- Within the agricultural area upstream of the highway, channel banks were straightened and armored with cabled logs.
- Within the highway right of way, the channel has been straightened immediately above and below the concrete box culvert.

Rule Call:

Resource Vulnerability:	High
Delivered Hazard:	High
Rule Call:	None applicable to non-forestry activities, volunteer action only.

Additional Comments:

Opportunities to improve habitat include: removal of bank armoring to allow the stream to regain sinuosity; the addition of in-channel structures for sorting of gravel and pool formation; and expansion of the riparian zone with tree species suitable for future wood recruitment and shade. Additional wood recruitment alone, however, will be ineffective in improving habitat if the channel confinement is not addressed. The design of any channel structures for stream and fish habitat rehabilitation requires professional expertise.

Due to bank armoring, bank erosion is minimal in this portion of Onion Creek. Habitat improvement projects that include regaining a more natural channel can be expected to temporarily elevate erosion and fine sediment into the stream until the channel has again stabilized. This short-term potential stream degradation is acceptable in light of the long-term gain in habitat.

CAUSAL MECHANISM REPORTS and PRESCRIPTIONS 3

Riparian Shade and LWD Conditions

The riparian vegetation within the Onion Creek WAU has been inventoried and evaluated with regard to function within the stream channels. This evaluation has identified shade requirements to meet water quality standards for temperatures in addition to stand conditions necessary to provide adequate bank protection and wood to streams. Areas where the current condition of riparian vegetation does not meet these targets due to land use activities are listed in Causal Mechanisms below.

The distribution of land use within Onion Creek concentrates the commercial forestry activities within the headwater areas and the non-forestry activities within the valleys where the majority of fish-bearing streams are located. Out of approximately 42 miles of known fish and potential fish-bearing streams within the WAU, 25 miles (60 percent) flow through non-forest or small land ownership (see Figure 2, Ownership Map). Many of the land use activities impacting the riparian areas along fish bearing streams are therefore exempt from Forest Practices rules.

Resource Situation - Shade

Maximum stream temperatures have been elevated due to land practices in several areas of the basin. At elevations above 2,300 feet, non-forestry activities have reduced riparian canopy closure along fish bearing streams resulting in elevated maximum summer stream temperatures above the water quality standard, and have aggravated naturally high summer water temperatures for streams below this elevation.

Both forestry and non-forestry activities have reduced canopy closure on selected non-fish bearing streams which have sufficient flow to contribute to elevated water temperatures in downstream fish bearing waters. Although slightly exceeding the water quality standard, the existing maximum stream temperatures are still within the suitable range for the non-native salmonids present upstream of the barrier falls in segment 3.

Objective:

1. Maintain or achieve adequate canopy closure to comply with water quality standards above 2,300 ft elevation.
2. Maximize canopy closure below 2,300 ft to avoid increasing naturally high stream temperatures.

Contributing Activities:

The percentage of the stream length affected by each activity relative to all stream segments addressed in this causal mechanism is provided to illustrate the relative contribution to shade

limiting situations from different conditions and land uses. Percentages may add up to more than 100% since some segments are affected by more than one activity.

1.	Naturally exceeds standard due to high air temperature/humidity	40%
2.	Naturally sparse canopy cover on wetlands	33%
3.	Adjacent agriculture and homesite development	14%
4.	Canopy reduction during stream channelization	9%
5.	Grazing	18%
6.	Roads parallel to stream	6%
7.	Recent harvest along non-fish bearing Type 4 streams	10%

Resource Situation - LWD

Suitable large woody debris (LWD) and streambank tree roots are lacking due to streamside roads and non-forestry activities. These activities reduce or prevent the recovery of the densely stocked stands of sufficiently large conifers within 50 feet of fish bearing streams and narrower riparian areas along smaller non-fish bearing streams. Lack of suitable woody debris results in loss of rearing and holding habitat for fish. Wood is also important for the trapping and sorting of gravel for suitable spawning habitat. LWD must be at least 12 inch average diameter to be functional and stable in the mainstem of Onion Creek and the larger tributary streams. Elsewhere, smaller diameter LWD (≥ 8" diam.) is functional.

Grazing has reduced streambank vegetation, and prevents conifer seedlings from regenerating in segment 7 (also see CMR 4.5). Historical beaver activity has also widened the area of brushy growth on the floodplain in segments 4 and 7, which are now naturally reseeding with conifers except where prevented by non-forestry activities.

Maintenance of existing streambank tree roots along streams (inclusive of non-fish bearing type 4 streams) is essential for the integrity of the erodible streambanks, particularly in headwater streams where additional runoff from roads or other land clearing activities may cause erosion of the channel. Where wetlands or other depressional swales do not intercept sediment eroded from streambanks, sediment is transported downstream to mainstem Onion Creek and lower tributaries where it fills pools and reduces winter survival to emergence success of incubating resident fish eggs in spawning gravel. Forest practices standard RMZ rules protect streambank integrity along fish-bearing streams.

Except where roads limit LWD recruitment from at least one side of the streams requiring LWD ≥12" diameter , the assessment team views Forest Practices standard RMZ rules as capable of providing sufficient functional LWD to fish bearing streams in the WAU. Smaller woody debris (≥ 8 inch diameter) is functional and stable in many of the streams.

All trees <12" dbh within the RMZ for fish bearing streams are left according to Forest Practices standard rules and a minimum total of 135 trees/acre >4" dbh must be left standing. These trees

can provide sufficient quantities of suitable woody debris to the smaller streams.

Assuming a mortality rate of 7% per decade of the leave trees (≥12" dbh) specified by standard rules, the riparian area will potentially yield 0.4 pieces LWD per channel width for those channel segments requiring larger LWD (≥12" dbh); this amount of LWD was judged adequate to maintain or improve fish habitat. (See Riparian Report for calculation of recruitment rates.) Forest Practices standard rules also protect streambank integrity on fish bearing streams.

Locating RMZ leave trees required by Forest Practices standard rules closer to the channel increases the probability of their naturally falling into the stream, especially if leaning towards the stream. Managers are encouraged to voluntarily select leave trees accordingly.

Streams in riparian LWD map units 3 and 8 have brushy floodplains. Streambank brush provides both root strength to the banks and shade; however, LWD recruitment is mostly from the outer margin of the riparian area for streams in these map units until the brushy floodplains fully revegetate with conifer. Harvest of trees growing on the outer margin of the riparian area cannot occur under Forest Practices standard RMZ rules unless the minimum riparian leave tree requirements are satisfied.

Objective:

1. To the extent practicable, within 50 feet of fish bearing streams, establish densely stocked stands of conifers sufficient in diameter to provide recruitment of functional LWD.
2. Protect streambank integrity by maintaining or improving tree roots embedded in the banks and streambank vegetation.

Forestry Contributing Factors for LWD:

Forest practices have contributed to the existing recruitment potential being inadequate relative to the size and amount of LWD needed in the stream for only three RCUs where fish are potentially present. These three RCUs account for 2% of the streambank length (streambank length = 2x channel length) of all fish bearing streams in the WAU. Stocking is currently sparse but long-term LWD recruitment potential is good. Contributing forestry factors are: RCU 9-3R old skid road within 50 feet of stream (now closed and growing over); selective harvesting on RCU 311-2 reduced stand density; RCU 801-4 was selectively harvested with a 25 ft riparian leave strip along this Type 4 water which under post-harvest emergency rules is now considered potentially inhabited by fish.

Non-Forestry Contributing Factors for LWD:

Percentages were computed (based on streambank length: 2x channel length) as the proportion of streambank length each factor contributes to riparian LWD map unit 4. This map unit affects 21% of the fish bearing waters in the WAU. Riverine wetlands incapable of supporting dense

conifer growth that are bordered by non-forestry lands are not included in map unit 4. Wetlands within LWD map unit 4 influence tree growth potential but do not preclude growth of conifers.

1.	Adjacent agriculture and homesite development	46%
2.	Roads parallel to stream	38%
3.	Grazing	10%
4.	Stream channelization	6%

3.1 Forest Practices Causal Mechanism Report for Preventative Canopy Closure Standards

Forest Practices standard RMZ rules for Type 1-3 streams provide sufficient canopy closure to meet water quality standards. Standard rules do not allow harvest of shade trees within the RMZ where existing shade is below the target level. Because target levels for Onion Creek are modified according to the following table based on the Riparian Assessment (Appendix D, Section 3.3.3), a causal mechanism report has been generated. The table may be modified in the future based on monitoring results.

Modified Minimum Shade Category (percent shade)	Elevation Zone (feet)
<10	> 4,450
15	4,200 - 4,450
21	4,000 - 4,200
27	3,800 - 4,000
33	3,600 - 3,800
40	3,350 - 3,600
50	3,200 - 3,350
55	2,900 - 3,200
67	2,750 - 2,900
75	2,440 - 2,750
90	2,300 - 2,750
100 or max possible	< 2,300

Resource Sensitive Areas: All fish-bearing streams Map D-4

Triggering Mechanisms:

1. Any future activity that reduces canopy closure below target levels.

Rule Call:

Resource Vulnerability:	High
Delivered Hazard:	High
Rule Call:	Prevent or Avoid

Additional Comments:

Brush vegetation overhanging the streambank provides the comparable insulative effects as trees and is capable of providing up to 100% canopy cover on small streams. The target canopy closure level can be achieved by a combination of brush and/or trees.

3.1 Prescriptions

Prescriptions:

Justification for Prescriptions:

Voluntary Action:

3.2 Forest Practice Causal Mechanism - Additional Canopy Closure on Type 4 streams

Resource Sensitive Area(s): Riparian Canopy Closure Map Unit 3, Map D-5
Also appears on map CMR-3
Non-fish bearing Type 4 streams potentially contributing to downstream temperature concerns, the lower 1,000 feet of RCUs 603-1, 710, 711

Triggering Mechanisms:

1. Clearcut harvest of trees removed canopy cover along the riparian corridor.

Rule Call:

Resource Vulnerability:	High
Delivered Hazard:	High
Rule Call:	Prevent or Avoid

Additional Comments:

Use the table of target canopy closure levels in CMR 3.1.

Brush vegetation overhanging the streambank provides the comparable insulative effects as trees and is capable of providing 100% canopy cover on small streams. The target canopy closure level can be achieved by a combination of brush and/or trees.

Verify fish presence in segment 709. If no fish, then CMR 3.2 does not apply to upstream segments 710 and 711.

3.2 Prescriptions

Prescriptions:

Justification for Prescriptions:

Voluntary Action:

3.3 Streambank Root Strength on Type 4 Streams Draining to Fish Streams

Resource Sensitive Area: Riparian area adjacent to the following channel segments: Map E-1/F-1
Non-fish bearing segments in Geomorphic Channel Unit 9: 207, 603, 604, 606, 710, 711
Geomorphic Channel Unit 10a: 51, 104, 105, 206, 302, 303, 304, 306, 307, 308, 309, 310, 313, 403, 404, 504, 508, 608, 802, 804, 806
Geomorphic Channel Unit 11a: 106, 107, 108, 109, 110, 312

Triggering Mechanisms:

1. Harvest of trees with roots embedded in erodible banks of non-fish bearing streams draining to fish streams.
2. Yarding which disturbs streambank vegetation.
3. Grazing.
4. Clearing of streambank vegetation related to non-forestry activities.

Rule Call:

Resource Vulnerability:	Moderate
Delivered Hazard:	Moderate
Rule Call:	Minimize

Additional Comments:

Root strength includes both trees with roots embedded in the banks and all other streamside vegetation. Segments 603, 710, and 711 are the only stream banks currently lacking streambank vegetation due to commercial forestry. Refer to CMR 3.2 regarding verification of fish presence.

3.3 Prescriptions

Prescriptions:

Justification for Prescriptions:

Voluntary Action:

3.4 Roads Within 50 feet of Fish Streams

(Forestry and non-forestry activities associated with roads are not separated here due to overlap of both road use and impacts to public resources.)

Resource Sensitive Area(s): LWD/Riparian vegetation Map Unit 4a, Map D-6
Existing roads: 6, 201-1, 501, 502, 801-1.
For future prevention, applies to riparian areas along all fish-bearing streams.

Triggering Mechanisms:

1. Existing forest roads constructed parallel to and within 50 feet of fish bearing streams (RCU 502).
2. Existing and future public and non-forestry private roads constructed parallel to and within 50 feet of fish bearing streams.

Rule Call:

Resource Vulnerability:	High
Delivered Hazard:	High
Rule Call:	Prevent or Avoid for forest practices No rule call applicable to non-forestry activities

Additional Comments:

Forest Practice standard rules call for minimizing future road construction within an RMZ unless locating elsewhere would cause greater harm to fish and wildlife. By meeting LWD requirements it is assumed that shade requirements would also be met.

Where a road impacts one stream bank, all LWD recruitment must come from the opposite bank.

Riparian Vegetation Impacted by Roads

Riparian Condition Unit	Road Name	Stream Length Affected (ft)	Comment
6	County Rd & residential/forest road	<1,000	Management of existing riparian between roads can met objectives.
201-1	Bodie Mt. Road	2,140	Right bank road periodically within riparian
501	forest/private rd	1,000	upstream of road crossing
502	forest/private rd	2,140	Right bank heavily impacted. Possible candidate for relocation.
801-1	County unpaved	1,900	Impacts may increase with future development

3.4 Prescriptions

Prescriptions:

Justification for Prescriptions:

Voluntary Action:

3.5 Non-Forest Practice LWD and Shade-Limiting Situations

Resource Sensitive Area(s): Segments listed on attached table.
Riparian Canopy Closure Map Units 1a, 1b, & 2, Map D-5
Fish bearing streams in LWD Riparian Vegetation Map Unit 4b, Map D-6

Triggering Mechanisms:

1. Clearing riparian trees or maintaining inadequate width buffers of trees along streams within agricultural and residential lands.
2. Stream channelization removes larger riparian trees, disturbs streambank vegetation roots (801), and reduces shade canopy.
3. Grazing reduces brush overhanging fish bearing stream, tramples conifer seedlings near the stream, and reduces streambank vegetation.
4. Roads parallel to the stream reduce canopy closure and wood recruitment potential.
5. Naturally high stream temperature at elevations below 2,300 feet.
6. Lack of riparian buffer to non-forested, permanently flooded wetlands where fish presence is known or suspected.

Rule Call:

Resource Vulnerability:	High/Moderate
Delivered Hazard:	High except seg. 306
	Moderate seg. 306
Rule Call:	None, non-forestry activities

Additional Comments:

See the Resource Situation discussion above for target riparian stand density and the minimum size functional for LWD for the different channel segments.

Managing non-forestry areas for adequate LWD recruitment along fish-bearing streams assumes maintenance of adequate root strength necessary for bank integrity.

Brush vegetation overhanging the streambank provides the comparable insulative effects as trees and is capable of providing 100% canopy cover on small streams. The target canopy closure level can be achieved by a combination of brush and/or trees.

Non-forested, permanently flooded wetlands where fish presence is known or suspected are included in this group as it is unclear how much protection is afforded to wetlands from non-forestry grading and clearing activities. Segment 52 and other agriculture stock ponds are exempt from canopy closure standards.

Voluntary effort on non-forestry lands to maximize canopy closure will minimize stream temperature impacts below 2,300 ft elevation.

Riparian Areas Affected by Non-Forestry Activities

Riparian Location Code	LWD Map Unit	Naturally exceeds temp standard due to <2,300 ft elevation	Adjacent agriculture or homesite development	Grazing	Parallel Roads reduce canopy & LWD	Stream channel-ization
2	4	x	x			x
6	4	x			x right bank	
7-2	4	x	x			
7-3	4	x		x		
8	4		x			
9-1	4		x			
9-2	4		x			
10	4		x	x		
201-1	4	x	x	x	x	
201-2	7	x				
202-2	4		x		x	
204	7		x			
205	4		x			
301-1	6	x	x			
404	7		x			x
501	4				x right bank	
502	4				x	
701	4	x	x			
702-2	4		x			
702-4	4		x			
801-1	4	x	x		x	
801-2	4	x	x			x

3.5 Prescriptions

Prescriptions:

Justification for Prescriptions:

Voluntary Action:

CAUSAL MECHANISM REPORT and PRESCRIPTIONS 4

Substrate Embeddedness and Lack of Sorted Spawning Gravel

Resource Situation:

Very few patches of sorted spawning gravel were noted by the fish habitat analyst in most surveyed reaches of the mainstem Onion Creek. Spawning gravel was somewhat more sorted in the 500 tributary. Resident fish spawn in 0.1 to 1 inch substrate but need to be able to move the sediment to construct redds. The substrate is currently mixed with angular rock that armors the bed and makes it difficult for the fish to move it. In addition, the larger substrate particles in both the mainstem and tributaries were frequently found to be 40 to 50 percent embedded with the finer gravel, resulting in few interstitial spaces for winter refuge and rearing. These conditions exist in spite of relatively good habitat indices and wood loading. Several factors, collectively or individually, may contribute to these conditions. These include an oversupply of a certain size-fraction of sediment within the channels, angularity of the coarse bedload, or perhaps the timing of field observations relative to periodic sediment flushing flows.

The majority of parent material available within the stream system is composed of glacial till high in angular granitic small gravel and sand and finer particles. The sand/fine gravel was observed to compose a fair percentage of the mobile stream bed in addition to collecting in pools and velocity shadows and may currently or chronically be in over supply relative to other size fractions. Silt and finer particles did not appear to be over abundant within the channels and are assumed to remain suspended or flush easily. Medium gravel and larger particles compose a smaller percentage of the till. The coarser sediment component of the bed was also observed to be sub-angular, lending itself somewhat more to packing and requiring more stream energy for bed mobilization.

Field observations were conducted following a snow melt runoff event of 6 years or greater recurrence. The unsorted sediment conditions observed may be the effect of transport of a pulse of sediment resulting from the recent high flows. It is also not known to what degree the system may still be flushing sediment from catastrophic failure of a tailings pond at the Van Stone Mine in 1961. Newspaper accounts indicate extensive erosion during that event.

Since it is unclear from the reconnaissance data collected to what extent the lack of sorting and embeddedness are natural conditions, the degree to which land use can exacerbate this is indeterminant. The conservative approach is to assume an oversupply of the 2 to 4 mm material (delivered hazard), identify for remediation the major sources of land-induced sediment supply to the streams, and recommend monitoring to help define the issue prior to renewal of the watershed analysis (5 years).

Objective:

1. Reduction in land-use induced sediment contributing coarse sand and fines to streams.
2. Monitoring of trends in bed particles sizes and sampling of source-sediment particle sizes to better define the problem.

Contributing Activities:

Current watershed analysis methodology assumes that sediment above 50 to 100 percent of background may be detectible and detrimental to fish habitat, usually within the lower gradient reaches of streams. Estimates of average annual sediment contributions by source are listed in Table CMR 4. Further analysis yielded the following:

1. Field evidence, historical and anecdotal accounts indicate that large-scale channel disturbances have occurred from mining activities at the Van Stone Mine. The exact timing, number of events, and volume of material delivered are not known, but may be significant.
2. The road erosion estimates indicate that road erosion above 50 to 100 percent of background is concentrated in Lower Onion Creek and the Onion Creek headwater areas (Table CMR 4.1).
   a. Road erosion sediment contributions in Lower Onion Creek are concentrated on the Johnson Grade Road and the Bodie Mountain Road.
   b. Road surface erosion, episodic gullying, and episodic road crossing and fill failures each account for approximately one third of the sediment estimate within the headwaters sub-basin. Infrequent mass wasting has also been linked to roads and road runoff.
3. A high potential exists for an increase of roading in wet swales (unchannelized drainages) that will increase runoff and sediment to streams.
4. Point sources of sediment also occur in areas where livestock grazing is concentrated.
5. Soil disturbance and sediment delivery to streams from other rural residential activities was not observed to be significant at this time.

The following Causal Mechanism Reports have been developed to address the main sediment source areas contributing to streams.

Table CMR 4. Estimates of average yearly sediment delivery in tons to connected streams by source in Onion Cr. WAU (Appendix B, Surface Erosion Assessment).

Sub-basin	**Estimated Back-ground Sediment (tons/yr)**	**Estimated Road-Related Sediment**				**Mining (mass wasting only)**	**Grazing**
		Surface Erosion	**Gullying**	**Mass Wasting**	**Potential Additional Future Input with Increased Harvest**		
Crown Cr	0	0	0	0	0	0	0
Five Mile Cr	5	5	0	0	0	0	0
Lower Onion Cr	305	1,240	15	25	0	0	80
Quinns Meadow	170	30	5	0	0	0	0
Onion Cr Headwaters	570	240	205	270	50-160	55*	0
Total	1,050	1,515	225	295	50-160	55*	80

* Estimated sediment input from mass wasting associated with Van Stone Mine facilities. Does not include 1961 tailing pond failure. Volume of additional input from surface erosion is unknown, but was likely significant in the past.

4.1 Causal Mechanism Report for Forest Practices Related Road Erosion

Resource Sensitive Area(s): Delivering segments of forest roads in Onion Creek headwaters and lower Onion Creek sub-basins, Map B-5, Form B-2
Mass Wasting Map Unit 1, Map A-1/A-2

Triggering Mechanisms:

1. The attached table lists the road segments contributing significant sediment along with the triggering mechanisms specific to those locations. In general, surface erosion from roads is driven by the following factors:
   a. Moderate current log truck traffic use
   b. Moderate to high residential and recreational traffic use of some forest roads
   c. Native surface material high in fines
   d. Lack of adequate cross drains (increases erosion and delivery)
   e. Moderate to high future log truck traffic use
   f. Road dust from the Bodie Mountain road cements the stream bed surface in segment 202.
2. Gullying of roads
   a. Rutting of tread by traffic on wet native-surfaced roads
   b. Plugged culverts route streams down roads
3. Episodic fill failure at cross drains.
   a. Undersized culverts
   b. Plugging of culverts
4. Discharge of concentrated road runoff onto steep slopes in inner gorge areas (MWMU 1) saturates soils and can result in shallow rapid failures. Road runoff in NW 1/4 of Section 33 (segment 505) may contribute to surface erosion of the landslide or gully scar (landslide D1) adjacent to the stream.

Rule Call:

Fine sediment routes easily from high gradient tributaries to sensitive downstream reaches. Segments rated with a moderate vulnerability are also adjacent or downstream of road sediment source areas but not listed here because the rule call defaults to the higher vulnerability. Fine sediment for purposes defined here also includes the granitic sand between approximately 2 and 4 mm diameter.

Resource Vulnerability Lower Onion:	High for fines in segments 201, 202, 205, 801, 7, 4, 2, 1
Resource Vulnerability Headwaters:	High for fines in segments 502, 501, 601, 10
Delivered Hazard:	Moderate to High, fine sediment
Rule Call:	Prevent or avoid

Additional Comments:

The particle size of the majority of sediment delivered from roads is < 2 mm. This particle size was not observed during field work to be contributing to habitat degradation in the mainstem Onion Creek at this time. However, during periods of low snow pack and low volume flushing flows, more fines may be stored in the bed. In areas of till soils, road runoff can also transport granitic sand-sized particles present in those soils.

Fine sediment was abundant in segment 202 adjacent to the Bodie Mountain road where high volumes of road sediment are delivered to the stream. Soils in this area are fine-textured from a slatey parent material source. The flat, angular slate particles also contribute to packing within the stream bed. Both forestry and residential use of the Bodie Mountain road contribute to the majority of sediment input to the streams paralleling the road. Road dust from the carbonate soils was also found to cement the bed surface in segment 202 adjacent to this road.

In the upper Onion Creek headwaters area, sediment delivery is dispersed among a number of delivering road segments. Increases in log truck traffic levels in the future will increase erosion delivery. The frequency of road gullies may increase with higher traffic levels or may decrease due to higher maintenance levels.

Landsliding in Mass Wasting Map Unit 1 (inner gorges) delivers directly to stream channels. Concentrated road runoff can saturate sandy till in areas where an impermeable layer prevents the sandy soil from draining. The saturated till then fails. Timber harvest upslope from these areas may have the potential to increase the likelihood of failure if the hydrology of the site is altered, but no mapped failures were associated with harvest. The landslide scar from slope gullying in 1968 located in NW 1/4 of Section 33 (segment 505) continues to erode. Road runoff draining to the landslide may contribute to surface erosion to the stream. Other forestry activities above the road grade above and adjacent to this slide may also increase water to the slope thereby increasing saturation and increasing the instability of the slope.

4.1 Prescriptions

Prescriptions:

Justification for Prescriptions:

Voluntary Action:

4.2 Causal Mechanism Report for Non-Forest Practices Related Road Erosion

Resource Sensitive Area(s): Bodie Mountain road, Johnson Grade Road, Hawks Road, Flora Road, residential use of forest roads, Map B-5, Form B-2

Triggering Mechanisms:

Surface erosion from residential use of county and forest roads delivered to streams. The highest delivery rates are triggered by:

1. Moderate to high residential traffic use of some forest and non-forest roads
2. Wide road tread (larger contributing area) on county roads
3. Road segments drain directly to streams
4. Lack of adequate cross drains, particularly on Johnson Grade Road
5. High raveling cutslope on Johnson Grade Road
6. Native surface material high in fines

Rule Call:

Resource Vulnerability:	High for fines in segments 201, 202, 205, 801, 7, 4, 2, 1
Delivered Hazard:	High
Rule Call:	None, non-forestry activities

Additional Comments:

A long stretch of Johnson Grade Road has no cross drains and delivers via a large gully to Onion Creek. This road receives high residential traffic use and has a high, raveling cutslope with a persistent landslide. The toe of the landslide is undermined by periodic road maintenance, re-activating the slide.

Fine sediment was abundant in segment 202 adjacent to the Bodie Mountain road where high volumes of road sediment are delivered to the stream. Soils in this area are fine-textured from a slatey parent material source. The flat, angular slate particles also contribute to packing within the stream bed. Both residential and forestry use of the Bodie Mountain road contribute to the majority of sediment input to streams in the lower Onion Creek sub-basin. Road dust from the carbonate soils was also found to cement the bed surface in segment 202 adjacent to this road.

4.2 Prescriptions

Voluntary Action:

4.3 Causal Mechanism Report for Forest Practices Roading in Swales

Resource Sensitive Area(s): Unchannelized swales hydrologically connected to streams. Most are unmapped, but could be unchecked ephemeral streams on Map E-1/F-1

Triggering Mechanisms:

1. Roads built in wet swales
2. Exposure of bare mineral soil and/or soil compaction from skidding that leads to permanent surface drainage.

Rule Call:

Resource Vulnerability:	High in channel geomorphic units 1, 2, 4, 7, 8 for fine sediment Moderate in channel geomorphic units 5, 6a, 9 for fine sediment
Delivered Hazard:	Moderate
Rule Call:	Prevent or Avoid

Additional Comments:

Grassy swales with no defined channel were removed from the stream layer. All or portions of these swales may in fact be wet during certain times of the year; however, surface runoff conditions are not sufficient for channel initiation. Segment 203 has a well-traveled road located within a former wet swale. The result has been a displacement of the absorption and filtering function of the swale. Former subsurface flow is now channelized into the road ditch and tread, and both the road surface and the ditch drain directly into a stream channel. A high potential exists for increasing the sediment-contributing drainage area in this manner due to the number of non-surface draining swales within the WAU.

Forest harvest activities have a higher potential to contribute to this situation than other land uses due to the intensity of ground-based operations within areas of swale topography. Conversion of forestry land to rural residential may also increase the potential of roading in swales from non-forestry activities.

4.3 Prescriptions

Prescriptions:

Justification for Prescriptions:

Voluntary Action:

4.4 Causal Mechanism Report for Mining Related Sediment Contributions

Resource Sensitive Area(s): Mass Wasting Map Unit 5: Van Stone Mine area

Triggering Mechanisms:

Both coarse and fine sediment have episodically been delivered to Onion Creek from mining-related activities.

1. A failure of the lower tailings pond in 1961 caused major gullying of the valley floor, destruction of at least one building, and delivery of a large but unspecified volume of sediment to Onion Creek.
2. Periodic tailings pipe bursts during operations have delivered unquantified volumes of tailing slurry to Onion Creek.
3. Evidence would indicate that a pipe burst may have been responsible for a large failure on the slope opposite the upper tailings pond visible in 1968, and chronic surface erosion of that scar continues to deliver granitic sand to the channel.

Rule Call:

Resource Vulnerability:	High in channel geomorphic units 1, 2, 7, 8 for coarse and fine sediment, and for fine sediment in unit 4 Moderate in channel geomorphic units 5 and 9 for coarse and fine sediment and for coarse sediment in unit 4.
Delivered Hazard:	Moderate
Rule Call:	None, non-forestry activity

Additional Comments:

The number and volume of mining-related discharges of tailing slurry to Onion Creek during years of operation are not well documented. The assessment team could not find or did not have access to any documents assessing the off-site impacts of sediment from the mine. Papers were available on the water quality implications, however (see Water Quality Resource Situation of Concern).

Richard LeCaire, currently the fisheries biologist with the Colville Confederated Tribes, worked at the mine during the late 1960's and early 1970's. He has communicated that it was not uncommon for the tailing slurry pipe to break and go unnoticed for an 8 hour shift (the mine produced ~1,000 tons/24 hr shift). The earliest aerial photos show traces of the lower tailing pond failure to the south of the pond on the valley floor.

Sections of concrete pipe were found at the toe of the slope failure that appears in the 1968 photographs opposite the upper tailings pond. The slope has the morphology of an extremely large gully as opposed to a slump or shallow soil slip, suggesting erosion by a large volume of

water. It is not clear from anecdotal accounts and field evidence if the upper failure is in fact the 1961 tailing pond break or a separate incident. Interpretation of downstream disturbance in succeeding photos indicates that the sediment may have taken 10 to 20 years to transport through the stream. Sediment from this failure and the chronic erosion of the scar in deep till soils may continue to be present in the stream.

4.5 Causal Mechanism Report for Erosion Related to Grazing

Resource Sensitive Area(s): Livestock grazing in and adjacent to stream segments 7 and 10

Triggering Mechanisms:

1. Erosion of streambanks by livestock access to water.
2. Removal and destruction of riparian vegetation critical to providing root strength for maintaining streambank integrity and recruitment of woody debris for channel and habitat complexity (some overlap with CMR 3).

Rule Call:

Resource Vulnerability:	High in channel segments 7 and 10 for coarse and fine sediment
Delivered Hazard:	Moderate
Rule Call:	None, non-forestry activity

Additional Comments:

Livestock access to streams in Onion Creek is concentrated in segment 7 upstream of the Onion Creek store and in segment 10 south of the lower mine tailings pond. A small herd of cattle have access to approximately 2,000 feet of channel in segment 7. Erosion of approximately 70 percent of the banks far exceeds that of non-grazed segments. In segment 10, several horses were observed to be pastured within the stream and are impacting a smaller point source area. Although grazing contributes a smaller percentage of estimated annual sediment, the effects are highly localized within potentially high quality, low gradient fish habitat. All particle-size fractions are represented in the banks and may contribute a higher percentage of the granitic sand than some road erosion.

4.6 Causal Mechanism Report for Landslide L1, Mass Wasting Map Unit 2

Resource Sensitive Area(s): Landslide L1, Mass Wasting Map Unit 2

Triggering Mechanisms:

Landslide L1 is a slump block in glaciolacustrine sediments exposed on the Johnson Grade Road. Small, sporadic failures occur by continual regrading of the inboard road that weakens the toe of the slide. Slide material is delivered to Onion Creek through the road ditch and outfall that has gullied the slope below the road. Forestry activities on the slope above the road that compact or direct water to this slide and associated slopes would increase saturation and contribute to the instability of the slope.

Rule Call:

Resource Vulnerability:	High for coarse and fine sediment in segments 1 and 2
Delivered Hazard:	Moderate
Modified Rule Call:	Minimize

Additional Comments:

The rule call has been modified from prevent or avoid to a minimize as delivery to the vulnerable resources is through surface erosion of the scar and transport through the road ditch. Currently, a lack of adequate cross drains on this road lends to additional erosion and delivery of sediment (CMR 4.2).

4.6 Prescriptions

Prescriptions:

Justification for Prescriptions:

Voluntary Action:

WATER QUALITY SITUATIONS OF CONCERN

Below are descriptions of existing or potential water quality conditions in Onion Creek not pertaining to forest practices. These findings are reported here because addressing these water quality conditions are not within the analytical or regulatory scope of this analysis.

Resource Situation - Fecal Coliform

The water quality monitoring data indicate that Onion Creek meets the Class AA standards with exceptions during low flow periods in late summer and early fall. With warm air temperature and low flow, the water temperature has exceeded 16°C and fecal coliform bacteria has exceeded 50 colonies/100 ml. A stream temperature analysis has been conducted within the Riparian Assessment, and situations of temperature concern to resources are addressed in Causal Mechanism Report 3. The fecal coliform bacteria may be contributed from livestock having direct access to the stream or from failing and poorly designed septic systems. Fecal coliform levels have the potential to increase in the future from increasing residential development and inadequate enforcement of building regulations. The bacteria does not adversely affect fish, and its presence in the water column is not associated with standard forest practices.

Resource Situation - Heavy Metals and pH

The Van Stone Mine has operated intermittently since 1926 when large lead and zinc deposits were discovered. Milled wastes are stored at two mine tailing ponds in the upper Onion Creek drainage. The tailings contain a number of trace metals including: aluminum, arsenic, barium, calcium, cadmium, chromium, copper, iron, potassium, magnesium, manganese, molybdenum, sodium, nickel, lead, antimony, selenium, vanadium and zinc.

Routh and Ikramuddin (1996) concluded that heavy metal contamination is buffeted by high pH due to calcium carbonate dissolution in Onion Creek. The metal oxides form insoluble trace metal complexes in the presence of the dissolved calcium carbonate which then precipitates or adsorbs to sediments in the upper reaches of Onion Creek downstream of the mine wastes. Although the concentration of lead and zinc are above background levels, water quality meets EPA regulatory standards.

Trace metal concentrations may be affected by changes in runoff and sediment scouring events (Routh and Ikramuddin, 1996), but have not been measured. The Van Stone Mine tailings consists primarily of sulfates, sulfides and carbonates that rapidly oxidize in oxygenated water (Routh, 1993). During a tailings pond breach or high runoff event that mobilizes tailings into Onion Creek, the pH might fall below the class AA standard of 6.5. Trace metals may be redissolved into the water column at low pH levels (Routh and Ikramuddin, 1996). Such an event would occur over a short time period of a few hours, but the long term affects on the aquatic

community are unknown.

Continued water quality monitoring of the Onion Creek WAU is recommended to identify the contribution of water quality effects from the Van Stone Mine. Samples should also be taken during the period of extreme rainfall and runoff events. In addition, monitoring the assemblages of aquatic macroinvertebrates may help to assess the chronic effects of inputs from the Van Stone Mine.

To ensure accuracy and validity of water quality data, collection methods employed by Equinox Resources should be required to meet the same standards of quality control as applied by the SCCD. Without quality control checks, water quality data are not valid.

References

Routh, J. 1993. Impact of lead-zinc mining on distribution of major and trace elements in water, sediment, and soil in Van Stone Mine Stevens County, Washington. Masters Thesis. Eastern Washington University.

Routh, J. and M. Ikranuddin. 1996. Trace-element geochemistry of Onion Creek near Van Stone lead-zinc mine (Washington, USA)-Chemical analysis and geochemical modeling. Chemical Geology, V. 133, pp 211-224.

Onion Creek
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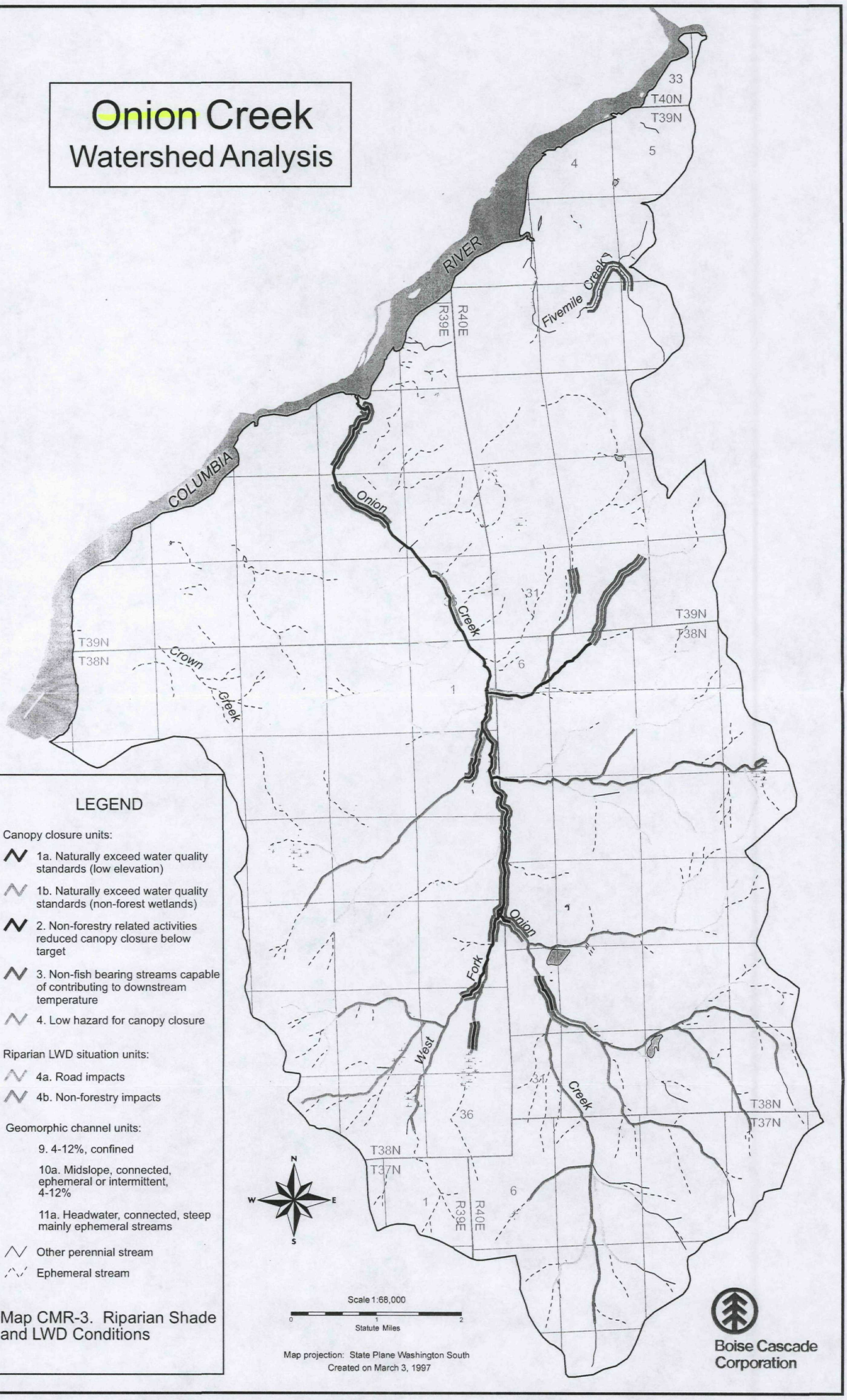

LEGEND

Canopy closure units:

- 1a. Naturally exceed water quality standards (low elevation)
- 1b. Naturally exceed water quality standards (non-forest wetlands)
- 2. Non-forestry related activities reduced canopy closure below target
- 3. Non-fish bearing streams capable of contributing to downstream temperature
- 4. Low hazard for canopy closure

Riparian LWD situation units:

- 4a. Road impacts
- 4b. Non-forestry impacts

Geomorphic channel units:

- 9. 4-12%, confined
- 10a. Midslope, connected, ephemeral or intermittent, 4-12%
- 11a. Headwater, connected, steep mainly ephemeral streams

- Other perennial stream
- Ephemeral stream

Map CMR-3. Riparian Shade and LWD Conditions

6.0 MONITORING

6.1 Validation Monitoring

1. The extended fish distribution based on the new channel definitions in the FPB emergency rule has not been field verified. The capacity of these small stream channels to support fish is uncertain. Fish surveys would help test the validity of this new rule. In addition, the presence of native bull trout, or cutthroat in the Onion Creek WAU has not been documented. We have suggested it is unlikely native bull trout or cutthroat occur in the Onion Creek WAU because of the glacial history of the watershed and the barrier falls near the mouth. However, there has been extremely limited fish surveys and more extensive surveys would help to verify this assertion.

2. Potential fish barriers have not been field checked at road crossings on the channel segments extended as Type 3 under the emergency rule. A determination of potential fish use in these segments may reduce the list of crossings to check for barriers.

3. Since there is uncertainty regarding the cause for a lack of sorted spawning gravel in Onion Creek, baseline data on bed particle composition is recommended in those reaches noted as lacking. Repeat measurements are recommended following major floods, large drought cycles, and major or local channel changes resulting from either disturbance events or enhancement. Additional data collected may include the angularity and lithology of medium-gravel size and larger particles. Analysis of data will quantify the abundance of certain particle sizes, the influence of local sediment sources, and effects of the flow regime on sediment size and distribution.

4. Road surveys on the segments of native surfaced roads that deliver to streams during the late spring (after snowmelt, prior to road maintenance/grading) would be helpful to determine the extent of gully erosion. Erosion from gullying may be a significant source of sediment if occurring on an annual basis.

5. Additional monitoring is recommended to verify target canopy closure levels as modified in this analysis. Thermograph monitoring with more stations deployed would increase the sample size in re-analyzing the multi-regressions for temperature and independent variables of elevation and shade. A minimum of 15 sites is suggested using Table D-11 as a monitoring site selection guide (Appendix D). A range of elevation and canopy closure conditions should be included in the monitoring sites. Air temperature and relative humidity should also be monitored simultaneous with water temperature at hourly recording increments using calibrated, continuous recording thermographs. Even instantaneous single water temperature readings by a hand held mercury thermometer during afternoon hours of a hot summer day between July 15 and August 15 would

provide usable data. Newly collected data can be combined with existing data from this report. Shade data should be collected concurrently with temperature monitoring. Sampling sites should have uniform canopy closure levels for a minimum of 1,000 feet upstream of the sampling site. Additional sampling may allow managers to set lower target shade levels according to the regression line with a far narrower confidence interval. Ensure that the monitoring program meets TMDL monitoring guidelines.

6. Continued water quality monitoring of the Onion Creek WAU is recommended to identify the contribution of water quality effects from the Van Stone Mine, agriculture, residential development and forest practices. To ensure accuracy and validity of water quality data, collection methods employed by Equinox Resources should be required to meet the same standards of quality control as applied by the SCCD. Without quality control checks, water quality data are not valid.

7. Water quality samples should be taken over the period of extreme rainfall and runoff events. During "normal" periods, mine tailing sediments are contained and trace metals adsorbed to sediment particles. During a rain storm event runoff from the tailing ponds or, less likely, harvest units may enter Onion Creek and have an acute impact with long term effects. In addition, monitoring the assemblages of aquatic macroinvertebrates may help to assess the chronic effects of inputs from the Van Stone Mine.

8. Model LWD recruitment based on regional riparian inventory study being done by CES/Boise using prognosis modelling.

6.2 Compliance Monitoring

Sediment

some monitoring for compliance appropriate - prescription team

6.3 Effectiveness Monitoring

Monitoring the effectiveness of the prescriptions in addressing the resource situations will provide valuable feedback to the adaptive management loop and provide data to support any appropriate changes to prescriptions at the five year review.

1. Monitoring of surface erosion from the county road segments following implementation of any erosion control measures (i.e. installation of cross-drains to direct runoff to surface floor) could be useful to test the effectiveness of the control measures. (Turbidity measurements?)

2. Monitoring of the mine facilities, particularly if the mine is re-opened, would help to quantify the amount of erosion associated with the mine works.

3. Effects on slope stability from changes in road construction methods (reducing risk of gullying and landsliding by reducing concentrated drainage discharge onto steep slopes) and management practices (maintaining culverts) should be seen over time by comparison of the existing mass wasting inventory with subsequent events, and by inventorying events that occur in areas of new road construction. New and existing roads in MWMU # 3 in particular should be monitored by observation for signs of incipient failure, such as tension cracks on road surfaces.

4. Monitoring the effectiveness of any enhancement efforts is recommended.

APPENDIX A
MASS WASTING

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Table A-1. Required Module Work Products and Comparable Products for Onion Creek

Required Module Product	Onion Creek WAU Mass Wasting Analysis Product	Location in this Report
Map A-1, Landslide Inventory	Map A-1/A-2 combined	Map A-1/A-2
Map A-2, Mass Wasting Map Units and Hazard Ratings	Map A-1/A-2 combined	Map A-1/A-2
Form A-1, Mass Wasting Inventory Data	Same as required product	Page A-14
Form A-2, Mass Wasting Map Unit Description	Same as required product	Page A-16
Form A-3, Mass Wasting Summary Table	Same as required product	Page A-21

APPENDIX A. MASS WASTING

1.0 INTRODUCTION

Mass wasting is the downslope movement of soil and rock material under the direct influence of gravity. Whether natural or management-induced, landslides can drastically alter the character of stream channels or adversely affect public resources, such as roads, bridges, or water supply.

The purpose of the mass wasting analysis is to evaluate the contribution of sediment delivered to stream channels by landslides. This is accomplished by inventorying historic and existing mass wasting features, identifying specific trigger mechanisms, and distinguishing among the types and rates of the processes active in the basin. In addition, the analysis attempts to distinguish between natural landslides (background) and landslides that are caused by land use activities or management activity, such as road building or logging.

The analysis methodology characterizes landscape areas that have produced landslides in the past and that have the potential to produce more landslides in the future. This is done by analyzing historical aerial photographs and conducting field surveys to create a landslide inventory; characterizing the geology underlying known landslides for its susceptibility to failure; and analyzing the geomorphic characteristics of the watershed that have produced landslides.

This assessment provides information based on geologic and terrain characteristics that will be used as guidance in developing forest management prescriptions for reducing mass wasting and the associated sediment delivery to streams. Information consists of maps and text that lead to ratings of delivered mass wasting hazard for geographic zones of the basin.

While the Onion Creek watershed has a complex geologic history, the most recent continental glaciation has left a subdued landscape. Glaciation has scraped weathered rock surfaces clean, rounded peaks and ridges, and deposited deep, well-drained soils throughout the watershed. Older Paleozoic rock and younger Mesozoic granite are competent, and not subject to rock fall or rock slide processes. The relatively dry climate, coupled with jointed bedrock and permeable soils, help reduce the hydrologic component driving mass wasting processes of the type and density associated with wetter areas of the state (i.e., western Cascades). In addition, many stream channels and swales are not connected throughout much of the lower portion and some of the upper portions of the watershed, providing little opportunity for mass wasting to adversely affect downstream resources.

1.1 Geologic Overview

The Onion Creek Watershed Administrative Unit (WAU) is located within the Northern Rocky Mountains physiographic province of northeast Washington (Easterbrook and Rahm, 1970), near Northport in Stevens County. The WAU is bounded on the north by the Columbia River, between nine and twenty-two river miles south of the Canadian border. It is bounded on the

south by Gillette Mountain, and on the west by Staghorn Mountain, Grande Mountain and O'Toole Mountain. The Deep Creek drainage is adjacent to the Onion Creek WAU to the east. Total relief in the basin is about 4,285 feet, rising from a pond elevation of about 1,290 feet on Roosevelt Lake Reservoir on the Columbia River to about 5,575 feet on Gillette Mountain to the south. The area receives about 24 inches of precipitation per year, much of it in the form of snow.

The area is near the south end of the Kootenay Arc, a 250 mile-long arcuate belt of multiple deformation extending from north of Revelstoke, British Columbia to south of Hunters, Washington. The belt consists of metasedimentary rock deposited in a continental margin basin environment (Yates, 1970). Ages of the deformed rocks range from late Precambrian to Middle Jurassic. Dominant rock types in the WAU belonging to the Kootenay Arc include very competent Paleozoic sedimentary and metasedimentary rock consisting of limestone, dolomite, argillite, phyllite, slate and quartzite. These rocks are intruded by a batholith of granitic composition (the Spirit Pluton) over a large area of the central portion of the WAU.

Structural lineaments are generally oriented northeast, sympathetic with the trend expressed by the Columbia River in that region. Metasedimentary rocks in the northern portion of the WAU have been tightly folded, in places overturned to the north-northwest. Bedding strikes throughout the area are generally northeast, and dips are moderate to steep to the northwest and southwest. Major and minor folds and their associated lineations plunge southwesterly. The time during which deformation took place is only approximately known. Folded strata of Paleozoic age near the Northport area are cut by dikes about 50 million years old, and a few miles south folded strata are cut by the Spirit Pluton, which has been dated to about 100 million years old. Hence, the latest deformation reasonably occurred between 100 and 200 million years ago (Mills and Nordstrom, 1973). Following deformation, the region was subjected to a mild flexure deformation, extension in a northeast-southwest direction with development of joints, and by thrust faulting probably in response to compressive stresses acting in a north-south direction.

Rock outcrop of the Spirit pluton exhibits strong jointing that trends northeast. This jointing acts as a control on most western drainage tributaries to Onion Creek, which trend northeast. Porosity due to jointing in the granitic rock is likely concentrated along fracture zones and likely increases with the width of the joints at depth.

In many ways the landscape of the Onion Creek WAU is a legacy of the last great ice age. Continental glaciation overwhelmed the peaks and ridges, which were subdued under a load of moving glacier ice and subject to the rounding effects of glacial scour. Where exposed, bedrock surfaces are generally fresh and unweathered. As with other valleys in the Northern Rocky Mountain Province, the north-south orientation of the Onion Creek valley was a pathway for lobes of the Cordilleran Ice Sheet during successive glacial advances.

Glacial landforms are entirely of Wisconsin Age and are well preserved. At the time of maximum glaciation during the late Wisconsin, about 18,000 years ago (Kiver and Stradling, 1986), the area was completely covered by glaciers. Erosional details include polished outcrops

and some rock-basin lakes. On some mountainslopes and foothills parallel to the north-south valley of Onion Creek the rock is locally eroded into streamlined forms. Bedrock surfaces in valleys above elevations of about 2,000 feet are extensively covered by a deep mantle of coarse to fine ablation till. Thin, discontinuous patches of till remain on mountain slopes and in the upper portions of tributary valleys. Glacial deposits also include large outwash terraces, and large terraces of ice-marginal lakes or kame terraces along the Columbia valley. The ice blocked off the Onion Creek tributary valley and provided conditions favorable to the development of terraces composed of low energy deposits of sands, silts and clays.

1.2 Geologic Map Units

Geology of the basin is displayed in Figure 4, Onion Creek Geology Map (Executive Summary, Section 2.2). The map was compiled from geologic maps and investigations by Joseph (1990), Kiver and Stradling (1986), and Yates (1964 and 1971). Unit Pmsu includes (from oldest to youngest): Cambrian Gypsy Quarzite, a thick-bedded quartzite interbedded with argillite; Cambrian Maitlen Phyllite, a fine-grained, thin bedded to medium-laminated phyllite interbedded with quartzite and limestone; Ordovician Ledbetter Slate, a slate and argillite with argillaceous limestone; and minor occurrences of Carboniferous phyllite and argillite. Unit Pl is comprised mostly of Cambrian to Ordovician Metaline Formation limestone and dolomite, that is subdivided into a lower thin-bedded limestone interbedded with shale and phyllite, a middle medium- to thick-bedded dolomite, and an upper massive limestone unit.

Unit Ki is Mesozoic granite of the Spirit pluton. The Spirit pluton regionally is elongate in an east-west direction, and locally cuts discordantly across northeast-trending folds in Paleozoic rock. The pluton consists of porphorytic biotite granodiorite and non-porphorytic granodiorite. Most exposures of the granite bedrock are fresh, having been scoured by recent glaciers. However, some exposures of the granite show its tendency to disintegrate rapidly into grus (angular, coarse-grained fragments derived from weathering of granitic rock). Where preserved, the accumulation of grus may be several yards thick. Much of the grus throughout the upper basin has been incorporated into till deposits mantling the foothills and mountain sideslopes and ridges.

Quaternary glacial units are mapped as glacial outwash (Qgo), glacio-lacustrine (Qgl), and till (Qgt). Glacial outwash and glacio-lacustrine units dominate the lower (northern) portion of the WAU along the Columbia River valley. Outwash is mostly crudely bedded, poorly sorted, fine to coarse sand, with rounded to well-rounded gravel, and silt with local inclusion of clay. Glacio-lacustrine deposits consists of very fine sand, silt, and clay interlaminated with silt in horizontal to wavy beds. Except for Five Mile Creek and drainages to Onion Creek, runoff drainages from hillslopes adjacent to the Columbia River valley do not extend down to the Columbia River; outwash terraces have high infiltration rates and contribute water to the ground-water systems. Much of the till (Qgt) in the valleys and footslopes of the upper portion of the watershed is deep ablation till, comprised of permeable fine to coarse sand. In tributary valleys on the eastern portion of the upper basin at about the 3,000 foot level, multiple more-or-less horizontal clayey beds are interbedded with coarse granular sands, suggesting probable ice-impounded drainage segments. Much of the deep till throughout the basin is permeable and well

drained, but may locally have relatively impermeable boundaries of a more clay-rich composition.

1.3 Soil Unit Descriptions

The formation of geologic units has a strong control on the distribution and properties of soils in the WAU. One of the important properties of these soils is their permeability, enabling them to drain rapidly. Soils in the basin can be generally grouped into three main categories (USDA Soil Conservation Service, 1982): (1) soils on mountains; (2) soils on foothills; and (3) soils on terraces (please refer to Table B-1.1, Appendix B: Surface Erosion, for a tabular display of pertinent soil characteristics).

Soils on mountains include two sub-groups: the Spokane-Moscow-Rock outcrop group, and the Huckleberry-Raisio-Hartill group. The Spokane-Moscow-Rock outcrop soils are moderately deep, well drained, nearly level to very steep soils formed in material weathered from granite, with an admixture of loess and volcanic ash, and rock outcrop. This soil group is generally found on south aspect sideslopes in the northern portion of the upper basin, and on east aspect granite sideslopes in the western portion of the upper basin. The Huckleberry-Raisio-Hartill soils are moderately deep, well drained, nearly level to very steep soils formed in material weathered from shaly rock. This soil group is generally found on north aspect sideslopes in the south portion of the upper basin.

Soils on foothills include two sub-groups: the Aits-Newbell-Donavan group and the Belzar-Smackout-Maki group. The Aits-Newbell-Donavan soils are very deep, well drained, nearly level to very steep soils formed in mixed glacial till, with a mantle or admixture of volcanic ash and loess. These occur on all footslopes and valleys in the upper basin. The Belzar-Smackout-Maki soils are moderately deep and very deep, well drained, nearly level to very steep soils formed in glacial till from shaly rock and residuum and colluvium from limestone, with a mantle or admixture of volcanic ash and loess. These are generally found in the lower portion of the basin east of Onion Creek.

Soils on terraces and terrace escarpments include the Clayton-Cedonia-Martella group, which are very deep, well drained, and moderately well drained, nearly level to very steep soils formed in lake sediment and glaciofluvial material, and the Springdale-Spens-Bisbee group, which is a very deep, somewhat excessively drained, nearly level to very steep soils formed in glacial outwash.

1.4 Major Basin Landforms

Figure A-1 displays a landform map for the basin. Landform designations are assigned to surface features based on the origin and development of the landscape as it is expressed in the topography. Landforms are the basis of mass wasting unit descriptions due to similarities of mass wasting types and densities.

Principal landform divisions in the watershed consist of:

- Steep (greater than 70 percent) sideslopes on foothills and mountains. Generally on north aspects of Paleozoic rock (Pmsu and Pl) in the lower portion of the watershed east and west of Onion Creek, and in minor areas on north aspects of Paleozoic rock in the upper portion of the watershed.

- Folded and faulted Paleozoic sedimentary and metasedimentary rock on sideslopes and ridgetops of foothills and mountains. Includes rock outcrop, colluvial soils, and shallow till.

- Subdued hills of Mesozoic granitic rock on footslopes and sideslopes of foothills in the upper watershed. Includes rock outcrop, colluvial soils, and shallow till.

- Deep till in valleys and on toeslopes and footslopes of foothills. Includes some areas of deep till on mountain sideslopes and ridgetops.

- Glacio-fluvial and glacio-lacustrine terraces in the lower portion of the watershed; includes alluvial fans on toe slopes of foothills.

- Steep-walled escarpments in glacio-fluvial and glacio-lacustrine terraces, mainly in the lower portion of the watershed.

The general topography of the basin is an expression of the erosive effects of recent glaciation on competent rock; surfaces are generally fresh and ridges are rounded. The extent of steep lands is generally limited to tilted strata of competent metasedimentary rock and terrace escarpments. The landscape also reflects depositional effects of glaciation as a mantling of till on sideslopes and in valleys in the upper basin, and deposition of glacial outwash and glacio-fluvial terraces in the lower basin. Terraces in the lower watershed include two features of probable collapsed ice-walled lakebeds west of Onion Creek, kame terraces at about 1720', 1760', and 1600,' and glacio-lacustrine terraces at about 1560' to 1610', 1410' to 1490', and 1320' to 1360' (Kiver and Stradling, 1986)

2.0 METHODS

Methods used for data collection and analysis for this module are those described in the Watershed Analysis Manual, Version 3.0 (Washington Forest Practices Board, 1995). A landslide inventory was conducted by analyzing historical aerial photographs and by conducting field surveys to verify mapped landslides. From these surveys the geology underlying known landslides was characterized for its susceptibility to failure. Finally, the geomorphic characteristics of the watershed that have produced landslides were analyzed to determine mass wasting map units and hazard ratings. As the purpose of this report is to evaluate the effects of past and future land use activities on mass wasting processes, landslides on shorelines of the reservoir were not considered in the analysis.

2.1 Aerial Photograph Analysis

Black and white photo copies of aerial photographs from 1968, 1980, 1987, and 1992, and aerial photographs from 1977 and 1995, were examined to identify landslide scars and structural features. All photos except the 1977 and 1995 set were of approximate scale 1:12,000; the 1977 and 1995 sets were approximately 1:60,000 and 1: 63,360, respectively.

Potential landslide locations were recorded on USGS 1:24,000 7.5 minute topographic maps. Soil types were taken from the 1:24,000 SCS soils maps for Stevens County (USDA Soil Conservation Service, 1982). Bedrock and surficial deposit types were determined from geologic maps at scales of 1:100,000 (Joseph, 1990), 1:31,680 (Yates, 1964 and 1971), and 1:24,000 (Kiver and Stradling 1986).

2.2 Field Reconnaissance

Four days (September 30, October 1, 3, and 4, 1996) were spent in the field to verify photo-identified sites, and to assist with the surface erosion inventory along county and forest roads. Few photo-identified sites were verified as landslides; the other suspected sites were verified as benign surface scars at landings or were blemishes in the copy quality of the photo-copied sets of aerial photographs.

3.0 ANALYSIS AND RESULTS

3.1 Mass Wasting Inventories

A total of 16 landslides, three of which are ancient (inactive), were identified on the aerial photos and in the field. All slides occurred within glacially derived material; no slides were identified that are associated with bedrock failures. Ten landslides delivered sediment to streams. A brief summary is given below:

8 shallow-rapid landslides related to roads

4 shallow-rapid landslides with no forest-related land use identified

1 deep-seated landslide related to roads

3 deep-seated ancient landslides

Road building and harvest have occurred extensively in all MWMU's. No mass wasting was associated with harvest in any area, while roads (including non-forest roads) were associated with about 70 percent (9 of 13) of all active mass wasting features. Map A-1 shows the locations of the mass wasting features. Results are also summarized on Forms A-1, A-2, and A-3 (at the end of this appendix).

Each identified mass wasting feature displayed on Map A-1 was given a landslide identification number based on the location of its point of origin. The identification number consists of the Township, Range, Section, 1/16 Section, and number of feature. For example, 38/40E-33D1 is

the first feature mapped in the "D" 1/16 Section in Section 33 of Township 38N, Range 40E. For simplicity, only the lettered 1/16 Section and feature number are displayed with the feature location on the map.

3.2 Observations

3.2.1 Field Verification

Of 21 potential features identified with aerial photos, 16 were visited in the field. Only three of the potential 21 features were verified as "real;" the other 13 were found to be cut slopes, landings, or blemishes on the photo copies. Five mass wasting features not visible on photos were found during field surveys, and five other photo-identified potential failures, excluding ancient deep-seated landslides, were not field checked.

3.2.2 Material Properties

All mass wasting in the WAU occurred in glacially derived sediments. These sediments exhibit a variety of properties, some of which are conducive to mass wasting and others of which are not. Till in the upper portion of the watershed consists of abundant amounts of coarse granitic sand, derived locally from grus and incorporated by the ice. For the most part, this till is well to very well drained. Portions of this till have a high sand, low clay content that maintains an angle of repose of less than about 35 degrees. Steeper slopes can be maintained with increasing clay content, but at the expense of reduced permeability. This can be problematic in areas of markedly contrasting permeability boundaries. In that case, groundwater can emerge as springs or seeps on cut banks of roads or stream channels, and induce shallow rapid landsliding as pore pressures are elevated.

Glacio-lacustrine and outwash sediments, generally on terraces and terrace escarpments in the lower portion of the WAU adjacent to the Columbia valley, consist of higher contents of silts and fine grained sand. Dry escarpments consisting mostly of silt and clay can retain steep slopes, but behave viscously when moist. They have lower permeability, and may retain moisture over extended periods of time, showing a tendency to cause saturation of overlying materials, with a consequent increase in pore pressures that can destabilize slopes.

3.2.3 Mass Wasting Processes

The inventory of landslides in the WAU shows that shallow rapid failures dominate, controlled in part by soils with contrasting permeabilities. It is a delicate balance at present; very little mass wasting occurs due to the lack of pore water pressure. Generally high permeabilities, coupled with deep soils and extensive jointing in the bedrock, help mitigate the tendency for landsliding in the Onion Creek WAU. If climate were to radically change for the wetter, we would expect to see more failures associated with prolonged saturation of soils and relatively greater duration of flood flows. A case can be made for expecting an increase in landsliding as a result of prolonged saturation by observing that a great number of landslides occur along the shore of Lake Roosevelt as a result of saturation by fluctuating reservoir levels (see Kiver and

Stradling, 1986, for an inventory of landslides included in their Lake Roosevelt Shoreline study).

4.0 MASS WASTING MAP UNITS

The basin landscape was partitioned into map units, based on physical characteristics contributing to slope instability and the potential for landslide sediment to enter streams or affect other public resources. Mass Wasting Map Units (MWMU) in the Onion Creek watershed are strongly related to landform. In addition to landslide processes, landslide densities, and landform, other criteria used to delineate MWMU's included slope gradients, bedrock type and structure, soil material, potential for sediment delivery to streams, and slope hydrology. Five MWMUs were delineated. These units are displayed on the combined Map A-1/A-2, and described below. In addition, a summary description of MWMU's is provided in Form A-2, and the number of mass wasting features associated with various land use activities is tabulated in Form A-3. Forms A-2 and A-3 can be found at the end of this report.

4.1 Mass Wasting Map Unit #1

MWMU # 1 is characterized by steep (greater than 60 percent), planar to concave slopes adjacent to confined stream channels within the 2,400 to 4,000 foot elevation range. These channels occupy relatively narrow valleys, with little or no intervening low-gradient flood plain or terrace between the channel and the valley slopes. The slopes generally steepen above the channel, and then break in gradient between the inner gorge slope and the lower gradient hillslope or footslope above.

Materials within MWMU # 1 are typified by moderately deep to deep (greater than 24") permeable sandy till overlying a relatively impermeable till with higher clay content, or lenses of horizontally bedded clay. Seeps and springs are not uncommon at these boundaries.

Five shallow rapid landslides were identified in this unit, at least one of which continued down the channel as a debris flow (landslide identification number 38/40E-33D1; photo year 1968). Slopes of mapped failures typically exceed 60 percent, and head scarps initiate at differential permeability boundaries. Erosion of toe slopes by stream incision may exacerbate failure on over-steepened slopes with long slope lengths. Four failures are associated with roads, at least one of which likely was triggered by concentrated surface water discharging onto a steep slope. The other three of the four slides may have been triggered by sidecast fill failures. A fifth slide was triggered at a seep as the sandy, dry overburden was saturated at an impermeable boundary (38/40E-19M1).

The hazard potential rating for MWMU # 1 is moderate. Failures indicate a moderate sensitivity to forest practices by roading. Sensitivity to harvesting is low, based on historical observation. Mass wasting potential under unmanaged conditions is low. The delivery potential is high, as steep slopes adjacent to stream channels have no where else to go when they fail.

4.2 Mass Wasting Map Unit #2

MWMU # 2 is characterized by planar, steep slopes (greater than 50 percent) on escarpments of glacio-lacustrine or outwash terraces. This landform occurs from 1,290 feet to about 2,000 feet. Materials are dominantly fine textured silty or sandy loams, or fine to coarse sand, interlayered with clay or fine silt.

A total of six landslides were observed in this unit. Three of the slides are ancient, very large, deep seated slides. Two of the three active slides are shallow rapid, one of which is (non-forest) road related. The road related slide (39/39E-28P1) appeared between aerial photo sets 1980 and 1987 following some small construction activity and development of a road at the escarpment crest. A third slide is a small, sporadic, chronic indication of a large persistent deep seated slide (39/39E-23L1).

Roading exacerbates the instability of steep escarpment slopes in several ways. Compaction of the surface by roading will allow surface water to concentrate, and discharge onto the steep slope. Road maintenance in the area of the large, persistent deep-seated slide continually removes the toe of the slumps by grading. Construction of roads at the top of this slide may further enhance instability by directing runoff onto the failure plane.

The hazard potential rating for MWMU # 2 is low, due to moderate mass wasting potential and a low delivery potential. Relative to its area, very few active slides were observed for this unit; however, with pressures of development and associated increase of road density, more frequent sliding could be a future concern. On the other hand, most terrace escarpments are remote from active streams. Only one active slide at present has the potential to deliver sediment to a stream (39/39E-23L1). Sediment delivered from this slide is routed through a gully developed from concentrated road runoff.

4.3 Mass Wasting Map Unit #3

MWMU # 3 is characterized by steep slopes (greater than 65 percent) on metasedimentary bedrock with dipslopes parallel to the hillslopes. These areas are further characterized by concave hollows adjacent to active stream channels, typically in the 1,800 feet to 5,000 feet elevation range. This unit delineates only those areas that could deliver sediment to streams.

Materials are dominantly shallow, fine to coarse colluvium or till overlying generally competent bedrock. The soils are moderately to very well-drained. In places these soils may be overlain by a mantle of volcanic ash, and so may be susceptible to puddling when compacted.

While no mass wasting was observed in this unit, concerns for failures in the future are justified by the presence of tension cracks in road tread and on fill, and by anecdotal evidence of a small fill failure at a stream crossing about fifteen years ago. In this case, trigger mechanisms relate to potential failure of saturated sidecast material placed on steep slopes, or to gullying of road fill at stream crossings due to undersized or blocked culverts.

The hazard potential rating for this unit is low due to low mass wasting potential. Sensitivity to harvesting is low, based on historical evidence that shows no discernible features in areas that have been harvested. However, the delivery potential is high everywhere, owing to the unit's mapped position in steep upland hollows adjacent to active streams.

4.4 Mass Wasting Map Unit #4

MWMU # 4 is characterized as relatively stable areas over a variety of landforms, slope gradients, and elevation ranges. This unit makes up the vast majority of the watershed, and so encompasses materials of all particle sizes of residuum, till, and rock outcrop.

Three mass wasting features were identified for this unit; all shallow rapid. One non-forest road related shallow landslide occurred in an unmanaged forest area, in shallow, fine- to coarse-textured colluvium and till overlying bedrock, with no sediment delivery to stream channel (40/40E-33N1). Two forest road related failures at stream crossings are included in this unit (37/40E-5J1 and 37/40E-5C1). They occurred at stream crossings and were probably caused by gullying of road fill resulting from culvert failure or overtopping of plugged culverts, contrasted to over-saturation and mass failure of the fill. The channels were incised for short distances downstream from the ripped culverts, but no degradation was observed upstream of the culverts.

Assuming standard forest practice rules are followed, the forest practice sensitivity is none, mass wasting potential is low (very low historical activity), delivery potential is low (very low historical activity), and the overall hazard potential rating is low.

4.5 Mass Wasting Map Unit #5

MWMU # 5 comprises 186 acres of lands in the Headwaters sub-basin that have been altered by mining activity. While other mining operations have historically occurred within the WAU, MWMU # 5 identifies only the operations of the Van Stone Mine because these are the only operations known to have a potential sediment delivery hazard.

The two tailings ponds are the mine features that have had historical mass wasting. These ponds have steep (greater than 60 percent), planar slopes constructed of relatively impermeable silt-sized material from mining waste. The northern and western walls of both the upper and lower ponds are proximal to streams with fish-bearing potential. The walls of the upper pond are adjacent to MWMU #1 (Map A-1).

Three shallow rapid landslides were identified in this unit. Evidence for one slide (38/40E-30A1) was observed during the 1996 field visit. This was a small shallow rapid slide of about 30 m^3 that initiated from the tailings wall of the lower pond, and deposited sediment into a sensitive stream. Evidence for a second probable slide that initiated on the upper tailings pond was observed from the 1968 aerial photos (38/40E-33D2). The slide may have been triggered by rapid surface runoff from upland slopes that surged through the pond, breached the wall and discharged onto the slopes below. A third slide included in this unit is based on anecdotal evidence of a large, catastrophic rapid landslide having occurred in 1958, ten years prior to the

earliest photo record. Triggering mechanisms for this slide are probably associated with rapid surface runoff and wall breach, either from rapid storm runoff or from ruptured slurry pipes.

A moderate hazard potential rating is assigned to MWMU # 5. There is a high potential for delivery of sediment to streams. The mass wasting potential, while high in the past, is rated moderate under present conditions. These conditions include actions taken by the owner to prevent rupture of slurry lines that deliver to the ponds. In the past, the slurry lines were above-ground, wooden pipes, and subject to rupture that would spill slurry into streams. These have been upgraded to high strength, flexible poly-fibre pipes. The owner has also regraded the area between the upper pond and the hillslope behind it, so that surface water will be diverted around the pond instead of through it. In addition, the owner is taking measures to stabilize the pond walls (see Appendix B for more discussion of mining management).

5.0 CONFIDENCE DISCUSSION

While the Onion Creek watershed has a complex geologic history, the most recent continental glaciation has left a subdued impression on the landscape. Glaciation has scraped weathered rock surfaces clean, rounded peaks and ridges, and deposited deep, well drained soils throughout the watershed. Older Paleozoic rock and younger Mesozoic granite are competent, and not subject to rock fall or rock slide processes. The relatively dry climate, coupled with jointed bedrock and permeable soils, help reduce the soil saturation potential associated with mass wasting. A low stream density (about 1.9 mi/mi^2) is also associated with a reduced mass wasting potential. In addition, stream channels and swales are not connected throughout much of the lower portion and some of the upper portions of the watershed, providing little opportunity for mass wasting to adversely affect stream resources.

An extensive road network provided adequate access for field verification of suspect landslides identified in aerial photos. Aerial photo coverage was available starting in 1968, but photo sets other than high altitude flights were of poor copy quality. Dense forest cover in the steeper, upper basin may have obscured small mass wasting failures.

5.1 Mass Wasting Inventory

Of 21 potential features identified with aerial photos, 16 were visited in the field. Only three of the potential 21 features were verified as actual mass wasting. The other 13 features were found to be cut slopes, landings, or blemishes on the photo copies. Five mass wasting features were found during field surveys, and five other photo-identified potential failures, excluding ancient deep-seated landslides, were not field checked.

Although some small features or healed mass wasting features could have been overlooked in the photo survey, field inventory provided confidence in defining mass wasting units and characterizing types, densities, and trigger mechanisms of features. In addition to the mass wasting analyst, the surface erosion, riparian, channel, and fish analysts were on the lookout for

features. A total of five (5) mass wasting features were found during 20 person-days of field time. Examples of all MWMU's were visited by the mass wasting analyst.

5.2 Analysis and Results

There were few opportunities for observing naturally occurring landslides under unmanaged conditions. Nearly all forested areas in the WAU have been cut over at least once.

Opportunities for observing the effects of forest practices on mass wasting activity did not vary much between MWMU's. Road building and harvest have occurred extensively in all MWMU's. No mass wasting was associated with harvest in any area, while roads (including non-forest roads) were associated with about 70 percent (9 of 13) of all active mass wasting features.

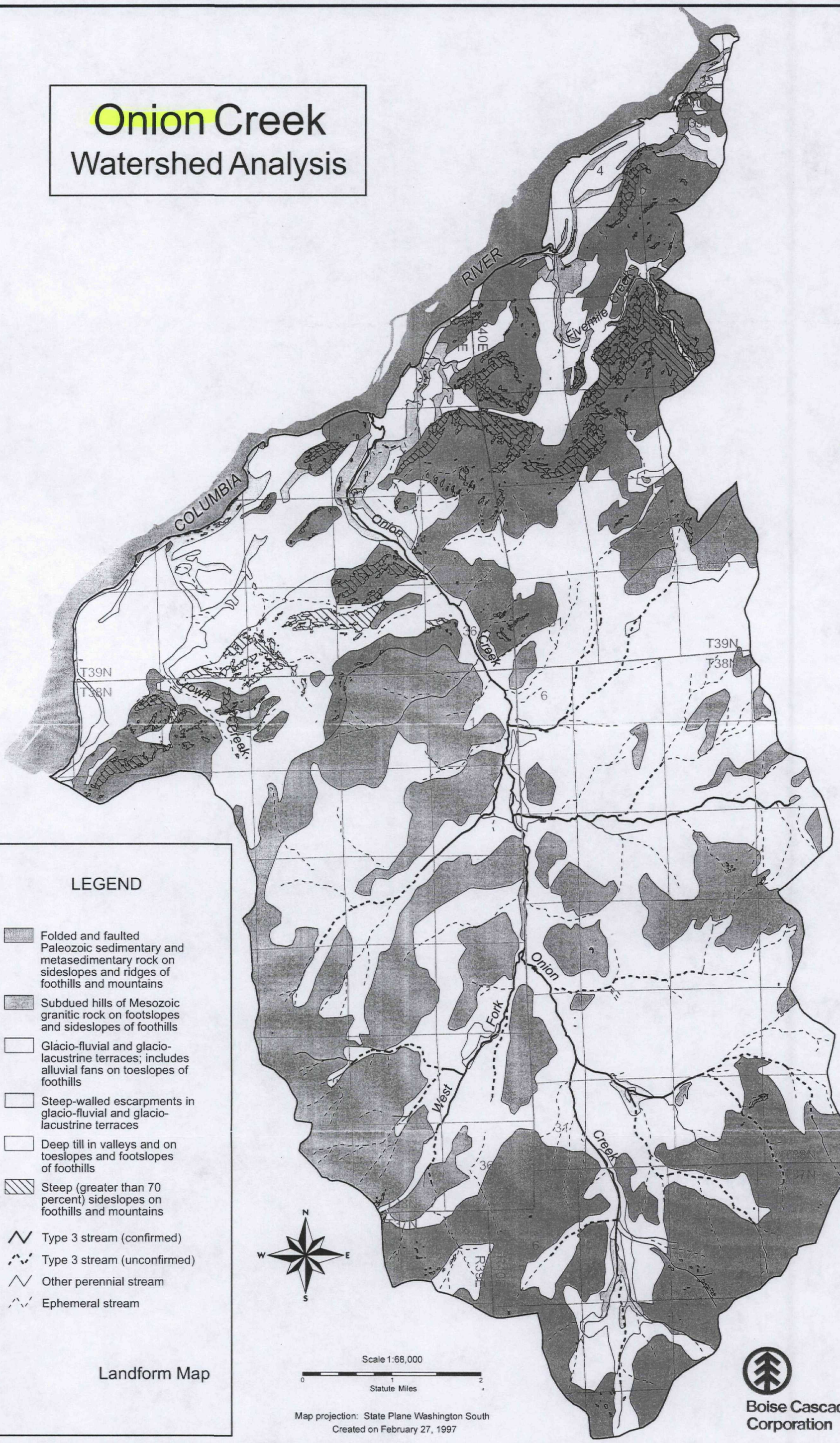
MWMU polygons were delineated on the map using characteristics gleaned from 1:24,000-scale topographic and soils maps; geologic maps of 1:100,000 and 1:31,680 and 1:24,000 scale; and aerial photos of about 1:12,000 and 1:63,000 scale. Confidence in mapping accuracy is high for all mass wasting features, due to the limited number of features (one-half of which were visited in the field), and due to excellent control on reference features such as roads.

Moderate to high confidence overall is estimated for map resolution for delineation of the MWMU polygons. Again, this is attributed to the paucity of landslides observed by all analysts in the field, over a wide portion of the basin. Moderate confidence is given for MWMU # 1, due to the characteristically small nature of the slides observed stream-side, and due to the forest cover in the upper portions of the watershed. Any error in mapping would likely fall on the side of excluding small areas of moderate (or high) hazard polygons contained within mapped low-hazard polygons.

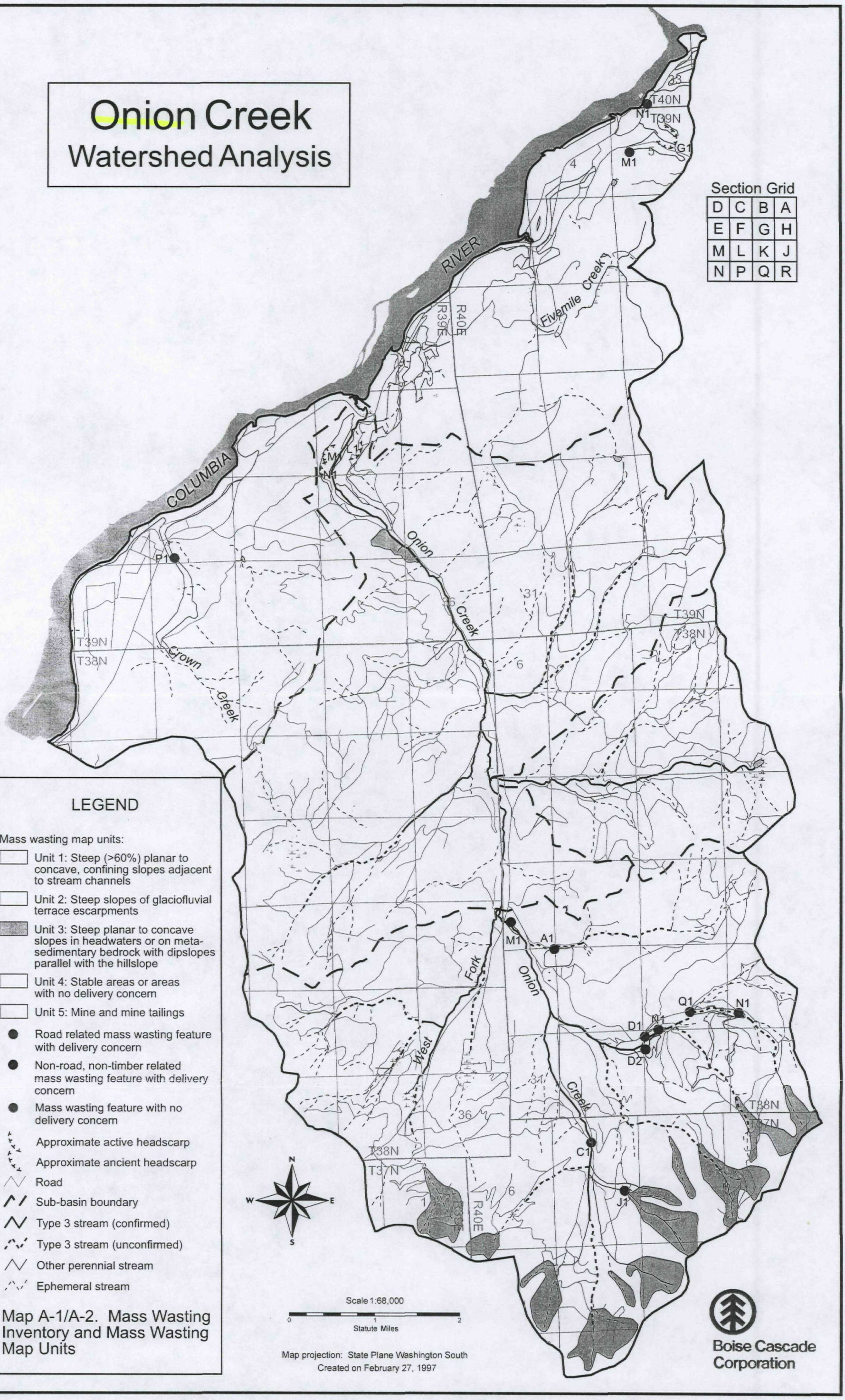
6.0 MONITORING RECOMMENDATIONS

Most landsliding is initiated as shallow rapid failures associated with roading. Effects on stability from changes in road construction methods (reducing risk of gullying and landsliding by reducing concentrated drainage discharge onto steep slopes) and management practices (maintaining culverts) should be seen over time by comparison of the existing mass wasting inventory with subsequent events, and by inventorying events that occur in areas of new road construction. New and existing roads in MWMU # 3 in particular should be monitored by observation for signs of incipient failure, such as tension cracks on road surfaces.

Onion Creek
Watershed Analysis



Onion Creek
Watershed Analysis



Map A-1/A-2. Mass Wasting Inventory and Mass Wasting Map Units

Form A-1. Mass Wasting Inventory Data

	a	b	c	d	e	f	g	h	i	j	k	l	m
	Sub-basin	Landslide I.D. and (photo year)	MWMU	Type	Landslide size (cubic meters)	Sediment delivered to stream? Y/N, (Type)	Surface erosion of scar (percent)	Associated land use activity	Slope gradient and type	Soil type and texture	Bedrock or parent material	Initiation elevation	Comment
1	Headwaters	37/40E-5J1 (92+)	4	G/d	170	Y (p)	100	FR	--	stoney till	Pmsu	3680	gullying (washout) of road fill from culvert at stream crossing
2	Headwaters	37/40E-5C1 (92+)	4	G/d	60	Y (f)	100	FR	--	stoney till	Pmsu	3200	gullying (washout) of road fill from culvert at stream crossing
3	Headwaters	38/40E-27N1 (68)	1	SR/q	640	Y (fp)	100	FR (?)	--	sandy till	Ki	3720	questionable side cast failure; more than 60% revegetated by 1980
4	Headwaters	38/40E-28Q1 (68)	1	SR/q	640	Y (fp)	100	FR (?)	60 % concave	sandy till	Ki	3400	questionable side cast failure; more than 60% revegetated by 1980
5	Headwaters	38/40E-28N1 (68)	1	SR/q	210	Y (fp)	100	FR (?)	--	sandy till	Ki	3180	questionable side cast failure; more than 60% revegetated by 1980
6	Headwaters	38/40E-33D1 (68)	1	SR/d	1360	Y (fp)	100	R	60 % concave	sandy till	Ki	3160	chronic source of sediment to channel, visible in all aerial photo sets and '96 field visit. 1968 shows evidence of 3,000 + feet of deposition in channel; initiation may be attributed to road culvert/ drainage failure.
7	Headwaters	38/40E-33D2 (68)	5	SR/p	680	Y (fp)	100	M	>60% concave, converging	fine-textured tailings	-	3160	probable failure in tailing pond wall; contribution to deposition in #6 above
8	Headwaters	38/40E-30A1 (92+)	5	SR/d	30	Y (fp)	100	M	35% planar	fine-textured tailings	-	2680	failure in tailing pond wall; silty tailings deposits on grassey vegetated bars in the channel below the slide
9	Headwaters	38/40E-19M1 (96)	1	SR/d	50	Y (fp)	95	N	100% concave	sandy till	Ki	2460	failure initiated at soil boundary between dry silty till and moist pebbley till with clay matrix
10	Lower Onion	39/39E-23L1 (96)	2	LPD/d	Very Large (see comments)	Y (f)	15	R	70% planar	silt loam	glacial terrace escarpment	1640	translational slump block exposed along road alignment; bare, planar cutslope reveals insipient failure lineament; no catastrophic failure, but small sporadic slumps give evidence to LPD classification; regrading of inboard road continually weakens toe of slide
11	Lower Onion	39/39E-23N1 Ancient	2	LAD/d	Very Large (greater than 5,000)	na	--	N	35% concave	fine sand	glacial terrace escarpment	1650	collapse in terrace at probable ice-wall contact

Form A-1, continued

	a	b	c	d	e	f	g	h	i	j	k	l	m
	Sub-basin	Landslide I.D. and (photo year)	MWMU	Type	Landslide size (cubic meters)	Sediment delivered to stream? Y/N, (Type)	Surface erosion of scar (percent)	Associated land use activity	Slope gradient and type	Soil type and texture	Bedrock or parent material	Initiation elevation	Comment
12	Lower Onion	39/39E-23M1 Ancient	2	LAD/d	Very Large (greater than 5,000)	na	--	N	35% concave	fine sand	glacial terrace escarpment	1600	collapse in terrace at probable ice-wall contact
13	Crown Creek	39/39E-28P1 (87)	2	SR/p	910	N	50	N (R)	60% concave	fine sand	glacial terrace escarpment	1600	slide evident following small construction activity
14	Five Mile Creek	39/40E-4M1 (87)	2	SR/p	510	N	--	N	30% converging	till	Pmsu	1760	in drainage; under canopy and poor photo = uncertainty
15	Five Mile Creek	39/40E-4G1 Ancient	2	LAD/d	Very Large (greater than 5,000)	na	--	N	15 % concave	fine sand	glacial terrace escarpment	1800	ancient landslide
16	Five Mile Creek	40/40E-33N1 (87)	4	SR/d	510	N	100	N (R)	65% planar	till and colluvium	Pz limestone	1520	30 % revegetated; dipslope into hillside; paved road at toe; railroad grade below that.

Footnotes:

column d:
- G = road crossing gully
- SR = shallow rapid
- LPD = large persistent deep-seated failure
- LAD = large ancient deep-seated failure
- d = definite
- p = probable
- q = questionable

column f:
- f = fish bearing
- fp = potential fish bearing
- p = perennial, non-fish bearing

column h:
- FR = forest road
- R = road
- M = mining
- N = no associated forest land use

Form A-2 Mass Wasting Map Unit Description

MWMU Number:	1
Description:	Steep (>60%) planar to concave slopes adjacent to stream channels.
Materials:	Moderately deep to deep (>24") permeable sandy till overlying relatively impermeable, more clay-rich till.
Landform:	Inner gorge: a narrow valley characterized by steepening of slope gradient above stream channels, with break in gradient between the inner-gorge slope and lower gradient hillslope or footslope above. Inner gorge delivers directly to the active stream channel with little or no intervening low-gradient flood plain or terrace.
Slope:	> 60% measured on site.
Elevation Range:	2,400 ft. to 4,000 ft.
Total Area:	0.75 acres
Mass Wasting Processes:	Three road-related shallow rapid landslides (probable side-cast failures); 1 definite debris flow initiated from a down-slope shallow rapid landslide associated with concentrated surface-water discharge from road; 1 non-road, non-forest related shallow rapid landslide;
Forest Practice Sensitivity:	Moderate sensitivity to roading; low to moderate sensitivity to harvesting based on no historical harvest-related slides observed.
Mass Wasting Potential:	Moderate potential under forest practices related to roading; Low potential under unmanaged conditions.
Delivery Potential:	High
Delivery Criteria:	Steep slopes adjacent to stream channels; historical delivery observed.
Hazard Potential Rating:	Moderate
Trigger Mechanisms:	Discharge of surface waters onto steep slopes, and saturation of overburden increasing pore water pressure at relatively impermeable boundary.

Form A-2 Mass Wasting Map Unit Description

MWMU	1 (continued)
Confidence:	High confidence that the potential hazard rating for this MWMU is moderate; Low confidence that entire area mapped as MWMU 1 is unstable. The poor copy quality of aerial photos provides low confidence for interpretation of three road-related shallow rapid landslides (probable side-cast failures).
Comment:	The shallow rapid failure from which the debris flow originated is a persistent source of sediment to the stream channel by sloughing and surface runoff from oversteepened slopes in the failure plane.

Form A-2 Mass Wasting Map Unit Description

MWMU Number:	2
Description:	Steep slopes of glacio-fluvial terrace escarpments
Materials:	Fine textured silty or sandy loams, or fine to coarse sand, interlayered with clay or fine silt
Landform:	Escarpments of glacio-lacustrine or outwash terraces
Slope:	> 50%
Elevation Range:	1,290 ft to 2,000 feet
Total Area:	993 acres
Mass Wasting Processes:	2 shallow rapid slides and 1 small sporadic slide related to persistent deep seated (excludes numerous shallow rapid slide at the reservoir); 3 ancient, very large deep-seated landslides
Forest Practice Sensitivity:	Road construction, especially in areas of active, large deep-seated slides
Mass Wasting Potential:	Moderate
Delivery Potential:	Low
Delivery Criteria:	Most terrace escarpments are remote from active streams; observed delivery is routed through a gully over long distances on slopes of decreasing gradient
Hazard Potential Rating:	Low
Trigger Mechanisms:	Road cuts across the base of a pre-existing slide, and continual removal of toe by road maintenance; compaction of surface by roading may concentrate discharge of water into (incipient) failure planes at impermeable boundaries
Confidence:	High, based on historical activity
Comment:	Where delivering to stream(s), the surface erosion of recent landslide scars is a persistent source of fine sediment

Form A-2 Mass Wasting Map Unit Description

MWMU Number:	3
Description:	Steep slopes (> 65%) on metasedimentary bedrock with dipslopes of bedding paralleling the hillslope
Materials:	Shallow to moderately deep fine to coarse colluvium and till
Landform:	Steep mountain sideslopes with concave hollows adjacent to active stream channels
Slope:	>65 %
Elevation Range:	1,800 ft to 5,000 ft.
Total Area:	1,420 acres
Mass Wasting Processes:	Shallow rapid failures possible (none observed)
Forest Practice Sensitivity:	Road construction
Mass Wasting Potential:	Low
Delivery Potential:	High
Delivery Criteria:	Steep slopes adjacent to active stream channels with few intervening depositional areas.
Hazard Potential Rating:	Low
Trigger Mechanisms:	Potential failure of saturated sidecast material placed on steep slopes (greater than 65%), and potential fill failures at stream crossings
Confidence:	Moderate; no discernible historical activity other than observed tension cracks on a few road surfaces on fill. Most of these areas are roaded and have been harvested in the past.

Form A-2 Mass Wasting Map Unit Description

MWMU Number:	4
Description:	Stable areas
Materials:	Rock outcrop, and all particle sizes of residuum and till
Landform:	Variable
Slope:	Variable
Elevation Range:	1,290 ft. to 5,575 ft.
Total Area:	53,862 acres
Mass Wasting Processes:	1 non-forest, road-related shallow rapid in shallow fine- to coarse-textured colluvium and till overlying bedrock (no delivery); (2 forest road related failures at stream crossings due to probable gullying of the fill caused by overtopping of debris-dammed culverts).
Forest Practice Sensitivity:	None, assuming standard forest practice rules are followed
Mass Wasting Potential:	Low
Delivery Potential:	Low
Delivery Criteria:	Minimal historical activity
Hazard Potential Rating:	Low
Trigger Mechanisms:	Undercutting or removal of toes at base of steep slopes, or concentrated drainage from roads, or blocked or failed culverts
Confidence:	High, based on historical activity

Form A-2 Mass Wasting Map Unit Description

MWMU Number:	5
Description:	Lands modified by mine works, especially mine tailings areas known to have contributed sediment to streams by mass wasting.
Materials:	Deep, relatively impermeable silt-sized material derived from mining tailings in limestone.
Landform:	Tailings ponds are constructed over deposits of till on toe slopes and footslopes of foothills and mountains. The ponds have a form characteristic of terraces, with steep-walled escarpments.
Slope:	The ponds are contained by steep (greater than 60%) walls constructed of silt-sized tailings.
Elevation Range:	2,680 ft. to 3,950 ft.
Total Area:	186 acres
Mass Wasting Processes:	Two observed shallow rapid landslides associated with concentrated surface-water discharge, probably from over-topping of the pond walls. (Anecdotal evidence for one very large catastrophic rapid landslide having occurred in the same way in 1958, 10 years prior to the photo history).
Forest Practice Sensitivity:	n/a
Mass Wasting Potential:	Moderate
Delivery Potential:	High
Delivery Criteria:	Steep slopes of tailings walls adjacent to stream channels; historical delivery.
Hazard Potential Rating:	Moderate
Trigger Mechanisms:	Discharge of surface waters from upslope hillslopes during storm events causing overtopping of tailings walls and gullying or washout.
Confidence:	High, based on historical activity and anecdotal evidence.

Form A-3. Mass Wasting Summary Table, MWMU #1

Activity	MASS WASTING FEATURE				
	Shallow Rapid LS	Large Persistent Deep-Seated Failures	Small Sporadic Deep-Seated Failures	Debris Torrents/ Debris Flows	Totals
Clear Cut 0-20 years	0	0	0	0	0
Clear Cut 20-50 years	0	0	0	0	0
Partial Cut	0	0	0	0	0
Road	3	0	0	1 (debris flow)	4
Stream Crossing	0	0	0	0	0
Landing	0	0	0	0	0
Other Forest Practices	0	0	0	0	0
Wildfire	0	0	0	0	0
Mature Forest	0	0	0	0	0
Non-Forest Land Use	1	0	0	0	1
Totals	4	0	0	1	5

Form A-3. Mass Wasting Summary Table, MWMU #2

Activity	MASS WASTING FEATURE				
	Shallow Rapid LS	Large Persistent Deep-Seated Failures	Small Sporadic Deep-Seated Failures	Debris Torrents/ Debris Flows	Totals
Clear Cut 0-20 years	0	0	0	0	0
Clear Cut 20-50 years	0	0	0	0	0
Partial Cut	0	0	0	0	0
Road	0	0	0	0	0
Stream Crossing	0	0	0	0	0
Landing	0	0	0	0	0
Other Forest Practices	0	0	0	0	0
Wildfire	0	0	0	0	0
Mature Forest	0	0	0	0	0
Non-Forest Land Use	2	0	1	0	3
Totals	2	0	1	0	3

Form A-3. Mass Wasting Summary Table, MWMU #3

Activity	MASS WASTING FEATURE				
	Shallow Rapid LS	Large Persistent Deep-Seated Failures	Small Sporadic Deep-Seated Failures	Debris Torrents/ Debris Flows	Totals
Clear Cut 0-20 years	0	0	0	0	0
Clear Cut 20-50 years	0	0	0	0	0
Partial Cut	0	0	0	0	0
Road	0	0	0	0	0
Stream Crossing	0	0	0	0	0
Landing	0	0	0	0	0
Other Forest Practices	0	0	0	0	0
Wildfire	0	0	0	0	0
Mature Forest	0	0	0	0	0
Non-Forest Land Use	0	0	0	0	0
Totals	0	0	0	0	0

Form A-3. Mass Wasting Summary Table, MWMU #4

Activity	MASS WASTING FEATURE: Shallow Rapid LS	Large Persistent Deep-Seated Failures	Small Sporadic Deep-Seated Failures	Debris Torrents/ Debris Flows	Totals
Clear Cut 0-20 years	0	0	0	0	0
Clear Cut 20-50 years	0	0	0	0	0
Partial Cut	0	0	0	0	0
Road	0	0	0	0	0
Stream Crossing	0	0	0	2 *	2
Landing	0	0	0	0	0
Other Forest Practices	0	0	0	0	0
Wildfire	0	0	0	0	0
Mature Forest	0	0	0	0	0
Non-Forest Land Use	1	0	0	0	1
Totals	1	0	0	2	3

* These failures are road fill failures caused by gullying of the road are classified here for convenience (see text in Section 4.4)

Form A-3. Mass Wasting Summary Table, MWMU #5

Activity	MASS WASTING FEATURE				
	Shallow Rapid LS	Large Persistent Deep-Seated Failures	Small Sporadic Deep-Seated Failures	Debris Torrents	Totals
Clear Cut 0-20 years	0	0	0	0	0
Clear Cut 20-50 years	0	0	0	0	0
Partial Cut	0	0	0	0	0
Road	0	0	0	0	0
Stream Crossing	0	0	0	0	0
Landing	0	0	0	0	0
Other Forest Practices	0	0	0	0	0
Wildfire	0	0	0	0	0
Mature Forest	0	0	0	0	0
Non-Forest Land Use	3	0	0	0	3
Totals	3	0	0	0	3

Appendix B
Surface Erosion

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Table B-1. Required Module Work Products and Comparable Products for Onion Creek.

Required Module Product	Onion Creek WA Channel Analysis Product	Location in this Report
General description of landscape influences on surface erosion		Section 1.0
Map B-1 Hydrologic analysis map (watershed partitioning)	Figure 2 in the Executive Summary of Main Report (WAU Map)	Sub-basins also marked on maps B-2 through B-6
Map B-2 Preliminary soil erosion potential map	Same as required product	Map B-2
Map B-3 Past 5 years activity map	Same as required product	Map B-3
Form B-1 Hillslope field/photo information	Same as required product	Form B-1
Map B-4 Final soil erosion potential map	Same as required product	Map B-4
Narrative on final map, hillslope erosion conditions, activity situations		Sections 3.3 and 3.4
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APPENDIX B. SURFACE EROSION

1.0 INTRODUCTION

This surface erosion assessment of the Onion Creek Watershed Administrative Unit (WAU) was conducted to evaluate the potential for surface erosion from disturbed soils in the watershed and the amount of sediment eroded and delivered to streams from background and land management activities. The primary land uses in the basin which have the potential to affect surface erosion include: timber harvest; road construction and use; agriculture/grazing; and mining activities.

1.1 Basin Characteristics Influencing Surface Erosion

The Onion Creek WAU is located in Stevens County in the northeastern portion of Washington state. The WAU includes land draining into Onion Creek as well as the small drainages of Crown Creek, Five Mile Creek, and several smaller, un-named streams. The town of Northport is located in the northeastern corner of the WAU. All drainages empty into the Columbia River impoundment of Lake Roosevelt.

1.1.1 Topography

Hillside slopes in the Onion Creek WAU are low to moderate (less than 45 percent) over much of the basin. Small areas with high slope and correspondingly higher surface erosion potential are located on the sideslopes of ridges crossing the northern part of the basin and in the southern headwaters of the basin. Steep slopes also occur where Onion Creek has incised into glacial outwash and lacustrine sediments in the lower 2 miles of its drainage.

1.1.2 Soils

The USDA Soil Conservation Service has completed a detailed soil survey of the Onion Creek WAU (USDA SCS 1982). Over 40 named soils, as well as slope categories within each named soil, were mapped in the basin. Properties of each of these soils pertinent to soil erosion and mass wasting are listed in Table B-1.1.

Soil properties reflect the parent materials from which they were developed (see Appendix A, Sections 1.1 and 1.2). Soils on the ridges in the northern portion of the basin and in the headwaters are rocky, moderately deep, and well-drained. Soils in the central portion of the basin are formed on glacial till or weathered granite and are deep and well drained. Soils formed on glacial outwash and lake sediments along the Columbia River are very deep and well drained.

Surface erosion potential for soils was rated by the SCS. The majority of the basin was rated as having a moderate surface erosion potential (70 percent). Erosion potential was tied to slope; high erosion potential soils occur on steep slopes (25 percent of the basin) and low erosion potential was related to flat slopes (5 percent of the land).

Soil compaction potential was also rated for soils and correlated with soil texture. Soils in the basin are almost evenly divided between moderate and high compaction potentials. Compaction can occur when vehicles repeatedly pass over the ground, such as along roads or skid trails. Compaction is most severe when soils contain fine-grained materials and are moist.

1.1.3 Climate

The Onion Creek WAU is characterized by warm summers and cold winters. Precipitation averages 24 inches/yr and is distributed fairly evenly throughout the year, although November, December and January are slightly wetter. Precipitation occurs as snow during the winter months, and a heavy snowpack often accumulates. Snowmelt in April/May results in high spring runoff and muddy conditions during "break-up."

A complete description of the climate and rainfall characteristics of the Onion Creek WAU are found in the Hydrology Module (Appendix C).

1.1.4 Land Ownership and Use

Land ownership in the Onion Creek WAU is a patchwork of federal, state, and private owners (Main Report, Section 2.1 and Figure 3). Federal (U.S. Forest Service, Bureau of Land Management), state (Department of Natural Resources) and major private (Boise Cascade Corporation, Vaagen Brothers, Arden Tree Farm) landowners hold the majority of upland areas and manage their lands for timber production. Numerous small, private landowners hold lands bordering the Columbia River along the northern boundary of the WAU and along Onion Creek and the West Fork of Onion Creek in the center of the WAU. Land use on these lands is varied, and includes residential, agricultural, and timber harvest uses.

The Van Stone Mine is located in the southeastern portion of the watershed and includes an open pit mine, an old tailings pond, and a newer, larger tailings pond. The mine was last worked in 1992 and rehabilitation/revegetation efforts are under way to reduce the risk of erosion from the tailings ponds (pers.comm., David Norman, DNR, 1996).

1.2 Watershed Partitioning

The Onion Creek WAU was divided into 5 sub-basins to help localize identification of the effects of land management activities on hydrology and sediment production (watershed partitioning (Map B-1) is displayed in the Main Report, Figure 2). The sub-basins include Five-Mile Creek and Crown Creek, which drain directly into the Columbia River, Lower Onion Creek (downstream of the confluence of Onion Creek and the West Fork of Onion Creek), Quinns Meadows, and Onion Creek Headwaters, upstream of the confluence of Onion Creek and the West Fork of Onion Creek.

2.0 BACKGROUND SEDIMENT YIELD

Calculation of the sediment yields from different erosion processes is useful to allow comparisons of the relative importance of each source. Calculation of the background sediment yield (the rate of sediment input into streams assuming undisturbed conditions in the basin) is important because it allows us to compare the amount that management activities in the basin have changed sediment input.

The major processes moving sediment downslope and into streams in undisturbed basins include soil creep, mass wasting, and stream bank erosion. Soil creep is the slow downslope movement of soil resulting from gravitational forces and in our discussions includes soil movement resulting from biological activities such as animal burrowing and soil attached to roots of fallen trees. Mass wasting often contributes considerable amounts of sediment to streams in areas with steep terrain. However, in the Onion Creek WAU, very few landslides were observed, probably due to the deep, well-drained soils and relatively small amounts of precipitation.

A component of stream bank erosion is included in the soil creep equations; however, in some channel types, particularly alluvial channels or in sections where channel banks are disturbed, bank erosion may be a larger component. Based on the observations of the channel analyst, a small percentage of most banks (10-15 percent) were eroding. It was assumed that the soil creep calculations were adequate to capture background rates of bank erosion. This assumption was backed up by a calculation of background bank erosion based on 10 to 15 percent of streambanks eroding and average soil depths, which produced about 1,200 tons of sediment a year, consistent with soil creep results.

2.1 Methods

2.1.1 Soil Creep

The sediment yield from soil creep was estimated using the following formula:

Annual Sediment Yield from Soil Creep = Length of Stream Channel * 2 banks* Soil Depth * Average Creep Rate

The length of channel was obtained from the GIS stream database and was overlain with the slope angle coverage to determine the average creep rate. A creep rate of 0.04 inches/yr (1 mm/year) was used for slopes less than 30 percent; a rate of 0.08 inches/year (2 mm/year) was used for steeper slopes (WDNR 1995). Stream channel length was multiplied by 2 to account for creep from both sides of the stream. Soil depths reported in the soil survey and GIS database were used. The calculated soil creep was multiplied by 1.5 to account for the bulk density of soil and convert the volumetric creep estimate to tons.

2.1.2 Mass Wasting

An estimate of the volume of sediment produced from mass wasting under undisturbed conditions in the basin was made based on mass wasting features noted by the mass wasting analyst. Information presented in Form A-1 (Mass Wasting Inventory) was sorted by land use associated with the slide (forested, forest road, mining/mining road), type of slide, whether or not the slide delivered to a stream, and date the slide was noted on the aerial photographs. The estimated delivered volume of each mass wasting feature that delivered to a stream was summed by land use type for each aerial photo period. An average annual sediment input was calculated by dividing the sediment yield by the number of years since the slides were noted on photos (a recurrence interval of 5 years was assumed for activity on 1992 photos or noted during 1996 field visit). The background sediment input from mass wasting was taken as the input from features occurring on forested lands. Sediment input from features associated with roads and mining activities was also calculated, and is reported in Section 5.

2.2 Analysis and Results

The background sediment yield from soil creep to all streams (both connected and unconnected) is calculated to be 1,765 tons/year; sediment from mass wasting is 20 tons/year. Total background sediment input to connected streams (those which are connected to downstream channels) is 1,050 tons/yr. Table B-2.1 shows estimated background sediment inputs by sub-basin. Based on soil texture (grain size) information from the Soil Conservation Service (1982), background sediment would be composed of approximately 15 percent gravel and large particles, 45 percent sand, and 40 percent silt and clay.

Table B-2.1. Background Sediment Yield.

Sub-Basin	Sub-Basin Area (acres)	Soil Creep to all Streams (tons/yr)	Mass Wasting (tons/yr)	Total Back-ground Sediment Input (tons/yr)	Background Sediment Input to Connected Streams (tons/yr)
Crown Creek	5,913	145	0	145	0
Five Mile Creek	6,068	130	0	130	5
Lower Onion Creek	14,952	535	0	535	305
Quinns Meadows	13,914	195	0	195	170
Onion Creek Headwaters	15,615	760	20	780	570
Total Watershed	56,462	1,765	20	1,785	1,050

2.3 Confidence Discussion

Overall confidence in the background sediment erosion estimates is moderate.

Estimates of soil creep were based on soil depths, hillside slopes, and stream lengths obtained from the GIS database. The existence/absence of streams was confirmed for many of the streams by the watershed analysis team during field work in the basin. As a check on the soil creep calculations, an estimate of the contribution of sediment from bank erosion was made based on average basin-wide bank erosion rates observed by the stream channel analyst. Input rates from bank erosion were comparable with those calculated for soil creep.

There was only one mass wasting event observed on forested areas in the basin. While confidence in the numerical value of 20 tons/yr of sediment input from mass wasting is low, confidence that mass wasting contributes only minor amounts of sediment to streams in the basin is high since few mass wasting events were observed.

3.0 HILLSLOPE SURFACE EROSION

Hillslope surface erosion results from the detachment and downslope movement of soil particles. Erosion is generally caused by rain or snowmelt, although freeze/thaw activity and dry raveling of steep slopes can also occur. Surface erosion processes observed in the Onion Creek WAU include sheetwash, rills, and gullies. Erosion is usually the result of land management activities that remove vegetation and duff that protect the underlying soil, removal of roots that hold the soil together, or soil compaction that reduces the infiltration capacity of the soil and result in rain or meltwater running over the surface of the soil. The principal activities contributing to hillslope surface erosion in Onion Creek include timber harvest, mining, and agriculture.

3.1 Methods

Initial soil erosion potential was obtained from the DNR soil database for the Onion Creek WAU. It is based on the Stevens County Soil Survey.

The most recent aerial photographs of the WAU (1995) were studied to select areas of bare soil resulting from harvest, mining, and agriculture to visit in the field. A sub-sample of these areas was visited during the week of September 30 ,1996 to visually check for types of erosion, causes, and delivery to streams.

Based on the field visits and the preliminary soil erosion potential map, a final map was produced showing areas of concern for hillslope soil erosion.

3.2 Preliminary Soil Erosion Potential

Soil erosion potential refers to how easily soil in an area could be eroded if it is disturbed. A preliminary soil erosion potential map (Map B-2) was produced based on soil erosion potential ratings made by the Soil Conservation Service. The majority of the WAU was rated as moderate erosion potential, with sections of high erosion potential in the steeper uplands and in areas of lacustrine sediments, and small sections of low erosion potential in flat, alluvial areas.

3.3 Analysis and Results

Areas of potential surface erosion were observed on aerial photographs and in the field. Observations included areas of timber harvest (skid trails, landings, burning), mining (mining and tailings pond), and agricultural uses. Form B-1 lists observations made in the WAU.

3.3.1 Timber Harvest

Over half of the Onion Creek WAU is managed for timber harvest. Corporate landowners managing for timber include Boise Cascade Corporation, Vaagen Brothers, Inland Paper, Arden Tree Farm, and Maurice Williamson (Main Report, Figure 3). Federal/state agencies that manage for timber harvest and other uses include the U.S. Forest Service, U.S. Bureau of Land Management, and Washington State Department of Natural Resources. In addition, many of the small private landowners in the WAU at least periodically harvest timber from their property.

Location of Past Harvest

Large landowners in the basin were contacted to determine areas where timber harvest has taken place within the past 5 years. Harvest information was obtained from Boise Cascade Corporation, Vaagen Brothers, Maurice Williamson, Bureau of Land Management, and Department of Natural Resources. In addition, the July 1995 aerial photographs were used to check for areas with signs of recent harvest, and harvest areas were noted during the field visit. This data was compiled and is displayed on Map B-3. Map B-3 is based on the best available data, and may not accurately reflect all harvest activity.

In addition to the areas shown on the map, there have been numerous small areas of harvest on private land. A check with the DNR Forest Practices office in Colville showed approximately 150 forest practices applications from the WAU in just the past three years. The majority of these are for small (40 acre) partial cuts by private landowners. Due to the large number of landowners and applications and the fact that forest practice applications do not necessarily mean timber has actually been harvested, these activities were not compiled and do not appear on Map B-3.

Surface Erosion Associated with Harvest Activities

The majority of timber harvest in the basin is partial cuts (overstory removal, selective cuts, etc.) yarded by tractor. A few clearcut units have been harvested, and a few units on steeper slopes have been cable-yarded.

Generally, tractor yarding results in more ground disturbance than cable yarding, assuming logs are suspended during cable yarding. Tractor yarded units visited in the Onion Creek WAU had areas of bare soil associated with skid trails. Evidence of surface erosion from overland flow and rills were present, but little sediment reached streams. Sediment delivery to streams was caused by concentrated runoff from roads or landings flowing down skid trail, or overland flow across skid trails that crossed streams.

7.0 REFERENCES AND BIBLIOGRAPHY

Easterbrook, Don J., and David A. Rahm. 1970. Landforms of Washington. Western Washington State College (Western Washington University), Bellingham, Washington.

Joseph, Nancy L. 1990. Geologic Map of the Colville 1:100,000 Quadrangle, Washington-Idaho. Washington Division of Geology and Earth Resources, Open File Report 90-13.

Kesten, S. Norman. 1970. The Van Stone Mine, Stevens County, Washington. *In* Weissenborn, A.E., editor, Lead-Zinc Deposits in the Kootenay Arc, Northeastern Washington and Adjacent British Columbia. State of Washington Department of Natural Resources, Bulletin No. 61.

Kiver, E.P., and Stradling, D.F. 1986. Lake Roosevelt Shoreline Study; Glacial Geology, Terraces, Landslides, and Lineaments. U.S. Bureau of Reclamation unpublished report.

Mills, Joseph W., and Harold E. Nordstrom. 1973. Multiple Deformation of Cambrian Rocks in the Kootenay Arc, near Northport, Stevens County, Washington. Northwest Science 47(3):185-202.

Sidle, R.C. 1985. Factors Influencing the Stability of Slopes. *In* Proceedings of a Workshop on Slope Stability: Problems and Solutions in Forest Management, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. General Technical Report PNW-180.

USDA SCS. 1982. Soil Survey of Stevens County, Washington. US Department of Agriculture, Soil Conservation Service.

Washington Forest Practices Board. 1995. Standard Methodology for Conducting Watershed Analysis. In Chapter 222-22 WAC, Version 3.0.

Yates, R. G. 1964. Geologic Map and Sections of the Deep Creek Area, Stevens and Pend Oreille Counties, Washington. U.S. Geological Survey Miscellaneous Geologic Investigations Map I-412, 1 sheet, scale 1:31,680.

Yates, Robert G. 1970. Geologic Background of the Metaline and Northport Mining Districts, Washington. *In* Weissenborn, A.E., editor, Lead-Zinc Deposits in the Kootenay Arc, Northeastern Washington and Adjacent British Columbia. State of Washington Department of Natural Resources, Bulletin No. 61.

Yates, R. G. 1971. Geologic Map of the Northport Quadrangle, Washington. U.S. Geological Survey Miscellaneous Geologic Investigations Map I-603, 1 sheet, scale 1:31,680.

3.3.2 Mining Activities

The Van Stone Mine is located in the southeastern portion of the Onion Creek WAU (Map B-3). The mine is located in Section 33, T38R40E. A small, older tailings pond is located in the same section, and a newer, larger tailings pond is located in Sections 29/30. In addition, several smaller quarries are located in the WAU. The large tailings pond and several quarries were visited in the field, but the mine itself was not accessible.

The Van Stone Mine operated intermittently from about 1926 - 1992 as a lead/zinc mine. The mine is not presently active, but could be re-opened in the future. The owners are working on a reclamation plan to stabilize and rehabilitate the workings.

Rock was removed from the mine, crushed on site, and the usable material trucked off site for further processing. Fine-grained (silt sized) tailings (waste) were carried in a slurry via an elevated wooden flume first to the old tailings pond, and later to a large tailings pond located in Sections 29/30. The slurry was dumped into the pond to allow the sediment to settle out of the slurry. The new tailings pond walls were built up from dried tailings and at present stand 10 to 50 feet above the ground surface. The wooden slurry line was replaced in 1991 (?) with a durable, flexible pipe (pers. comm., Herb Buffan, former pit foreman, 1996).

In the past, the mine, slurry flume, and tailings ponds were likely a source of sediment to streams in the Onion Creek WAU. Based on aerial photo evidence and anecdotal reports from area residents, the slurry flume periodically broke, and the tailings slurry was dumped into the stream north of the old tailings pond for hours at a time before the break was discovered and repaired. In addition, it is reported that the old tailings pond wall had a major episode of erosion at least once in the past (mid 1950's), transporting tailings material into the stream (pers. comm., Randy Miller, DNR, 1996).

The new tailings pond is not reported to have had any major erosion episodes, however, there is a layer of tailings material several feet thick covering the stream valley north of the new tailings pond. There may have been an erosion episode from the pond walls or a secondary flume noticed on the north side of the pond that resulted in the sediment build up. This material is now vegetated and stabilized in the stream valley, but continues to be a small source of sediment to the stream as a result of stream bank erosion.

At present, the steep outer walls of the tailing ponds are subject to surface erosion, as evidenced by the rills and gullies developed on the walls. A small berm has been made around the tailings ponds to contain eroded material and is effective in containing eroded material. The mine owner is testing erosion control methods on the tailings pond walls and it is anticipated that the mine works will become a smaller source of sediment in the future as more effective erosion control and containment methods are put in place.

The quarries visited in the field are not being actively used. None of them are located near streams or waterbodies and they do not appear to be a source of sediment to any waterbodies.

3.3.3 Agriculture

The primary agricultural use in the Onion Creek WAU is cattle and livestock grazing, with a few small areas used for fodder production. Grazing occurs mostly on privately owned lands, in fenced pastures. Little surface erosion was observed to result from most agricultural activities in the WAU, however, areas of bank erosion were associated with cattle and horse grazing along the mainstem of Onion Creek (Segments 7 and 10). The channel analyst reported 70 percent of the banks (average 3 feet high) were eroding along 3,500 feet of channel. Assuming 0.1 feet of bank erosion every year, this would result in about 80 tons/yr of sediment input to Onion Creek.

3.4 Conclusions

Surface erosion from timber harvest was not observed to contribute substantial volumes of sediment to streams in the Onion Creek WAU.

The Van Stone Mine and associated activities contributed substantial amounts of sediment to streams in the WAU in the past. In the future, the mine will contribute much less sediment assuming the rehabilitation of the mine workings is successful. If the mine is re-opened, erosion control measures should be implemented to minimize erosion at the mine, along the tailings pipeline, and tailings ponds.

Grazing along two sections of Onion Creek contributes to increased bank erosion in those areas.

3.4.1 Final Soil Erosion Potential Map

A final soil erosion potential map was prepared based on the preliminary map and field observations of erosion (Map B-4). In general, erosion potential of most areas appeared to be moderate. Field observations indicated that soil erosion was only a problem in areas where water was concentrated and allowed to flow across disturbed ground. These occurred where runoff draining from roads or landings drained across skid trails or other disturbed areas or where the mine tailings flume failed.

Few changes were made to the preliminary erosion potential map. Erosion potential ratings were added to blank spots on the map based on information in the Stevens County Soil Survey (USDA SCS 1982). The lacustrine sediments on steep slopes were changed to a very high erosion potential rating, and the mine tailings walls were changed from varied to a high rating. It should be noted when using the soil erosion potential map that potential delivery of sediment to streams should also be taken into account for any activity. Ground disturbing activities along even small, intermittent streams have the potential to deliver sediment to fish-bearing streams if improperly conducted. On the other hand, sediment produced from activities far away from streams even on areas with high erosion potential cannot reach streams.

3.5 Confidence Discussion

Confidence is high that harvest activities yield relatively little sediment to streams in the Onion Creek WAU. Confidence is moderate to low on volumes of sediment delivered from mining activities. There was probably considerable sediment input in the past when mine was operating, but no record of quantities eroded or contributed to streams was found.

4.0 ROAD EROSION

The construction and use of roads can be a significant source of sediment in forested basins. Road construction removes vegetation from the road cutslope, fillslope, ditch, and tread, leaving these areas susceptible to erosion. Over time, the cutslope and fillslope revegetate and erosion from these sources is reduced, however, the road tread and ditch continue to be sediment sources as long as the road is in use. Research has shown that the most important factors determining how much sediment is produced from the road tread are how much the road is used and the amount and type of road surfacing. In addition to these factors, the configuration of the road drainage system, particularly whether or not road drainage reaches the stream network, determines if sediment produced from roads has the potential to affect aquatic resources.

4.1 Methods

Methods used to inventory and calculate road sediment in the Onion Creek WAU vary slightly from the standard methodology as described below. The road inventory concentrated on roads that had the potential to deliver to streams (i.e. had stream crossings or were within 500 feet of a stream). Individual segments delivering to streams were delineated and characterized rather than using average road characteristics. Road calculations for tread, cutslope, and fillslope were based on actual road dimensions, and road use factors included both residential and logging uses.

Erosion from roads in the basin was estimated using formulas based on empirical relationships between road use, parent material, road surfacing, cutslope and fillslope vegetative cover, and delivery of eroded sediment to the stream network (WDNR 1995, Beschta 1978, Bilby et al. 1989, Megahan et al. 1986, Reid and Dunne 1984, Sullivan and Duncan 1980, Swift 1984). Approximately half of the total miles of road in the basin were surveyed during October, 1996. The field survey concentrated on roads that crossed or were adjacent to streams and had the potential to deliver sediment to aquatic resources. Approximately 90 percent (85 segments) of the road segments with delivery potential were visited. Information on the road tread, cutslope, fillslope, ditch, gullies within the road prism and delivery of road runoff to a stream were recorded for each road segment that delivered to a stream (Form B-3). Each of these delivering segments was also marked on a map. After returning from the road survey, these delivering segments were transferred to a base map for entry into the GIS system. Delivering segments were also delineated on the map for the non-surveyed roads in the basin. Average tread width, surfacing, cutslope and fillslope cover, and delivery rates were assigned to non-inventoried road segments (10 segments) based on observations of similar types of roads in the basin.

The average annual volume of sediment delivered to a stream system at each stream crossing was calculated based on the following formulas:

Total Sediment Delivered from each Road Segment (in tons/year) = Tread + Cutslope + Fillslope + Gully Erosion

Tread = Basic Erosion Rate x Tread Surfacing Factor x Traffic Factor x Segment Length x Road Width x Delivery Factor

Cutslope = Basic Erosion Rate x Cutslope Cover Factor x Segment Length x Cutslope Height x Delivery Factor

Fillslope = Basic Erosion Rate x Fillslope Cover Factor x Fillslope Segment Length x Fillslope Height x Delivery Factor

Gully Erosion = volume of gully in road prism delivering to a stream (width x depth x length estimated in field) x 1.5 tons/cu yd

Values for each factor in the equations were obtained from information collected during the road inventory. These values were linked to lookup tables to calculate total sediment delivered from each road segment (based on WDNR 1995). Tables B-4.1 through B-4.4 show the tables that were used.

Table B-4.1. Basic Erosion Rate.

Parent Material	Basic Erosion Rate (tons/ acre/ year)
alluvium/outwash	30
lacustrine sediments	60
sandy granitic till	30
silty granitic till	60
granite	30
quartzite	30

Parent material for each road segment was assigned based on observations of the road cut.

Table B-4.2. Road Tread Surfacing Factor.

Surface Type	Surfacing Factor
Asphalt	0.03
Gravel	0.2
Some gravel	0.5
Some vegetation	0.75
Native surface (no surfacing)	1

Table B-4.3. Traffic Factor.

Road Use (Logging/ Residential Use)	Traffic Factor
H/H	20
L/L	1
L/M	1.2
M/H	5
M/L	2
M/M	2
N/L	0.05
N/N	0.02

Roads were rated for both logging and residential use because of the heavy residential use of many roads in the basin. Traffic factors were rated as heavy (H), medium (M), low (L) and no use (N) for each use type. Traffic factors for combined logging and residential use were interpolated from factors in the standard methodology as shown in Table B-4.3. Modified traffic factors were applied for roads with light logging use and moderate residential use (L/M), moderate logging use and high residential use (M/H) and no logging use but light residential use (N/L).

Table B-4.4. Cutslope and Fillslope Cover Factor.

Percent Vegetation or Rock Cover	Cover Factor
100	0.1023
90	0.1500
80	0.2003
70	0.2540
60	0.3116
50	0.3742
40	0.4435
30	0.5222
20	0.6155
10	0.7700
0	1.0000

The delivery of sediment from each of the road prism components was determined based on the road drainage configuration (Table B-4.5) and the delivery of road runoff as noted in the field for each segments (directly to a stream channel - 100 percent delivery; within 200 feet of a stream - 10 percent delivery; or to the forest floor - no delivery).

Table B-4.5. Road Component Delivery.

Road Drainage Configuration	Length of Road Component Delivering		
	Tread	Cutslope	Fillslope
Insloped	All	All	Length noted in field
Outsloped	Equal to length of fillslope delivering	Equal to length of fillslope delivering	Length noted in field
Crowned	Half width for total length plus other half width equal to length of fillslope noted	All	Length noted in field

Gully erosion was estimated based on the dimensions of gullies in the road tread, ditch, and fillslope estimated in the field. It was assumed that gullies present during the field work were eroded within the past year and represent an average annual gully erosion rate for that segment. The field work for this module was done during early October, 1996; it is probable that additional gullies form in other road segments during rainy or snowmelt conditions and were eradicated during road grading prior to field work.

4.2 Analysis and Results

There are approximately 278 miles of roads in the Onion Creek WAU, not including roads within the town of Northport (Table B-4.6, Map B-5). Major roads (Highway 25, and main county roads paralleling Onion Creek and connecting to the Deep Creek valley) are paved, accounting for 28 miles of the total. Within the Onion Creek and Five Mile Creek sub-basins are an additional 18 miles of gravel-covered county road. These roads are wide, well-maintained, gravel surfaced roads with high residential use.

Table B-4.6. Miles of Roads.

Sub-basin	Asphalt	Gravel County Road	Gravel Forestry Road	Native	Total	Road Density (mi/sq mi)
Crown Creek	7	0	0	21	29	3.1
Five Mile Creek	11	2	0	13	25	2.7
Lower Onion Creek	6	12	0	73	92	3.9
Quinns Meadows	0	0	0	31	31	5.1
Onion Cr Headwaters	4	4	3	91	101	4.1
Total	28	18	3	229	278	3.8

A small percentage of forestry roads are gravel surfaced. The remaining 229 miles of roads in the basin are native surface (unsurfaced) and receive varying logging and residential traffic

volumes depending upon the amount of residential development and timber harvesting operations along the road. Current residential and log traffic use rates for each road segment delivering to a stream are included on Form B-3.

4.2.1 Sediment Delivery from Roads under Current Conditions

Sediment produced from each road segment delivering to a stream was calculated and is displayed on Form B-2 and Map B-6. Approximately 17 miles (6 percent) out of the total 278 miles of road delivers sediment to a stream in the Onion Creek WAU. Based on current road traffic rates, an average of approximately 1,540 tons of sediment are delivered to streams in the WAU from surface erosion annually; an additional 225 tons are estimated to be contributed from gullying of the road prism.

Table B-4.7. Sediment Delivery from Roads.

Sub-basin	Total Miles of Road	Miles of Road Delivering	Sediment Delivered from Surface Erosion (tons/yr)	Estimated Gully Erosion (tons/yr)	Total Road Erosion (tons/yr)	Road Erosion to Connected Streams (tons/yr)
Crown Creek	29	0.2	20	0	20	0
Five Mile Creek	25	0.5	10	0	10	5
Lower Onion Creek	92	9.0	1,240	15	1,255	1,255
Quinns Meadows	31	1.1	30	5	35	35
Onion Creek Headwaters	101	6.2	240	205	445	445
Total Watershed	278	17	1,540	225	1,765	1,740

As shown on Map B-5 and Form B-2, the majority of road sediment is delivered from a few road segments in the Lower Onion Creek sub-basin. Over half of the total sediment in the entire WAU is produced from just 6 road segments: segment 36 (along the Johnson Grade Road near the mouth of Onion Creek), segments 7, 8, 9, and 10 (along the Bodie Mountain Road) and segment 17 (along Hawks Road). These segments all drain directly to a stream, are county road segments with moderate log truck use rates, high residential use rates, and wide, graveled surfaces.

A few road segments in the WAU were located in small swale or valley bottoms and had evidence of a stream channel flowing along the tread. Based on anecdotal evidence from local residents, there was no surface flow in these locations prior to road construction. Use of the road evidently compacted soils enough to turn sub-surface flow into surface flow and is currently resulting in road erosion and sediment delivery to a stream channel.

4.2.2 Sediment Delivery under Future Scenarios

The Onion Creek WAU may receive heavier log truck use rates in the future, and the Van Stone Mine may re-open, with additional truck and car traffic using roads accessing the mine. In order to help land managers understand the effects of additional traffic on road erosion, a number of different road use rate scenarios were developed based on input from landowners in the basin. For each scenario, road use rate factors were changed as appropriate to reflect the higher use rates on road segments accessing parcels where harvest/mine activity may take place.

The following possible future use information was provided by landowners:

Landowner	Possible activity over next 5 years	Change in use rates
Van Stone Mine	If the mine is re-opened, 6 heavy trucks and 42 cars per day would access the mine.	Roads accessing mine changed to HH use.
Vaagen Brothers	An average of 50 loads of timber per year over the next 5 years.	No change (light use)
Boise Cascade Corporation	An average of about 330 truckloads per year from the very southern portion of the WAU (Onion Creek Headwaters sub-basin). Hauling would take place from July through November (5 months - average 3 trucks per day).	Roads accessing BCC lands in Headwaters sub-basin changed to (2 scenarios run): • M logging use all year; or • H logging use for 5 months, L logging use for other 7 months

The results of the possible use scenarios are displayed in Table B-4.8. Note that only surface erosion from roads is included in these estimates. Gully erosion is not included since there is no good method to determine changes in gullies; gullies could increase with heavier road use, but heavier use may also result in better road maintenance and decrease gully erosion.

Table B-4.8. Increase in Road Surface Erosion under Possible Future Scenarios (average tons/yr).

Sub-basin	Existing Conditions	Increase with New Harvest, Assuming Moderate Use Rate	Increase with New Harvest, Assuming Heavy Use Rate for 5 mos/yr	Increase With Mine Active
Crown Creek	20	0	0	0
Five Mile Creek	10	0	0	0
Lower Onion Creek	1,240	0	0	0
Quinns Meadows	30	0	0	0
Onion Creek Headwaters	240	50	160	60
Total Watershed	1,540	50	160	60

All possible mine and major harvest activity would take place in the Onion Creek Headwaters sub-basin. Mine activity traffic would increase road surface erosion by about 60 tons/year; harvest traffic would result in a 50 to 160 tons/year increase. If both the mine and harvest activity took place, a total of about 100-200 additional tons/yr of sediment would be added to the streams from road surface erosion.

4.2.3 Sediment Delivery to Wetlands

The water quality analyst requested information on sediment input to wetlands with high sediment vulnerabilities. Table B-4.9 lists sediment input from roads to these wetlands under current use conditions. A complete discussion of wetlands and sediment vulnerabilities is included in the Water Quality Module (Appendix G).

Table B-4.9. Sediment Input from Roads to Wetlands with High Sediment Vulnerabilities.

Wetland	Sediment Input from Upstream Roads (tons/yr)
1	1,510
2	1,300
7	1,260
507	0
607a	1
607b	0
607c (608)	0
701-2a	25
701-2b	25
701-3	0
702	0
701-1	55
705	0
708	0
709	0
712	0
903a	1

4.3 Effects of Possible Strategies to Reduce Road Erosion

Road use in the Onion Creek WAU is the largest contributor of sediment resulting from management activities, adding about the equivalent of the background sediment yield to streams. Roads in the Lower Onion Creek sub-basin contribute the most sediment. The majority of

sediment comes from heavy residential use of wide, gravel-surfaced county roads. Two strategies could be used to reduce sediment input to streams:

(1) Pave segments with heavy use that drain to streams (see Map B-6 for 7 primary segments);

or

(2) Direct road drainage to the forest floor for filtering by installing additional cross drains. This would be particularly effective for the Johnson Grade Road where there are no relief drains for a very long section of road (over half a mile). This strategy would not be as effective along sections of the Bodie Mountain Road that closely parallel the stream.

Sediment from use of unsurfaced logging roads also contributes sediment to streams during use of the roads by log trucks. Sediment could be reduced from these roads by reducing the length of road that drains to streams (installing cross drains that drain to the forest floor) and by surfacing sections of road that do drain to streams with gravel.

4.4 Confidence Discussion

Confidence in the location and relative sediment input from segments of road that deliver to streams is high. The majority of the road network that crossed or paralleled streams was visited in the field to identify delivering segments. Road tread, cutslope, and fillslope conditions were observed in the field. Road use rates were based on the analyst's observations and input from land managers. The amounts of sediment computed to come from road surface erosion should be regarded as estimates; they are based on the best available road erosion research, but no measurements of road erosion were made in this basin.

Confidence in estimates of gully erosion is moderate to low. The road field work took place in late summer. Gullies and ruts form in response to heavy rains and snowmelt that occurs during the fall and spring and traffic use of wet roads; many roads were likely graded before the field work took place, removing evidence of gullies. In addition, it is not known if the large gully in the Headwaters Sub-basin road segment 536 which accounts for most of the gully erosion (150 tons of sediment) is a typical, every year occurrence.

5.0 SUMMARY OF EFFECTS ON PUBLIC RESOURCES

The primary management-related sediment input in the Onion Creek WAU is from road erosion (surface and gully erosion), with an unknown component from mining activities (Table B-5.1). Sediment delivered from road surface erosion is primarily fine-grained (clay, silt, fine sand). Gully erosion may also include coarser sand. The largest input is to the Lower Onion Creek sub-basin, from erosion along the Johnson Grade and Bodie Mountain Roads. Road-related sediment input is 4 times the background sediment input in this sub-basin and has the potential to affect fisheries and wetland resources in lower Onion Creek and the stream paralleling Bodie Mountain Road.

The Onion Creek Headwaters sub-basin also receives a considerable amount of sediment from road erosion, split almost equally between surface erosion, gullying, and mass wasting. Current road use levels in the Headwaters sub-basin increase sediment input approximately 140 percent over background, an amount that may affect fisheries and wetland resources. The major component of gully input in this sub-basin may not be indicative of average annual conditions. Increased use of roads in the Headwaters sub-basin in the future as a result of re-opening the Van Stone Mine and/or projected timber harvest could increase road erosion by several hundred tons per year.

Table B-5.1. Summary of Sediment Delivery to Connected Streams under Present Use Conditions (average tons/yr).

	Background		Management-Related					
Sub-basin	Soil Creep	Mass Wasting	Road Surface Erosion	Road Mass Wasting	Mining Mass Wasting	Grazing	Total Manage-ment	Percent Increase
Crown Creek	0	0	0	0	0	0	0	0%
Five Mile Creek	5	0	5	0	0	0	5	100%
Lower Onion Creek	305	0	1,255	25	0	80	1,360	450%
Quinns Meadows	170	0	35	0	0	0	35	20%
Onion Cr Headwaters	550	20	445	270	55*	0	770	140%
Total	1,030	20	1,740	295	55*	80	2,170	210%

* Estimated sediment input from mass wasting associated with Van Stone Mine facilities. Volume of additional input from surface erosion is unknown, but was likely significant in past.

The Five Mile Creek sub-basin is estimated to have a 100 percent increase in sediment levels due to road surface erosion, however, since there is likely no fish use of the creek, and the road input is small (5 tons/yr), it has an overall low surface erosion hazard rating.

6.0 MONITORING RECOMMENDATIONS

The major known and/or unknown but potentially large sources of sediment resulting from land use in the Onion Creek WAU include:

(1) Surface erosion of gravel-surfaced county roads with heavy residential use delivering to streams (known large amount - segments 36, 7, 8, 9, 10 and 17 on Map B-6);

(2) Gully erosion on native surfaced roads (unknown but potentially large amount); and

(3) Erosion from mine facilities and activities (unknown but potentially large amount).

Monitoring of surface erosion from the county road segments following implementation of any erosion control measures (i.e. installation of cross-drains to direct runoff to surface floor) could be useful to test the effectiveness of the control measures.

Monitoring of the mine facilities, particularly if the mine is re-opened, would help to quantify the amount of erosion associated with the mine works.

Road surveys on the segments of native surfaced roads that deliver to streams during the late spring (after snowmelt, prior to road maintenance/grading) would be helpful to determine the extent of gully erosion.

7.0 REFERENCES

Beschta, R.L., 1978. Long-term Patterns of Sediment Production Following Road Construction and Logging in the Oregon Coast Range. Water Resources Research. 14:1011-1016.

Bilby, R.E., K. Sullivan and S.H. Duncan, 1989. The Generation and Fate of Road-surface Sediment in Forested Watersheds in Southwestern Washington. Forest Science 35(2):453-468.

Megahan, W.F., K.A. Seyedbagheri, T.L. Mosko, and G.L. Ketcheson, 1986. Construction Phase Sediment Budget for Forest Roads on Granitic Slopes in Idaho. *In*: Drainage Basin Sediment Delivery, R.F. Hadley, ed. International Institute of Hydrologic Science, Publication 159 p. 31-39.

Reid, L.M. and T. Dunne, 1984. Sediment Production from Forest Road Surfaces. Water Resources Research 20(11):1753-1761.

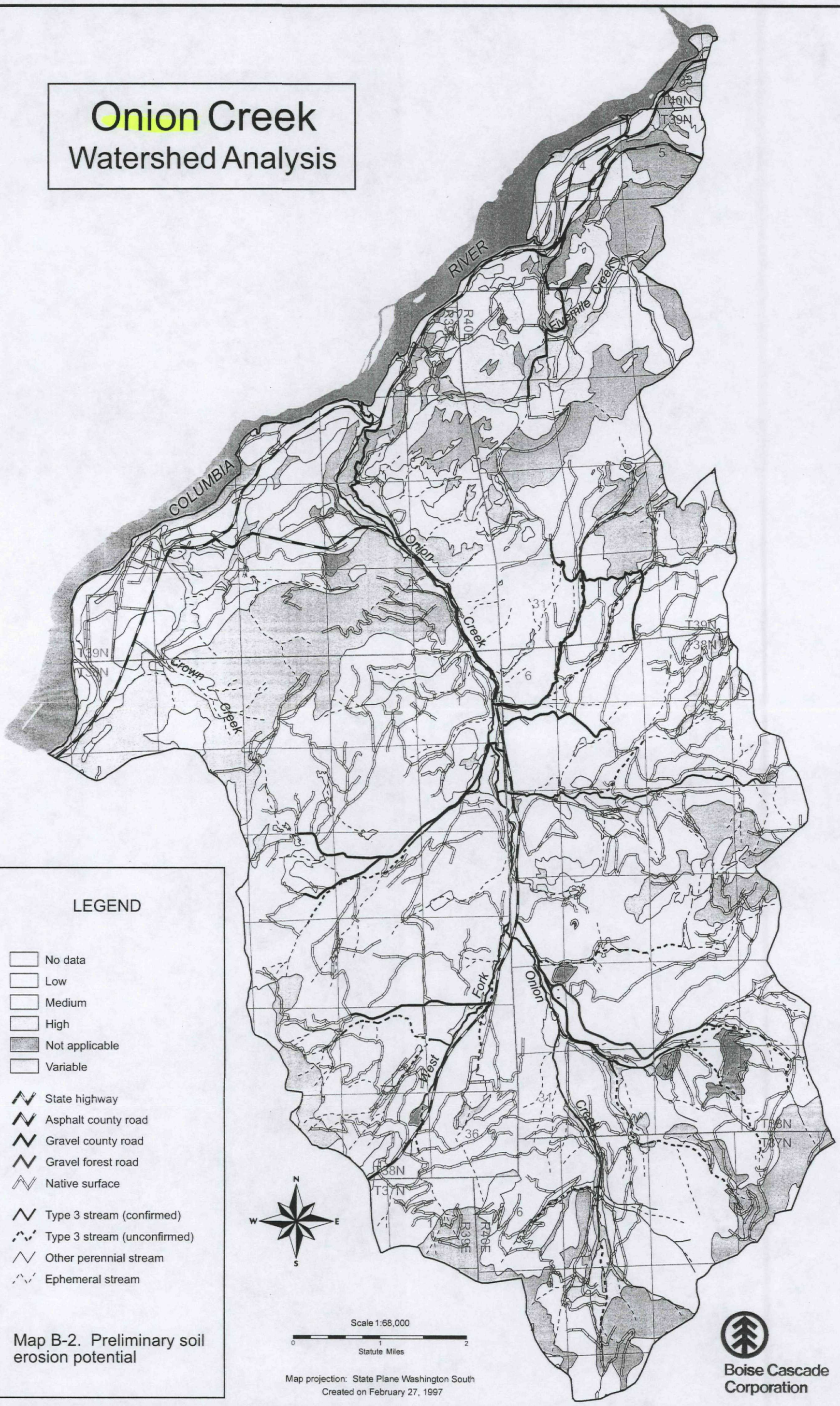
Sullivan, K.O. and S.H. Duncan, 1980. Sediment Yield from Road Surfaces in Response to Truck Traffic and Rainfall. Weyerhaeuser Technical Report 042-4402.80. Weyerhaeuser Company, Technical Center, Tacoma, WA 98477.

Swift, L.W. Jr., 1984. Gravel and Grass Surfacing Reduces Soil Loss from Mountain Roads. Forestry Science 30:657-670.

USDA SCS, 1982. Soil Survey of Stevens County, Washington. US Department of Agriculture, Soil Conservation Service. July 1982.

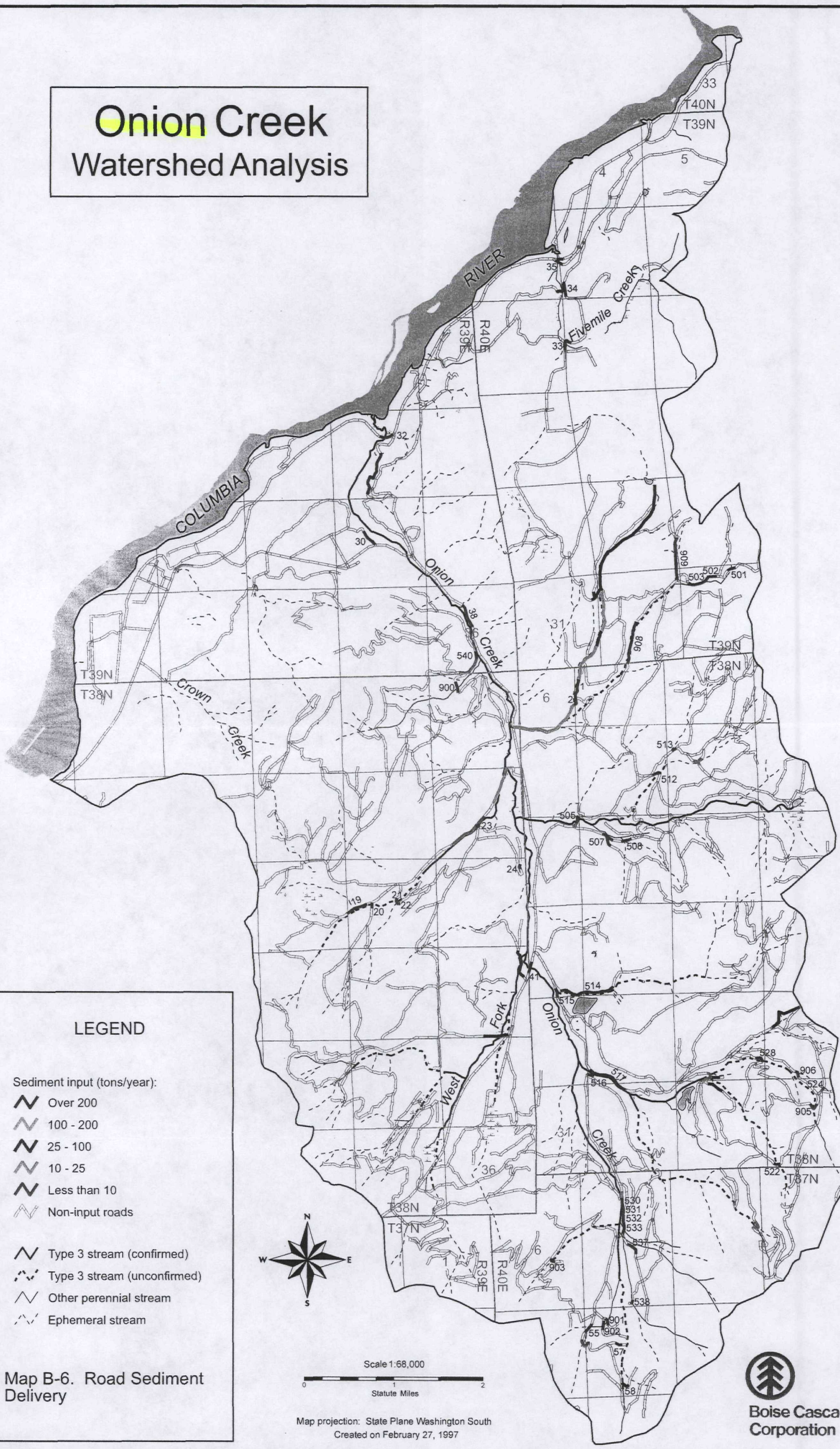
WDNR, 1995. Standard Methodology for Conducting Watershed Analysis, Version 3.0. Washington Forest Practices Board.

Onion Creek
Watershed Analysis



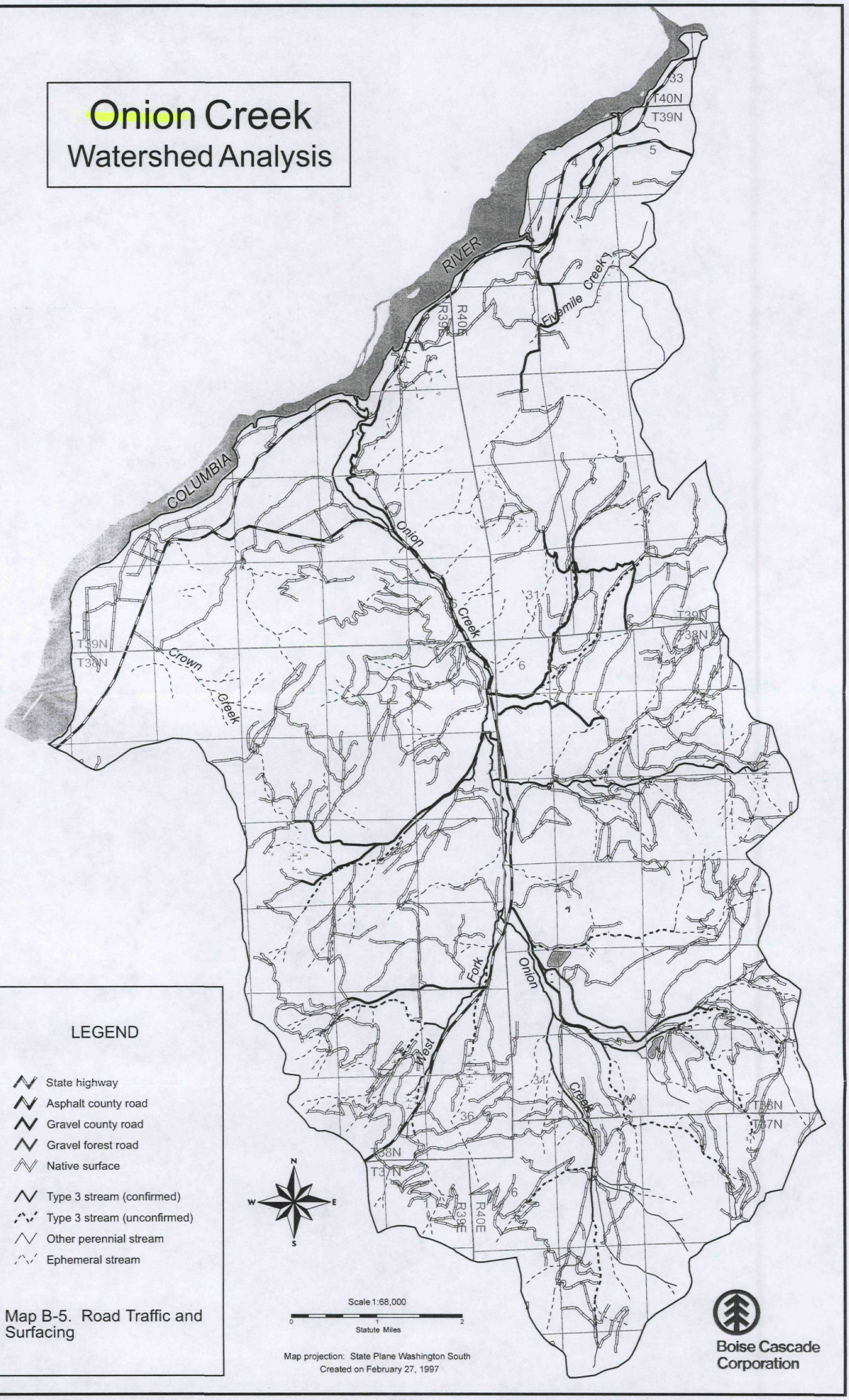
Map B-2. Preliminary soil erosion potential

Onion Creek
Watershed Analysis



Map B-6. Road Sediment Delivery

Onion Creek
Watershed Analysis



Map B-5. Road Traffic and Surfacing

Onion Creek
Watershed Analysis

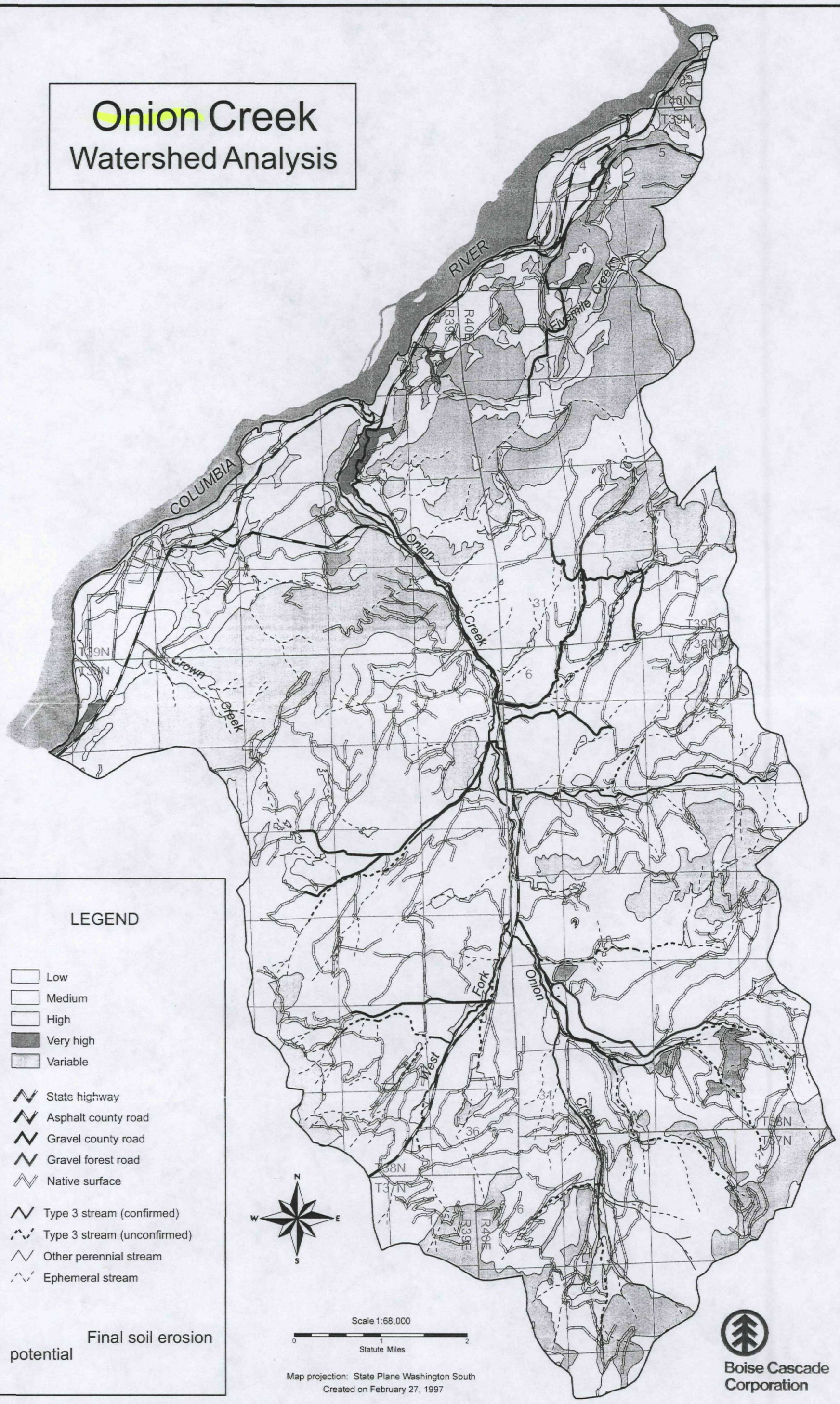


Table B-1.1 Soil Properties

State Soil Number	Soil Name	Slope (percent)	Area (acres)	Parent Material	Surface Erosion Potential	Mass Wasting Potential when Disturbed	Mass Wasting Potential	Road Construc-tion Hazard	Logging Hazard	Compaction Potential
0023	Ahren	2-20	52	Volcanic ash over glacial till	M	L	insig.	M	M	H
0024	Ahren	20-40	136	Volcanic ash over glacial till	M	L	L	M	M	H
0026	Ahren	40-65	35	Volcanic ash over glacial till	H	M	M	H	M	H
0031	Aits	0-15	394	Volcanic ash over glacial till	M	L	insig.	L	M	H
0033	Aits	15-25	653	Volcanic ash over glacial till	M	L	insig.	L	M	H
0035	Aits	25-40	214	Volcanic ash over glacial till	M	L	L	M	M	H
0037	Aits	0-40	79	Volcanic ash over glacial till	M	L	L	M	M	H
0040	Aits	40-65	688	Volcanic ash over glacial till	H	L	L	M	M	H
0496	Belzar	5-25	25	Volcanic ash over argillite	M	L	insig.	L	M	H
0497	Belzar	25-40	38	Volcanic ash over argillite	M	L	L	M	M	H
0499	Belzar	25-40	125	Volcanic ash over argillite	M	L	L	M	M	H
0500	Belzar	40-65	719	Volcanic ash over argillite	H	M	M	H	M	H
0542	Bisbee	0-15	1,099	Volcanic ash over glacial outwash	M	M	L	M	L	L
0544	Bisbee	25-45	271	Volcanic ash over glacial outwash	H	M	M	H	M	L
0585	Bonner	0-10	168	Volcanic ash over glacial outwash	L	L	insig.	L	M	M
0586	Bonner	30-65	481	Volcanic ash over glacial outwash	H	M	M	M	M	M
0588	Bonner	0-10	1,098	Volcanic ash over glacial outwash	L	L	insig.	L	M	H
0600	Bossburg	0-3	149	Mucks over alluvium	L	N/A		N/A	H	H
0629	Bridgeson	0-3	11	Aluvium/volcanic ash	L	N/A		N/A	M	H
0654	Buhrig	25-40	91	Volcanic ash over basalt	M	L	L	M	M	M
0655	Buhrig	40-65	632	Volcanic ash over basalt	M	M	M	H	H	M
0994	Cedonia	5-25	17	Volcanic ash over glacial lacustrine sediments	M	L	insig.	M	M	H
1000	Cedonia	5-15	398	Volcanic ash over glacial lacustrine sediments	M	L	insig.	M	M	H
1016	Chamokane	0-3	7	Sandy alluvium	L	N/A		N/A	M	M
1017	Chamokane	0-3	127	Sandy alluvium	L	N/A		N/A	M	M
1060	Chewelah	0-3	61	Sandy alluvium	L	N/A		N/A	M	H
1121	Clayton	5-15	50	Volcanic ash over glacial outwash	M	L	insig.	L	M	M
1164	Colville	0-3	14	Aluvium/volcanic ash	L	N/A		N/A	M	H

Table B-1.1 Soil Properties

State Soil Number	Soil Name	Slope (percent)	Area (acres)	Parent Material	Surface Erosion Potential	Mass Wasting Potential when Disturbed	Mass Wasting Potential	Road Construc-tion Hazard	Logging Hazard	Compaction Potential
1334	Cedonia	0-5	249	Volcanic ash over glacial lacustrine sediments	M	L	insig.	M	M	H
1335	Cedonia	30-65	177	Volcanic ash over glacial lacustrine sediments	very H	H	H	H	H	H
1338	Colville	0-3	1	Aluvium/volcanic ash	L	N/A		N/A	M	H
1631	Dehart	15-25	8	Volcanic ash over glacial outwash	L	L	insig.	L	L	L
1632	Dehart	25-40	37	Volcanic ash over glacial outwash	M	L	L	M	L	L
1687	Donavan	8-25	20	Volcanic ash over glacial till	L	L	insig.	L	M	M
1688	Donavan	25-40	139	Volcanic ash over glacial till	M	L	L	M	M	M
1694	Donavan	30-65	171	Volcanic ash over glacial till	H	L	L	M	M	M
1939	Eloika	0-15	15	Volcanic ash over glacial outwash	L	L	insig.	L	M	H
2801	Hagen	0-15	1,044	Glacial outwash	M	L	insig.	M	L	M
2803	Hagen	15-40	301	Glacial outwash	H	H	M	H	M	M
2935	Histosols	0-1	33	Mucks	L	L	insig.	N/A	N/A	N/A
3013	Huckleberry	0-15	36	Volcanic ash over argillite	M	L	insig.	L	M	H
3018	Huckleberry	40-65	1,117	Volcanic ash over argillite	H	M	M	H	H	H
3028	Hunters	0-5	38	Volcanic ash over glacial lacustrine sediments	L	L	insig.	M	M	H
3991	Koerling	0-5	57	Glacial outwash	L	L	insig.	N/A	M	M
3992	Koerling	5-15	215	Glacial outwash	M	L	insig.	M	M	M
4262	Leadpoint	0-25	368	Volcanic ash and till over limestone and shale	M	L	L	L	M	M
4263	Leadpoint	25-40	278	Volcanic ash and till over limestone and shale	M	M	M	M	M	M
4264	Leadpoint	40-65	234	Volcanic ash and till over limestone and shale	H	H	H	H	M	M
4265	Leadpoint	25-40	357	Volcanic ash and till over limestone and shale	M	M	M	M	M	M
4266	Leadpoint	40-65	296	Volcanic ash and till over limestone and shale	H	H	H	H	M	M
4625	Maki	25-40	234	Volcanic ash and till over limestone	M	L	L	M	M	M

Table B-1.1 Soil Properties

State Soil Number	Soil Name	Slope (percent)	Area (acres)	Parent Material	Surface Erosion Potential	Mass Wasting Potential when Disturbed	Mass Wasting Potential	Road Construc-tion Hazard	Logging Hazard	Compaction Potential
4626	Maki	40-65	1,078	Volcanic ash and till over limestone	H	M	M	H	M	M
4638	Manley	0-20	13	Volcanic ash over glacial till	M	L	insig.	M	M	H
4640	Manley	20-40	0	Volcanic ash over glacial till	M	L	L	M	M	H
4642	Manley	0-40	50	Volcanic ash over glacial till	M	L	L	M	M	H
4661	Martella	0-5	66	Volcanic ash over glacial lacustrine sediments	M	L	insig.	M	M	H
4663	Martella	5-15	192	Volcanic ash over glacial lacustrine sediments	M	L	insig.	M	M	H
4665	Martella	25-40	127	Volcanic ash over glacial lacustrine sediments	H	H	M	H	H	H
4729	Merkel	0-40	2,787	Volcanic ash over glacial till	M	L	L	M	M	M
4731	Merkel	40-65	485	Volcanic ash over glacial till	M	L	L	M	M	M
4732	Merkel	0-40	415	Volcanic ash over glacial till	M	L	L	M	M	M
4733	Merkel	40-65	55	Volcanic ash over glacial till	M	M	M	H	M	M
4807	Moscow	0-25	87	Volcanic ash over granite	M	L	insig.	M	M	H
4809	Moscow	25-40	240	Volcanic ash over granite	M	L	L	M	M	H
4814	Moscow	0-30	2,461	Volcanic ash over granite	M	L	insig.	M	M	H
4815	Moscow	30-55	1,503	Volcanic ash over granite	H	M	M	H	M	H
5218	Narcisse	0-5	37	Alluvium	L	N/A		N/A	M	H
5281	Newbell Nevine	0-25	2,503	Volcanic ash over glacial till	M	L	insig.	M	M	M
5282	Newbell	25-40	510	Volcanic ash over glacial till	M	L	L	M	M	M
5284	Newbell	40-65	49	Volcanic ash over glacial till	H	M	M	H	M	H
5291	Newbell	0-40	6,360	Volcanic ash over glacial till	M	L	L	M	M	H
5293	Newbell Nevine	30-65	434	Volcanic ash over glacial till	H	M	M	H	H	M
5294	Nevine	0-30	3,624	Volcanic ash over glacial till	M	L	insig.	M	M	M
5295	Nevine	30-45	1,992	Volcanic ash over glacial till	M	L	L	M	M	M
6073	Peone	0-5	19	Aluvium/volcanic ash	L	N/A		N/A	M	H
6142	Pits	0-99	311		H	variable		variable	N/A	variable
6218	Peone	0-5	217	Aluvium/volcanic ash	L	N/A		N/A	M	H
6623	Raisio	40-65	1	Volcanic ash and till over argillite	H	H	H	H	M	M
6625	Raisio	40-65	152	Volcanic ash and till over argillite	H	H	H	H	M	M

Table B-1.1 Soil Properties

State Soil Number	Soil Name	Slope (percent)	Area (acres)	Parent Material	Surface Erosion Potential	Mass Wasting Potential when Disturbed	Mass Wasting Potential	Road Construc-tion Hazard	Logging Hazard	Compaction Potential
6629	Rathdrum	0-3	44	Aluvium/volcanic ash	L	L	insig.	N/A	M	H
6672	Republic	0-25	302	Volcanic ash over glacial drift	L	L	insig.	L	L	M
6675	Republic	25-40	30	Volcanic ash over glacial drift	M	L	L	M	M	M
6734	Riverwash	0-5	3	Gravelly alluvium	variable	variable		variable	N/A	variable
6771	Rock Outcrop	50-90	767		M					
6773	Rock Outcrop	30-65	136		H					
6786	Rock Outcrop	30-65	87		H					
6792	Rock Outcrop	30-65	1,618		H					
6795	Rock Outcrop	30-65	393		H					
6859	Rufus	30-65	176	Volcanic ash and till over argillite	M	M	M	H	H	M
7143	Saltese	0-2	44	Peaty	L	N/A		N/A	H	H
7415	Smackout	0-5	36	Volcanic ash over glacial till	M	L	insig.	M	M	H
7416	Smackout	5-20	482	Volcanic ash over glacial till	M	L	insig.	M	M	H
7417	Smackout	20-40	127	Volcanic ash over glacial till	M	L	L	M	M	H
7418	Smackout	40-65	191	Volcanic ash over glacial till	H	M	M	H	M	H
7453	Spens	30-65	47	Glacial outwash	M	M	M	M	M	L
7489	Springdale	0-20	17	Glacial outwash	L	L	insig.	L	L	L
7495	Springdale	0-15	4	Glacial outwash	L	L	insig.	L	L	L
7664	Saltese	0-2	28	Peaty	L	N/A		N/A	H	H
7667	Spokane	0-40	19	Volcanic ash over granite	M	L	L	M	M	M
9011	Waits	0-15	186	Volcanic ash over glacial till	M	L	insig.	L	M	H
9012	Waits	15-25	216	Volcanic ash over glacial till	M	L	insig.	L	M	H
9013	Waits	25-40	155	Volcanic ash over glacial till	M	L	L	M	M	H
9014	Waits	40-65	8	Volcanic ash over glacial till	H	L	L	M	M	H
9015	Waits	25-40	440	Volcanic ash over glacial till	M	L	L	M	M	H
9016	Waits	40-65	1,715	Volcanic ash over glacial till	H	L	L	M	M	H
9158	Wolfeson	0-3	33	Volcanic ash over glacial outwash	L	N/A		N/A	M	H
9159	Wolfeson	0-3	67	Volcanic ash over glacial outwash	L	N/A		N/A	M	H
9169	Wethey	0-3	10	Alluvium	L	N/A		N/A	M	M

Onion Creek WAU Road Erosion Summary (average tons/yr)

Form B-4. Surface Erosion Summary

Sub-basin	Sediment Delivered from:	Delivery by Parent Material				Delivery by Surfacing			Delivery by Traffic Use (Logging/Residential Use)							
		Glacial Drift	Glacial Lake Seds	Granite	Quartz lte	Asphalt	Gravel	Native	HH	MH	MM	ML	LM	LL	NL	NN
Crown Creek	Tread	-	13	-	-	13	-	-	13	-	-	-	-	-	-	-
	Cutslope	-	6	-	-	6	-	-	6	-	-	-	-	-	-	-
	Fillslope	-	1	-	-	1	-	-	1	-	-	-	-	-	-	-
	Gullies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Five Mile Creek	Tread	5	-	-	-	2	-	3	2	-	-	-	-	3	-	-
	Cutslope	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Fillslope	1	-	-	-	1	-	-	-	-	-	-	1	-	-	-
	Gullies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Onion Creek	Tread	950	156	3	-	6	1,000	104	3	799	156	39	23	89	-	-
	Cutslope	63	51	1	-	4	78	32	-	24	51	6	-	33	-	1
	Fillslope	12	-	-	-	2	7	3	2	7	-	-	-	3	-	-
	Gullies	17	-	-	-	1	14	2	-	1	-	14	-	2	-	-
Onion Cr Headwaters	Tread	163	-	-	42	-	32	172	-	33	59	-	16	97	-	-
	Cutslope	31	-	-	4	-	1	34	-	1	4	-	19	11	-	-
	Fillslope	1	-	-	1	-	-	2	-	-	-	-	-	2	-	-
	Gullies	185	-	-	20	-	-	205	-	-	150	-	-	30	-	25
Quinns Meadows	Tread	33	-	-	-	-	-	33	-	7	25	-	-	-	-	-
	Cutslope	1	-	-	-	-	-	1	-	-	1	-	-	-	-	-
	Fillslope	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Gullies	5	-	-	-	-	-	5	-	-	2	-	3	-	-	-
Total WAU	Tread	1,151	170	3	42	22	1,032	312	19	840	240	39	40	188	-	-
	Cutslope	95	58	1	4	11	79	68	6	24	56	6	20	44	-	1
	Fillslope	15	1	-	1	5	7	5	4	7	-	-	1	4	-	-
	Gullies	207	-	-	20	1	14	212	-	1	152	14	3	32	-	25

Onion Creek WAU

Hillslope Surface Erosion Form

Location (T/R Section)	Year	Prelim. Soil Erosion Potential/ Activity Rating	Activity (harvest type/ method, fire, rec)	Erosion							Buffering/Mitigation				Comments
				Type/ Severity	Area/ Length/ Width	Causes	Slope (%)	Particle Sizes	Gullies?	Com-paction?	Reveg (%)	Grade Break?	Veg Buffer?	Delivery to Stream	
T 38N R 40E Sec 29/30		Variable	Tailing Pond	Rill/ High	1500' x 1000'	rain	varies	silt/sand	Rills	N	0	Y	Y	Not at present (contained by berm)	
T 38N R 40E Sec 27	?	Med	Harv - partial cut, skidder	Rill	100' x 15'	concen-trated road runoff	30	sand	Y	Y	0	N	N	Y (inter-mittent)	photos
T 38N R 40E Sec 27	?	Med	skidder/ tractors up creek												
T 38N R 40E Sec 27	?	Med	Harvest - skid trails	None!	0	none	60	sandy granitic till	N		0	N	N	N	
T 38N R 40E Sec 28	1996	Med	Harvest - skid trails	Rills	100' x 2'	concen-trated road runoff	10 to 60	sand/ silt	Rills	Y	0	Y	Y	N	granitic till
T 38N R 40E Sec 28	1996	Med	Landing	Overland	100' x 300'	rain	0 to 10	sand/ silt	N	Y	0	Y	Y	N	photos
T 38N R 40E Sec 28	1996	Med	Harvest - partial cut	Overland	along creek - 300'	rain	0	sand	N	N	50	Y	Y (but no harvest stream buffer)	Y	stream crossing (52)

Onion Creek WAU

Hillslope Surface Erosion Form

Location (T/R Section)	Year	Prelim. Soil Erosion Potential/ Activity Rating	Activity (harvest type/ method, fire, rec)	Erosion							Buffering/Mitigation				Comments
				Type/ Severity	Area/ Length/ Width	Causes	Slope (%)	Particle Sizes	Gullies?	Com-paction?	Reveg (%)	Grade Break?	Veg Buffer?	Delivery to Stream	
T 37N R 40E Sec 8	1996	High	Harvest - skid trail fill across creek	Gully - fill washed out at creek crossing	100 cu yd	creek	0 to 60	sand	Y	N	0	N	N	Y	
T 37N R 40E Sec 8	1996	High	Landing - slash pile burning	removes all veg											
T 38N R 40E Sec 28	1995/6	Med	Road	overland, gully	1000 sq ft	black pipe route	20	sand/ gravel	Y	N	15	N	Y	50%	
T 38N R 40E Sec 28	1996?	Med	Harvest - landing	overland	100' x 40'	bulldozed landing	20	sand/ gravel	N	N	0	Y	Y	< 10%	
T 37N R 40E Sec 5	1996	Low	Harvest	overland	2 acres		30	sand to small cobble	potential at stream	N	0	Y	N	20%	erosion likely only at pulled road crossing
T 37N R 40E Sec 5	?	Low	Harvest	overland	2000 sq ft	concen-trated road runoff	30	sand/ gravel	Y	Y	20	Y	N	30%	
T R Sec															

Onion Creek WAU Road Erosion Calculation Sheet

Form B-2. Roads Calculation Sheet

							Tread Information						Cutslope					Fillslope							
Segment Number	Sub-basin	Segment Length (ft)	Parent Material	Basic Erosion Rate*	Config. (Inslope/ Outslope/ Crowned)	Ditch Delivery to Stream (%)	Surface (Asphalt, Gravel, Native) & depth	Surface Factor	Traffic Use (Log Truck/ Residential)	Traffic Factor	Tread Width (ft)	Delivered Tread Erosion** (tons/yr)	Material	Ground Cover Density (%)	Cover Factor	Height (ft)	Delivered Cutslope Erosion** (tons/yr)	Material	Ground Cover Density (%)	Cover Factor	Height (ft)	Length Delivering to Stream (ft)	Delivered Fillslope Erosion** (tons/yr)	Gully Erosion (tons/yr)	Total Erosion (tons/yr)
1	Lower Onion Creek	1,288	T	30	I	10	G<2"	0.8	MH	5	25	8.87	T	35	0.52219	5	0.23	T	95	0.149955	3	0	0.00		9
2	Lower Onion Creek	380	T	30	O	100	G<2"	0.8	MH	5	25	3.44	-		n/a		0.00	T	90	0.149955	3	50	0.02		3
3	Lower Onion Creek	1,336	T	30	C	100	G<2"	0.8	MH	5	20	38.20	T	10	0.77	5	3.54	T	90	0.149955	10	50	0.05		42
4	Lower Onion Creek	2,360	T	30	I	100	G<2"	0.8	ML	2	15	39.01	T	50	0.37422	10	6.08	T	95	0.149955	2	2,360	0.49	14	60
5	Lower Onion Creek	1,757	T	30	I	100	N	1	LL	1	15	18.15	T	10	0.77	25	23.30	T	50	0.374222	3	1,757	1.36		43
6	Lower Onion Creek	3,481	T	30	I	100	N	1	LL	1	15	35.96	T	60	0.31157	5	3.73	T	95	0.149955	3	3,481	1.08		41
7	Lower Onion Creek	2,601	T	30	I	100	G<2"	0.8	MH	5	25	179.11	T	60	0.31157	10	5.58	T	95	0.149955	3	2,601	0.81		186
8	Lower Onion Creek	954	T	30	O	100	G<2"	0.8	MH	5	25	65.70	T	40	0.44352	15	4.37	T	50	0.374222	5	954	1.23		71
9	Lower Onion Creek	2,419	T	30	I	100	G<2"	0.8	MH	5	25	166.61	T	80	0.20032	5	1.67	T	95	0.149955	3	2,419	0.75		169
10	Lower Onion Creek	4,502	T	30	C	55	G 2-6"	0.5	MH	5	30	180.22	T	70	0.25395	5	2.17	T	95	0.149955	5	4,502	2.32		185
16	Lower Onion Creek	569	T	30	I	50	G>2"	0.6	MH	5	30	17.63	T	90	0.14995	2	0.06	F	10	0.77	10	100	0.53		18
17	Lower Onion Creek	1,763	T-si	60	C	100	G>2"	0.6	MH	5	30	120.19	T	70	0.25395	5	1.54	T	50	0.374222	5	176	0.23		122
18	Lower Onion Creek	2,630	T	30	O	10	G>2"	0.6	MH	5	30	16.30	T	60	0.31157	5	0.28	T	80	0.200324	15	263	0.54		17
19	Lower Onion Creek	1,316	T	30	C	100	G>2"	0.6	LL	1	25	6.90	T	100	0.10232	3	0.28	T	100	0.102315	5	20	0.01		7
20	Lower Onion Creek	356	T	30	I	100	N	1	LL	1	15	3.68	T	90	0.14995	3	0.11	T	80	0.200324	3	10	0.00		4
21	Lower Onion Creek	255	T	30	I	100	80%N-VEG	0.9	LL	1	15	2.37	T	70	0.25395	3	0.13	T	80	0.200324	3	40	0.02		3
22	Lower Onion Creek	261	T	30	I	100	80%N-VEG	0.9	LL	1	15	2.43	T	80	0.20032	3	0.11	T	100	0.102315	3	10	0.00		3
23	Lower Onion Creek	435	T	30	I	100	G-6"	0.2	LL	1	15	0.90	T	50	0.37422	5	0.56	T	100	0.102315	20	40	0.06		2
24	Lower Onion Creek	312	GRAN	30	I	100	N	1	LL	1	15	3.23	GRAN	60	0.31157	10	0.67	GRAN	95	0.149955	20	20	0.04		4
25	Onion Cr Headwaters	1,766	T	30	C	100	N/G	0.75	LM	1.2	18	10.07	T	10	0.77	20	18.73	T	95	0.149955	5	40	0.02		29
26	Onion Cr Headwaters	1,458	T/O	30	I	100	G	0.2	MH	5	25	25.10	T/O	100	0.10232	5	0.51	T	100	0.102315	3	40	0.01		26
27	Onion Cr Headwaters	348	T-sa	30	O	100	N	1	LL	1	15	0.21	T-sa	50	0.37422	10	0.05	T	100	0.102315	25	20	0.04		0
28	Onion Cr Headwaters	273	T-sa	30	O	10	N/100%VEG	0.8	LL	1	15	0.17	T	100	0.10232	2	0.00	T	100	0.102315	15	20	0.02		0
30	Lower Onion Creek	1,113	T-sa	30	C	100	G/100%VEG	0.8	NN	0.02	15	0.09	T	90	0.14995	5	0.57	T	100	0.102315	20	10	0.01		1
31	Crown Creek	1,229	L	60	C	50	A	0.03	HH	20	40	13.46	L	50	0.37422	20	6.34	T	50	0.374222	25	200	1.29		21
32	Lower Onion Creek	857	ALLUV	30	O	0	A	0.03	HH	20	40	3.31	-		n/a		0.00	F	0	1	15	200	2.07		5
33	Five Mile Creek	978	T-sa	30	I	10	G	0.2	LM	1.2	20	0.32	T-sa	95	0.14995	20	0.20	F	100	0.102315	15	100	0.11		1
34	Five Mile Creek	325	T-sa	30	C	10	A	0.03	MM	2	20	0.03	T	50	0.37422	15	0.13	T	95	0.149955	25	50	0.13		0
34	Five Mile Creek	272	T-sa	30	I	100	N	1	LL	1	15	2.81	T	70	0.25395	5	0.24	T	100	0.102315	3	100	0.02		3
35	Five Mile Creek	479	T-sa	30	C	10	A	0.03	LM	1.2	20	0.06	-		n/a		0.00	T	100	0.102315	30	200	0.42		0
35	Five Mile Creek	479	T-sa	30	C	10	A	0.03	HH	20	40	2.05	-		n/a		0.00	T	100	0.102315	30	200	0.42		2
36	Lower Onion Creek	3,023	L	60	I	100	G 2"	0.75	MM	2	25	156.13	L	20	0.61549	20	51.25	-		n/a		0	0.00		207
37	Lower Onion Creek	493	ALLUV	30	C	0	A	0.03	MH	5	35	0.27	-		n/a		0.00	F	50	0.374222	5	150	0.19		0
38	Lower Onion Creek	1,477	T	30	C	100	A	0.03	MH	5	35	2.67	T-sa	80	0.20032	20	4.08	-		n/a		0	0.00	1	7
39	Lower Onion Creek	264	T	30	C	0	A	0.03	MH	5	35	0.09	-		n/a		0.00	T	100	0.102315	7.5	50	0.03		0
40	Quinns Meadows	651	T	30	C	0	A	0.03	MH	5	35	0.09	-		n/a		0.00	T	100	0.102315	7.5	50	0.03		0
41	Onion Cr Headwaters	689	T	30	C	10	A	0.03	MH	5	35	0.40	T	90	0.14995	5	0.04	F	100	0.102315	30	150	0.32		1
50	Onion Cr Headwaters	2,498	Gran T	30	C	100	N	1	LL	1	18	15.48	T-sa	50	0.37422	5	3.22	T	80	0.200324	5	0	0.00	7	26
51	Onion Cr Headwaters	580	Gran T	30	O	10	N	1	LL	1	18	0.12	T-sa	0	1	10	0.07	T	100	0.102315	10	10	0.01		0
52	Onion Cr Headwaters	480	Gran T	30	I	100	N	1	LL	1	18	5.95	T-sa	10	0.77	15	3.81	T	50	0.374222	15	100	0.39	3	13

Onion Creek WAU Road Erosion Calculation Sheet

Form B-2. Roads Calculation Sheet

							Tread Information						Cutslope					Fillslope							
Segment Number	Sub-basin	Segment Length (ft)	Parent Material	Basic Erosion Rate*	Config. (Inslope/ Outslope/ Crowned)	Ditch Delivery to Stream (%)	Surface (Asphalt, Gravel, Native) & depth	Surface Factor	Traffic Use (Log Truck/ Residential)	Traffic Factor	Tread Width (ft)	Delivered Tread Erosion** (tons/yr)	Material	Ground Cover Density (%)	Cover Factor	Height (ft)	Delivered Cutslope Erosion** (tons/yr)	Material	Ground Cover Density (%)	Cover Factor	Height (ft)	Length Delivering to Stream (ft)	Delivered Fillslope Erosion** (tons/yr)	Gully Erosion (tons/yr)	Total Erosion (tons/yr)
55	Onion Cr Headwaters	639	QTZ	30	I	100	N	1	LL	1	20	8.80	QTZ	90	0.14995	5	0.33	QTZ	50	0.374222	5	50	0.06		9
56	Onion Cr Headwaters	880	QTZ	30	I	100	N	1	LL	1	20	12.12	QTZ	90	0.14995	5	0.45	QTZ	50	0.374222	5	50	0.06		13
57	Onion Cr Headwaters	450	QTZ	30	C	100	N	1	LL	1	18	2.85	QTZ	60	0.31157	3	0.29	F	90	0.149955	5	10	0.01		3
58	Onion Cr Headwaters	500	QTZ	30	C	100	N	1	LL	1	20	4.13	QTZ	0	1	5	1.72	F	0	1	10	100	0.69	20	27
501	Lower Onion Creek	499	T	30	C	10	N	1	LL	1	16	0.55	T	75	0.25395	2	0.02	T	95	0.149955	3	50	0.02		1
502	Lower Onion Creek	812	T	30	O	-	N	1	LL	1	18	0.62	T	15	0.77	6	0.16	T	95	0.149955	4	50	0.02	2	3
503	Lower Onion Creek	1,080	T	30	O	70	N	1	LL	1	18	1.24	T	15	0.77	12	0.64	T	85	0.200324	15	100	0.21		2
504	Lower Onion Creek	459	T	30	C	0	G<2"	0.8	LM	1.2	20	0.20	-		n/a	-	0.00	T	95	0.149955	3	30	0.01		0
505	Quinns Meadows	487	T	30	I	10	N	1	MH	5	16	2.68	T	50	0.37422	8	0.10	T	85	0.200324	6	20	0.02		3
506	Quinns Meadows	1,075	T	30	C	15	N	1	MH	5	15	4.68	-		n/a	-	0.00	T	95	0.149955	8	20	0.02		5
507	Quinns Meadows	300	T	30	C	100	N	1	MM	2	15	3.10	T	50	0.37422	2	0.15	-		n/a	-	0	0.00		3
508	Quinns Meadows	300	T	30	C	50	N	1	MM	2	16	1.65	T	60	0.31157	2	0.06	-		n/a	-	0	0.00	2	4
509	Quinns Meadows	434	T	30	O	40	N	1	NL	0.05	12	0.02	T	55	0.37422	8	0.08	T	85	0.200324	10	40	0.06		0
510	Quinns Meadows	412	T	30	I	15	N	1	NL	0.05	12	0.03	T	80	0.20032	6	0.05	T	85	0.200324	5	30	0.02		0
511	Quinns Meadows	454	T	30	O	40	N	1	LM	1.2	16	0.20	T	75	0.25395	4	0.01	T	95	0.149955	10	15	0.02	3	3
512	Quinns Meadows	551	T	30	I	20	N	1	MM	2	16	2.43	T	60	0.31157	2	0.05	T	100	0.102315	3	20	0.00		2
513	Quinns Meadows	308	T	30	C	60	N	1	MM	2	12	1.53	T	80	0.20032	2	0.05	-		n/a	-	0	0.00		2
514	Onion Cr Headwaters	3,367	T	30	I	5	N	1	LM	1.2	14	1.95	T	70	0.25395	3	0.09	T	95	0.149955	4	0	0.00		2
515	Onion Cr Headwaters	589	T	30	O	5	G<2"	0.8	MH	5	27	2.98	T	75	0.25395	1	0.01	T	95	0.149955	15	40	0.06		3
516	Onion Cr Headwaters	785	T	30	I	10	G<2"	0.8	MH	5	20	4.32	T	90	0.14995	2	0.02	T	80	0.200324	2	30	0.01		4
517	Onion Cr Headwaters	2,232	T	30	O	10	N	1	LM	1.2	8	1.98	T	95	0.14995	1	0.03	T	100	0.102315	4	300	0.08		2
518	Onion Cr Headwaters	1,228	T	30	O	60	G<2"	0.8	MH	5	25	0.00	-		n/a	-	0.00	-		n/a	-	0	0.00		0
519	Onion Cr Headwaters	615	T	30	I	50	N	1	NN	0.02	12	0.05	T	50	0.37422	4	0.32	T	95	0.149955	3	0	0.00	25	25
520	Onion Cr Headwaters	700	T	30	I	50	N	1	MM	2	20	9.64	T	60	0.31157	2	0.15	T	95	0.149955	4	0	0.00		10
521	Onion Cr Headwaters	989	T	30	I	100	N	1	MM	2	20	27.25	T	70	0.25395	2	0.35	-		n/a	-	0	0.00		28
522	Onion Cr Headwaters	409	T	30	I	40	N	1	LL	1	18	2.03	-		n/a	-	0.00	T	80	0.200324	8	30	0.03		2
523	Onion Cr Headwaters	187	T	30	O	20	N	1	LL	1	18	0.00	T	80	0.20032	2	0.00	-		n/a	-	0	0.00		0
524	Onion Cr Headwaters	280	T	30	I	20	N	1	LM	1.2	20	0.93	T	75	0.25395	2	0.02	-		n/a	-	0	0.00		1
525	Onion Cr Headwaters	401	T	30	O	0	N	1	LM	1.2	15	0.00	T	80	0.20032	1	0.00	-		n/a	-	0	0.00		0
526	Onion Cr Headwaters	672	T	30	O	20	G<2"	0.8	LM	1.2	20	0.00	-		n/a	-	0.00	T	90	0.149955	8	0	0.00		0
527	Onion Cr Headwaters	916	T	30	O	20	G<2"	0.8	LM	1.2	24	0.00	-		n/a	-	0.00	T	80	0.200324	8	0	0.00		0
528	Onion Cr Headwaters	630	T	30	I	10	N	1	LM	1.2	18	0.94	T	55	0.37422	8	0.13	T	70	0.253952	6	0	0.00		1
529	Onion Cr Headwaters	416	T	30	I	5	VEG	0.8	LL	1	10	0.11	T	85	0.20032	2	0.01	-		n/a	-	0	0.00		0
530	Onion Cr Headwaters	627	T	30	I	25	N	1	MM	2	16	3.46	T	50	0.37422	2	0.08	T	60	0.311568	3	100	0.06		4
531	Onion Cr Headwaters	533	T	30	C	100	N	1	MM	2	16	6.43	T	25	0.61549	4	0.90	T	75	0.253952	3	50	0.03		7
532	Onion Cr Headwaters	506	T	30	C	100	N	1	MM	2	16	5.57	T	15	0.77	6	1.61	-		n/a	-	0	0.00		7
533	Onion Cr Headwaters	477	T	30	I	60	N	1	MM	2	16	6.31	T	15	0.77	3	0.46	-		n/a	-	0	0.00		7
534	Onion Cr Headwaters	330	T	30	I	10	N	1	LM	1.2	16	0.44	T	40	0.44352	1	0.01	T	95	0.149955	12	20	0.02		0
535	Onion Cr Headwaters	335	T	30	O	10	N	1	LM	1.2	12	0.00	-		n/a	-	0.00	-		n/a	-	0	0.00		0
536	Onion Cr Headwaters	398	T	30	O	100	N	1	MM	2	16	0.44	T	90	0.14995	4	0.01	T	95	0.149955	5	20	0.01	150	150
537	Onion Cr Headwaters	889	T	30	I	40	N	1	LL	1	16	3.92	T	60	0.31157	2	0.15	-		n/a	-	0	0.00		4
538	Onion Cr Headwaters	278	T	30	I	50	N	1	LL	1	18	1.73	T	75	0.25395	2	0.05	-		n/a	-	0	0.00		2

Onion Creek WAU Road Erosion Calculation Sheet

Form B-2. Roads Calculation Sheet

							Tread Information						Cutslope					Fillslope							
Segment Number	Sub-basin	Segment Length (ft)	Parent Material	Basic Erosion Rate*	Config. (Inslope/ Outslope/ Crowned)	Ditch Delivery to Stream (%)	Surface (Asphalt, Gravel, Native) & depth	Surface Factor	Traffic Use (Log Truck/ Residential)	Traffic Factor	Tread Width (ft)	Delivered Tread Erosion** (tons/yr)	Material	Ground Cover Density (%)	Cover Factor	Height (ft)	Delivered Cutslope Erosion** (tons/yr)	Material	Ground Cover Density (%)	Cover Factor	Height (ft)	Length Delivering to Stream (ft)	Delivered Fillslope Erosion** (tons/yr)	Gully Erosion (tons/yr)	Total Erosion (tons/yr)
539	Lower Onion Creek	600	T	30	I	0	N	1	LM	1.2	18	0.00	T	90	0.14995	1	0.00	T	95	0.149955	4	50	0.02		0
540	Lower Onion Creek	488	T	30	I	10	N	1	LM	1.2	18	0.73	T	100	0.10232	4	0.01	T	95	0.149955	8	100	0.08		1
541	Lower Onion Creek	1,489	T	30	I	100	N	1	LM	1.2	18	22.15	T	80	0.20032	2	0.41	-		n/a	-	0	0.00		23
900	Lower Onion Creek	703	T	30	I	100	N	1	LL	1	18	8.72	T	80	0.20032	2	0.19	T	95	0.149955	5	50	0.03		9
901	Onion Cr Headwaters	469	QTZ	30	I	100	N	1	LL	1	20	6.46	QTZ	70	0.25395	4	0.33	QTZ	50	0.374222	5	50	0.06		7
902	Onion Cr Headwaters	564	QTZ	30	I	100	N	1	LL	1	20	7.77	QTZ	70	0.25395	4	0.39	QTZ	50	0.374222	5	50	0.06		8
903	Onion Cr Headwaters	382	T	30	O	100	N	1	LL	1	15	0.52	-		n/a		0.00	T	95	0.149955	5	50	0.03		1
904	Onion Cr Headwaters	809	T	30	I	100	N	1	LL	1	18	10.03	T	80	0.20032	2	0.22	T	95	0.149955	5	50	0.03		10
905	Onion Cr Headwaters	733	T	30	I	100	N	1	LL	1	18	9.09	T	80	0.20032	2	0.20	T	95	0.149955	5	50	0.03		9
906	Onion Cr Headwaters	448	T	30	I	100	N	1	LL	1	18	5.55	T	80	0.20032	2	0.12	T	95	0.149955	5	50	0.03		6
907	Quinns Meadows	797	T	30	I	100	N	1	MM	2	15	16.46	T	70	0.25395	2	0.28	T	100	0.102315	3	20	0.00		17
908	Lower Onion Creek	2,592	T	30	C	10	N	1	LL	1	18	1.92	T	15	0.77	10	1.37	T	90	0.149955	8	50	0.04		3
909	Lower Onion Creek	2,569	T	30	C	10	N	1	LL	1	18	1.90	T	15	0.77	10	1.36	T	90	0.149955	8	50	0.04		3
Total for Basin ***		89,776	ft									1366					157						17	227	1,767
		17	miles																						

Notes: * Basic Erosion Rate for cutslope and fillslope may be slightly different if different composition (i.e. fill) was noted in field.
** Delivered sediment for each prism component takes into account road configuration (inslope, outslope, crowned) as well as ditch delivery for tread and cutslope.
*** Total by sub-basin is included in Tables B-4.6 and B-4.7.

							Tread Information			Cutslope					Fillslope					Ditch			
Segment Number	Sub-basin	Segment Length (ft)	Parent Material	Road Slope (avg. %)	Hillside Slope (avg. degrees)	Config. (Inslope/ Outslope/ Crowned)	Surface (Asphalt, Gravel, Native) & depth	Traffic Use (Log Truck/ Residential)	Tread Width (ft)	Material	Ground Cover Density (%)	Slope (degrees)	Height (ft)	Water Seepage ?	Material	Ground Cover Density (%)	Slope (degrees)	Height (ft)	Length Delivering to Stream (ft)	Present?	Gullies ?	Delivery to Stream (%)	Comments
1	Lower Onion Creek	1,288	T		45	I	G<2"	MH	25	T	35	60	5	N	T	95	30	3		Y	N	10	+250' cutslope from segment 2
2	Lower Onion Creek	380	T	10	45	O	G<2"	MH	25	-					T	90	60	3	50			100	stream crossing
3	Lower Onion Creek	1,336	T	15	60	C	G<2"	MH	20	T	10	70	5	N	T	90	60	10	50	Y	N	100	
4	Lower Onion Creek	2,360	T	5	V	I	G<2"	ML	15	T	50	60	10	N	T	95	30	2	2,360	Y	stream	100	stream runs in road (intermittent); gullied tread
5	Lower Onion Creek	1,757	T	5	V	I	N	LL	15	T	10	60	25	N	T	50	30	3	1,757	Y		100	parallel stream
6	Lower Onion Creek	3,481	T	5		I	N	LL	15	T	60	60	5	N	T	95	30	3	3,481	Y		100	muddy, rutted
7	Lower Onion Creek	2,601	T	10	20	I	G<2"	MH	25	T	60	60	10	N	T	95	45	3	2,601	Y		100	
8	Lower Onion Creek	954	T	10	30	O	G<2"	MH	25	T	40	60	15	Y	T	50	45	5	954	Y	Y	100	
9	Lower Onion Creek	2,419	T	10	20	I	G<2"	MH	25	T	80	60	5	N	T	95	45	3	2,419	Y		100	
10	Lower Onion Creek	4,502	T	7.5	45	C	G 2-6"	MH	30	T	70	60	5	N	T	95	60	5	4,502	Y		55	from stream.
16	Lower Onion Creek	569	T	5	5	I	G>2"	MH	30	T	90	60	2	N	F	10	60	10	100	Y		50	part direct/part to 50 of stream
17	Lower Onion Creek	1,763	T-si	5	0-5	C	G>2"	MH	30	T	70	60	5		T	50	70	5	176	Y		100	fill @ crossing - us side - graded over slope
18	Lower Onion Creek	2,630	T	2	0-5	O	G>2"	MH	30	T	60	60	5		T	80	60	15	263	Y		10	parallel to stream
19	Lower Onion Creek	1,316	T	5	0-5	C	G>2"	LL	25	T	100	45	3		T	100	60	5	20	Y		100	
20	Lower Onion Creek	356	T	10	10	I	N	LL	15	T	90	60	3		T	80	70	3	10	Y		100	
21	Lower Onion Creek	255	T	15	15	I	80%N-VEG	LL	15	T	70	60	3		T	80	60	3	40	Y		100	cow trail - on tread. (harvest-no deliv)
22	Lower Onion Creek	261	T	5	5	I	80%N-VEG	LL	15	T	80	60	3		T	100	45	3	10	Y		100	
23	Lower Onion Creek	435	T	2	0-5	I	G-6"	LL	15	T	50	60	5		T	100	60	20	40	Y		100	
24	Lower Onion Creek	312	GRAN	2	45	I	N	LL	15	GRAN	60	60	10		GRAN	95	60	20	20	Y		100	
25	Onion Cr Headwaters	1,766	T	10	30	C	N/G	LM	18	T	10	65	20		T	95	45	5	40	Y		100	
26	Onion Cr Headwaters	1,458	T/O	5	5	I	G	MH	25	T/O	100	45	5	N	T	100	60	3	40	Y		100	
27	Onion Cr Headwaters	348	T-sa	2	15	O	N	LL	15	T-sa	50	45	10	N	T	100	60	25	20	Y		100	
28	Onion Cr Headwaters	273	T-sa	2	30	O	N/100%VEG	LL	15	T	100	30	2		T	100	60	15	20	Y		10	
30	Lower Onion Creek	1,113	T-sa	10	45	C	G/100%VEG	NN	15	T	90	60	5	Y	T	100	60	20	10	Y	N	100	culvert-has plugged in past, stream down road
31	Crown Creek	1,229	L	5	5	C	A	HH	40	L	50	60	20		T	50	60	25	200	Y	N	50	
32	Lower Onion Creek	857	ALLUV	0	0	O	A	HH	40	-					F	0	60	15	200			0	Onion Creek cossing
33	Five Mile Creek	978	T-sa	5	30	I	G	LM	20	T-sa	95	60	20		F	100	60	15	100	Y		10	
34	Five Mile Creek	325	T-sa	10	45	C	A	MM	20	T	50	60	15		T	95	60	25	50	Y		10	
34	Five Mile Creek	272	T-sa	5	0-30	I	N	LL	15	T	70	60	5	Y	T	100	45	3	100	Y		100	
35	Five Mile Creek	479	T-sa	0		C	A	LM	20	-					T	100	60	30	200			10	crossing
35	Five Mile Creek	479	T-sa	2		C	A	HH	40	-					T	100	60	30	200			10	crossing
36	Lower Onion Creek	3,023	L	10	45	I	G 2"	MM	25	L	20	60	20	N	-				0	Y	Y 1'X6"	100	Johnson Grade Road Photo 23, 24
37	Lower Onion Creek	493	ALLUV	0		C	A	MH	35	-					F	50	60	5	150	N		0	Onion Creek crossing
38	Lower Onion Creek	1,477	T	5	30	C	A	MH	35	T-sa	80	60	20	N	-				0	Y	N	100	downspouted culvert - broken downspout; gully in fill
39	Lower Onion Creek	264	T	0-2	0	C	A	MH	35	-					T	100	60	7.5	50			0	
40	Quinns Meadows	651	T	0-2	0	C	A	MH	35	-					T	100	60	7.5	50			0	
41	Onion Cr Headwaters	689	T	2-5	0	C	A	MH	35	T	90	60	5	N	F	100	60	30	150	Y	N	10	
50	Onion Cr Headwaters	2,498	Gran T	5-10	20	C	N	LL	18	T-sa	50	60	5		T	80	30	5	0	Y	Y	100	tread gullied
51	Onion Cr Headwaters	580	Gran T	0-5	45	O	N	LL	18	T-sa	0	60	10		T	100	80	10	10	Y		10	
52	Onion Cr Headwaters	480	Gran T	0-5	10	I	N	LL	18	T-sa	10	60	15		T	50	45	15	100	Y	N	100	fillslope gullied 1' deep x 1' wide x 50' long

							Tread Information			Cutslope					Fillslope					Ditch			
Segment Number	Sub-basin	Segment Length (ft)	Parent Material	Road Slope (avg. %)	Hillside Slope (avg. degrees)	Config. (Inslope/ Outslope/ Crowned)	Surface (Asphalt, Gravel, Native) & depth	Traffic Use (Log Truck/ Residential)	Tread Width (ft)	Material	Ground Cover Density (%)	Slope (degrees)	Height (ft)	Water Seepage ?	Material	Ground Cover Density (%)	Slope (degrees)	Height (ft)	Length Delivering to Stream (ft)	Present?	Gullies ?	Delivery to Stream (%)	Comments
55	Onion Cr Headwaters	639	QTZ	10	30	I	N	LL	20	QTZ	90	60	5	Y	QTZ	50	60	5	50	Y	N	100	
56	Onion Cr Headwaters	880	QTZ	0-10	30	I	N	LL	20	QTZ	90	60	5	Y	QTZ	50	60	5	50	Y	N	100	
57	Onion Cr Headwaters	450	QTZ	2	10	C	N	LL	18	QTZ	60	60	3	Y	F	90	60	5	10	Y	N	100	lots of sm grav. in crk dst. through CC
58	Onion Cr Headwaters	500	QTZ	5	15-20	C	N	LL	20	QTZ	0	60	5	+FAILURE	F	0	60	10	100	Y	Y	100	blowdown at us end of CC; cutslope major erosion; road over fill/gully photos
501	Lower Onion Creek	499	T	5	15	C	N	LL	16	T	75	45	2	N	T	95	30	3	50	Y	N	10	only silt-sizes of consequence; flat deposition pond area
502	Lower Onion Creek	812	T	10	35	O	N	LL	18	T	15	45	6	N	T	95	60	4	50	N	-	-	ruts in road, delivery of wash by small gullies
503	Lower Onion Creek	1,080	T	13	40	O	N	LL	18	T	15	45	12	N	T	85	65	15	100	Y	Y	70	cuts are failing in sheets; granular-rich till
504	Lower Onion Creek	459	T	10	10	C	G<2"	LM	20	-	-	-	-	N	T	95	35	3	30	-	-	0	
505	Quinns Meadows	487	T	20	40	I	N	MH	16	T	50	60	8	N	T	85	45	6	20	N	N	10	inslope drainage acts as ditch, providing 10% delivery
506	Quinns Meadows	1,075	T	10	10	C	N	MH	15	-	-	-	-	-	T	95	45	8	20	Y	Y	15	
507	Quinns Meadows	300	T	13	NA	C	N	MM	15	T	50	60	2	N	-	-	-	-	0	Y	Y	100	*delivers to SEG #506
508	Quinns Meadows	300	T	12	20	C	N	MM	16	T	60	60	2	N	-	-	-	-	0	Y	Y	50	culvert erosion at tailO; buried cable exposed via caving. see photo 13, roll 1
509	Quinns Meadows	434	T	15	35	O	N	NL	12	T	55	45	8	N	T	85	65	10	40	Y	Y	40	
510	Quinns Meadows	412	T	10	30	I	N	NL	12	T	80	45	6	N	T	85	60	5	30	Y	Y	15	2 ft culvert
511	Quinns Meadows	454	T	10	25	O	N	LM	16	T	75	55	4	N	T	95	60	10	15	Y	Y	40	
512	Quinns Meadows	551	T	15	30	I	N	MM	16	T	60	65	2	N	T	100	20	3	20	Y	N	20	bankfull width of stream about 3 ft; gravel/cobble substrate; flow about 15 gpm
513	Quinns Meadows	308	T	10	10	C	N	MM	12	T	80	45	2	N	-	-	-	-	0	Y	Y	60	bankfull width of stream about 1 ft; silty substrate; no flow
514	Onion Cr Headwaters	3,367	T	5	30	I	N	LM	14	T	70	45	3	N	T	95	45	4	0	Y	Y	5	
515	Onion Cr Headwaters	589	T	10	30	O	G<2"	MH	27	T	75	60	1	N	T	95	60	15	40	Y	Y	5	outslope at culvert tail gullied about 2 ft x 2 ft
516	Onion Cr Headwaters	785	T	10	10	I	G<2"	MH	20	T	90	45	2	N	T	80	45	2	30	Y	Y	10	
517	Onion Cr Headwaters	2,232	T	3	30	O	N	LM	8	T	95	45	1	Y	T	100	45	4	300	Y	Y	10	
518	Onion Cr Headwaters	1,228	T	5	-	O	G<2"	MH	25	-	-	-	-	-	-	-	-	-	0	Y	Y	60	ditch grassed 50%; about 75% of road runoff goes to gully to Type 5 intermittent
519	Onion Cr Headwaters	615	T	25	35	I	N	NN	12	T	50	45	4	N	T	95	45	3	0	Y	Y	50	ditch is a gully about 3 ft wide x 1 ft deep (photo 25, roll 1; point "B" on topo)
520	Onion Cr Headwaters	700	T	15	35	I	N	MM	20	T	60	45	2	Y	T	95	45	4	0	Y	Y	50	culverts (logs?) need replacing; ditch runout flat and grassed (roll 2, photo4)
521	Onion Cr Headwaters	989	T	6	25	I	N	MM	20	T	70	45	2	N	-	-	-	-	0	Y	Y	100	delivers to SEG #520
522	Onion Cr Headwaters	409	T	2	40	I	N	LL	18	-	-	-	-	-	T	80	60	8	30	Y	N	40	3 ft culvert; wet road surface; channel below culvert tail is about 4 ft bankfull width; flow about 100 gpm; large cobble in culvert
523	Onion Cr Headwaters	187	T	10	30	O	N	LL	18	T	80	70	2	N	-	-	-	-	0	Y	N	20	2 ft culvert
524	Onion Cr Headwaters	280	T	5	20	I	N	LM	20	T	75	60	2	N	-	-	-	-	0	Y	N	20	1 ft culvert, plugged; road wash delivery; intermittent channel
525	Onion Cr Headwaters	401	T	5	10	O	N	LM	15	T	80	30	1	N	-	-	-	-	0	N	N	0	1 ft culvert, plugged; road wash delivery; intermittent channel
526	Onion Cr Headwaters	672	T	5	30	O	G<2"	LM	20	-	-	-	-	-	T	90	60	8	0	Y	Y	20	
527	Onion Cr Headwaters	916	T	5	30	O	G<2"	LM	24	-	-	-	-	-	T	80	65	8	0	Y	Y	20	
528	Onion Cr Headwaters	630	T	12	30	I	N	LM	18	T	55	45	8	N	T	70	60	6	0	Y	Y	10	
529	Onion Cr Headwaters	416	T	6	25	I	VEG	LL	10	T	85	60	2	N	-	-	-	-	0	Y	N	5	
530	Onion Cr Headwaters	627	T	7	30	I	N	MM	16	T	50	45	2	N	T	60	45	3	100	Y	Y	25	very recently regraded

							Tread Information			Cutslope					Fillslope					Ditch			
Segment Number	Sub-basin	Segment Length (ft)	Parent Material	Road Slope (avg. %)	Hillside Slope (avg. degrees)	Config. (Inslope/ Outslope/ Crowned)	Surface (Asphalt, Gravel, Native) & depth	Traffic Use (Log Truck/ Residential)	Tread Width (ft)	Material	Ground Cover Density (%)	Slope (degrees)	Height (ft)	Water Seepage ?	Material	Ground Cover Density (%)	Slope (degrees)	Height (ft)	Length Delivering to Stream (ft)	Present?	Gullies ?	Delivery to Stream (%)	Comments
531	Onion Cr Headwaters	533	T	10	30	C	N	MM	16	T	25	45	4	N	T	75	45	3	50	Y	-	100	18 inch culverts at SEGS 530/531; 100% ditch delivery; ditch is bare soil
532	Onion Cr Headwaters	506	T	10	30	C	N	MM	16	T	15	45	6	Y	-	-	-	-	0	Y	-	100	18 inch culverts at SEGS 531/532; 100% ditch delivery; ditch is bare soil
533	Onion Cr Headwaters	477	T	7	20	I	N	MM	16	T	15	45	3	Y	-	-	-	-	0	Y	-	60	grassy swale at stream
534	Onion Cr Headwaters	330	T	5	20	I	N	LM	16	T	40	45	1	N	T	95	45	12	20	N	Y	10	grassy and brushy fill over 3 ft culvert
535	Onion Cr Headwaters	335	T	7	20	O	N	LM	12	-	-	-	-	-	-	-	-	-	0	Y	N	10	
536	Onion Cr Headwaters	398	T	2	40	O	N	MM	16	T	90	40	4	N	T	95	45	5	20	Y	N	100	18 inch culvert; tail hanging about 2 ft over channel; drop scour erosion; ditch about 40% grassed
537	Onion Cr Headwaters	889	T	7	<15	I	N	LL	16	T	60	40	2	N	-	-	-	-	0	Y	-	40	
538	Onion Cr Headwaters	278	T	15	20	I	N	LL	18	T	75	45	2	N	-	-	-	-	0	N	Y	50	photos 20, 21, 22; roll 2
539	Lower Onion Creek	600	T	<4	40	I	N	LM	18	T	90	45	1	N	T	95	45	4	50	N	N	0	
540	Lower Onion Creek	488	T	2	40	I	N	LM	18	T	100	45	4	N	T	95	45	8	100	N	Y	10	
541	Lower Onion Creek	1,489	T	20	35	I	N	LM	18	T	80	45	2	N	-	-	-	-	0	Y	Y	100	* contributes to SEG #540
900	Lower Onion Creek	703	T			I	N	LL	18	T	80		2		T	95		5	50			100	Segments over #900 not visited in field
901	Onion Cr Headwaters	469	QTZ			I	N	LL	20	QTZ	70		4		QTZ	50		5	50			100	compiled from similar segments.
902	Onion Cr Headwaters	564	QTZ			I	N	LL	20	QTZ	70		4		QTZ	50		5	50			100	
903	Onion Cr Headwaters	382	T			O	N	LL	15	-					T	95		5	50			100	
904	Onion Cr Headwaters	809	T			I	N	LL	18	T	80		2		T	95		5	50			100	
905	Onion Cr Headwaters	733	T			I	N	LL	18	T	80		2		T	95		5	50			100	
906	Onion Cr Headwaters	448	T			I	N	LL	18	T	80		2		T	95		5	50			100	
907	Quinns Meadows	797	T			I	N	MM	15	T	70		2		T	100		3	20			100	
908	Lower Onion Creek	2,592	T			C	N	LL	18	T	15		10		T	90		8	50			10	
909	Lower Onion Creek	2,569	T			C	N	LL	18	T	15		10		T	90		8	50			10	

Note: road identifiers not included; there are no road numbering systems in this basin.

Appendix C
Hydrologic Change

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Form C-2	Summary of Water Available for Runoff	Table C-16, page C-46 Table C-17, page C-46
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Appendix C
Hydrologic Change Assessment

1.0 SUMMARY

The primary focus of this section of the Onion Creek Watershed Analysis was to assess the hydrologic effects due to forest management practices in the Onion Creek Watershed Administrative Unit (WAU). Onion Creek watershed is located south of Northport, north of Kettle Falls, Washington and drains directly into the Columbia River above Roosevelt Dam. The Onion Creek WAU includes the town of Northport, the Onion Creek watershed and Five Mile and Crown Creeks which also flow directly into the Columbia River. The total drainage area of the WAU covers roughly 72.6 square miles (mi^2) and ranges in elevation from 1,300 to 5,760 feet; the mean elevation is 2,920 feet. The watershed area considered in the hydrologic analysis was limited to the 53.9 mi^2, specifically the Onion Creek watershed. Portions of the 18.6 mi^2 outside of Onion Creek basin are primarily in agriculture; in addition, much of this area contains ephemeral streams which deliver spring runoff to the Columbia River and drain subsurface the rest of the year.

The mean elevation of the Onion Creek watershed was 3,199 feet and 49 percent of this area falls above the rain-on-snow precipitation zone defined by the Washington Department of Natural Resources (DNR). Average annual precipitation over the entire WAU is 22 inches (Miller et al. 1973); mean annual precipitation over the Onion Creek basin was 24 inches. Fifty to 55 percent of the precipitation falls between November and March, mostly as snow.

Forest practices have been documented to affect hydrology during rain-on-snow storm events and spring snowmelt. Peak flows from winter rain-on-snow (WROS) storms occur during unusually high temperatures (higher than the average of maximum monthly temperatures) at elevations where snowpack is transient and warm rains cause the snow to melt. At higher elevations, the deeper snowpack tends to absorb the precipitation until the pack becomes completely saturated at which time runoff is triggered. In the Onion Creek basin, spring snowmelt peak flows dominate the annual series at all recurrence intervals. Since the volume and timing of spring runoff is known to change with changes in land use practices (Troendle 1983), it was important to investigate the effects of forest practices on spring runoff in Onion Creek.

Data from Northport and Colville AP climate stations and streamflow data from the United States Geological Survey (U.S.G.S.) gauge sites on Mill Creek, Deep Creek and the Colville River (Figure C-1) indicated rain-on-snow storms have occurred in this region. The rain-on-snow storms have produced or augmented peak flow events in both the winter and spring months. At the Mill Creek gauge, rain falling on a snowpack in winter generally produced low to moderate sized peak flows with a recurrence interval from 1 to 16 years, while peak flows generated from rain-free or rain-on-spring snowmelt had recurrence intervals ranging from 1 to 48 years. The maximum peak flow of record (April 24, 1969) was generated by snowmelt

combined with 0.80 inches of precipitation (recurrence interval of one year) falling over a three-day period at Colville AP. At Northport 1.5 inches of precipitation (recurrence interval of 1.1 year) fell over the same time period.

The Mill Creek gauge was selected as the most representative of Onion Creek because of the similar basin size, mean elevation, and period of record. For the 47 years of record at the Mill Creek gauge, 13 percent of the annual peak flow events were generated by winter rain-on-snow storms and 87 percent were generated by spring snowmelt, primarily spring rain on snow. These three processes were considered in the modeling exercise since each process could produce peak flows that may adversely affect the fluvial geomorphology of the watersheds.

The Washington Department of Natural Resources (DNR) adopted methods defined in Version 3.0 of *Standard Methodology for Conducting Watershed Analysis* (Standard Methodology; Washington Forest Practices Board [WFPB] 1995) for the analysis of winter rain-on-snow events. The Standard Method of storm event modeling was applied with modifications in this analysis to simulate winter and spring rain-on-snow events. An additional model was applied to assess changes in rain-free snowmelt as a function of land use practices. For each model, four different vegetative cover scenarios were analyzed: historic, fire suppression, current, and clearcut. Historic conditions assume a lower crown closure than currently exists due to historic fire regimes and naturally sparse to lightly forested conditions. The lower crown closure translates into larger snowmelt values or a decrease in snowmelt from historic to current conditions. The fire suppression scenario represents a situation in which no harvest has occurred and no fires are allowed to burn which translates to an underestimate of snowmelt and an overestimate of change compared to current conditions.

A comparison analysis was conducted to determine the percent increase from historic to current conditions and from fire suppression to current conditions. While changes from historic to clearcut and from fire suppression to clearcut are not realistic because harvest management practices in northeastern Washington watersheds rarely include clearcutting an entire basin, modeling these scenarios can perhaps indicate the largest magnitude of change in the forested landscape should a pervasive forest fire occur.

From historic to current conditions, the winter and spring rain-on-snow models resulted in a net decrease (less than 0 percent change) in water available for runoff and peak flows in all subbasins. This means Water Available for Runoff (WAR) and peak flows were higher under the assumed historic condition than under current conditions (1995). The change in peak flows from fire suppression to current conditions was less than 10 percent in all subbasins.

Annual peak flows generated by rain-free snowmelt conditions occur, on the average, over a 4- to 7-day sustained melt period. The rain-free snowmelt model accounts for the different variables of solar radiation, snow albedo, air temperature, relative humidity, and wind. Twenty-four hour snowmelt values were simulated using the rain-free snowmelt model; however, peak flows under these conditions cannot be produced from a single daily snowmelt value. A continuous modeling approach would be necessary to simulate peak flows from daily snowmelt values, but was not done here due to time and budget limitations.

Under rain-free snowmelt conditions, the change in snowmelt from historic to current conditions ranged from -16 to 0 percent and from fire suppression to current conditions ranged from 0 to +6 percent. A true background condition to which current conditions can be compared is probably bracketed by the historic and fire suppression scenarios and probably ranges from -5% to +5%. The increase in a 24-hour snowmelt translated into an increase in discharge is unknown at this time.

In conclusion, peak flows under spring snowmelt and rain-on-snow processes, do not appear to be affected currently by changes in forest canopy through harvest practices; therefore, all subbasins were assigned a low hazard deliverability.

An additional scenario was developed to reflect forest management plans over the next five years. The models were rerun with 22 percent of the upper watershed lands (1330 acres) currently classified as heavily forested reclassified to either a lightly forested condition (570 acres) or to a sparse condition (760 acres). In a winter rain-on-snow event, the increase in peak flow attributable to this forest plan is estimated to be 2%. In spring runoff conditions, a 24-hour snowmelt value is predicted to increase from 4.0 inches to 4.64 inches in the headwaters of Onion Creek. This represents a 13.8% increase in snowmelt. While estimating peak flow is not possible from this single value, it is unlikely that this will represent substantial increases in peak flow.

2.0 INTRODUCTION

2.1 Watershed Overview

The Onion Creek Watershed Analysis Unit (WAU) is located south of Northport, Washington and drains directly into the Columbia River above Roosevelt Dam. Onion Creek WAU includes Onion Creek watershed and Five Mile and Crown Creeks which also flow directly into the Columbia River. The total drainage area of the WAU covers roughly 46,462 acres or 72.6 square miles (mi^2). The WAU ranges in elevation from 1,300 to 5,760 feet with a mean elevation of 2,920 feet. The watershed area considered in the hydrologic analysis was limited to the 53.9 mi^2 of the Onion Creek watershed (mean elevation of 3,199 feet) since channels outside of the Onion Creek watershed were either ephemeral (intermittent) or drained primarily agricultural lands. Forty nine percent of the study area falls above the rain-on-snow precipitation zone defined by the Washington Department of Natural Resources (DNR). Average annual precipitation over the entire WAU is 22 inches (Miller et. al., 1973) of which 40 to 45% falls as snow; mean annual precipitation over the Onion Creek watershed is slightly higher at 24 inches (Miller et. al., 1973).

Land ownership in the Onion Creek WAU is shared among numerous public and private entities with less than half categorized as land for potential forestry usage. Boise Cascade Corporation owns and manages nearly 23 percent (10,777 acres) while other commercial forestry entities own and manage less than 12 percent of the Onion Creek WAU. Nine percent of the area is classified as State Trust Lands and is managed by the Department of Natural Resources. Less than eight percent of the basin is under federal jurisdiction and managed by the U.S. Forest Service, Bureau of Reclamation, and the Bureau of Land Management. The Bureau of Reclamation owns the land adjacent to Lake Roosevelt to mitigate landslides caused by creation of the reservoir; these lands are not managed for forest production. The remaining lands (48%) are under control of small, private landowners, primarily residential plots (5-20 acre), many of which are forested; other minor uses include mining and agriculture.

Currently, 50 percent of the Onion Creek WAU has been identified as heavily forested (crown closure greater than 70 percent), 29 percent has been identified as lightly forested (crown closure from 30 to 70 percent), nearly 10 percent has been identified as sparse forest (crown closure from 10 to 30 percent), slightly more than four percent has been identified as open forest (crown closure of less than 10 percent), and seven percent of the Onion Creek watershed has been identified as non-forest lands.

2.2 Study Approach

Forest practices have been documented to affect hydrology through winter rain-on-snow storm events and spring snowmelt events. Rain-on-snow storms, in which warm fall/winter rainstorms can substantially augment runoff by melting a portion or all of the snow on the ground, are common hydrologic processes found in western Washington watersheds. While winter rain-on-snow events do occur in some portions of eastern Washington, the predominant process through which forest practices can affect hydrology is rain-free snowmelt or spring runoff. The volume

and timing of spring runoff is known to change with changes in land use practices (Troendle, 1983). The literature has also documented increases in annual water yield directly attributable to the reduction in evaporative loss following timber harvest. Increases have been documented throughout the year with the most pronounced effect varying as a function of the hydrologic regime. In the Pacific Northwest (west of the Cascade Crest), Rothacher (1970) found that the greatest increase in yield occurred during the rainy season (October to March) while in more arid, snowmelt-dominated regimes (eastern Washington), Troendle (1983) reported that the greatest increase in yield most often occurred during spring snowmelt. A few studies have observed decreases in summer water yield attributable to harvesting in areas where fog drip is an important component (Harr, 1982) and where hardwoods revegetated the riparian corridor (Hicks, 1991). The majority of the water yield research has not focused on summer low flows nor long-term effects.

The annual hydrograph (Figure C-3) in Onion Creek peaks during the snowmelt season (in late April or early May). At the onset of the Onion Creek watershed analysis the issue of increases in summer low flows was raised. Since the literature has documented that most water yield increases occur on the rising limb of the peak flow portion of the annual hydrograph, increases in annual water yield associated with timber harvesting in Onion Creek would be expected to occur during the snowmelt season. In other words, summer low flows were not expected to increase due to timber harvest in this basin, therefore, no further investigation of low flows was conducted. This study does not attempt to quantify the annual water yield increase but does investigate the peak flow increases.

To analyze peak flow increases resulting from harvest practices, the general approach taken in this analysis was to first collect and summarize local and regional data. Climate, streamflow, and snow stations were identified in the region of the Onion Creek WAU; specific information about each station is located in Addendum C-I. Figure C-1 shows the location of these stations as well as the streamflow gage and snow course/SNOTEL sites relative to the basin of interest. Climate stations report daily precipitation, snowfall, snow depth or snowpack, maximum and minimum temperature and, less frequently, wind data. Snow stations include both snow course and SNOTEL. Snow courses are generally monitored manually on a bimonthly basis during the winter months. SNOTEL data sites collect and telemeter daily data including snow water equivalent, precipitation, and maximum, minimum and average temperatures. The summary statistics from the data collected at these different sites were compiled, used to determine the presence of rain-on-snow storms, and used to develop relationships more specific to the study area.

After data acquisition, compilation, and initial analysis of the climatic relationships, the streamflow, precipitation, temperature, and snowpack or snow water equivalent records were reviewed to gain an understanding of the hydrologic processes present in the region of interest. Once the presence or absence of storms and the timing of peak flows was established, the level of effort for the snowmelt analysis was determined.

In the modelling exercise for the Onion Creek Watershed Analysis Hydrologic Change Assessment, three conditions were simulated:

1. Winter rain-on-snow inputs (snowmelt plus precipitation) generated along with estimates of associated peak flows.

2. Spring rain-on-snow inputs (snowmelt plus precipitation) generated along with estimates of associated peak flows.

3. Spring rain-free snowmelt generated without any corresponding peak flows.

The DNR adopted methods defined in the Watershed Analysis Manual (WFPB, 1995) to specifically analyze winter rain-on-snow events. These methods, with certain modifications, were used in this analysis since winter rain-on-snow storms have been known to occur in the Onion Creek watershed. This same model was adapted for modelling spring rain-on-snow events. Spring rain-on-snow processes are more complicated in that precipitation is falling on a melting snowpack and runoff is well along the rising limb of the hydrograph. Modelling spring rain on snow as an event without accounting for the background snowmelt can be misleading.

An additional model was developed to assess changes in rain-free snowmelt as a function of land use practices. A continuous model is a more preferable tool for modelling spring runoff events than the storm event model developed by the WFPB. Due to time and budget constraints within the watershed analysis framework, the rain-free snowmelt model was patterned after the storm event model to produce 24-hour snowmelt values. Snowmelt was not translated into a peak flow estimate due to the difficulty in translating a 24-hour snowmelt which is part of a longer process contributing to the generation of peak flow discharge. While a continuous model can generate streamflow from snowmelt and the rain-free model developed here cannot, the latter can be used as an index to potential impacts from changing forested conditions. Details on methods for each process can be found in Section 5.0.

2.3 Subbasin Delineation and Elevation Zones

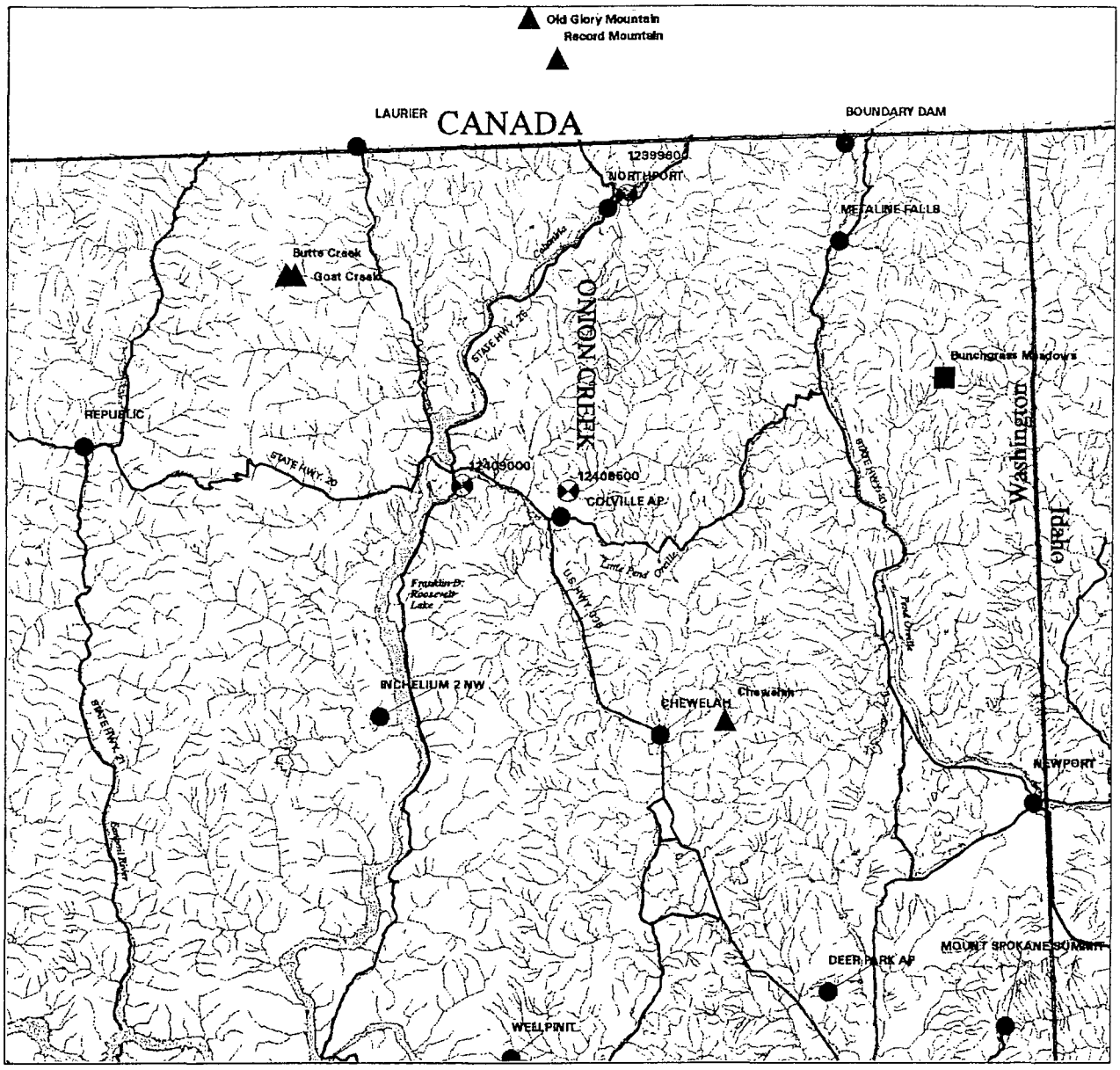
The Onion Creek WAU was divided into five subbasins. The subbasins were delineated by the watershed analysis team members based on the tributary drainage area, channel size, and fisheries resource value (Table C-1). The mean elevation of the subbasins ranges from 2,094 to 3,595 feet. The drainage area of the subbasins range from 6.1 to 24.4 square miles.

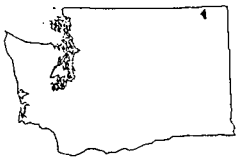
The DNR produced digital maps outlining precipitation zones based on available snow course data and regional climate information (Brunengo et. al., 1992). This information was used to determine mean elevation of each precipitation zone within each subbasin for application in the rain-on-snow and rain-free modeling efforts. Four zones, shown on Map C-2, were present in the Onion Creek study area: rain dominated, rain-on-snow, snow dominated, and highland.

For purposes of analyzing the impacts of forest management on peak flows, hydrologic modeling was carried out for three of the five subbasins. Fivemile and Crown Creeks are lower elevation watersheds and do not have significant channels (See Channel Module).

Table C-1: Summary of Subbasin Information

Subbasin number	Subbasin name	Area (acres)	Area (mi^2)	Minimum Elevation (feet)	Maximum Elevation (feet)	Mean Elevation (feet)	Percentage of Area above Rain-on-Snow Elevation
1	Headwaters Onion Cr	15,615	24.40	2,371	5,760	3,595	68
2	Quinn Meadows	3,914	6.10	2,160	4,320	3,177	58
3	Lower Onion Cr	14,952	23.40	1,318	4,120	2,792	27
	Subtotal	**34,481**	**53.90**	**1,318**	**5,760**	**3,199**	**49**
4	Five Mile Cr	6,068	9.20	1,300	3,760	2,094	9
5	Crown Cr	5,913	9.50	1,300	4,080	2,142	18
	Grand Total	**46,462**	**72.60**	**1,300**	**5,760**	**2,920**	**40**





WASHINGTON

Onion Creek Watershed Administrative Unit

Climate and Streamflow Station Locations

5000 12500 0 25000 50000 FEET

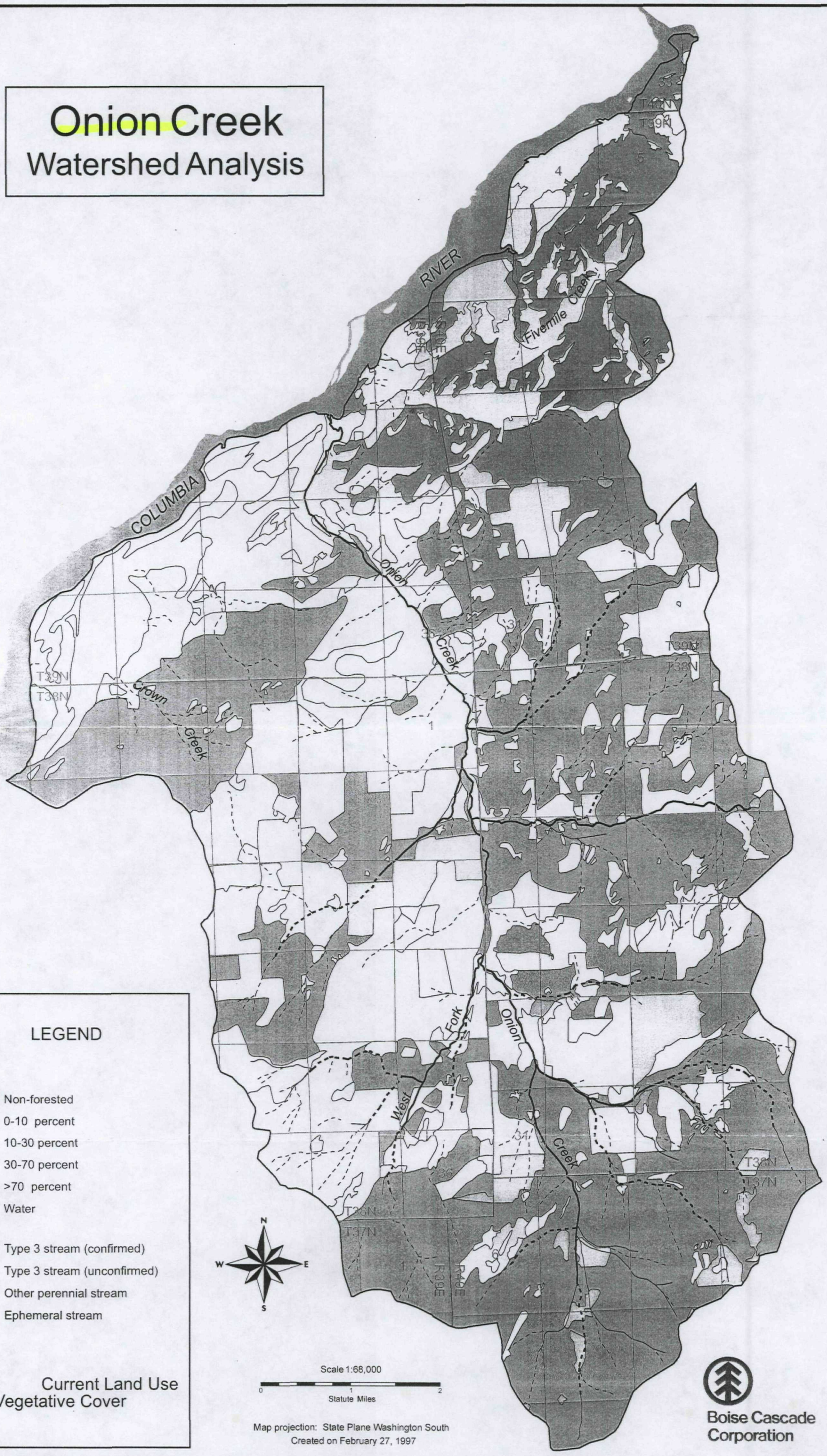
Map projection: State Plane Washington South

- ● Climate station
- ■ Snotel
- ▲ Snow course
- ⊗ Streamflow station

Boise Cascade Corporation

FIGURE C-1

Onion Creek
Watershed Analysis



3.0 CHARACTERIZATION OF THE HYDROLOGIC REGIME

The Standard Methodology for the Hydrologic Change module focuses on fall/winter rain-on-snow events. Before applying the Standard Method to Onion Creek, it was important to identify the hydrologic processes causing peak flow events in the study area, particularly since Onion Creek is located in northeastern Washington where spring runoff tends to be the major contributor in generating peak flows. An analysis was conducted using climate, streamflow, and snow records from stations within or near the watershed of interest. The first step was to examine the magnitude of precipitation events and the time of year in which they occur. In addition, records from the nearest streamflow gauging station were investigated to determine the shape of the hydrograph and provide initial information on when peak flows occur in the watershed. A summary of the top ten precipitation events and streamflow events at selected climate and streamflow stations can be found in Tables C-3 through C-5.

3.1 Precipitation

Several climate stations were located within reasonable proximity to the study area; Northport was the only climate station situated within the WAU. Table C-2 lists the stations available for use in the analysis of precipitation, temperature, and/or snowfall data; Figure C-1 shows the location of the climate stations with respect to the Onion Creek.

Table C-2: Summary Data from Regional Climate Stations

Station Number	Station Name	Elevation (feet)	Average Annual Precip. (inches)	Average Maximum Monthly Temperature		
				Feb (°F)	April (°F)	May (°F)
844	Boundary Dam	1800	26.94	38.0	57.3	65.4
5946	Northport	1320	19.05	38.7	63.5	73.5
5317	Metaline Falls	2110	27.26	37.3	58.9	68.5
1650	Colville AP	1650	18.48	39.1	59.2	68.5
1395	Chewelah	1670	20.72	39.9	60.3	69.9

Northport and Colville AP climate stations were the closest to and the most representative of the Onion Creek watershed. The precipitation data from these two stations along with Metaline Falls, were analyzed to assess the timing and magnitude of storms. Metaline Falls was the highest elevation climate station relatively near the study area.

Installation of SNOTEL sites in northeastern Washington did not occur until 1984. The closest SNOTEL site to Onion Creek is Bunchgrass Meadows, located about 19 miles east of the study

basin. SNOTEL records can also be used in the assessment of storms and peak flow events since SNOTEL stations collect precipitation, temperature, and snow water equivalent data; however, the period of record for Bunchgrass Meadows data does not overlap with the period of record for selected streamflow gauge data which makes the SNOTEL data less useful in this analysis.

Four of the top ten precipitation events at Northport occurred in the summer season (June 21-September 21) while 30% occurred during the spring snowmelt season and 30% occurred in the fall. At Colville AP, six of the ten largest storms occurred in the late fall and winter months while the remaining 40% were split evenly between spring and summer months. Sixty percent of the largest ten storm events at Metaline Falls occurred in the summer months while forty percent of the top ten events occurred in the fall and winter seasons. It is likely the climate in the Onion Creek WAU is most similar to Northport since it is located in the Onion Creek WAU, situated on the southeast side of the Columbia River with a northwest aspect.

Table C-3: Top Ten Ranked Annual Maximum 24-hr Storms

	Station: Northport Station ID #: 5946 POR: 1920-1992			Station: Colville AP Station ID #: 1650 POR: 1948-1987			Station: Metaline Falls Station ID #: 5317 POR: 1926-1965		
Rank	Date	Precip (inches)	Season	Date	Precip (inches)	Season	Date	Precip (inches)	Season
1	06/13/92	2.49	Spring	06/21/84	1.73	Summer	09/11/27	1.65	Summer
2	10/03/38	1.57	Fall	01/07/62	1.44	Winter	09/05/37	1.64	Summer
3	06/28/70	1.53	Summer	07/20/81	1.31	Summer	09/04/60	1.62	Summer
4	08/01/82	1.48	Summer	11/11/68	1.29	Fall	11/18/46	1.53	Fall
5	05/06/79	1.48	Spring	02/15/86	1.21	Winter	06/24/55	1.37	Summer
6	09/30/44	1.43	Fall	04/28/53	1.18	Spring	08/09/64	1.35	Summer
7	10/01/40	1.40	Fall	05/19/57	1.17	Spring	02/21/56	1.33	Winter
8	09/05/37	1.28	Summer	11/21/74	1.07	Fall	12/01/51	1.31	Fall
9	09/17/88	1.23	Summer	03/01/82	1.04	Winter	09/05/40	1.30	Summer
10	05/23/89	1.20	Spring	11/15/73	1.03	Fall	10/03/38	1.30	Fall

In analyzing the entire period of record from the Northport climate station, eight percent of the total daily data set reported rain-on-snow events primarily occurring in December, January, and February. Ten percent of the total daily data set at Colville AP showed rain occurring while a snowpack was on the ground at that site. The climatic variables in conjunction with antecedent conditions did not necessarily translate to peak flow events; snowpack may have been deep enough that the rain caused consolidation of the pack rather than the melting of it, precipitation may have been low enough so as to affect the snowpack in a minor way, or temperatures may not have been high enough to trigger a larger event.

At Northport, the largest amount of precipitation which fell with snow on the ground was 1.1 inches (recurrence interval [R.I.] of 3.5 years) on December 5, 1981. The temperature ranged

from 15°F to 45°F for that day; records indicate the snowfall was zero. At Colville Airport, the largest amount of precipitation falling on a snowpack occurred on January 7, 1962 when 1.44 inches in 24 hours (R.I. = 18 years) fell on a 17 inch snowpack. The maximum temperature at Colville was 39°F and the minimum temperature for the day was 31°F. The depth of the snowpack buffered the initiation of snowmelt. In addition, precipitation was falling as snow during part of the day; 12 inches was recorded. The result was an increased snowpack rather than a melting snowpack.

An examination of the precipitation occurring for three consecutive days or 72 hours produced similar results to the analysis of the 24-hour precipitation. At Northport, 50% of the top ten 72-hour events occurred in the summer/early fall season with 40% occurring in the spring months, the remaining event happened in late fall. Of the ten largest storms at the Colville AP climate station, 70% occurred in the late fall/early winter season; thirty percent occurred in the spring snowmelt season.

Table C-4: Top Ten Ranked Annual Maximum 72-hr Storms

	Station: Northport Station ID #: 5946 POR: 1920-1992				Station: Colville AP Station ID #: 1650 POR: 1948-1987			
Rank	Date	Precip (inches)	Season	Recurrence Interval (years)	Date	Precip (inches)	Season	Recurrence Interval (years)
1	09/24/58	2.75	Fall	73.0	11/21/74	2.13	Fall	41.0
2	06/14/92	2.58	Spring	36.5	05/20/57	2.05	Spring	20.5
3	05/06/79	2.13	Spring	24.3	06/09/84	2.02	Spring	13.7
4	07/01/55	2.04	Summer	18.2	11/16/73	1.97	Fall	10.2
5	05/14/41	1.98	Spring	14.6	12/04/80	1.91	Fall	8.2
6	09/19/88	1.94	Summer	12.2	11/14/66	1.86	Fall	6.8
7	05/26/42	1.89	Spring	10.4	11/22/59	1.74	Fall	5.9
8	06/30/70	1.83	Summer	9.13	04/28/53	1.72	Spring	5.1
9	10/05/49	1.82	Fall	8.1	12/11/68	1.72	Fall	4.6
10	11/19/46	2.65	Fall	7.1	11/18/82	1.70	Fall	4.1

3.2 Streamflow

A continuous streamflow gauge did not exist in the Onion Creek watershed, therefore, to gain an understanding of the type of peak flow events which the Onion Creek system may experience, other nearby records were examined. Three U.S.G.S. streamflow gauges were identified near Onion Creek (Figure C-1); Mill Creek was selected as the most representative because of the similar basin size, mean elevation, and period of record. Deep Creek had a short period of record and a much larger basin size. The Colville River had a long period of record but the

drainage area was too large for the records to be useful in understanding flows in Onion Creek.

The gauge records for the three gauge sites were reviewed. Of the top ten events, most of the peak flows tended to occur during the spring; only one of the top ten events for Mill Creek and the Colville River occurred as a winter rain-on-snow event (Table C-1b in Addendum I; Table C-5).
The highest peak flow of record at the Colville River gauge occurred on January 21, 1974 with a recurrence interval of nearly 71 years. The streamflow was associated with a fairly common precipitation event (0.57 inches over 4 days; R.I. less than one year) at the Colville Airport climate station. The highest winter peak flow at the Mill Creek gauge occurred on March 10, 1983. The peak flow was produced by storms recorded at Northport and Colville Airport with a recurrence interval of three years or less; 1.2 inches and 1.36 inches over five days at Northport and Colville AP, respectively. Snow data was not available at high elevations to understand the processes going on in the upper watershed. For the winter storms to produce peak flow events, there had to have been warm temperatures and a transient snowpack (often less than 12 inches) at a wide range of elevations in the Mill Creek basin as well as in the Colville River basin.

Of the 47 annual peak flows recorded at the Mill Creek gauge site, six, or 13%, happened during the winter (January through mid-March). The largest had a return period of 16 years and the smallest had a return period of one year. The remaining 41 peak flows occurred during the spring runoff season; eight were rain-free snowmelt generated peak flows, 30 were from spring rain on snow, and precipitation was unavailable for the remaining three. Figure C-2 shows the monthly distribution of these annual peak flows and Figure C-3 illustrates the average annual hydrograph for Mill Creek.

Precipitation records at Northport overlapped most of the period of record for which Mill Creek streamflow was available. Linking the two records, 5 of the 47 annual peak flows on Mill Creek coincided with annual maximum 72-hour precipitation events. The recurrence interval of the precipitation events ranged from one to ten years while the peak flow recurrence interval ranged from 3 to 48 years. All five events occurred in the spring snowmelt season.

Figures C-4 and C-5 illustrate how the different parameters of streamflow, precipitation, snowpack and temperature change over time in winter rain-on-snow and spring snowmelt conditions, respectively.

Table C-5: Top Ranked Annual Maximum Peak Flows

	Colville R nr Kettle Falls USGS Gauge #12409000			Mill Cr nr Colville USGS Gauge #12-408500			Deep Cr nr Northport USGS Gauge #12-399600		
Rank	Date	Annual Peak Flow (cfs)	Type of Event	Date	Annual Peak Flow (cfs)	Type of Event	Date	Annual Peak Flow (cfs)	Type of Event
1	1/21/74	3440	WROS	4/24/69	694	SROS	4/24/74	982	SROS
2	4/23/56	3230	SM	5/10/61	618	SROS	5/11/76	822	SROS
3	4/19/38	2690	SROS	3/10/83	616	WROS	5/04/75	810	SROS
4	4/25/69	2630	SROS	4/22/56	609	SM	5/06/79	441	SROS
5	4/21/52	2550	SROS	5/03/75	596	SROS	5/29/78	357	SROS
6	5/12/61	2340	SROS	4/29/53	570	SROS	5/16/73	240	SM
7	4/29/60	2300	SROS	4/19/52	538	SM	6/04/77	82	ND
8	5/05/75	2260	SROS	5/04/48	538	SROS			
9	4/14/51	2240	SM	5/20/57	526	SROS			
10	5/14/48	2240	SROS	4/19/46	466	SROS			

WROS = winter rain on snow
SROS = spring rain on snow
SM*= snowmelt, presence of rain unknown
ND=no data

3.3 Hydrologic Processes Identified

The hydrologic regime of the three gauges analyzed most likely represents the Onion Creek flow regime which then leads to the conclusion that both spring runoff and winter rain-on-snow events needed to be further analyzed in the hydrologic modeling process. It is worthwhile to address the winter rain-on-snow events; however, these occur infrequently and at various magnitudes of flow. Spring snowmelt peak flows generated primarily from rain-on-snow processes dominated the records; flows occurred at all magnitudes and recurrence intervals.

The smaller peak flow events (1-3 year recurrence interval) tend to be the most significant in terms of channel-forming processes. Changing forest practices will potentially have greater impact on these more frequent events. The extreme events which occur less often tend to cause substantial damage to a watershed and it is unclear and undocumented whether harvest management practices contribute significantly to the damage. The effect of flow increases from forest practices tends to decrease with increasing magnitude of flows; the increase associated with forest practices is an increasingly smaller percentage of the total flow.

Figure C-3

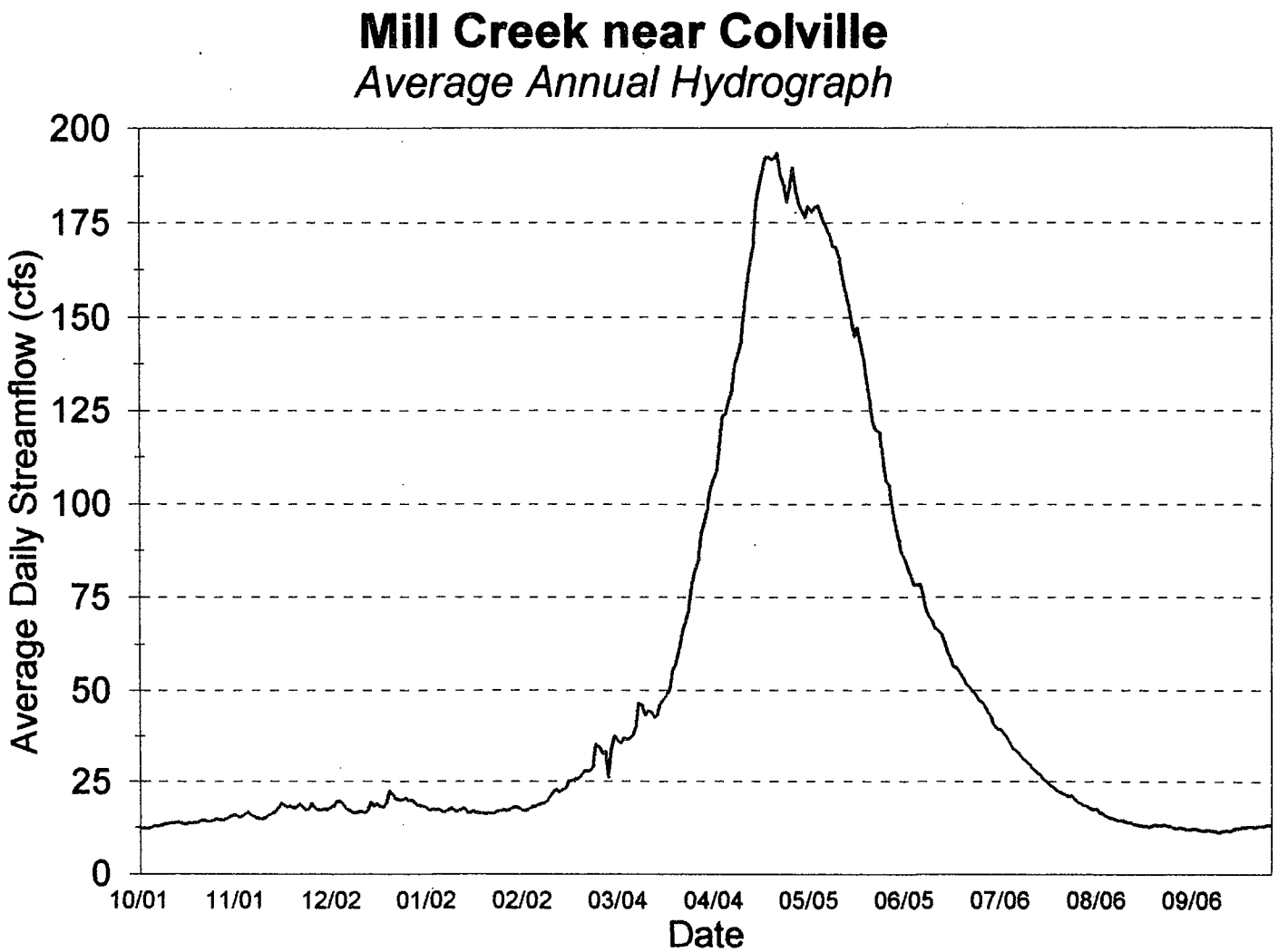

Mill Creek near Colville
Average Annual Hydrograph
Average Daily Streamflow (cfs)
200
175
150
125
100
75
50
25
0
10/01
11/01
12/02
01/02
02/02
03/04
04/04
05/05
06/05
07/06
08/06
09/06
Date

Figure C-2

Mill Creek nr Colville

Peak Flow Monthly Distribution

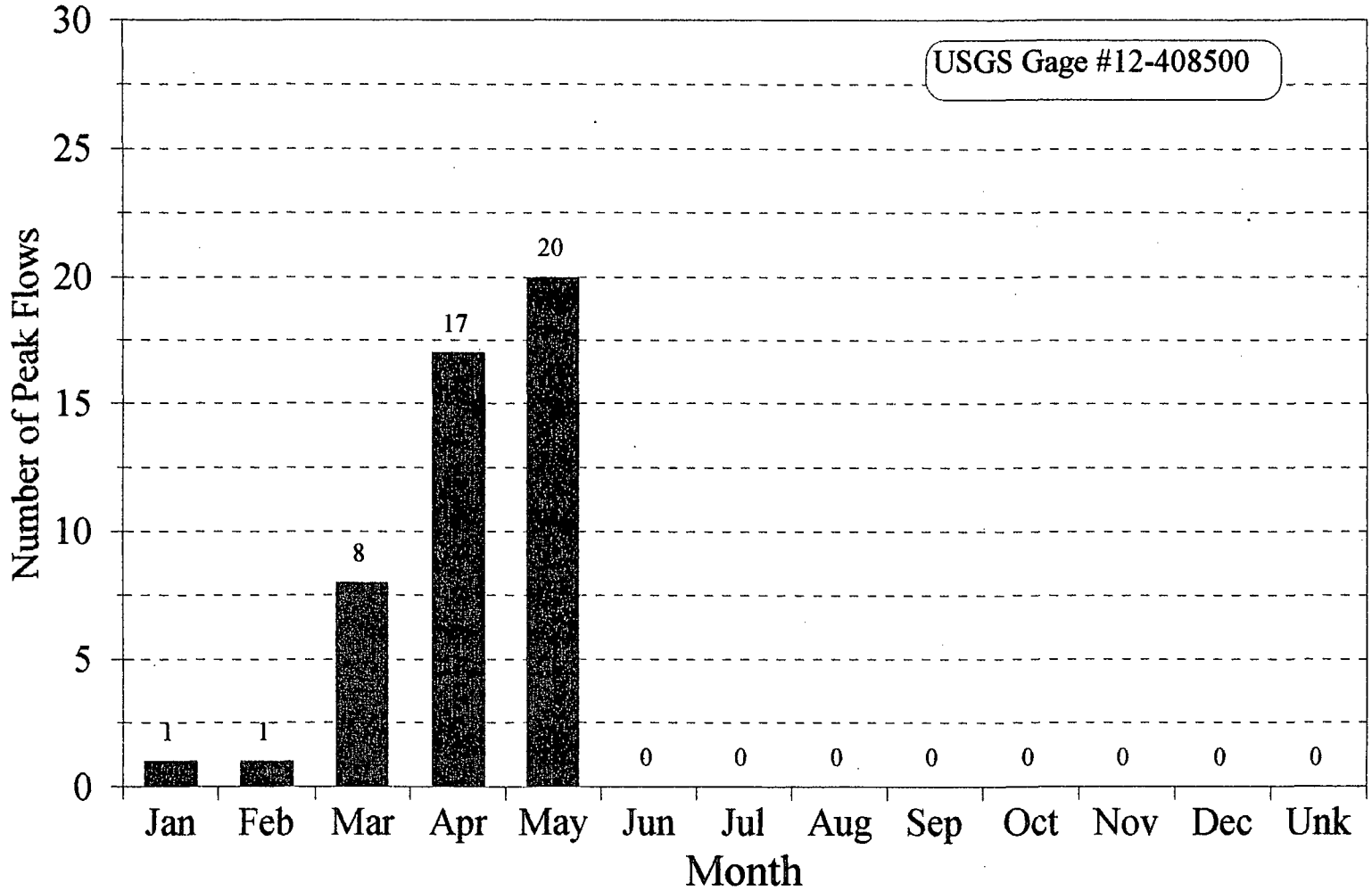


Figure C-4

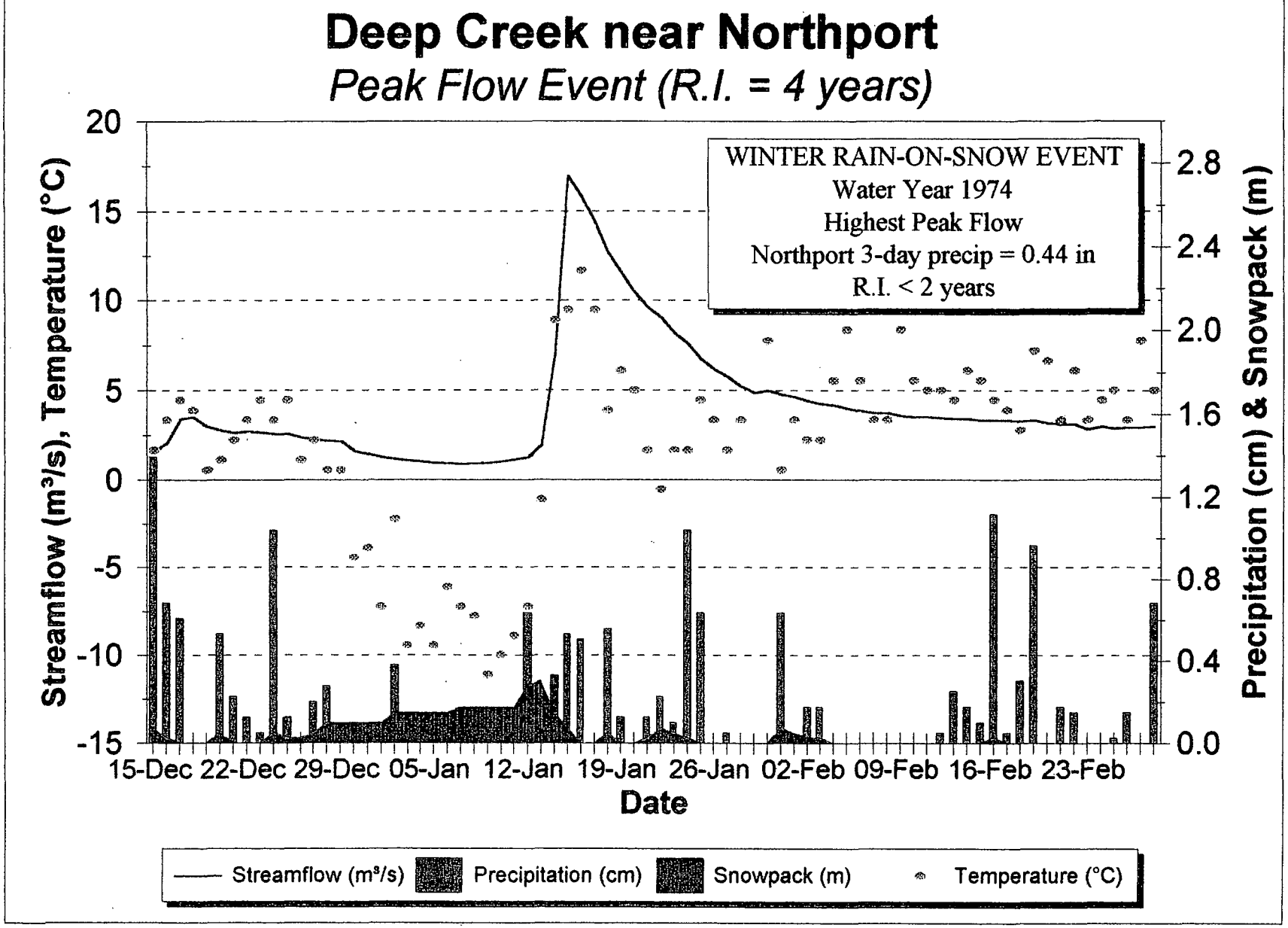
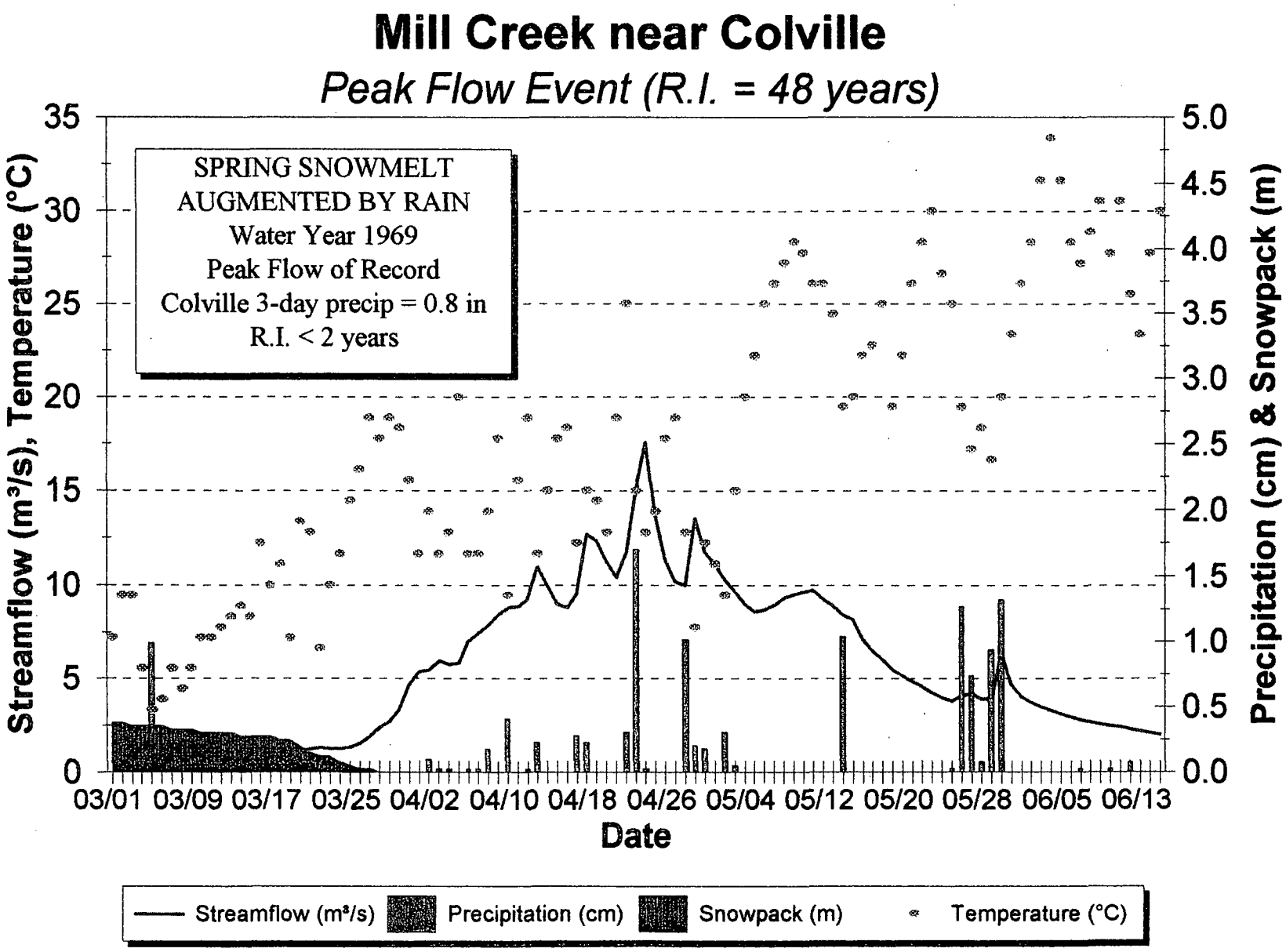

Deep Creek near Northport
Peak Flow Event (R.I. = 4 years)
WINTER RAIN-ON-SNOW EVENT
Water Year 1974
Highest Peak Flow
Northport 3-day precip = 0.44 in
R.I. < 2 years
Streamflow (m³/s), Temperature (°C)
Precipitation (cm) & Snowpack (m)
20
15
10
5
0
-5
-10
-15
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
15-Dec 22-Dec 29-Dec 05-Jan 12-Jan 19-Jan 26-Jan 02-Feb 09-Feb 16-Feb 23-Feb
Date
Streamflow (m³/s)
Precipitation (cm)
Snowpack (m)
Temperature (°C)

Figure C-5


Mill Creek near Colville
Peak Flow Event (R.I. = 48 years)
SPRING SNOWMELT
AUGMENTED BY RAIN
Water Year 1969
Peak Flow of Record
Colville 3-day precip = 0.8 in
R.I. < 2 years
Streamflow (m³/s), Temperature (°C)
Precipitation (cm) & Snowpack (m)
35
30
25
20
15
10
5
0
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
03/01 03/09 03/17 03/25 04/02 04/10 04/18 04/26 05/04 05/12 05/20 05/28 06/05 06/13
Date
Streamflow (m³/s)
Precipitation (cm)
Snowpack (m)
Temperature (°C)

4.0 DEVELOPMENT OF INPUTS TO HYDROLOGIC MODELS

4.1 Vegetative Cover

A key to understanding the watershed and how it responds to hydrologic processes lies in assessing the vegetative conditions, both currently and historically. How has the vegetation in these subbasins changed over time? And what is the effect of these changes on peak flow events? Fire history is an important factor in determining vegetative cover conditions in northeastern Washington. Specifically, the interest in this analysis is on forested lands.

4.1.1 Current Crown Closure Conditions

The current crown closure data was estimated for the entire Onion Creek WAU based on the most recent aerial photographs (1992) and orthophoto quadrangle maps (1995). Using the aerial photographs, orthophotos, and the designations defined in Table C-6, polygons were delineated identifying the different canopy cover classes in each subbasin.

Table C-6: Crown Closure Designations

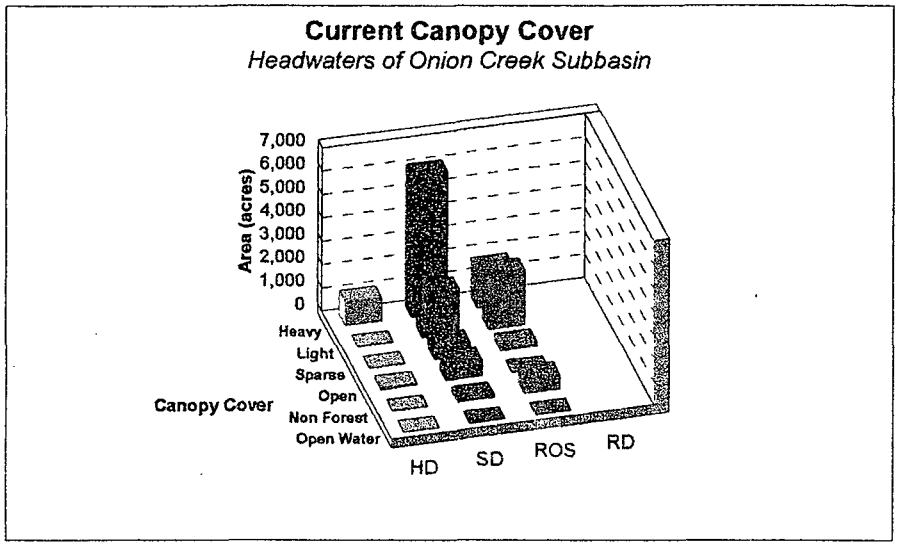
% Canopy Cover	Designation
>70%	Heavily forested lands
30-70%	Lightly forest lands
10-30%	Sparsely forested lands
<10%	Open or Clearcut

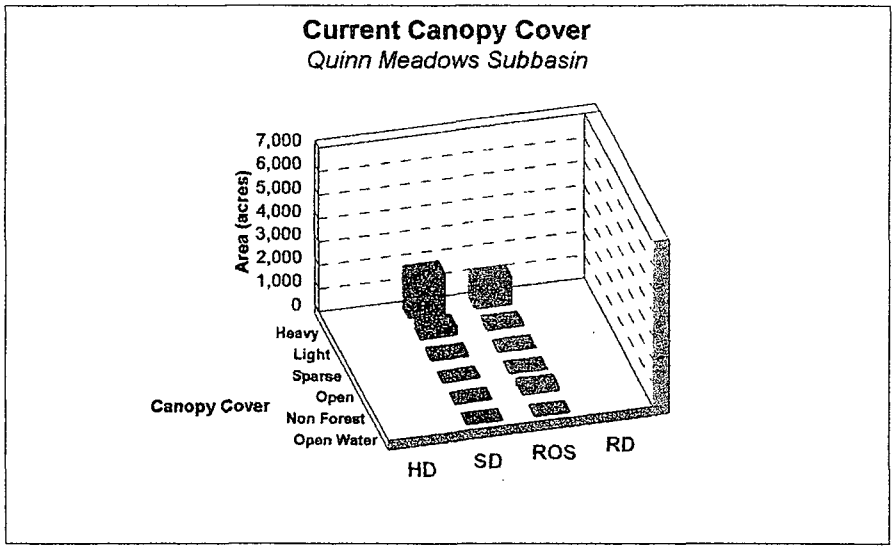
Table C-7 shows the number of acres in each category for each subbasin. This method of identifying canopy cover classes differs from the standard methods which use hydrologic maturity as a measure of crown closure. The modification here reflects the different climate and vegetation which occurs east of the Cascade Crest where hydrologically mature forests may have canopy closure which is less than 70%. Historically, the pre-fire suppression forests were more sparse than would be found in western Washington. Addendum C-II contains Form C-1, the canopy cover information further classified by precipitation zone for each subbasin. Figure C-6 graphically shows the distribution of canopy cover by precipitation zone and by subbasin. Map C-1 illustrates the estimated canopy cover.

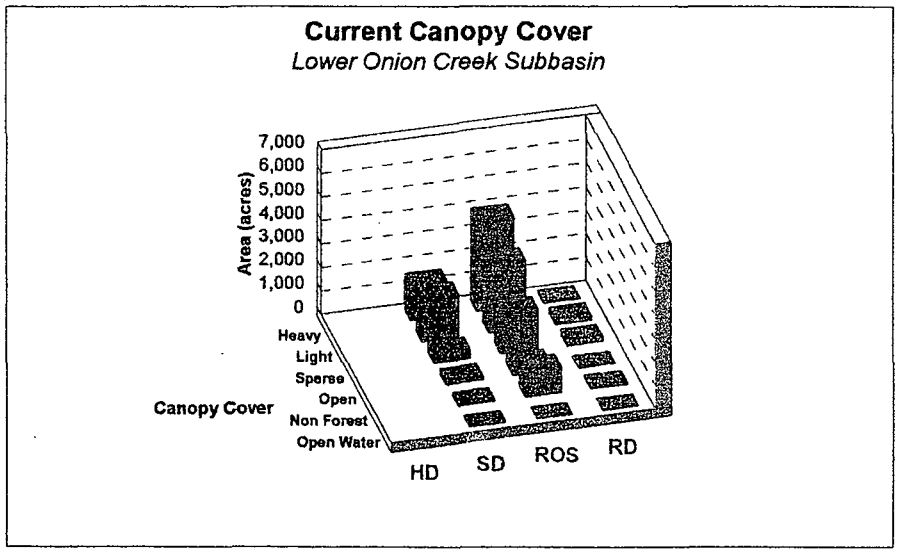
Table C-7: Canopy Cover Information by Subbasin (Acres)

	Headwaters Onion Creek	Quinn Meadows	Lower Onion Cr	Total
Heavily Forested	8,718	2,967	5,475	17,160
Lightly Forested	4,346	546	5,050	9,942
Sparse	831	124	2,408	3,364
Open	*846*	*36*	*655*	1,536
Total Forested Lands	**14,741**	**3,673**	**13,588**	**32,002**
Non-Forested Lands	836	233	1,352	2,420
Open Water	39	7	12	58
Total Non-Forested Lands	875	240	1,363	2,478
Grand Total	**15,615**	**3,914**	**14,952**	**34,481**

Figure C-6: Current Canopy Cover In Each Subbasin







4.1.2 Historic Crown Closure Conditions

Fire History

Fire history and crown closure estimations for historic and fire suppression conditions were developed by Krista Gollnick-Waid, Fire Ecologist. The complete report can be found in Addendum C-III while excerpts are presented here.

Overview

The Onion Creek WAU is located in an area where fire played a major role in the development of forests. Virtually all of the Colville National Forest ecology plots (including those surrounding and within Onion Creek) contained evidence of past fire such as fire-scarred trees, charred logs, stumps or wood or charcoal in the soil. A series of large fires has burned over much of northeastern Washington in the last 100 years. The pattern of several large, catastrophic fires early in the century appear within the cycle of natural fire patterns. Large fires took place at irregular intervals depending on variations in weather and available fuels. Native Americans also used fire to manipulate vegetation.

Effects of Management and Fire Suppression

In general, the current situation reflects stand conditions which have changed as a result of fire suppression and management activities occurring over the past century, especially within the "low" and "moderate" fire regimes. Generally, the suppression of fires on the landscape, in areas that historically experience frequent fire, has led to increased stand densities and canopy closures, average stand diameter reductions, changes in vegetative composition, decreases in shrub/herb growth, increases in forest litter/duff accumulations, and increases in large woody debris on the forest floor.

Fire suppression has had the largest effect on the character of forest stands on sites with a natural history of repeated underburns. This is especially true of drier habitats within the Douglas-fir and grand fir series. Stand structures have changed from relatively open single or two-storied stands dominated by large individuals of seral, fire resistant species (like Douglas-fir and ponderosa pine) to denser, smaller-stemmed, multi-layered stands with a higher proportion of fire sensitive, late seral or climax species (such as grand fir). Fire suppression and other activities have contributed to the development of extensive contiguous areas of late seral forest conditions that had no precedent in pre-settlement landscapes.

Table C-8 displays historic fire regime information by plant series, as well as historic and fire suppression crown closure estimations (does not specifically include the effects of forest management).

Table C-8: Crown Closure Estimations

Vegetative Climax Series	Historic Fire Regime	Historic Crown Closure	Estimated Crown Closure with Fire Suppression
Subalpine Fir: Queencup Beadlily Cascades Azalea Cascades Azalea-Bear Grass Big Huckleberry	High Intensity	80%	80%
Western Hemlock/Queencup Beadlily	Moderate/High Intensity	60%	80%
Grand Fir/Big Huckleberry	Moderate Intensity	50%	80%
Grand Fir/Douglas Maple	Moderate Intensity	50%	80%
Western Red Cedar/Big Huckleberry	Moderate Intensity	50%	80%
Douglas Fir/Ninebark	Low Intensity	30%	60%
Grand Fir/Ninebark	Low Intensity	30%	60%

4.1.3 Determination of Forest Cover Factors

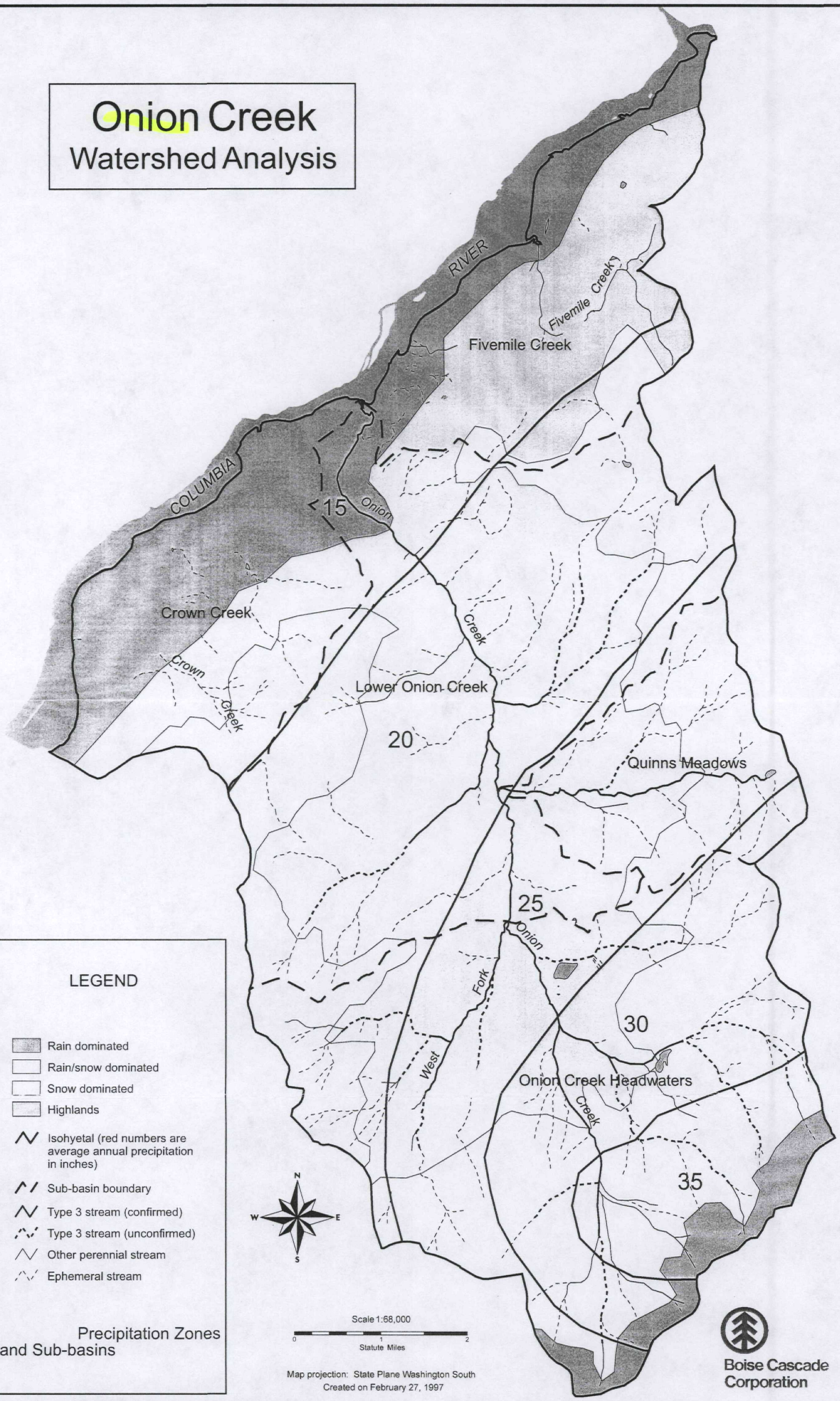
The crown closure data shown in Table C-8 was used to determine the forest cover factors, F_c, required in the hydrologic models. Stand density in areas above 5000 feet (Headwaters subbasin only) was high due primarily to the plant associations present (subalpine fir and western hemlock) and the low frequency of fire occurrence. For areas below 5000 feet in elevation, the stand densities were higher on north/northeastern slopes and drainage bottoms. Plant associations in these areas included grand fir, western hemlock and western red cedar series. The forest cover factors were the same for areas above 5000 feet and north/northeastern slopes below 5000 feet. The more sparse areas (south/southwestern slopes below 5000 feet) were assigned forest cover factors with lower densities.

4.1.4 Modeling Scenarios Based on Canopy Cover

The Standard Methodology recommends three scenarios to analyze: full forest, current conditions, and clearcut. While the full forest scenario may be appropriate for western Washington watersheds, it does not adequately represent "background" conditions for eastern Washington. The research and resulting estimates of historic crown closure and fire suppression conditions conducted for this analysis led to the development of two "background" scenarios: Historic and Fire Suppression.

The forest cover factors in the rain-on-snow model (for winter and spring events) were simplified to fit within the model since the framework does not need to account for slope and aspect. The *Historic Scenario* assumed canopy cover of 55% and 30% for lightly forested and sparsely forested lands, respectively. *Fire Suppression* was modeled with heavily forested lands at an assumed canopy cover of 80% while lightly forested lands were assumed to have 55%

Onion Creek
Watershed Analysis



density of cover.

The *Historic Scenario* for the rain-free snowmelt model were estimated to best represent the true condition of the Onion Creek drainage prior to any management activities. Northeastern Washington watersheds are noted for a naturally sparse (relative to western Washington) forest canopy cover condition due to climate, soils, topography, etc. Taking this information into account led to certain assumptions:

1. Dense forests did not naturally occur in the Onion Creek WAU.

2. North, east, and flat aspects are naturally more dense than south and west aspects.

3. At elevations greater than 5000 feet, the canopy cover was assumed to be heavily forested with a cover factor of 70%.

4. Below 5000 feet in elevation, north, east, and flat aspects were assumed to be lightly forested (average of the forest cover = 50 percent, and south and west aspects were assumed to be sparsely forested (average crown closure = 30 percent).

The *Fire Suppression Scenario* reflects increased stand density and decreased diameter of trees, hence an increased crown closure compared to a historic forest. The assumptions, therefore, for fire suppression in the Onion Creek watershed included the following:

1. Heavily forested areas develop under fire suppression.

2. At elevations greater than 5000 feet, the canopy cover was assumed to be heavily forested with a forest cover factor of 80%.

3. Below 5000 feet in elevation, north, east, and flat aspects were assumed to be lightly forested (average crown closure of the forest canopy = 80 percent, and south and west aspects were assumed to be sparsely forested (average crown closure = 60 percent).

Table C-9 presents an overview of the vegetative cover scenarios for forested lands in each subbasin. Quinn Meadows subbasin was found to have a higher crown closure currently than under the assumed fire suppression scenario. This indicates the fire suppression scenario underestimated crown closure when assigning south and west facing slopes as more sparsely vegetated than north and east. Those present at Synthesis indicated that south and west slopes are, in fact, heavily forested since the soil in that area is quite good and adequate water is available to the vegetation. The fire suppression scenario for the Quinn Meadows subbasin was subsequently changed so that current conditions were assumed to represent the fire suppression scenario.

Table C-9: Vegetative Cover of Forested Lands for Management Scenarios

		Vegetative Cover (percentage)									
		Round 1 Historic Conditions			Round 2 Fire Suppression Conditions			Round 3 Current Conditions			
Subbasin Number	Subbasin Name	HF[a]	LF[b]	SP[c]	HF[a]	LF[b]	SP[c]	HF[a]	LF[b]	SP[c]	OPN[d]
1	Headwaters Onion Creek	8	54	38	62	38	0	59	30	5	6
2	Quinn Meadows	0	32	68	32	68	0	81	15	3	1
3	Lower Onion Creek	0	54	46	54	46	0	40	37	18	5
	Total Onion Creek Watershed	4	51	45	55	45	0	54	31	10	5

[a] Heavy forest (crown closure of > 70 percent)
[b] Light forest (crown closure of 30 to 70 percent)
[c] Sparse forest (crown closure of 10 to 30 percent)
[d] Open forest (crown closure of < 10 percent)

An additional scenario was developed to reflect forest management plans over the next five years. The models were rerun with 22 percent of the upper watershed lands (1330 acres) currently heavily forested reclassified to either a lightly forested condition (570 acres) or to a sparse condition (760 acres).

4.2 Precipitation Frequency Analysis

Precipitation data from the regional climate stations were used to determine the mean annual precipitation distribution and to compute the magnitude of precipitation which occurs at particular recurrence intervals. The mean annual precipitation and the 10-year 24-hour precipitation event were supplied by DNR in digital form. These data were used to compute the weighted mean annual precipitation and weighted 10-year event for each subbasin in the Onion Creek watershed.

Precipitation frequency analysis was conducted using the Log Pearson Type III Distribution on the annual maximum data series from the Northport and Colville AP climate stations. A storm with a recurrence interval of 2 years at Northport produced 0.96 inches; the same frequency storm at Colville AP produced nearly that same amount (0.91 inches) over a 24-hour period. A storm with the probability of occurring 1 percent of the time in any given year resulted in 2.06 inches at Northport and 1.78 inches at Colville AP (Table C-10).

Table C-10: Precipitation Frequency Analysis of Regional Climate Stations

Recurrence Interval	24-hour Precipitation (inches)	
	Northport	Colville AP
2-year	0.96	0.91
5-year	1.22	1.12
10-year	1.40	1.27
25-year	1.59	1.42
50-year	1.85	1.62
100-year	2.06	1.78

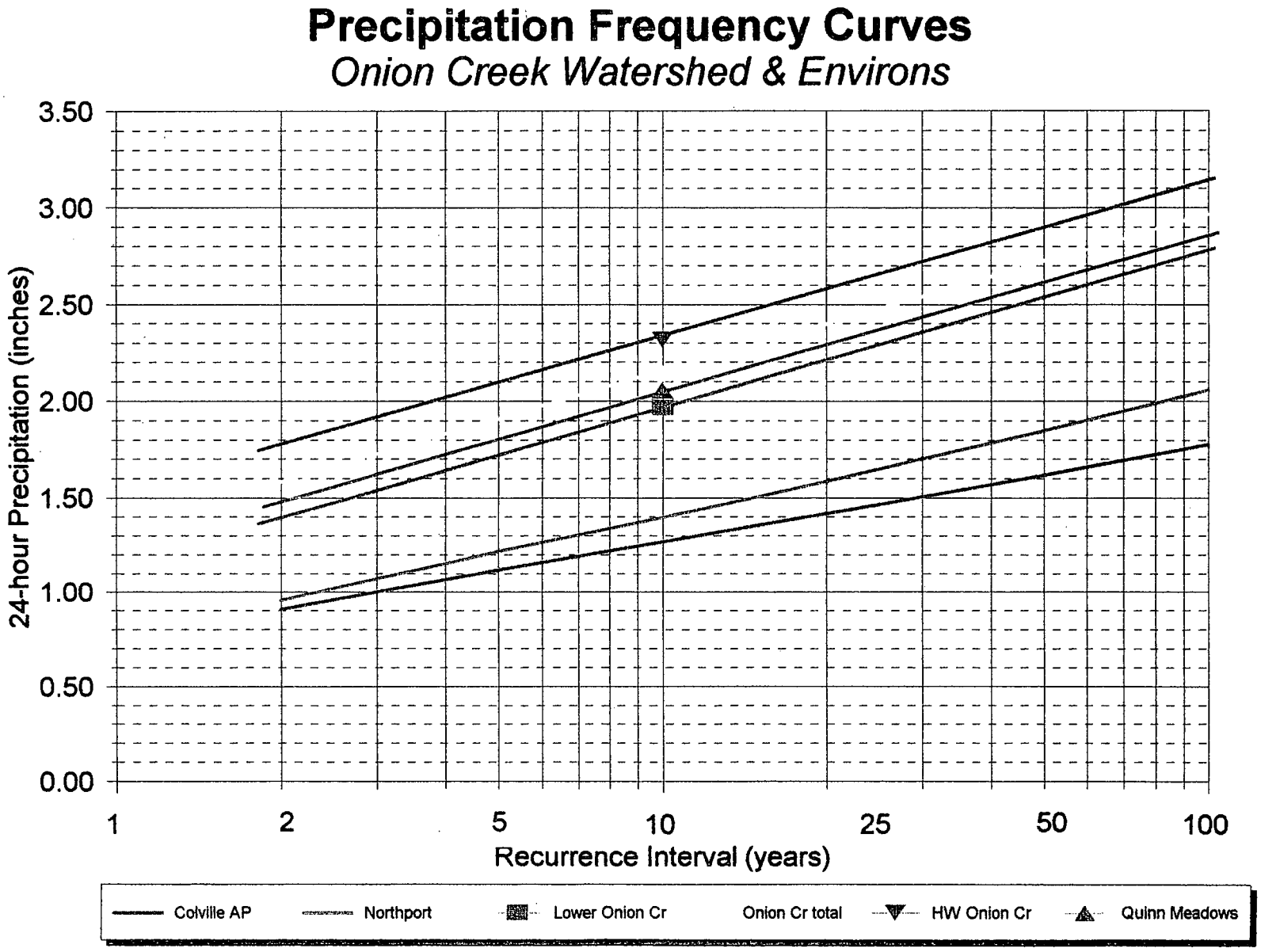
The data from Table C-10 were subsequently plotted on a graph to assess the similarities in the slope of the line at the two stations. Figure C-7 shows the results of the precipitation frequency analysis for the two climate stations. In addition, the 10-year 24-hour precipitation event for each subbasin is also plotted. The slopes of the lines for each of the two stations were slightly different and the assumption was made that Northport climatic conditions were more similar to the Onion Creek watershed than Colville AP. A second assumption was made that the relationship among the precipitation events at various recurrence intervals for each subbasin was the same. A line with the same slope as the one connecting the Northport data was drawn to intersect the 10-year storm event for each subbasin on the graphs. The design storms for the mean elevation of each subbasin were read from the graph and summarized in Table C-11.

Table C-11: Precipitation Frequency Analysis Results and Mean Annual Precipitation

Subbasin Name	2-year 24-hour event	5-year 24-hour event	10-year 24-hour event	25-year 24-hour event	50-year 24-hour event	100-year 24-hour event	Mean Annual Precipitation (inches)
Headwaters Onion Creek	1.8	2.1	2.3	2.6	2.8	3.1	28.2
Quinn Meadows	1.6	1.8	2.1	2.4	2.6	2.8	25.4
Lower Onion Cr	1.4	1.7	2.0	2.3	2.5	2.7	20.0
Entire Basin	1.6	1.9	2.1	2.4	2.7	2.9	24.3

These data were required to generate the precipitation-runoff relationships for each subbasin. The resulting equations translate the modeled output of water available for runoff into peak discharge rates. While not the best method for arriving at peak flows, it is the only one outlined in the Standard Methods to date for application in the winter rain-on-snow model.

Figure C-7


Precipitation Frequency Curves
Onion Creek Watershed & Environs
24-hour Precipitation (inches)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1
2
5
10
25
50
100
Recurrence Interval (years)
Colville AP
Northport
Lower Onion Cr
Onion Cr total
HW Onion Cr
Quinn Meadows

4.3 Flood Frequency Analysis

Since Onion Creek is an ungauged basin, design peak flow events must be estimated from other gauged data or regional equations. As part of the rain-on-snow analysis, estimates of peak flows for each design event were necessary to determine the precipitation-discharge relationship for each subbasin. Application of the U.S.G.S. regional equations is the recommended approach outlined in the Standard Methods; the U.S.G.S. developed equations for different regions throughout the state using data with varying periods of record and drainage areas. The results from using the USGS equations have been found by hydrology analysts to significantly over- or underestimate peak flows.

Mill Creek was the closest watershed of similar size to Onion Creek which had a streamflow record spanning sufficient number of years for it to be useful in this analysis. A flood frequency analysis was conducted of the annual peak series for Mill Creek near Colville using the Log Pearson Type III distribution (HEC-FFA computer program). Figure C-8 shows the outcome of the flood frequency analysis for the Mill Creek gauge. These results were compared to the flood frequency estimates reported in Williams and Pearson (1985) as well as the estimates derived from the USGS regional equations for the Mill Creek basin (Cummans et. al.,1975).

Table C-12 summarizes the flood frequency results derived from the different methods. With the exception of the USGS equations, the estimates are quite comparable. The USGS equations appear to overestimate the design flow events by 70% to 90%. The HEC-FFA and the peak flows published in Williams & Pearson are similar and based on a true record of annual peak flows for Mill Creek.

Table C-12: Mill Creek Flood Frequency Analysis

Return Period *(years)*	Mill Creek near Colville, WA USGS Gauge #12-408500 Maximum Daily Streamflow (cfs)			
	HEC-FFA	Williams & Pearson		USGS Regional Equations
		Systematic Record	WRC Estimate	Cummans et.al.
2	297	306	291	—
5	456	476	476	845
10	563	569	602	988
25	700	666	758	1263
50	795	725	872	1377
100	892	774	983	1523

To derive peak flows for Onion Creek, the unit runoff from Mill Creek HEC-FFA flows were multiplied by Onion Creek drainage area. Actual field data were used to verify the Onion Creek flows. A pebble count, a cross-section of the channel below the highway bridge, and a longitudinal profile at the same location comprised the data collected and analyzed. The pebble count data were used to determine the roughness coefficient or Manning's *n*. The cross section

data was input into the XSPRO computer program (Grant, 1992) which was subsequently calibrated against actual flow measurements taken by the Department of Ecology at roughly the same location. Most of the miscellaneous measurements were taken during the low flow season, however, a few captured storm events. The model was calibrated against the two highest instantaneous flow measurements taken in May 1986 and June 1991. Based on this information and the data collected, XSPRO computed a bankfull discharge of 270 cfs. Assuming the bankfull discharge occurs between the one and three year recurrence interval, the use of the synthetic Onion Creek flows based on the Mill Creek gauged data was acceptable (between Q_2 & Q_5) while the synthetic flows based on the U.S.G.S. equations were high.

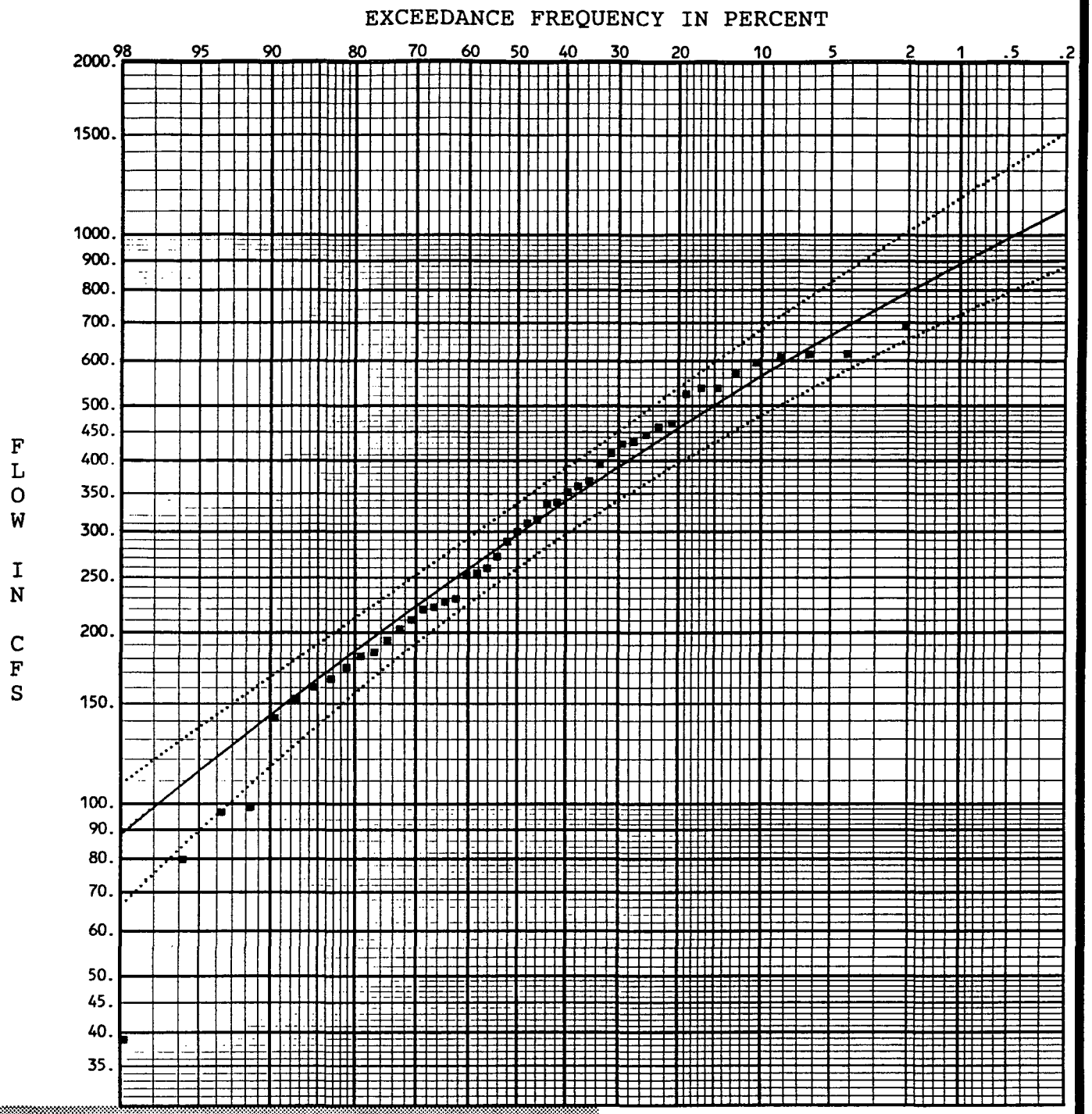
Table C-13: Onion Creek Flood Frequency Analysis

	Onion Creek near Northport Estimated Streamflow (cfs)	
Return Period *(years)*	Calculated using Mill Cr unit runoff from HEC-FFA peak flow values	USGS Equations Cummans et.al.
2	193	—
5	296	530
10	366	634
25	455	821
50	516	905
100	579	1010

The estimated design peak flow events for each subbasin were computed using the unit runoff from Mill Creek and the subbasin area. Mill Creek unit runoff for each peak flow event was multiplied by the drainage area for each subbasin. The resulting flood frequency estimates for each subbasin, shown in Table C-14, were correlated with the corresponding precipitation frequency events (Section 3.1.1) for that subbasin to develop the relationship which was used to translate inputs (precipitation + snowmelt) into discharge. These equations were used to translate the water available for runoff calculated in the rain-on-snow model into streamflow values which could subsequently be compared for changes due to changing forest conditions.

Table C-14: Flood Frequency Analysis for Onion Creek Subbasins

	Discharge (cfs)					
Subbasin Name	**2-year**	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**
Headwaters Onion Creek	87	134	165	206	234	262
Quinn Meadows	22	34	41	52	59	66
Lower Onion Creek	84	128	158	197	224	251
Entire Basin	193	296	365	454	516	579



——Flow Frequency (without Exp. Prob.)

■ Weibull Plotting Positions

·····5% and 95% Confidence Limits

FREQUENCY STATISTICS

LOG TRANSFORM OF FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.4606	HISTORIC EVENTS	0
STANDARD DEV	.2327	HIGH OUTLIERS	0
SKEW	-.3979	LOW OUTLIERS	1
REGIONAL SKEW	.0000	ZERO OR MISSING	0
ADOPTED SKEW	-.3000	SYSTEMATIC EVENTS	47

Figure C-8

USGS Annual Max Data Series
Mill Creek
nr Colville,WA
Period of Record 1940-1986
BASIN AREA = 83 SQ MI

4.4 Temperature-Elevation Relationships

Temperature data from the regional climate stations were used to establish a representative, local relationship between maximum monthly temperature and elevation. A correlation analysis was performed on the data from Table C-2 for the months of February and May, the months considered the most representative of winter rain-on-snow and spring runoff peak flows, respectively. Based on the information shown in Tables C-3 through C-5, winter rain-on-snow storms occur infrequently. The February equation, shown below, was used in the winter rain-on-snow model, however, this equation produced temperature values too cold to melt snow.

$$T_{Feb} = 6.57 - 0.005 * E$$
$$r^2 = 0.92$$

Where: T_{Feb} = average maximum monthly temperature (°C)
E = elevation (m)

A more detailed analysis was conducted to examine temperatures during the six actual storm events which occurred in January, February, and March. The temperatures at eleven different climate stations for the day of the peak flow events were averaged and correlated with the station elevations. The new equation, T_{wros}, produced warmer temperatures and subsequent snowmelt in the winter rain-on-snow model. Figure C-9 graphically illustrates the higher temperatures from actual storms compared to the maximum monthly temperatures for February and the equation supplied in the Standard Methods.

$$T_{wros} = 13.52 - 0.007 * E$$
$$r^2 = 0.79$$

The May equation below (Figure C-10) was used in the rain-free snowmelt and spring rain-on-snow model since most spring peak flows occur in May. Methods for deriving springtime temperatures to analyze spring events were not part of the Standard Methods. Therefore, the May equation was assumed to adequately reflect the temperature which produces the maximum amount of snowmelt. This assumption will result in a conservative estimate in understanding hydrologic changes due to harvest management practices.

$$T_{May} = 25.85 - 0.009 * E$$
$$r^2 = 0.94$$

Where: T_{May} = average maximum monthly temperature (°C)
E = elevation (m)

4.5 Snow Water Equivalent-Elevation Relationships

Snow data were analyzed from six snow course and one SNOTEL stations (listed in Addendum C-I, Table C-Ic) for the months of February and April. For these months, the data were adequate to establish a regional relationship between snow water equivalent and elevation. Snow water

equivalent data for the month of February were correlated with elevation to determine the appropriate relationship for the area (Figure C-10). February represents snow water equivalent for the winter rain-on-snow scenario. The standard error for the snow water equivalent estimate was 8.65 cm.

$$\mathbf{SWE_{Feb} = -30.42 - 0.039 * Elevation}$$
$$\mathbf{r^2 = 0.76}$$

For the spring rain-on-snow and rain-free snowmelt models, April snow water equivalent data were used in conjunction with the station elevations to develop a spring snow water equivalent-elevation relationship (Figure C-12). Insufficient data were available in May to develop an adequate relationship; 3 stations reported data in May while seven stations reported data in April. In addition, the peak flows usually occur from late April to early May, therefore, the April equation was considered appropriate.

$$\mathbf{SWE_{April} = -54.50 + 0.064 * Elevation}$$
$$\mathbf{r^2 = 0.77}$$

4.6. Wind Speed

Wind speed is a variable in both the rain-on-snow and rain-free snowmelt models. It is difficult to find good wind data that is appropriate for mountains, mountainsides, and river valleys with varying degrees of vegetative cover. Most often, wind speed is taken at airports, which are level and open. The rain-on-snow equation has been found to be quite sensitive to wind inputs; the rain-free snowmelt equations are more sensitive to solar radiation inputs.

The Weather Service Office at the Spokane Airport and Old Glory Mountain in British Columbia, Canada were the nearest climate stations that collected wind speed data. For February, the average wind speed at Spokane Airport was 9.2 mph or 4.1 m/sec. Old Glory Mountain reported an average February wind speed of 34.2 km/hr or 9.5 m/sec. The average of these two stations was 6.8 m/sec. Standard Methods suggest the use of the 50 percent exceedance rate, which, in this case, would result in wind speeds of 2.2 m/second at Spokane. Application of this value may underestimate the results, therefore, the average of wind speeds at Spokane and Old Glory Mountain were used in the winter rain-on-snow analysis for the average conditions.

The average wind speed for May at Spokane Airport was 9.3 mph, which translated into 359 km/day (4.2 m/sec). At Old Glory Mountain the average May wind speed was 6.1 m/sec or 528 km/day. The average of these two data points (443.5 km/day or 5.1 m/sec) was used as wind input to the model.

Because wind speed has been shown to differ as a function of crown closure, the wind speed values were modified based on crown closure described in Section 4.1.3. The wind equation (Dunne and Leopold, 1978) that modifies wind speed as a function of crown closure, F_c, is:

$$U_v = U_o * [1-(0.8 * F_c)]$$

Where: U_o = wind speed data
U_v = wind speed adjusted for vegetative cover

Figure C-9

Temperature-Elevation Relationship

Winter

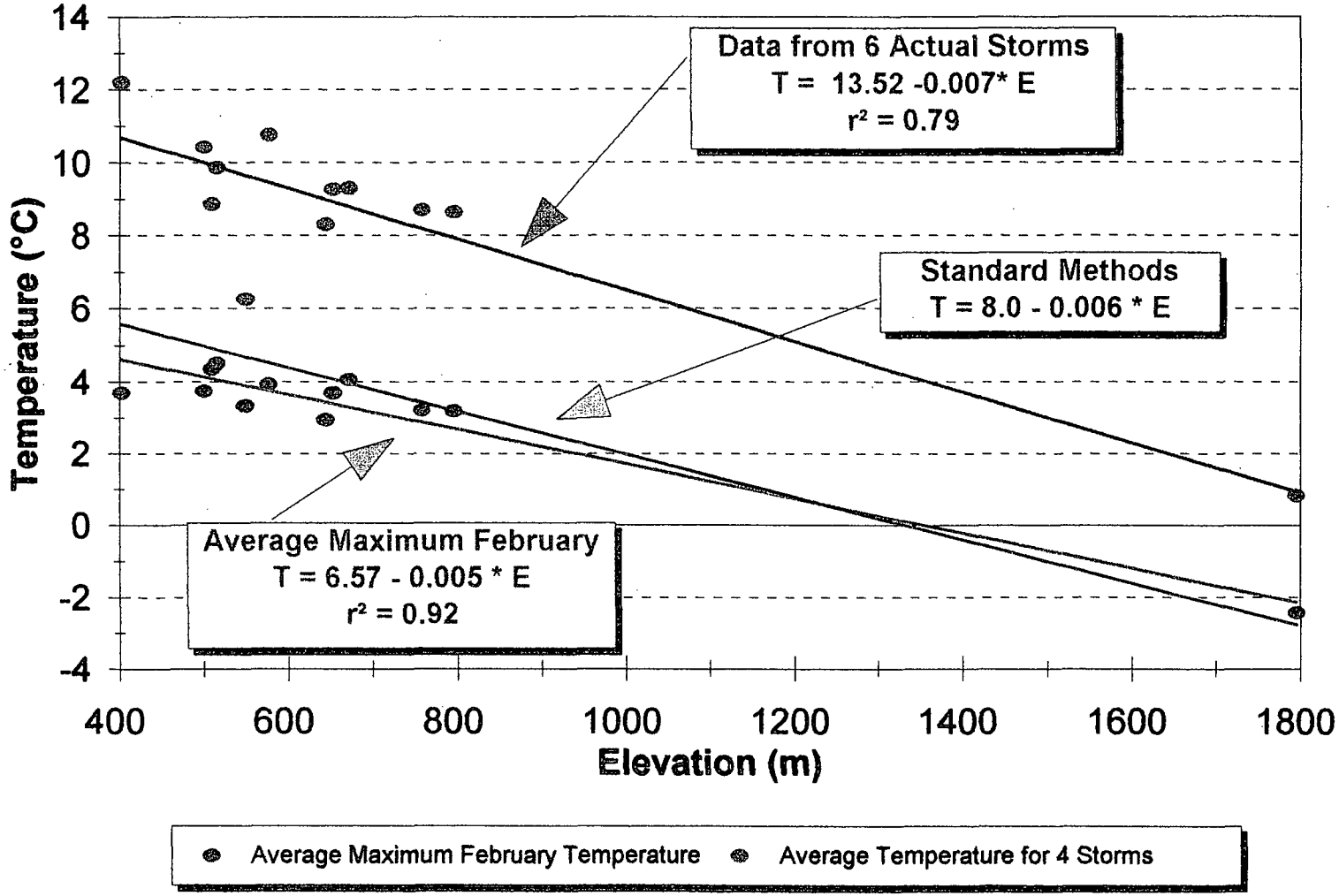


Figure C-10

Temperature-Elevation Relationship

Spring

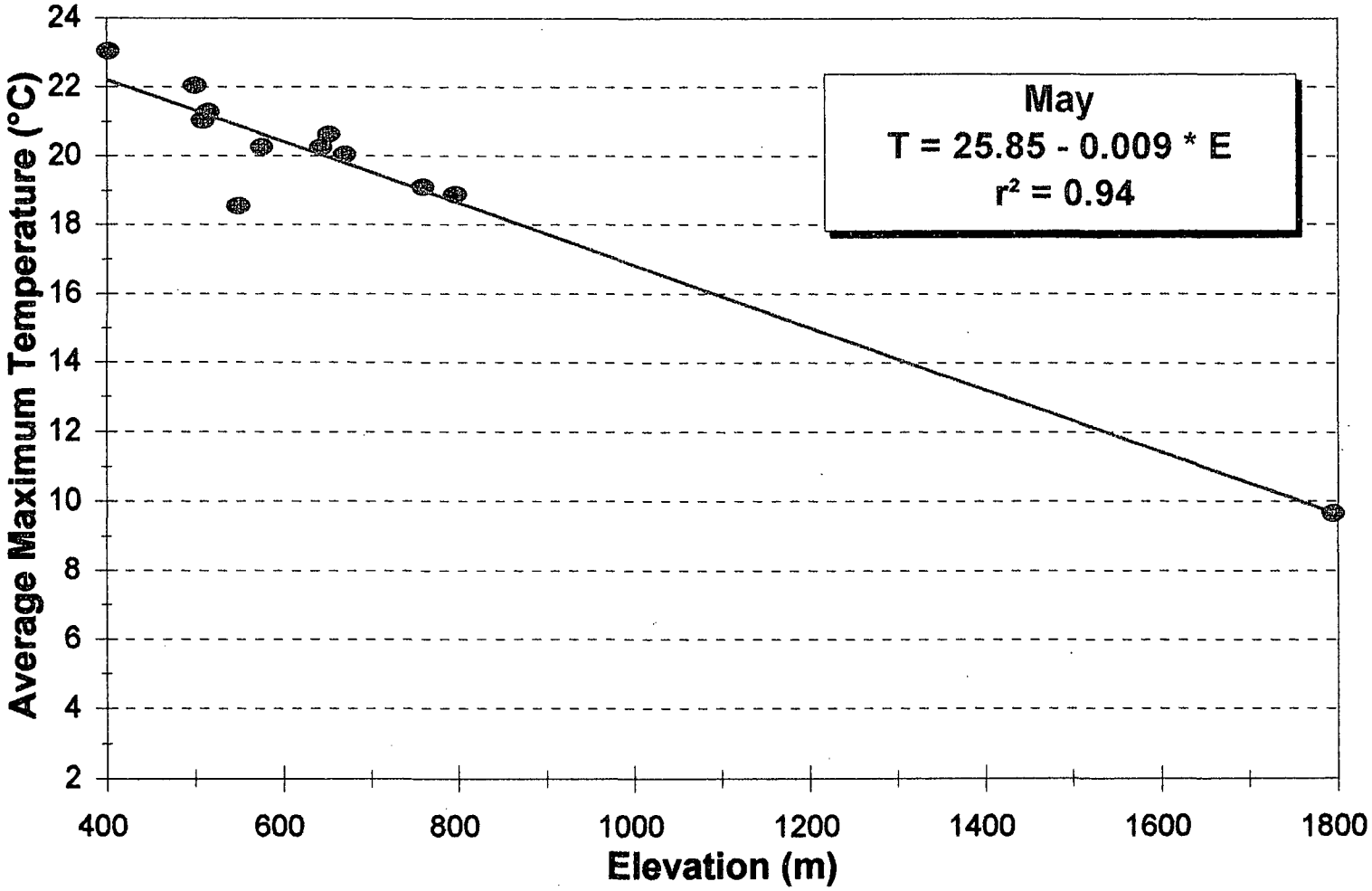


Figure C-11

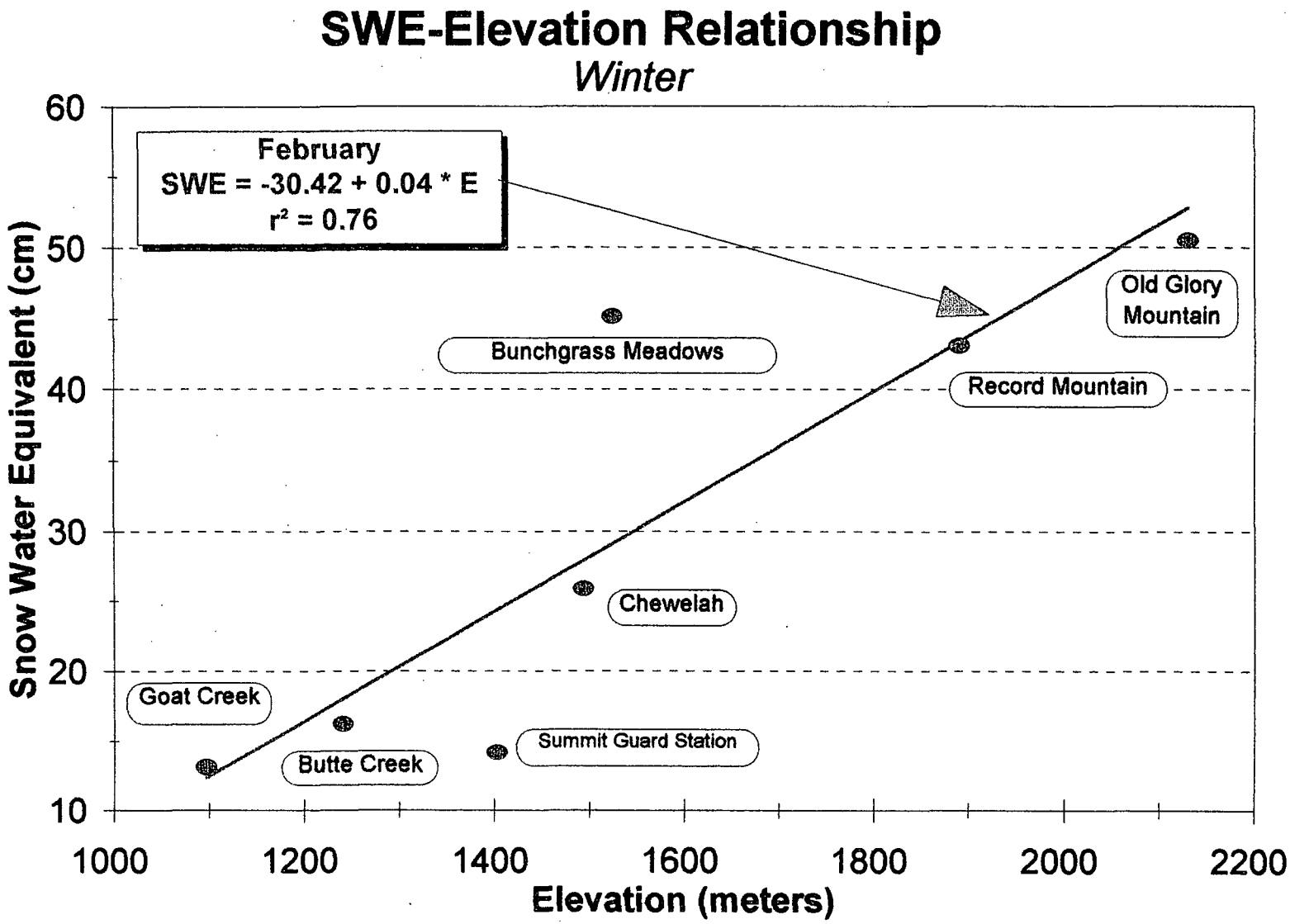
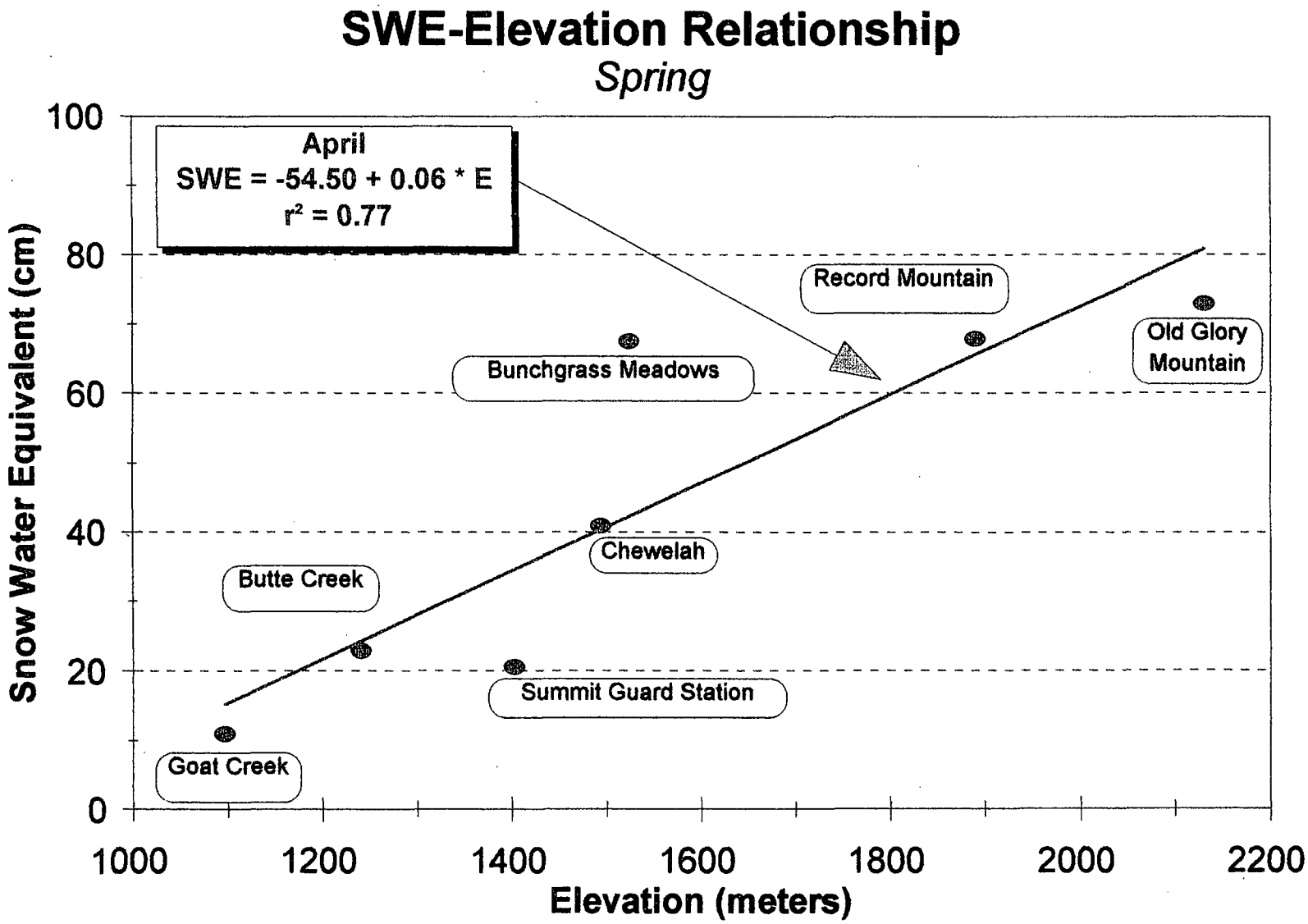

SWE-Elevation Relationship
Winter
February
SWE = -30.42 + 0.04 * E
r² = 0.76
Snow Water Equivalent (cm)
60
50
40
30
20
10
1000
1200
1400
1600
1800
2000
2200
Elevation (meters)
Old Glory Mountain
Bunchgrass Meadows
Record Mountain
Chewelah
Goat Creek
Summit Guard Station
Butte Creek

Figure C-12


SWE-Elevation Relationship
Spring
April
SWE = -54.50 + 0.06 * E
r² = 0.77
Record Mountain
Old Glory Mountain
Bunchgrass Meadows
Chewelah
Butte Creek
Summit Guard Station
Goat Creek
Snow Water Equivalent (cm)
0
20
40
60
80
100
1000
1200
1400
1600
1800
2000
2200
Elevation (meters)

4.7 Solar Radiation

Solar radiation or insolation, Q_s (cal/cm^2/day), is the amount of shortwave radiation reaching the surface of the earth and is necessary to calculate spring snowmelt. Solar radiation varies with slope and aspect of the land surface as well as latitude. Table C-16 summarizes the insolation values assumed for the analysis of the Onion Creek watershed, which is located between 48° and 49° North Latitude. Peak spring snowmelt runoff has generally occurred late April to early May. Solar radiation data were published for April 16 and May 1; May 1 data were used in this analysis (Buffo et al. 1972) since the date is closest to the average day on which peak flows occur.

Table C-15: Solar Radiation at 48°50' North Latitude by Slope and Aspect May 1 (cal/cm²/day)

	Aspect			
Slope	**North**	**East**	**South**	**West**
0°	706	706	706	706
< 15°	657	697	733	697
15-30°	540	668	764	668
> 30°	245	520	617	520

Source: Buffo et al. 1972

Albedo, or snow reflectivity (α), is a function of the age of the snow. By spring time, albedo can range from 0.4 to 0.6 (U.S. Army Corps of Engineers 1956). For purposes of this spring snowmelt analysis, albedo of 0.5 was assumed.

4.8 Relative Humidity

The National Weather Service publishes data for relative humidity at the Spokane Airport, the station closest in location to the Onion Creek WAU with available data. The rain-free snowmelt analysis used the average May relative humidity over a 24-hour period of 58 percent. Relative humidity was not a required input into the winter rain-on-snow model.

4.9 Dewpoint Temperature

Dewpoint temperature (T_d) was computed from air temperature in °C (T_a) and relative humidity (h) using the following equation (Linsley et al. 1975).

$$T_d = h^{1/8} (112 + 0.9T_a) - 112 + 0.1T_a$$

5.0 HYDROLOGIC MODELING ANALYSIS

5.1 Winter Rain-on-Snow Processes

5.1.1 Winter Rain-on-Snow Methods

A spreadsheet model was designed to compute snowmelt under rain-on-snow conditions using the U.S. Army Corps of Engineers snowmelt equation. The model is based on the procedure defined in the Hydrologic Change module of the Watershed Analysis Manual (WFPB 1995) and used in conjunction with WAU-specific data, where possible.

This model executes the calculation of one snowmelt equation under different input climate conditions for each combination of elevation zone and crown closure class for each subbasin. Four scenarios for crown closure were simulated to assess affects of land use on peak streamflows: Historic Conditions, Fire Suppression Conditions, Current Conditions (1995), and Clearcut Conditions.

Results were derived using *average* winter rain-on-snow conditions. The divergent points from the standard methods include the use of the temperature-elevation equation derived from six actual winter rain-on-snow storms, the SWE-elevation relationship developed from more localized data and the forest cover factors and scenarios reflective of eastern Washington watershed conditions. The use of the Log Pearson Type III frequency analysis of the Mill Creek U.S.G.S. streamflow gauge, adjusted for area and applied to each subbasin, replaced the use of the regional equations developed by the U.S.G.S. and suggested in the Standard Methods. Average winter wind speed data from Spokane and Old Glory Mountain (British Columbia) were used.

The U.S. Army Corps of Engineers' (1956) snowmelt equation was used to estimate the amount of snowmelt occurring during rain-on-snow conditions for a given temperature, wind speed, and 24-hour precipitation events:

$$\mathbf{SM = T * [0.133 + (0.086 * U) + (0.0126 * P_{24/R})] + 0.23}$$

Where:
SM = snowmelt (cm/day)
U = wind speed (m/second)
P = 24-hr precipitation (cm)
T = temperature (°C)

Input variables were derived using the equations described in Section 4.0, Development of Inputs to Hydrologic Models.

Once the snowmelt was computed, 24-hour precipitation for each recurrence interval was added. The result, water available for runoff, became inputs (I = P+SM, P = precipitation, SM = snowmelt) to the regression equations translating precipitation to peak flows.

5.1.2 Winter Rain-on-Snow Results

The results of the winter rain-on-snow analysis are summarized in Tables C-16 through C-19: Water Available for Runoff, Changes in Water Available for Runoff, Peak Discharge, and Changes in Peak Discharge. These tables replace Form C-2 and Form C-3 in the Standard Methods for the Hydrologic Change module. The results for the two-year and 100-year design events are illustrated in Figures C-13 through C-16.

The WAR results are reported to the second decimal place to facilitate calculating the percent increase between scenarios. However, the results should not be interpreted at this level of precision or accuracy since there are numerous assumptions built into the model. Estimated peak flow rates are reported to the nearest cfs. The important aspect of the results is the relative change which occurs and not the magnitude of the peak flows; the magnitude of these estimates should be used with caution.

For all scenarios and storm events, the change from historic to current conditions for both water available for runoff and the peak flow rate were negative. The negative values indicate more water was available under historic conditions than is currently available.

The largest change from the fire suppression scenario to current conditions for the 2-year event resulted in an increase of 0.16 cm of WAR in the Lower Onion Creek subbasin. The changes in WAR from fire suppression for the 100-year event were approximately the same as for the 2-year event. The percent change however, decreases with increasing magnitude of the design event. The percent change in WAR from fire suppression scenarios to the current condition was less than 10% for all of the subbasins.

Peak flow increases were not significant when examining the change from historic and fire suppression to current conditions; the percent change in each subbasin for all design events was well below the 10 percent threshold. A low delivered hazard was assigned to all subbasins based on the outcome of the winter rain-on-snow modeling effort.

Changes from historic to clearcut and fire suppression to clearcut were modelled, however, the outcome was not considered as part of the effects on public resources. Harvest management to a clearcut condition is an unlikely forest practice in eastern Washington watersheds. The extreme scenario of fully clearcut does provide a relative index for understanding which basins are most susceptible to potential peak flow increases.

An additional scenario was developed to reflect forest management plans over the next five years. The models were rerun with 22 percent of the upper watershed lands (1330 acres) currently heavily forested reclassified to either a lightly forested condition (570 acres) or to a sparse condition (760 acres). In a winter rain-on-snow event, the increase in peak flow attributable to this forest plan is estimated to be 2%.

Figure C-13

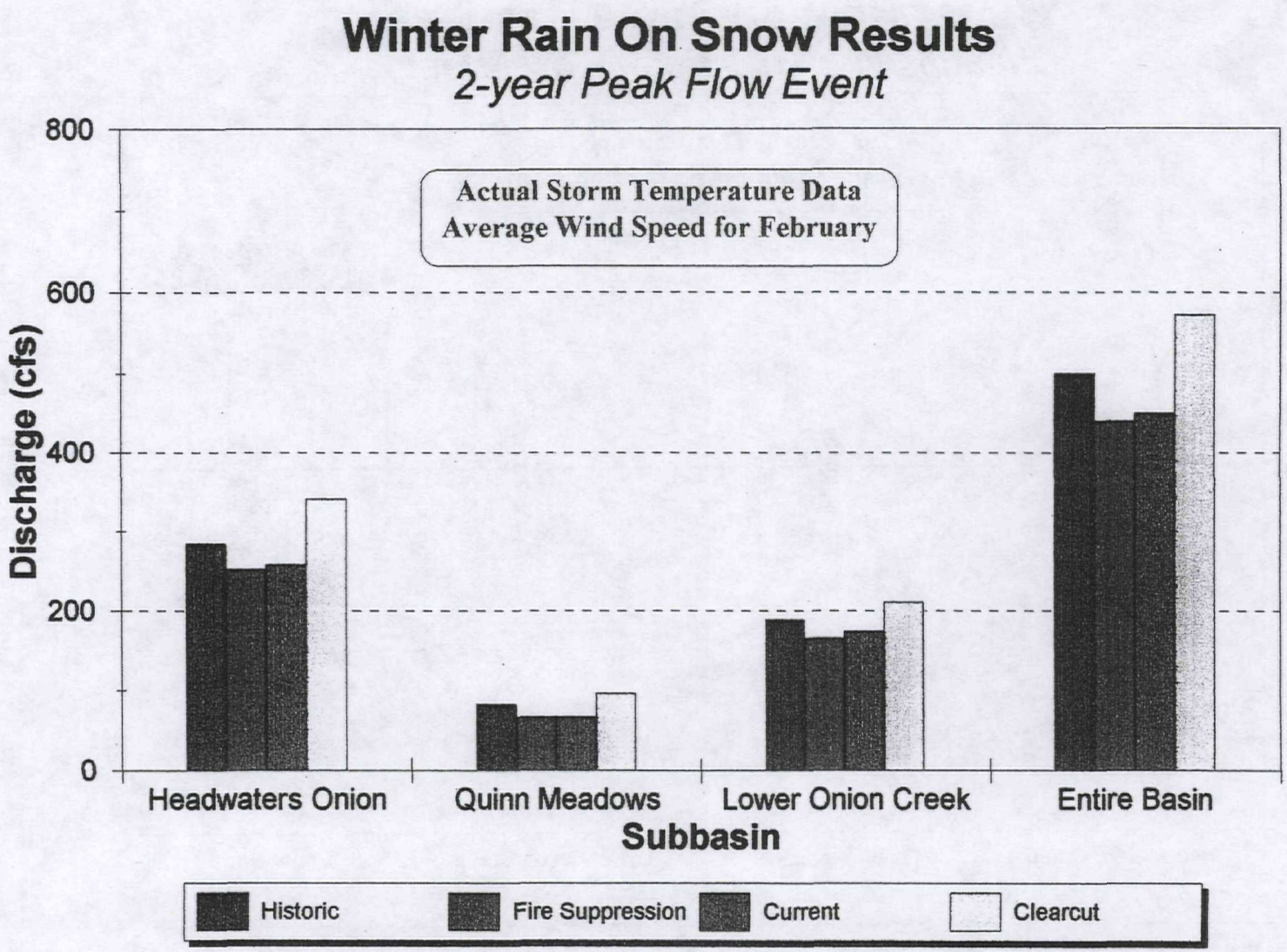

Winter Rain On Snow Results
2-year Peak Flow Event
Actual Storm Temperature Data
Average Wind Speed for February
Discharge (cfs)
800
600
400
200
0
Headwaters Onion
Quinn Meadows
Lower Onion Creek
Entire Basin
Subbasin
Historic
Fire Suppression
Current
Clearcut

Figure C-14

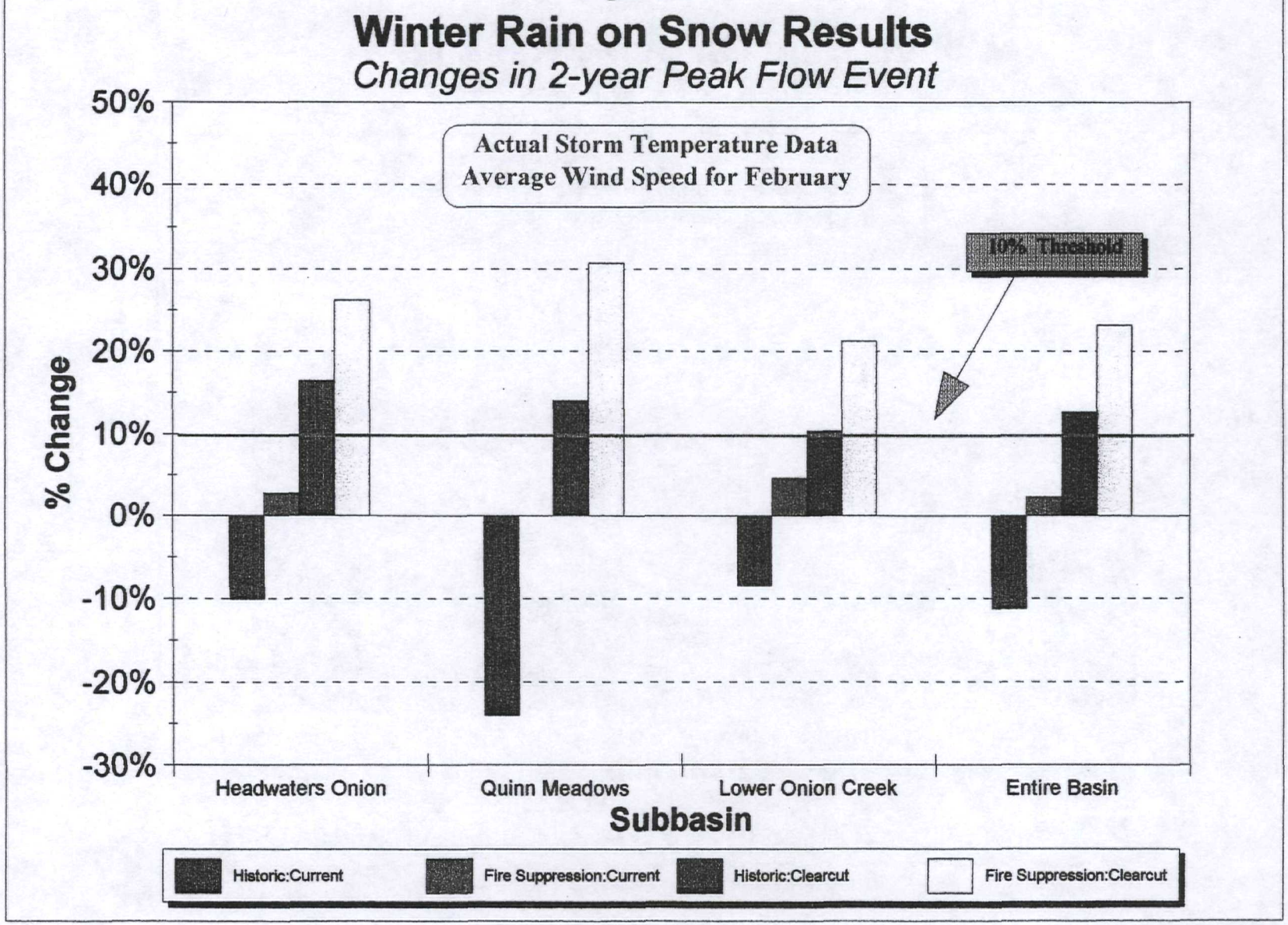

Winter Rain on Snow Results
Changes in 2-year Peak Flow Event
Actual Storm Temperature Data
Average Wind Speed for February
10% Threshold
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
% Change
Headwaters Onion
Quinn Meadows
Lower Onion Creek
Entire Basin
Subbasin
Historic:Current
Fire Suppression:Current
Historic:Clearcut
Fire Suppression:Clearcut

Figure C-15

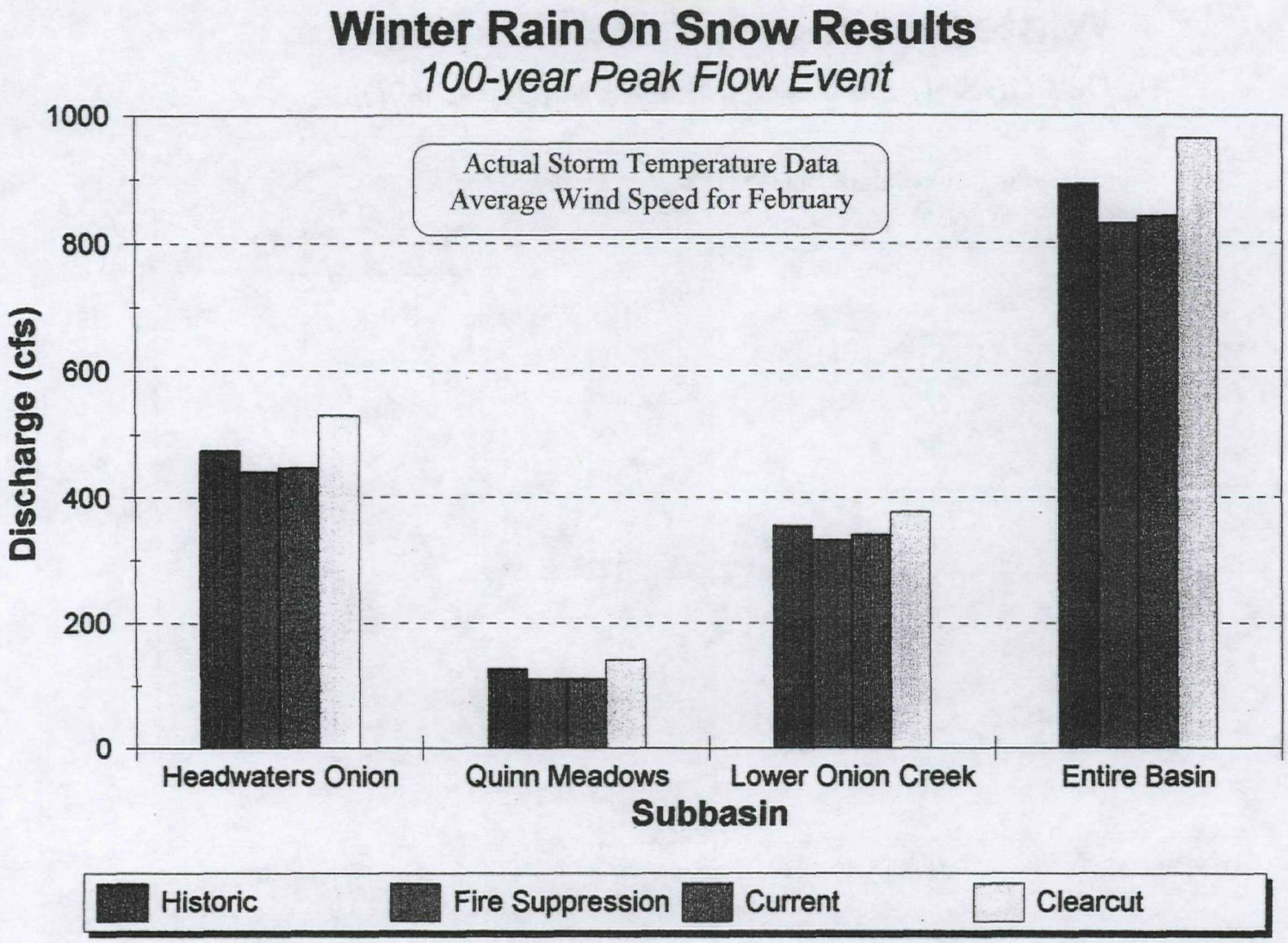

Winter Rain On Snow Results
100-year Peak Flow Event
Actual Storm Temperature Data
Average Wind Speed for February
Discharge (cfs)
1000
800
600
400
200
0
Headwaters Onion
Quinn Meadows
Lower Onion Creek
Entire Basin
Subbasin
Historic
Fire Suppression
Current
Clearcut

Figure C-16

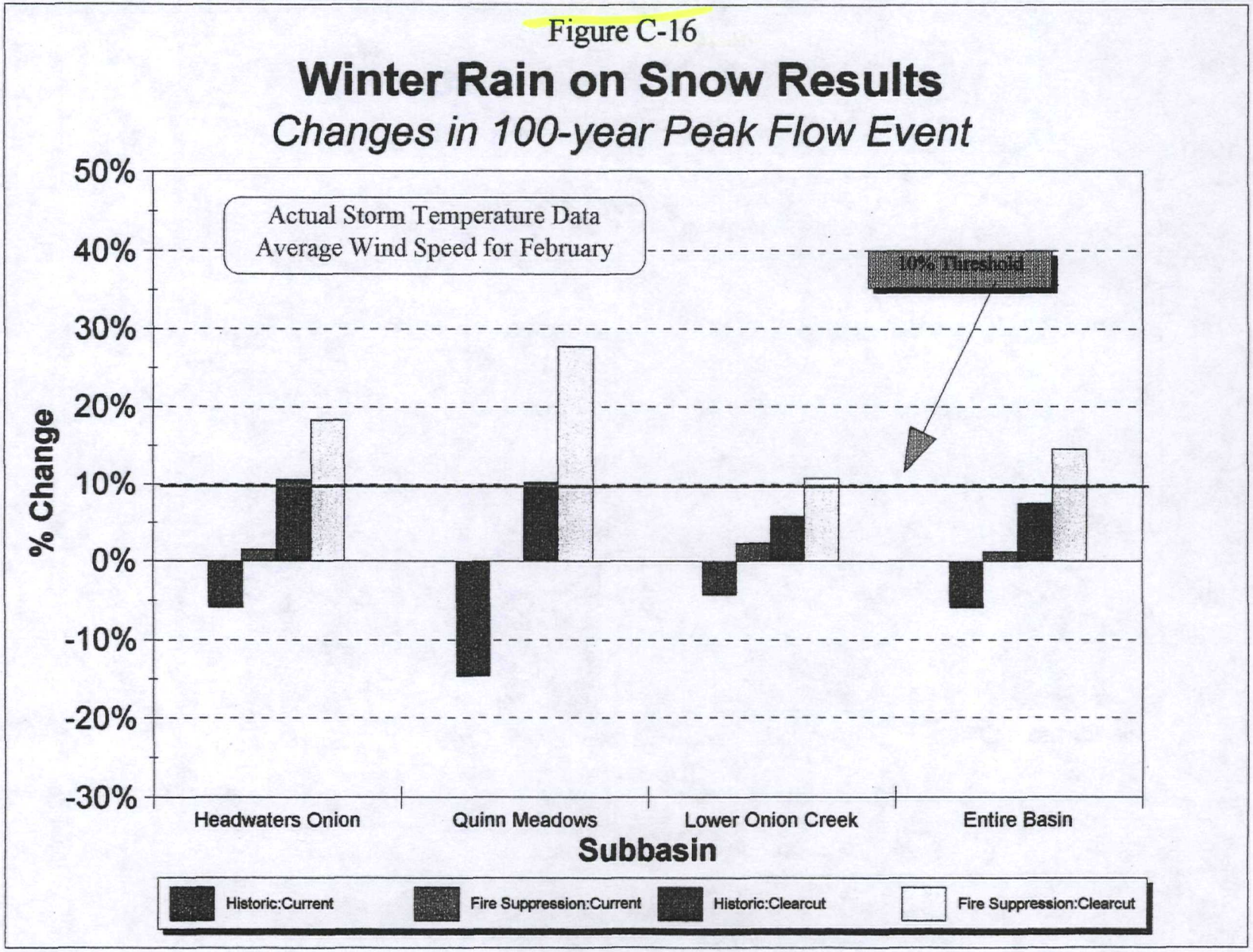

Winter Rain on Snow Results
Changes in 100-year Peak Flow Event
Actual Storm Temperature Data
Average Wind Speed for February
10% Threshold
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
% Change
Headwaters Onion
Quinn Meadows
Lower Onion Creek
Entire Basin
Subbasin
Historic:Current
Fire Suppression:Current
Historic:Clearcut
Fire Suppression:Clearcut

Table C-16: Water Available for Runoff, Winter Rain-on-Snow Results (Form C-2)

Subbasin Number	Subbasin Name	Return Period (years)	Water Available for Runoff (cm/day) Round 1 Historic Conditions	Round 2 Fire Suppression Conditions	Round 3 Current Conditions	Round 4 All Clearcut
1	Headwaters Onion Creek	2	8.15	7.53	7.66	9.19
		5	8.97	8.35	8.48	10.01
		10	9.51	8.89	9.02	10.56
		25	10.33	9.71	9.84	11.37
		50	10.87	10.26	10.39	11.92
		100	11.69	11.08	11.21	12.74
2	Quinn Meadows	2	8.34	7.17	7.17	9.32
		5	8.87	7.71	7.71	9.87
		10	9.68	8.51	8.51	10.70
		25	10.49	9.31	9.31	11.52
		50	11.03	9.85	9.85	12.07
		100	11.57	10.38	10.38	12.63
3	Lower Onion Creek	2	5.64	5.18	5.34	6.08
		5	6.42	5.96	6.12	6.86
		10	7.20	6.74	6.90	7.64
		25	7.98	7.52	7.68	8.42
		50	8.49	8.04	8.20	8.94
		100	9.01	8.55	8.71	9.45
4	Total Onion Creek Watershed	2	6.62	6.09	6.18	7.25
		5	7.41	6.89	6.97	8.04
		10	7.94	7.41	7.50	8.57
		25	8.73	8.20	8.29	9.36
		50	9.52	8.99	9.08	10.15
		100	10.05	9.52	9.61	10.68

Table C-17: Changes in Water Available for Runoff, Winter Rain-on-Snow Results (Form C-2)

Subbasin Number	Subbasin Name	Return Period (years)	Water Available for Runoff (percent change) R1:R3 Historic: Current	R2:R3 Fire Suppression: Current	R1:R4 Historic: Clearcut	R2:R4 Fire Suppression: Clearcut
1	Headwaters Onion Creek	2	-6.0	1.7	12.8	22.1
		5	-5.4	1.5	11.7	19.9
		10	-5.1	1.5	11.0	18.7
		25	-4.7	1.3	10.1	17.1
		50	-4.5	1.3	9.6	16.2
		100	-4.2	1. 2	8.9	15.0
2	Quinn Meadows	2	-14.0	0.0	11.8	23.0
		5	-13.2	0.0	11.2	21.6
		10	-12.1	0.0	10.5	19.7
		25	-11.2	0.0	9.8	18.1
		50	-10.7	0.0	9.5	17.2
		100	-10.2	0.0	9.1	16.4
3	Lower Onion Creek	2	-5.3	3.1	7.8	17.4
		5	-4.7	2.7	6.9	15.1
		10	-4.2	2.4	6.1	13.4
		25	-3.8	2.1	5.5	12.0
		50	-3.5	2.0	5.2	11.2
		100	-3.3	1.9	4.9	10.5
4	Total Onion Creek Watershed	2	-6.6	1.5	9.5	19.0
		5	-5.9	1.3	8.5	16.8
		10	-5.5	1.2	7.9	15.6
		25	-5.0	1.1	7.2	14.1
		50	-4.6	1.0	6.6	12.9
		100	-4.4	0.9	6.3	12.2

Table C-18: Peak Discharge Estimates, Winter Rain-on-Snow Results (Form C-3)

Subbasin Number	Subbasin Name	Return Period (years)	Peak Discharge Estimates (cfs)			
			Historic Conditions	Fire Suppression Conditions	Current Conditions	All Clearcut
1	Headwaters Onion Creek	2	285	252	259	341
		5	329	296	303	385
		10	358	325	332	414
		25	402	369	376	458
		50	431	398	405	487
		100	475	442	449	531
2	Quinn Meadows	2	83	67	67	97
		5	90	74	74	104
		10	102	85	85	116
		25	113	96	96	127
		50	120	104	104	135
		100	128	111	111	142
3	Lower Onion Creek	2	189	166	174	211
		5	227	205	213	249
		10	266	243	251	288
		25	305	282	290	327
		50	331	308	316	352
		100	356	334	341	378
4	Total Onion Creek Watershed	2	500	439	449	572
		5	590	530	540	662
		10	651	590	600	723
		25	741	681	691	813
		50	832	771	781	904
		100	892	831	842	964

Table C-19: Changes in Peak Discharge Estimates, Winter Rain-on-Snow Results (Form C-3)

Subbasin Number	Subbasin Name	Return Period (years)	Peak Discharge Estimates (percent change)			
			R1:R3 Historic: Current	R2:R3 Fire Suppression: Current	R1:R4 Historic: Clearcut	R2:R4 Fire Suppression: Clearcut
1	Headwaters Onion Creek	2	-9	3	20	35
		5	-8	2	17	30
		10	-7	2	16	27
		25	-7	2	14	24
		50	-6	2	13	22
		100	-6	2	12	20
2	Quinn Meadows	2	-19	0	16	33
		5	-18	0	15	30
		10	-16	0	14	27
		25	-14	0	13	24
		50	-14	0	12	22
		100	-13	0	11	21
3	Lower Onion Creek	2	-8	5	12	27
		5	-7	4	10	22
		10	-6	3	8	18
		25	-5	3	7	16
		50	-4	3	7	15
		100	-4	2	6	13
4	Total Onion Creek Watershed	2	-10	2	14	30
		5	-9	2	12	25
		10	-8	2	11	22
		25	-7	2	10	19
		50	-6	1	9	17
		100	-6	1	8	16

5.1.3 Winter Rain-on-Snow Conclusions

The most important comparison of scenarios to examine were the changes from historic to current conditions and the changes from fire suppression to current conditions. In general, a decrease in flows occurred between historic and current conditions due to the fact that estimated crown closure density was lower historically than it is today. The change from fire suppression to current conditions produced an increase in flows yet the increase was less than 10 percent.

For winter rain-on-snow processes, all subbasins were assigned a low hazard deliverability.

5.2 Spring Rain-on-Snow Processes

5.2.1 Spring Rain-on-Snow Methods

The methods used to analyze spring rain-on-snow events were similar to those used for winter rain-on-snow processes. The difference is primarily in the input variables. The equations describing the snow water equivalent-elevation and temperature-elevation relationships for April and May conditions were used to replace the winter equations. In addition, the average wind speed for May was used as input (5.1 m/sec).

The precipitation design events and the flood frequency events were developed based on annual maximum data series and were not specific to a particular time of year. One inherent problem with estimating increases in spring peak flows on a 24-hour event basis is that the underlying snowmelt from antecedent solar radiation is not accounted for. While the WAR estimates from the spring rain-on-snow assessment may be used as an index to changes in peak flows attributable to forest practices, the discharge values can be misleading. A continuous hydrologic model would better estimate peak flows, however, it requires a commitment of time and money to develop.

5.2.2 Spring Rain-on-Snow Results

For the two higher elevation subbasins (Headwaters and Quinn Meadows), the water available for runoff (WAR) produced from the spring rain-on-snow model was higher, by a few centimeters, than those produced under winter rain-on-snow conditions. This was due primarily to the increased snowpack available to melt in April than was available in February. Lower Onion Creek subbasin produced similar WAR values under both winter and spring conditions.

For all storm events, the change from historic to current conditions for water available for runoff were negative. The negative values indicate more water was available under historic conditions than is currently available. The percent change in WAR from the fire suppression scenario to the current condition was less than 10% for all of the subbasins. Figures C-17 through C-20 illustrate the WAR estimates and the percent change from one scenario to another for both the two-year event and the 100-year event.

5.2.3 Spring Rain-on-Snow Conclusions

The most important comparison of scenarios to examine were the changes from historic to current conditions and the changes from fire suppression to current conditions. In general, a decrease in flows occurred between historic and current conditions due to the fact that estimated crown closure density was lower historically than it is today. The change from fire suppression to current conditions produced an increase in flows yet the increase was less than 10 percent. For spring rain-on-snow processes, all subbasins were assigned a low hazard deliverability.

Figure C-17

Spring Rain On Snow Results

WAR for 2-year Recurrence Interval

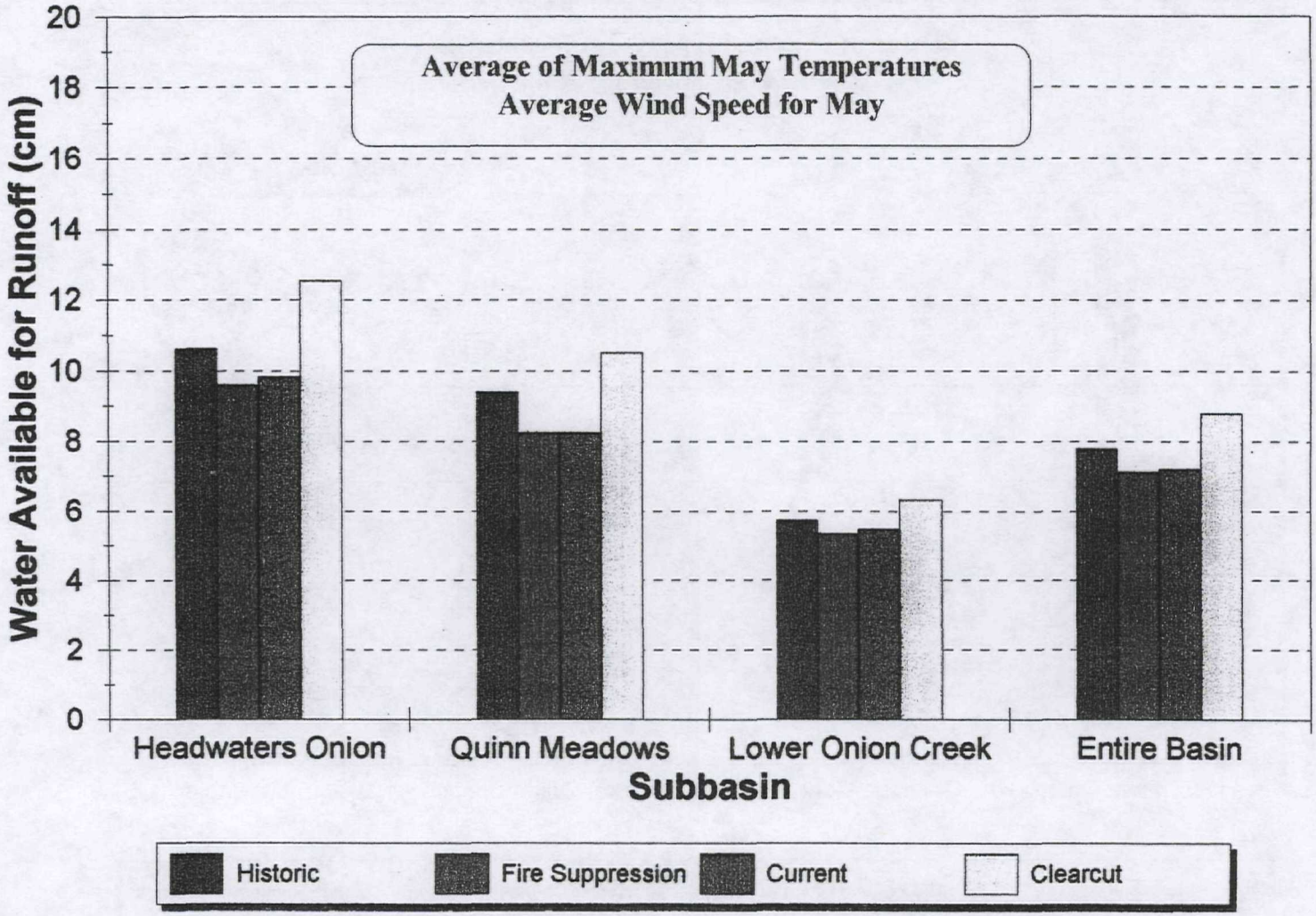


Figure C-18

Spring Rain on Snow Results

Changes in WAR for 2-year R.I.

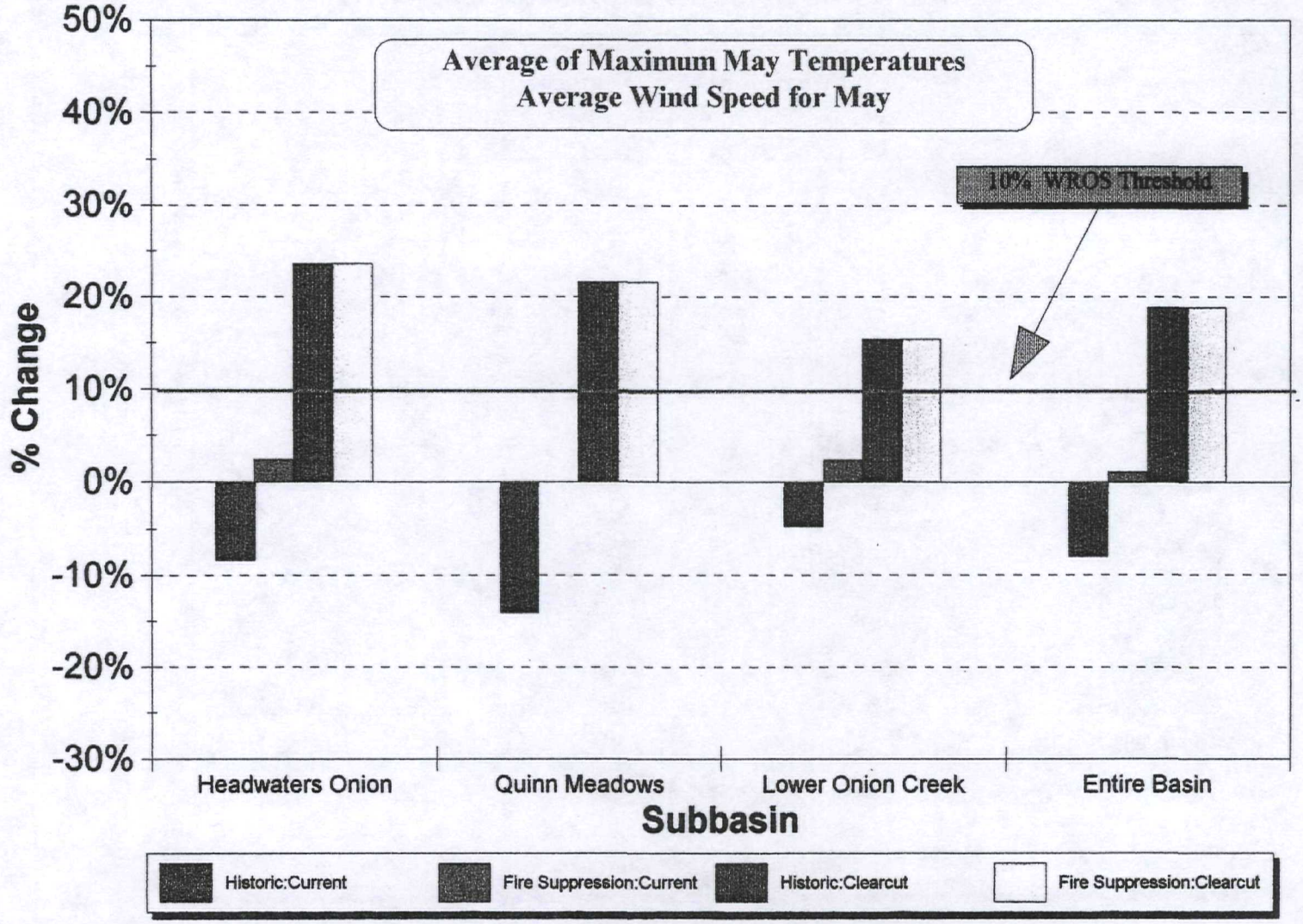


Figure C-19

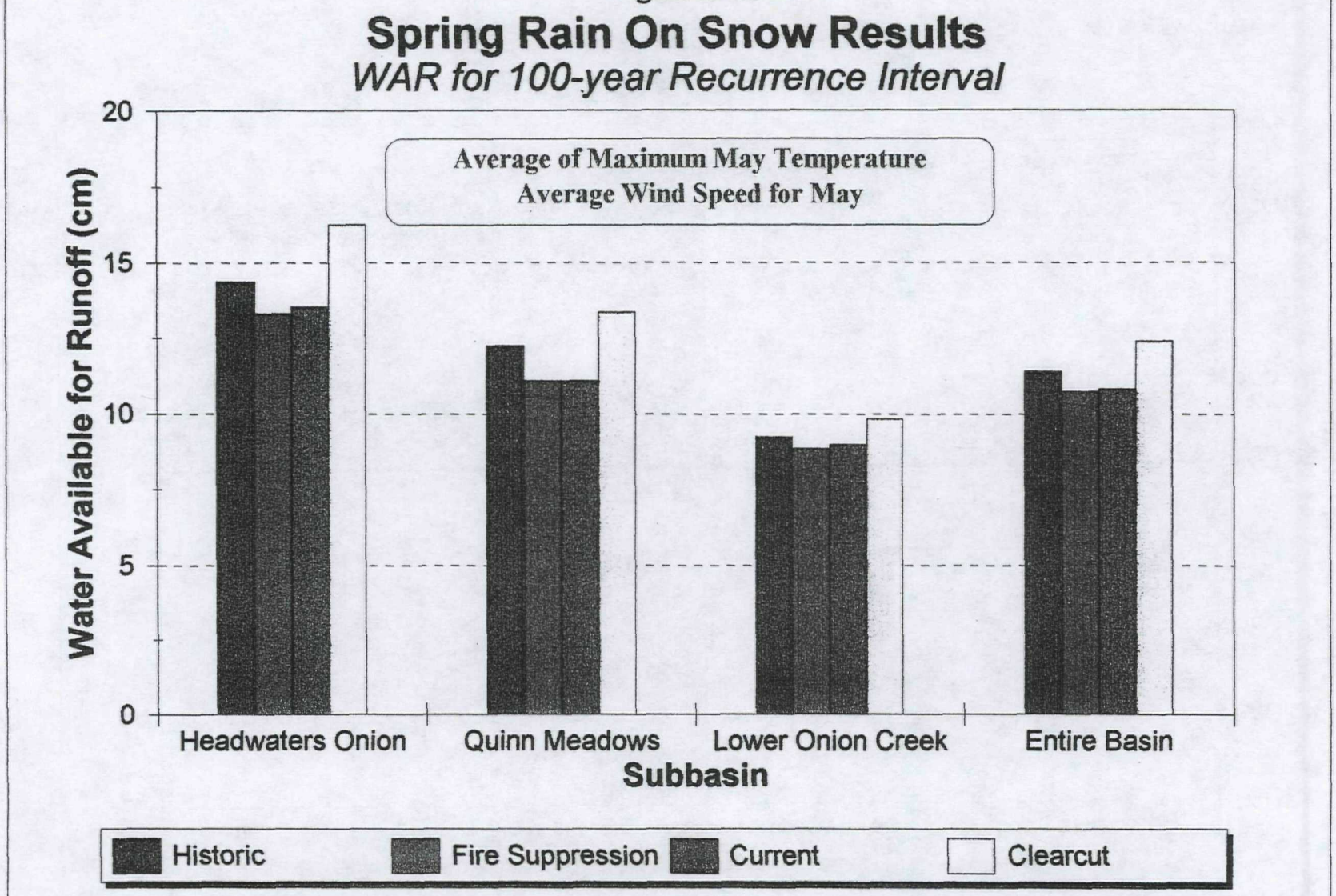
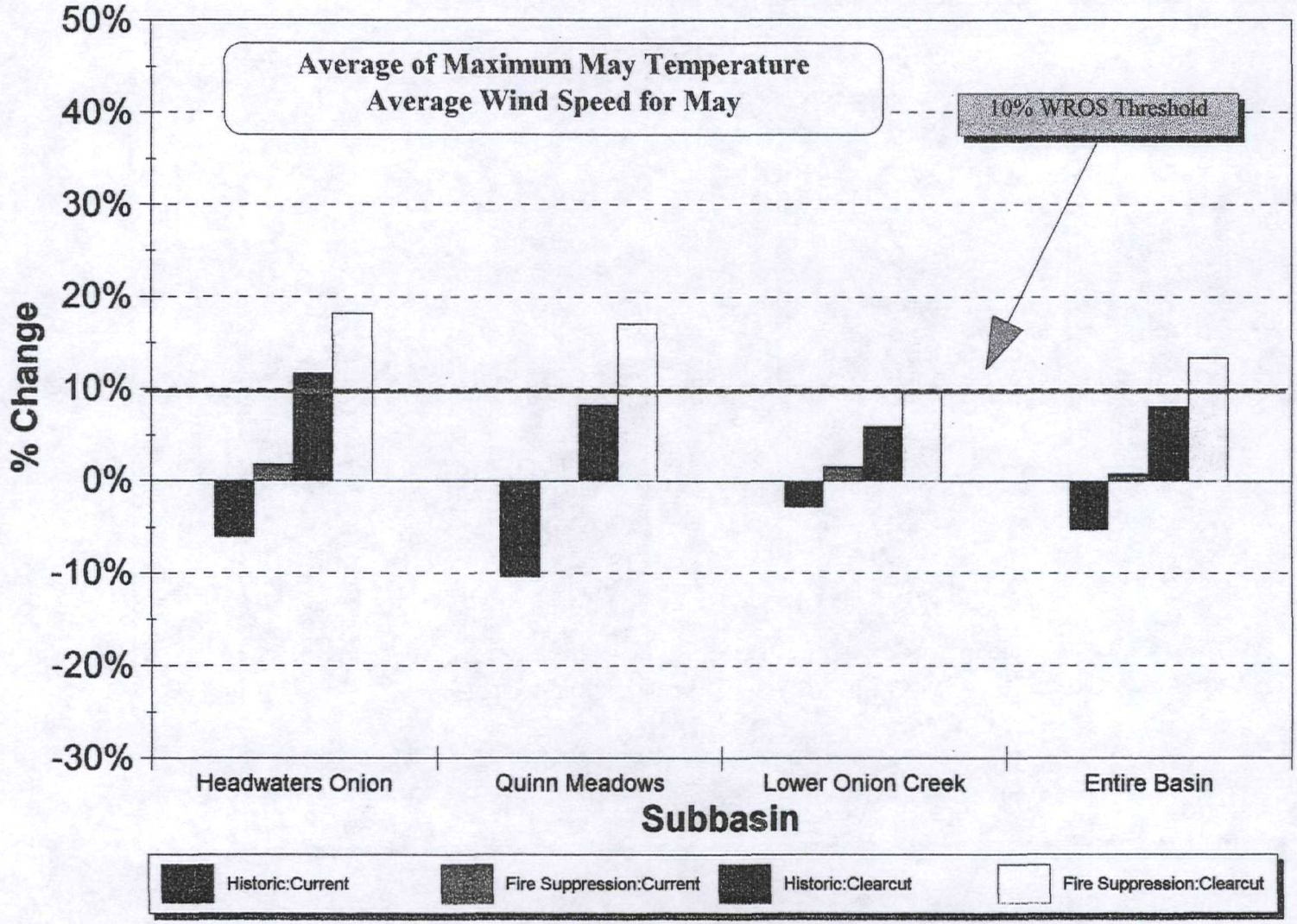

Spring Rain On Snow Results
WAR for 100-year Recurrence Interval
Average of Maximum May Temperature
Average Wind Speed for May
Water Available for Runoff (cm)
20
15
10
5
0
Headwaters Onion
Quinn Meadows
Lower Onion Creek
Entire Basin
Subbasin
Historic
Fire Suppression
Current
Clearcut

Figure C-20

Spring Rain on Snow Results

Changes in WAR for 100-year R.I.



5.3 Rain-Free Snowmelt Processes

5.3.1 Rain-Free Snowmelt Methods

Dunne and Leopold (1978) summarized rain-free snowmelt equations based on the U.S. Army Corps of Engineers literature (1956). These equations were used in this analysis to represent different crown closure situations: open forest (crown closure less than 10 percent), sparse and light forest (crown closure from 30 to 60 percent), heavy forest (crown closure from 60 to 80 percent), and dense forest (crown closure greater than 80 percent). Due to the physical environment in eastern Washington where crown closure is not generally more than 80 percent, the last equation was not used in this analysis.

The snowmelt equation for open areas requires input data from solar radiation, albedo or snow reflectivity, air temperature, dewpoint temperature, wind speed, forest cover, and cloud cover. For purposes of this analysis, the cloud cover, C, was set to zero for clear sky conditions. This situation represents a maximum amount of snowmelt during rain-free conditions. The following equations represent the revised versions taking this assumption into account:

For open areas (crown closure of less than 10 percent):

$$\mathbf{M = 0.0125 * Q_s(1 - \alpha) + (0.104T_a - 2.13) + .013T_a + 0.00078u(0.42T_a + 1.51T_d)}$$

For lightly forested and sparse conditions (crown closure from 10 to 60 percent):

$$\mathbf{M = 0.01(1-F_c) * Q_s (1 - \alpha) + 0.00078u(1-.8F_c)(0.42T_a + 1.51T_d) + .14F_c T_a}$$

For heavily forested areas (crown closure from 60 to 80 percent):

$$\mathbf{M = 0.00078u(1-.8F_c)(0.42T_a + 1.51T_d) + .14T_a}$$

Where:
- M = snowmelt (cm/day)
- Q_s = insolation (cal/cm^2/day)
- α = albedo
- u = wind speed in km/day
- T_a = air temperature (°C)
- T_d = dewpoint temperature (°C)
- F_c = forest cover factors

The inputs to these equations were developed as described in Section 4.0.

5.3.2 Rain-Free Snowmelt Results

Lower Onion Creek produced results equal in all scenarios; forest cover did not affect the outcome because the melting power under each condition was much greater than the amount of

snow to be melted.

Results from the rain-free snowmelt modeling effort represent one climatic condition on May 1 and produce a one-day snowmelt value. Table C-20 and Figure C-21 show the actual resulting values and Table C-21 shows the percent increase from one scenario to another, Figure C-22 illustrates this change. Because of the one-day nature of this analysis, snowmelt values were not translated into a one-day peak discharge rate. A one-day snowmelt value would not correlate well with a one-day peak flow value since snowmelt peak flows occur on a sustained basis generally over a period from four to seven days. Continuous snowmelt modeling could provide results with a higher confidence level, but this effort requires large amounts of data for inputs and a considerable amount of time and money.

An assumption in the modeling effort was the uniform distribution of snowpack and snowmelt at different slopes and aspects throughout the basin. This assumption tends to overestimate snowmelt values since snowpack is not usually distributed uniformly. Snow drifts will have different melting potential and melt rates than areas from where the snow moved . The only way to more accurately incorporate this type of information is to monitor the snowpack at several places in the basin using snow stakes and conduct frequent monitoring.

Changes from historic to clearcut and fire suppression to clearcut were modeled, however, the outcome was not considered as part of the effects on public resources. Harvest management to a clearcut condition is an unlikely forest practice in eastern Washington watersheds. The extreme scenario of fully clearcut does provide a relative index for understanding which basins are most susceptible to potential peak flow increases should a pervasive fire occur.

Under rain-free snowmelt conditions, the percent change in snowmelt from historic to current conditions ranged from -16% to 0% and from 0% to 6% for the change from fire suppression to current conditions. Historic conditions assume a lower canopy cover than currently exists which translates into larger snowmelt values (solar radiation is more effective in open areas and snow accumulation increases due to lower evapotranspiration and interception rates).

The interpretation of the result is, therefore, that very little effect on rain-free snowmelt has occurred under changing forest practices. Figure C-21 illustrates the outcome of the modeling exercise and shows the small amount of increase in the Headwaters and Lower Onion Creek subbasin from fire suppression to current conditions.

Table C-20: Rain-Free Snowmelt Results, Average Maximum May 1 Conditions

		Snowmelt (inches/day)			
Subbasin Number	**Subbasin Name**	**Round 1 Historic Conditions**	**Round 2 Fire Suppression Conditions**	**Round 3 Current Conditions**	**Round 4 All Clearcut**
1	Headwaters Onion Creek	4.73	3.78	4.00	5.66
2	Quinn Meadows	2.96	2.73	2.73	2.96
3	Lower Onion Creek	1.22	1.22	1.22	1.22
	Total Onion Creek Watershed	**3.66**	**3.03**	**3.11**	**4.23**

Table C-21: Rain-Free Snowmelt Results, Average Maximum May 1 Conditions

		Snowmelt (percentage increase)			
Subbasin Number	**Subbasin Name**	**R1:R3 Historic: current**	**R2:R3 Fire supp: current**	**R1:R4 Historic: clearcut**	**R2:R4 Fire supp: clearcut**
1	Headwaters Onion Creek	-16	6	20	50
2	Quinn Meadows	-8	0	0	8
3	Lower Onion Creek	0	0	0	0
	Total Onion Creek Watershed	**-15**	**3**	**16**	**40**

An additional scenario was developed to reflect forest management plans over the next five years. The models were rerun with 22 percent of the upper watershed lands (1330 acres) currently heavily forested reclassified to either a lightly forested condition (570 acres) or to a sparse condition (760 acres). In spring runoff conditions, a 24-hour snowmelt value is predicted to increase from 4.0 inches to 4.64 inches in the headwaters of Onion Creek. This represents a 13.8% increase in snowmelt. While estimating peak flow is not possible from this single value, it is unlikely that 0.64 inches increase in snowmelt will represent substantial increases in peak flow.

5.2.3 Rain-Free Snowmelt Conclusions

The generally acceptable threshold for rain-on-snow events is 10% based, in part, on a watershed's ability to withstand change and, in part, on the accuracy of data measurement

devices. For example, streamflow gauge records are rated "good" by the USGS if 95% of the measured values are within 10% of the true value. Rain-free snowmelt modeling is new to the watershed analysis process and acceptable thresholds have not been defined for this procedure. If the 10% threshold is applied to the rain-free results, the hazard call due to hydrologic changes from historic or fire suppression to current conditions would be rated low.

Figure C-21

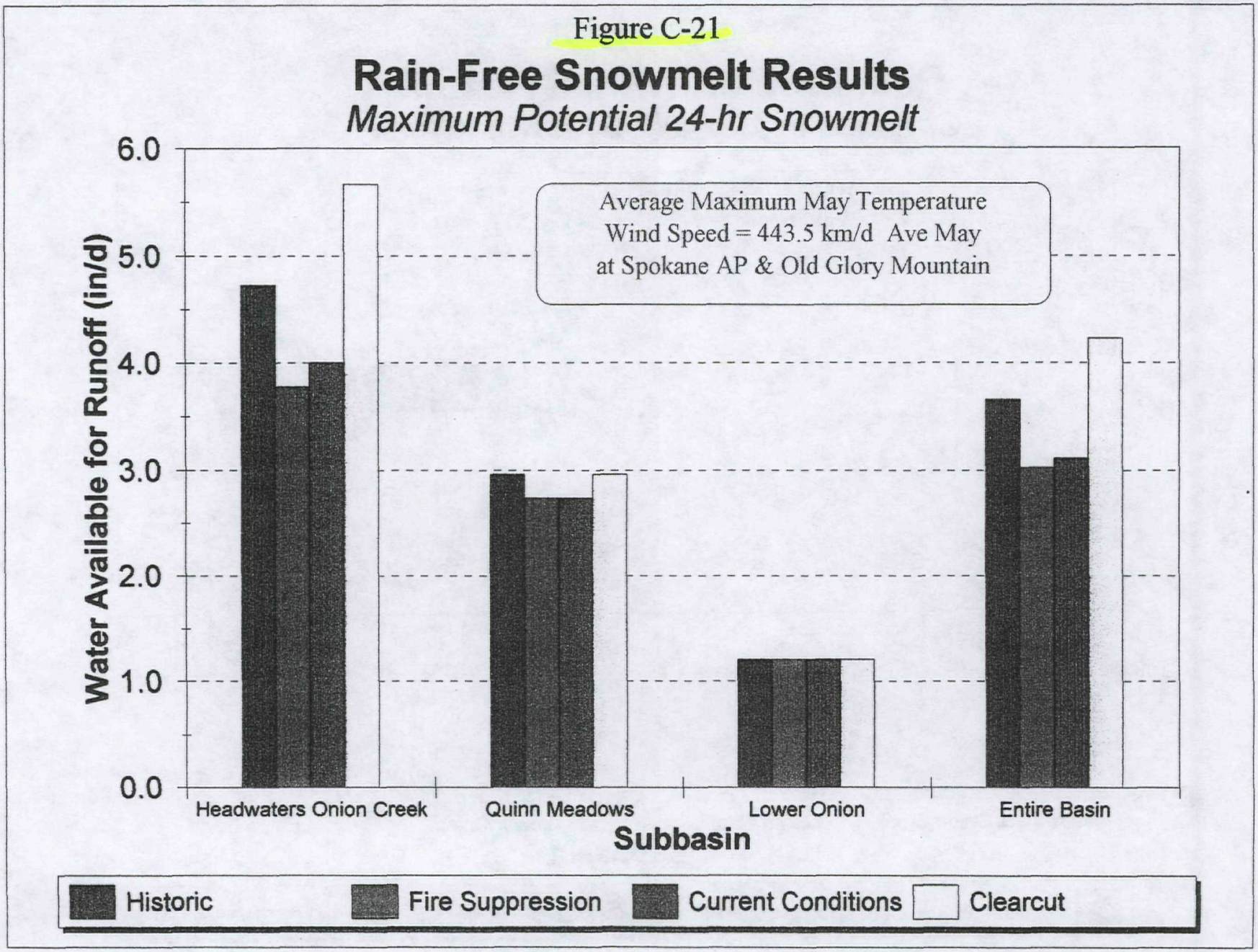
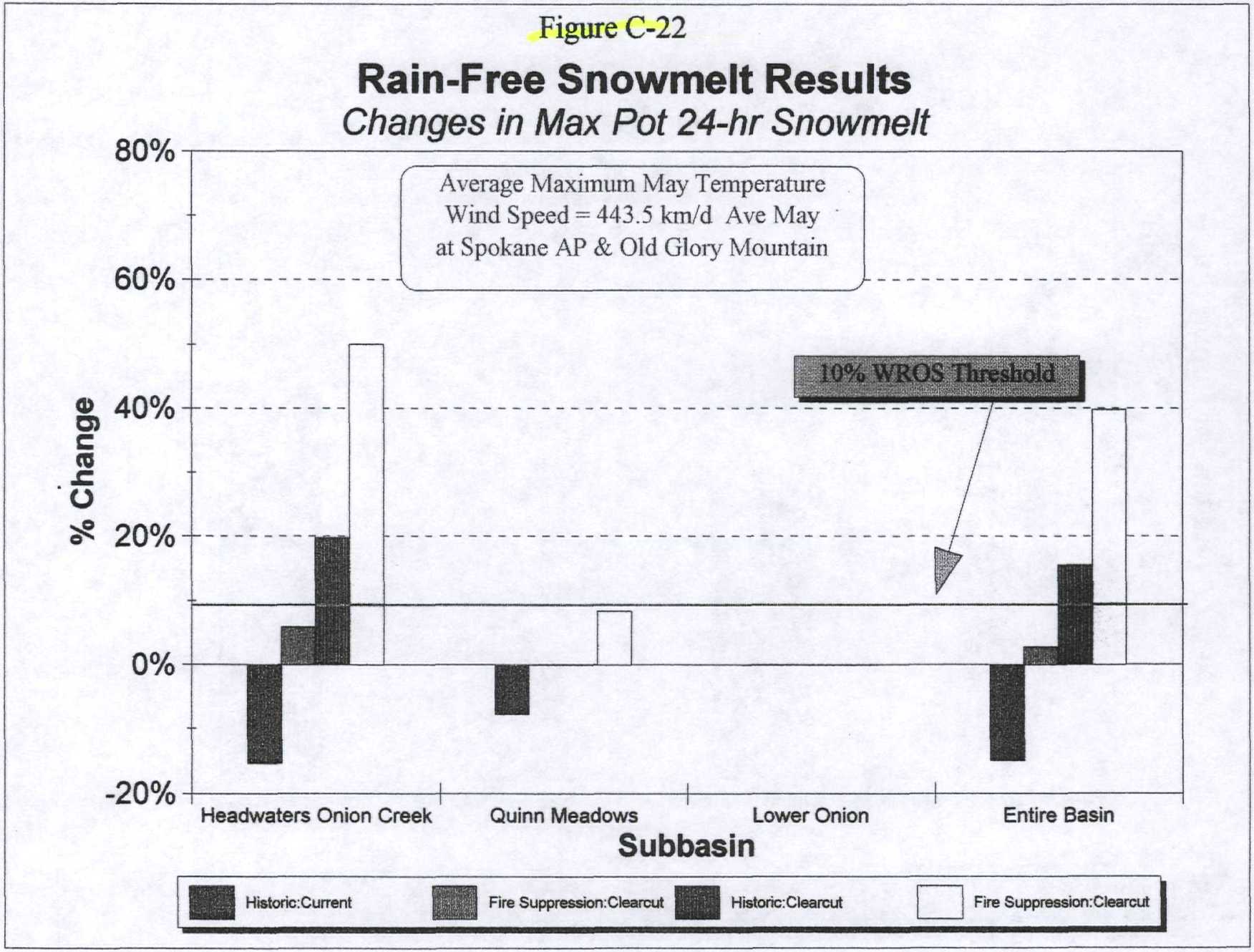

Rain-Free Snowmelt Results
Maximum Potential 24-hr Snowmelt
Average Maximum May Temperature
Wind Speed = 443.5 km/d Ave May
at Spokane AP & Old Glory Mountain
Water Available for Runoff (in/d)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Headwaters Onion Creek
Quinn Meadows
Lower Onion
Entire Basin
Subbasin
Historic
Fire Suppression
Current Conditions
Clearcut

Figure C-22


Rain-Free Snowmelt Results
Changes in Max Pot 24-hr Snowmelt
Average Maximum May Temperature
Wind Speed = 443.5 km/d Ave May
at Spokane AP & Old Glory Mountain
10% WROS Threshold
80%
60%
40%
20%
0%
-20%
% Change
Headwaters Onion Creek
Quinn Meadows
Lower Onion
Entire Basin
Subbasin
Historic:Current
Fire Suppression:Clearcut
Historic:Clearcut
Fire Suppression:Clearcut

6.0 EFFECTS OF PEAK FLOW CHANGES ON PUBLIC RESOURCES

For the snowmelt and peak flow generating processes investigated (winter rain on snow, spring rain on snow and spring snowmelt), the effects on peak flows attributable to forest practices were assessed as minimal under current conditions. This is primarily due to the fact that the vegetative cover currently is more dense than the estimated historic crown closure. Therefore, little, if any change in peak flow generation has occurred relative to historic conditions causing minimal effects on public resources at this time.

Scenarios to represent any future land use activities were not developed for analysis. It would be wise to re-run the models as a predictive tool for planned harvest units to determine whether or not the increased harvest will alter the peak flows sufficiently to cause a change in the results of this analysis.

7.0 CONFIDENCE IN ASSESSMENT

Historic and fire suppression estimates of crown closure are very generalized. The estimates for this analysis were based solely on aggregated aspect, elevation, and slopes. A more comprehensive approach would be based on potential natural vegetation, which would include such variables as soils, precipitation, geology.

The fire suppression scenario most likely underestimates the WAR and peak flows which in turn overestimates the percent change from fire suppression to current conditions. This scenario assumes 100% effective fire suppression along with no harvest activities. Perhaps the most realistic fire suppression scenario would include a distribution of the basin acreage for dense, light, and sparse canopy cover accounting for forest fires which occur even with fire suppression. For eastern Washington watersheds, a "background condition" scenario needs to be defined as some combination of historic and a more realistic picture of fire suppression with some occurrence of forest fires and an index to site productivity potential.

Confidence in the winter rain-on-snow results is moderate; use of local data to develop the inputs to the model enhance the confidence. There are numerous refinements which may increase the confidence of the rain-on-snow model. The important issues are outlined and presented in a draft paper by the author, "Hydrologic Change Module: Results, Modifications, and Issues," and are, therefore, not elaborated on here. In addition, recommendations are put forth in that document to encourage the development of a methodology which addresses spring snowmelt processes.

Confidence in the spring rain-on-snow results is low to moderate. The same concerns stated for the rain-on-snow model apply here. In addition, spring rain on snow may occur when the onset of spring runoff has already begun. The storm event model does not take into account the streamflow generated from direct solar radiation preceding a spring rain on snow nor does it account for successive spring rain-on-snow events which may occur.

Confidence in the rain-free snowmelt modeling results is low due to the simplifying assumptions

(wind data, uniform distribution of snowpack and snowmelt, snowmelt parameters etc.) and primarily the limitation of the model to estimate snowmelt over a 24-hour period rather than snowmelt peak flows which occur on a sustained basis. Because of the sustained melt, a one-day snowmelt value would not correlate well with a one-day peak flow value. Continuous snowmelt modeling could provide results with a higher confidence level but this effort requires large amounts of data for inputs and a considerable amount of time and money to setup and run.

8.0 MONITORING RECOMMENDATIONS

No monitoring recommendations are necessary at this time.

9.0 REFERENCES

Agee, J. K. 1993. Fire Ecology of Pacific Northwest Forests. Island Press, Washington DC.

Agee, J. K. 1994. *Fire and Weather Disturbances in Terrestrial Ecosystems of the Eastern Cascades.* US Department of Agriculture Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-320, Portland, Oregon.

Agee, J. K. 1995. *Fires History Report for the 1994 Tyee Fire (Draft).*

Belt, G. H. 1995. *Recovery of Enhanced Rain-on-snow Melt Caused by Harvesting: a Review of Scientific Literature.* College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow.

Brunengo, M.J., S.D. Smith, and S.C. Bernath. 1992. *Screening for a Watershed Analysis. A GIS Based Method of Modeling the Water Input from Rain-on-snow Storms, for Management and Regulation of Clearcut Forest Harvest.* Forest Practices Division. Washington Department of Natural Resources, Olympia, WA. 21 pp.

Buffo, J., L. J. Fritschen, and J. L. Murphy. 1972. *Direct Solar Radiation on Various Slopes from 0 to 60 Degrees North Latitude.* Pacific Northwest Forest and Range Experiment Station, US Department of Agriculture Forest Service Research Paper PNW-142, Pacific Northwest Research Station, Portland, Oregon.

Cheng, J. D. 1989. *Streamflow Changes after Clear-cut Logging of a Pine Beetle-infested Watershed in Southern British Columbia, Canada.* Water Resources Research 25(3).

Crane, M.F. and William C. Fischer. 1986. Fire Ecology of the Forest Habitat Types of Central Idaho. USDA Forest Service General Technical Report INT-218. Intermountain Research Station. Ogden, Utah.

Cummans, J. E., M. R. Collins, and E. G. Nassar. 1975. *Magnitude and Frequency of Floods in Washington.* US Geological Survey Open File Report 74-336.

Daubenmire, R. F. 1968. *Forest Vegetation of Eastern Washington and Northern Idaho.* Washington Agricultural Experiment Station, Technical Bulletin 60.

Dunne, T., and L. B. Leopold. 1978. Water in Environmental Planning. W. H. Freeman and Company, San Francisco, California.

Fischer, W. C., and A. F. Bradley. 1987. *Fire Ecology of Western Montana Forest Habitat Types.* US Department of Agriculture Forest Service General Technical Report INT-223, Intermountain Research Station, Ogden, Utah.

Grant , G.E., J.E. Duval, G.J. Koerper, and J.L. Fogg. 1992. *XSPRO: A Channel Cross-Section Analyzer*. USGS General Technical Report 387, 53 pp.

Greenberg, Joanne and Karen F. Welch. 1997. *Results, Modifications, and Issues from the Hydrologic Change Module*. DRAFT. Sponsored by Boise Cascade Corporation.

Harr, R.D., 1982. "Fog Drip in the Bull Run Municipal Watershed, Oregon." *Water Resources Bulletin* 18(5): 785-789.

Hendrick, R. L., B. D. Filgate, and W. M. Adams. *Application of Environmental Analysis to Watershed Snowmelt*. Journal of Applied Meteorology 10:418-429.

Hicks, B.J., R.L. Beschta, and R.D. Harr. 1991. "Long-Term Changes in Streamflow Following Logging in Western Oregon and Associated Fisheries Implications." *Water Resources Bulletin*, 27:217-26.

Hydrosphere Data Products. 1996a. Climate Data, National Climate Data Center, Summary of the Day, Volume 7.3. Hydrosphere Data Products, Boulder Colorado.

Hydrosphere Data Products. 1996b. Hydrodata, USGS Daily Values, Volume 8.3. Hydrosphere Data Products, Boulder Colorado.

Hydrosphere Data Products. 1996c. Hydrodata, USGS Peak Values, Volume 7.0. Hydrosphere Data Products, Boulder Colorado.

Linsley, R. K. Jr., M. A. Kohler, and J. H. Paulhus. 1975. Hydrology for Engineers. McGraw Hill Series in Water Resources and Environmental Engineering, McGraw Hill Book Company.

Miller, J. F., R. H. Frederick, and R. J. Tracy. 1973. Precipitation Frequency Atlas of the Western United States; Volume Ix - Washington. National Oceanic and Atmospheric Administration NOAA Atlas 2.

Rothacher, Jack. 1970. "Increases in Water Yield Following Clearcut Logging in the Pacific Northwest." *Water Resources Research*, 6(2): pp. 653-658.

Swift, L. W. Jr. 1976. *Algorithm for Solar Radiation on Mountain Slopes*. Water Resources Research 12(1).

Thompson, E. S. 1976. *Computation of Solar Radiation from Sky Cover*. Water Resources Research, 12(5).

Troendle, C. A. 1983. *The Potential for Water Yield Augmentation from Forest Management in the Rocky Mountain Region*. Water Resources Bulletin, American Water Resources Association, 19(3).

U.S. Army Corps of Engineers. 1956. Snow Hydrology. Summary Report of the Snow Investigations. North Pacific Division, Portland, Oregon.

U.S. Department of Agriculture, Natural Resources Conservation Service. Washington Annual Data Summary, Water Year 1994. SNOTEL and Snow Course Summary Data.

Washington Forest Practices Board (WFPB). 1995. *Standard Methodology for Conducting Watershed Analysis under Chapter 222-22 WAC, Version* 3.0. Timber/Fish/Wildlife Agreement and WFPB, Olympia.

Western Regional Climate Center. 1996. Climate Data from National Climate Data Center. Western Regional Climate Center, Desert Research Institute, Reno, Nevada.

Williams, J. R., and H. E. Pearson. 1985. *Streamflow Statistics and Drainage-basin Characteristics for the Southwestern and Eastern Regions, Washington. Volume II: Eastern Washington.* U.S. Geological Survey Open File Report 84-145-B, prepared in cooperation with the State of Washington Department of Ecology, Tacoma.

Williams, C. K., and B. G. Smith. 1991. *Forested Plant Associations of the Wenatchee National Forest, Draft.* U.S. Department of Agriculture Forest Service, Wenatchee National Forest, Wenatchee, Washington.

Addendum C-I

Table C - Ia: Regional Climate Stations

Station Number	Station Name	Location (Latitude Longitude	Elevation (feet)	Type of Data Available	Period of Record
839	Boundary	N 49:00:00 W117:38:00	1390	Precipitation	1948-59
844	Boundary Dam	N 48:59:00 W117:21:00	1800	Precipitation Temperature Snowfall	1965-95
849	Boundary Switchyard	N 48:59:00 W117:21:00	2500	Precipitation	1971-92
1395	Chewelah	N 48:17:00 W117:43:00	1670	Precipitation Temperature Snowfall	1948-95
1650	Colville AP	N 48:33:00 W117:53:00	1650	Precipitation Temperature Snowfall	1948-87
2066	Deer Park AP	N 48:58:00 W117:26:00	2200	Precipitation Temperature Snowfall	1948-77
3903	Inchelium 2NW	N 48:19:00 W118:13:00	1690	Precipitation Temperature Snowfall	1953-75
4549	Laurier	N 49:00:00 W118:14:00	1640	Precipitation Temperature Snowfall	1948-86
5317	Metaline Falls	N 48:52:00 W117:22:00	2110	Precipitation Temperature Snowfall	1926-65
5844	Newport	N 48:11:00 W117:03:00	2140	Precipitation Temperature Snowfall	1927-95
5946	Northport	N 48:55:00 W117:47:00	1320	Precipitation Temperature Snowfall	1920-95
5949	Northport 6ENE	N 48:57:00 W117:40:00	1350	Precipitation Temperature Snowfall	1959-60
6974	Republic	N 48:39:00 W118:44:00	2610	Precipitation Temperature Snowfall	1948-95
9058	Wellpinit	N 47:54:00 W118:00:00	2490	Precipitation Temperature Snowfall	1958-95

Table C-lb: Summary of USGS Streamflow Gauging Stations

USGS Station #	Station Name	Period of Record	Mean Elevation (feet)	Drainage Area (sq.mi.)	Location
12399600	Deep Cr nr Northport	1972-76s 1973-79ap	*NA	191	N 48:55:47 W 117:44:59
12408500	Mill Cr nr Northport	1940-72 1977-86s 1940-86ap	3510	83	N 48:34:44 W 117:51:56
12409000	Colville R at Kettle Falls	1922-94s	3000	1400	N 48:35:40 W 118:03:41

*NA = not available
s = systematic gauge record
ap = annual peak record

Table C-lc: Snow Course and SNOTEL Stations

Station Number	Station Name	Period of Record	Elevation *(feet)*	Location *(Latitude/ Longitude)*
17A06	Baird	1959-1989	3220	N 48:37:00 W 117:34:00
17A07	Baird #2	1987-1996	3220	N 48:37:00 W 117:34:00
17A08	Chewelah #2	1958-1996	4900	N 48:18:00 W 117:36:00
18A04	Goat Creek	1961-1993	3600	N 48:51:00 W 118:21:00
18A03	Butte Creek	1961-1993	4070	N 48:51:00 W 118:22:00
18A15	Butte Creek #2	1989	4070	N 48:51:00 W 118:22:00
18A07	Summit G.S.	1961-1993	4600	N 48:54:00 W 118:24:00
18A16	Summit G.S. #2	1987-1996	4600	N 48:54:00 W 118:24:00
17A01 17A01S	Bunchgrass Meadows	1937-1996 1984-1996	5000	N 48:42:00 W 117:11:00
2B09	Record Mountain	1975-1993	6201	N 49:06:00 W 117:52:00
2B03	Old Glory Mountain	1948-1982	6989	N 49:09:00 W 117:55:00

Addendum C-II

Form C-1 - Basin Acreage by Precipitation Zone and Land Use / Cover Type

Headwaters Onion Creek

	ROS	Snow Dominated	Highland	Total
High	1670	6038	1010	8718
Intermediate	2383	1963	0	4346
Sparse	237	567	27	831
Open	18	726	101	846
Total Forest	**4308**	**9295**	**1138**	**14741**
Non-Forest	662	173	0	836
Water	24	15	0	39
Total Non-Forest	**686**	**188**	**0**	**875**
Total	***4994***	***9483***	***1138***	***15615***

Quinn Meadows

	ROS	Snow Dominated	Highland	Total
High	1214	1753	0	2967
Intermediate	147	400	0	546
Sparse	39	85	0	124
Open	36	0	0	36
Total Forest	**1435**	**2238**	**0**	**3673**
Non-Forest	213	21	0	233
Water	0	7	0	7
Total Non-Forest	**213**	**28**	**0**	**240**
Total	***1648***	***2265***	***0***	***3914***

Lower Onion Creek

	Rain Dominated	ROS	Snow Dominated	Total
High	49	3908	1519	5475
Intermediate	239	2945	1866	5050
Sparse	236	1776	396	2408
Open	0	456	199	655
Total Forest	**524**	**9086**	**3979**	**13588**
Non-Forest	95	1163	93	1352
Water	0	1	11	12
Total Non-Forest	**95**	**1164**	**104**	**1363**
Total	***619***	***10250***	***4083***	***14952***

Total Onion Creek Watershed

	Rain Dominated	ROS	Snow Dominated	Highland	Total
High	49	6792	9310	1010	17160
Intermediate	239	5475	4228	0	9942
Sparse	236	2052	1048	27	3364
Open	0	510	925	101	1536
Total Forest	**524**	**14829**	**15512**	**1138**	**32002**
Non-Forest	95	2038	287	0	2420
Water	0	25	33	0	58
Total Non-Forest	**95**	**2063**	**320**	**0**	**2478**
Total	***619***	***16892***	***15832***	***1138***	***34481***

Addendum C-III

FIRE HISTORY AND VEGETATIVE CONDITIONS DATA FOR THE ONION CREEK WAU WATERSHED ANALYSIS

for Joanne Greenberg, P.E. and Boise Cascade Corporation

Prepared by
Krista Gollnick-Waid, Fire Ecologist
October 26, 1996

The information provided in this report was obtained from *Forested Plant Associations of the Colville National Forest* (Williams et. al. 1995). As a part of a larger vegetation classification effort on National Forest lands in eastern Washington state, reconnaissance sampling of the Colville National Forest took place in 1980 and intensive sampling in 1982 and 1983. A total of 511 plots were sampled. Information was collected on slope, aspect, elevation, herbs, shrubs, understory and overstory vegetation. Onion Creek WAU lies adjacent to and is surrounded by the areas sampled in the Colville National Forest effort. Though only a few plots exist within the boundaries of Onion Creek, soils, geologic, climatic and topographic information was compared and utilized to infer information about historic, potential and current vegetation and fire history within the WAU.

Fire History

In general, Onion Creek WAU is located in an area where fire played a major role in the development of forests. Virtually all of the Colville National Forest ecology plots (including those surrounding and within Onion Creek) contained evidence of past fire such as fire-scarred trees, charred logs, stumps or wood or charcoal in the soil. A series of large fires has burned over much of northeastern Washington in the last 100 years. The pattern of several large, catastrophic fires early in the century appear within the cycle of natural fire patterns. Large fires took place at irregular intervals depending on variations in weather and available fuels. Native Americans also used fire to manipulate vegetation.

Vegetative Conditions and Fire Regimes Existing within the WAU

Given the variety of fire effects likely experienced on the landscape, the Onion Creek drainage was historically and is currently represented by a mosaic of vegetative patterns, with areas of park-like, lightly stocked stands, to dense forested thickets prone to insect and disease infestations and catastrophic fire. The mosaic pattern was created in a random pattern, based on human use, fire occurrence, topography, soils, vegetation, and weather conditions.

High Intensity/Low Frequency Fire Regime
("High" Fire Regime)

Areas generally above 5,000 feet, in the southernmost part of the WAU, within the subalpine fir (ABLA2) and western hemlock (TSHE) vegetation zones, historically experienced infrequent stand-replacing fires at mean intervals of 140-340 years. Currently these forests exhibit open or closed forest characteristics within more mesic or higher elevation (subalpine) areas. Most forests sampled classed as closed canopy forests (>60% canopy closure) with the absence of recent fire. Fuel and vegetative characteristics within these stands generally present conditions that would contribute to a large, catastrophic fire. Since fire starts in these areas are relatively infrequent, fire risk is relatively low. Potential Natural Vegetation maps indicate that less than 25 percent of Onion Creek WAU lies within the "high" fire regime. Below is a list of the Plant Associations within the subalpine fir and western hemlock series that could potentially occur within Onion Creek WAU. Please see Table 1 for the definitions of the associations listed:

I. ABLA2/CLUN
II. ABLA2/RHAL
ABLA2/RHAL-XETE
III. ABLA2/VAME
IV. TSHE/CLUN (transition to the "moderate" fire regime)

Moderate Intensity/Moderate Frequency Fire Regime
("Moderate" Fire Regime)

Areas below 5,000 feet, most commonly found in drainage bottoms and on north/northeastern slopes, are generally occupied by the grand fir (ABGR), drier western hemlock (TSHE), and drier western red cedar (THPL) plant series. These areas burned randomly and variably on the landscape, with varying intensities. The "moderate" fire regime exhibits a variety of vegetation patterns, density, and composition based on past fire occurrence and management activities. Currently stands exhibit between 30-70% canopy closure, with patches of more open-canopied stands scattered across the landscape. Potential Natural Vegetation Maps indicate that approximately 30 percent of the Onion Creek WAU lies within the "moderate" fire regime, generally occupying middle elevation, mid-slopes throughout the watershed, and valley bottoms at lower elevations. Below is a list of the Plant Associations within the grand fir, drier western hemlock, and drier western red cedar series that could potentially occur within Onion Creek WAU. Please see Table 1 for definitions of the associations listed:

I. TSHE/CLUN (transition to "high" fire regime)
II. ABGR/VAME/CLUN
III. ABGR/ACGLD/CLUN
IV. THPL/VAME

Low Intensity/High Frequency Fire Regime
("Low" Fire Regime)

Drier, more xeric sites within Onion Creek WAU (primarily on lower and mid-slope positions and with south to southwesterly exposures) are occupied by the drier grand fir/Douglas-fir (ABGR/PSME) plant series. Historically these sites supported less vegetative growth than other Plant Associations as fires frequently (mean fire intervals of 5-15 years) underburned stands reducing understory growth and controlling stocking levels. Historically, these areas were likely comprised of stands with less than 30 percent canopy closure. Currently, these stands have become denser presenting a high risk of catastrophic, high intensity fire in a zone that likely experience less intense fire historically. These areas experience the highest fire occurrence rate and tend to exhibit higher probabilities of experiencing a fire start. Potential Natural Vegetation maps indicate that the grand fir/Douglas-fir Series occupies approximately 75 percent of the Onion Creek WAU (these series contain acres within both the "moderate" and "low" fire regimes). Estimates from topographic and climatic information suggest that approximately 30-45 percent lies within the "low" fire regime. Below is a list of the Plant

Associations within the grand fir/Douglas-fir series that could potentially occur within Onion Creek WAU. Please see Table 1 for definitions of the associations listed:

I. PSME/PHMA
II. PSME/PHMA-LIBOL
III. ABGR/PHMA

Effects of Management and Fire Suppression On Vegetation

In general, current conditions reflect stand conditions which have changed as a result of fire suppression and management activities occurring over the past century, especially within the "low" and "moderate" fire regimes. Generally, the suppression of fires on the landscape, in areas that historically experience frequent fire, has led to increased stand densities and canopy closures, average stand diameter reductions, changes in vegetative composition, decreases in shrub/herb growth, increases in forest litter/duff accumulations, and increases in large woody debris.

Fire suppression has had the largest effect on the character of forest stands on sites with a natural history of repeated underburns. This is especially true of drier habitats within the Douglas-fir and grand fir series. Stand structures have changed from relatively open single or two storied stands dominated by large individuals of seral, fire resistant species (like Douglas-fir and ponderosa pine) to denser, smaller-stemmed, multi-layered stands with a higher proportion of fire sensitive, late seral or climax species (such as grand fir). Fire suppression and other activities have contributed to the development of extensive contiguous areas of late seral forest conditions that had no precedent in pre-settlement landscapes.

Table 1 below displays historic fire regime information by plant series, as well as a comparison of historic vs. current crown closure estimations as a result of fire suppression (does not specifically include the effects of forest management). The following information explains the information presented in Table 1:

Plant Associations. A Plant Association is defined as a unit of vegetation classification based on the projected climax community type. The Onion Creek WAU was grouped by Plant Series and then sub-grouped into Plant Association Groups. This classification system identifies the "potential natural vegetation". In the WAU, within four different series, approximately 11 Plant Associations were identified. Common names are also listed in this column.

Historic Fire Regime. Fire regime is a generalized description of the role fire plays in an ecosystem and is an effective way to classify the effects of fire on vegetation (Agee 1993). Vegetation within the ***low fire regime*** can be expected to exhibit fire behavior characteristics of a low severity fire. Low severity fires will occur when fuels present will support less than or equal to three foot flame lengths and will result in less than 20 percent basal area reduction. Historically, fuel accumulation was mitigated by frequent fires of large size. Within the low fire regime, a landscape pattern was created which

consisted of patches of dense, even-aged clumps within a matrix of open, park-like vegetation. Vegetation within the ***moderate fire regime*** experienced a more complex interaction of low, moderate and high severity fire. Fire history is more difficult to reconstruct in these areas because of the variability of fire on the landscape. It is predicted that 30 percent of the are within a moderate severity fire regime will burn with high or moderate severity (reducing basal area by more than 80 percent)over time, while 70 percent of the area will burn with low severity (Agee 1994). Historically, community structure was described as relatively dense (greater than 60 percent canopy closure), multi-storied stands, with an abundance of snags and downed wood, interspersed with park-like stands where fire burned more frequently (i.e. ridgetops, south aspects). Vegetation within the ***high fire regime*** experience long-return interval crown fires and severe surface fires (generally > 100 year fire-free intervals). Fire in these areas typically resulted in high stand mortality; stand replacement fires, though infrequent, were most common. Agee predicts that, within the high fire regime, 80 percent of the area can be expected to burn with high severity in the event of a landscape-level wildfire.

Average Trees per Acre. For Plant Associations present within the Onion Creek WAU, an average number of trees per acre was estimated using numbers provided by Williams et. al. Data was obtained from the 511 plots sampled. This number represents the average existing stand density and was utilized to aid in the estimation of current canopy closure within Plant Associations present.

Estimated Historic Crown Closure. Plant Association information and fire regimes were used to estimate an average historic crown closure. Sources listed were utilized to interpolate a likely historic canopy closure range.

Estimated Crown Closure with Fire Suppression. Plant Association, productivity, and series descriptions were utilized to estimate an average existing crown closure range.

TABLE 1. Plant Association, Historic Fire Regimes and Crown Closure Estimations for the Onion Creek WAU

Plant Association	Historic Fire Regime	Average Trees per Acre	Average Estimated Historic Canopy Closure	Average Estimated Canopy Closure with Fire Supp.
ABLA2/CLUN (subalpine fir/ queencup beadlily)	"High"	563	80%	80%
ABLA2/RHAL (subalpine fir/ cascades azalea)	"High"	656	80%	80%
ABLA2/RHAL-XETE (subalpine fir/ cascades azalea-beargrass)	"High"	557	80%	80%
ABLA2/VAME (subalpine fir/ big huckleberry)	"High"	975	80%	80%
TSHE/CLUN (western hemlock/ queencup beadlily)	"High" and "Mod"	547	60%	80%
ABGR/VAME/CLUN (grand fir/ big huckleberry/ queencup beadlily)	"Mod"	392	50%	80%
ABGR/ACGLD/CLUN (grand fir/ Douglas maple/ queencup beadlily)	"Mod"	589	50%	80%
THPL/VAME (western red cedar/ big huckleberry)	"Mod"	568	50%	80%
PSME/PHMA (Douglas-fir/ninebark)	"Low"	310	30%	60%
PSME/PHMA-LIBOL (Douglas-fir/ninebark-twinflower)	"Low"	331	30%	60%
ABGR/PHMA (grand fir/ninebark)	"Low"	302	30%	60%

Literature Cited

Agee, J.K. 1993. Fire Ecology of Pacific Northwest Forests. Island Press, Washington D.C.. pp. 493.

Williams, C.K., Brian F. Kelley, Bradley G. Smith, and Terry R. Lillybridge. 1995. Forested Plant Associations of the Colville National Forest. U.S.D.A. Forest Service, PNW-GTR-360.

APPENDIX D
RIPARIAN FUNCTION ASSESSMENT

CONTENTS

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The riparian module assessment for the Onion Creek Watershed Administrative Unit was conducted in accordance with version 3.1 *Standard Methodology for Conducting Watershed Analysis, Riparian Function*, Washington Forest Practices Board, February 1996.

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CROSS REFERENCE OF WORK PRODUCTS

A cross reference of titles for maps, worksheets and other products required for completion of the Riparian Module version 3.1 (WFPB 1996) is provided to assist reviewers.

Required Module Product	Onion Creek WA Riparian Analysis Product	Location in this Report
Narrative Requirements		
Aerial photos used	Table D-1	Section 2.2.1
Basin history and land management effects	Table D-6	Section 2.1 and 2.3.4
Summary of riparian conditions	Table D-5, D-6, D-7	Section 2.3
Methods Modifications	Same as required product	Section 2.2.4: LWD Section 3.2.2: Canopy Closure
Long-term recruitment assessment methods	Methods and results are presented in report	Section 2.2.2 Section 2.3.4
Summary of Current and Target Shade Levels	Table D-12 Worksheet D-3	Section 3.3.4 Appendix D-1
Confidence	LWD Canopy Closure	Section 2.4 Section 3.4
Maps and Worksheets		
Map D-1 Riparian Vegetation Condition	Map D-1	
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Required Module Product	Onion Creek WA Riparian Analysis Product	Location in this Report
Worksheet D-1 Stream Length by Riparian Vegetation Condition and Channel Segment	Table D-5 and Table D-6	Section 2.3.2
Worksheet D-2 Recruitment Hazard Call by Channel Segment	Worksheet D-2 (modified)	Appendix D-1
Worksheet D-3 Canopy Closure by Channel Segment	Worksheet D-2 Table D-12	Appendix D-1 Section 3.3.4
Additional Information	Worksheet D-4 and Supporting Documentation	Appendix D-1 Appendix D-2

RIPARIAN FUNCTION ASSESSMENT

1.0 INTRODUCTION

A level II assessment was conducted for the riparian analysis. The riparian assessment was initiated under Version 3.1 of the Watershed Analysis Manual: Riparian Function (WFPB 1996). The riparian functional assessment is divided into two sub-sections; large woody debris (LWD) recruitment and canopy closure/stream temperature. The level II assessment adds additional field verification effort to the level I procedures so that no indeterminate calls remain and riparian stand successional pathways can be predicted. The large woody debris assessment, as applied in this analysis, considers both near-term and long-term recruitment potential. Near-term recruitment considers existing potential for the stand to provide adequate LWD. Long-term recruitment potential evaluates the probability that an existing stand, if left unmanaged without stand replacing fires, would provide sufficient LWD to the adjacent stream channel at 200+ years from present. Riparian stand density, community species composition, physical character and management history were used to predict the successional pathway each riparian segment was likely to follow. Riparian hazard calls incorporate both the near-term recruitment potential and the channel sensitivity to LWD. The latter has been determined by the channel and fish analysts.

Part II of the riparian module evaluates canopy closure relative to water quality regulations for water temperature. Streams in this WAU are Class AA streams for which the State water quality maximum temperature criteria is (16.0°C). Available stream temperature data from the Onion Creek Watershed Administrative Unit (WAU) were used to modify the default canopy closure (shade) requirements for eastern Washington streams.

Work products of this module include: a riparian condition map, maps for recruitment potential and probability of adverse impacts, a riparian situation map, maps of canopy closure and stream temperature hazard, and tabular summaries of riparian conditions. The report discusses confidence in the assessment as well recommendations for monitoring and in-stream enhancement.

2.0 LARGE WOODY DEBRIS RECRUITMENT

2.1 Early-Management Effects

Management activities date back to earlier this century. Most of the forested portions of the WAU are currently vegetated in mature second growth forest. Tree harvesting and subsequent maintenance of clearings for residential and agricultural uses have reduced riparian areas to narrow bands of mixed conifers and hardwoods on 9.2% of the streams in the WAU. Forest practices conducted in about the last 25 years within or adjacent to riparian areas have generally maintained dense stockings of mature conifers within the riparian zone. Selective, partial cuts

are typical where timber harvesting for forestry purposes have occurred within riparian management zones (RMZ). Extensive mining activity in the WAU has also affected riparian conditions. The VanStone Mine located in the upper watershed is the largest mining development and has been in intermittently in operation since 1926. Road construction adjacent to streams and occasional mining related catastrophic events have influenced riparian conditions within that sub-basin downstream of the VanStone Mine and tailings pond.

The inclusion of western larch (LAOC - *Larix occidentalis*) and lodgepole pine (PICO - *Pinus contorta*) within riparian stands along streams in the upper Onion Creek sub-basin and the Van Stone Mine sub-basin suggest stand replacing fires burned through much of the riparian forest in these sub-basins. Tree cores collected from western larch placed the time of this fire at about 1929 - 1933; this date coincides with a large regional fire reported in 1929 (Chance 1991). Infrequent, slow burning, non-catastrophic fires were likely more typical of the historic fire regime within moist riparian areas. Full fire suppression for at least the last 50 years has led to an increased dominance of grand fir and western hemlock in the riparian areas.

2.2 Methods

2.2.1 Assessment of Near-Term Recruitment

Aerial photo interpretation was done to assess riparian corridor characteristics for all streams in the WAU. Stand type, tree size composition, and density within a 75 foot-wide (22.9 m) riparian corridor were noted separately for each bank as distinct riparian condition units (RCU). Coding of RCUs was established for sub-segments of the channels classification for easy cross referencing. RCUs shorter than 1,000 feet (305 m) were occasionally delineated when timber conditions presented sharp contrasts in LWD recruitment potential. Indeterminate reaches were noted when resolution from the aerial photos of the above information was uncertain. Stand type and size class data from each of the major land owners were also consulted when available. This analysis relied on the most recent aerial photo coverage available at a suitable scale. Although high altitude aerial photos were available from July 1995, the resolution was not adequate for detailed analysis. Historical aerial photos were viewed to aid in determination of tree size class and to note chronological changes in riparian condition. The latter is useful in evaluating successional pathways. Recent and historical aerial photo dates used in this are listed in Table D-1.

Table D-1 Aerial Photos Used in Riparian Analysis

Photo Date	Contrast	Scale
May - Sept. 1992	Black and White	1:14,000 - 1:16,400
July 29, 1987	Black and White	app. 1:13,000
July 24, 1980	Black and White	1:14,400
July 2, 1968	Black and White	1:22,580

Riparian condition was coded according to definitions listed in Table D-2. Eastern Washington timberlands often have mixed aged stands due to selective harvesting. The size class assigned to an RCU is based on the predominant tree size that is capable of providing functional LWD now or in the future. Stands with a dense stocking of small diameter trees and only a few larger trees were typically noted as small since this dense stocking will ultimately provide suitable LWD. Stands with a mix of medium and large trees were assigned to a size class based on the more predominant of these two sizes.

TABLE D-2 Riparian Condition Definitions

Dominant Vegetation Type		
≥ 70% conifer species	Conifer	C
≥ 70% hardwood dominated	Hardwood	H
All other cases	Mixed	M
Dominant Tree Size Class		
<12 inch dbh	Small	S
≥ 12 and < 20 inch dbh	Medium	M
≥ 20 inch dbh	Large	L
Stand Density Class		
No overstory on more than ½ ground (photo) <u>or</u> stocking level of dominant size class and larger trees is less than 70 trees/acre	Sparse	S
All other cases	Dense	D

The streambank lengths (2 * channel length) for individual RCUs within fish-bearing and non-fish-bearing streams were tallied according to riparian code. The frequency distribution of riparian vegetation conditions were also analyzed relative to size requirements for functional

LWD; the latter being associated with channel geomorphic groups. The frequency distribution of riparian conditions were also analyzed relative to adjacent land use (forestry, residential/agricultural, roads, wetland, other). The importance of various LWD recruitment mechanisms and the role of LWD once recruited to the stream vary among channel geomorphic units. Land use is likely the most significant factor affecting riparian condition in the WAU. Analyzing riparian condition relative to land use provides an indication of causative factors leading to impaired riparian function. Land use was determined through aerial photo analysis and field surveys. Industrial forest lands were not distinguished from forested private lands in this analysis.

In consultation with the channel analyst, floodplain topography was defined and the recent activity level of channel migration across the floodplain and overbank flood scouring were evaluated. In some basins channel shifting flood scour can be an important LWD recruitment mechanisms. Initially all riparian areas visible on the air photos with channel avulsions or areas with shrubby vegetation contrasting to adjoining upland vegetation were identified as potential flood-related LWD recruitment areas. Field verification of floodplain effects on riparian condition were later made to qualitatively evaluate the floodplain elevation relative to the bankfull channel elevation. Only areas that showed signs of recent channel shifting or a high probability of near-term channel shifting with recruitment of LWD through flood scouring were confirmed as floodplain LWD recruitment areas. Areas with vegetated cut and fill terraces were not considered further unless active and pronounced channel disturbance was evident.

Indeterminate calls based on aerial photo interpretation and representative RCU's of each channel type were verified through field visits. Field studies included both plot sampling within riparian areas and visual assessments. Two to four circular plots were established within selected RCU's to quantify stand conditions within a 75 foot-wide (22.9 m) corridor for each bank. The longitudinal location of the first plot was randomly selected at a position 0-100 feet (30.5 m) from the access point. Subsequent plots were set 100 feet apart parallel to the stream bank. Sample plot centers varied from 17 to 35 feet (5.2 - 10.7 m) distance perpendicular from the bankfull channel edge so that sample data were representative of gradations in stocking with distance from the stream. Locating plot centers at no more than 35 feet placed all the plots within the inner half of the potential recruitment zone; a desirable sampling criteria since recruitment rates are typically higher with increasing proximity to the channel (McDade et al, 1990). Field measurements were made on 1/50 acre circular plots. These plots were evenly distributed along the sampled stream segment. Within the plots, all trees greater than 4.5 feet (1.37 m) in height were tallied according to diameter size class and recorded on a standardized field form. It is important to note that willows (*Salix spp.*), and shrubby alders (*Alnus sinuata)* with multiple trunks were not counted because it is unlikely that these species will produce highly functional LWD.

The plant association group (dominant overstory and underbrush) were noted at each sample plot. Plant association groups generally conformed to Williams et al. (1995). Slope, aspect, soil condition and distance from channel edge were also noted. The height and basal diameter (dbh)

were measured for the five largest trees within the RCU. Site potential trees recorded as the largest trees in the RCU need not be within a sample plot. All trees within the sample plot were enumerated by species and dbh size class. Other information on tree disease, fire history, grazing impacts and physical limitations to riparian stand production were noted. Primary LWD recruitment mechanisms operating within a channel segment were recorded. In-channel LWD counts were made in conjunction with riparian surveys for selected channel segments. The fish analyst provided additional in-channel LWD data.

Riparian sample plot radius for enumerating canopy and understory trees was 16.7 feet (1/50 acre). Sample plot radius for sampling seedlings was 11.8 feet (1/100 acre). Stocking rates (trees per acre) were then computed as the average of the individual plot data within a single RCU.

Limited sample plot data may not be reliable in sparsely stocked areas or areas with patchy distribution. Therefore an additional form of field sampling was used. For riparian areas mapped as sparsely stocked, all trees within 75 feet (22.9 m) of the stream were tallied by size class for a measured length of channel distance (most often 1,000 feet).

The recruitment potential for each RCU was defined by the riparian condition according to Table D-3. Recruitment potential for individual sites was modified if there was an identifiable and documented reason for modified recruitment rates (i.e. fire charred stand with high proportion of snags likely to be recruited to the channel, etc.)

TABLE D-3 LWD Recruitment Potential (WFPB 1996)

Dominant Tree Type	Size Class and Density					
	Small		Medium		Large	
	Sparse	Dense	Sparse	Dense	Sparse	Dense
Conifer	L	L	M	H	M	H
Mixed	L	L	M	H	M	H
Deciduous	L	L	L	M	L	M

recruitment potential code: H = high (good potential), M = moderate, L = low (poor)

2.2.2 Assessment of Long-Term LWD Recruitment

Data on the existing riparian condition were used to predict trends in long-term recruitment potential. Late seral conditions (forest age 200+ years) are highly dependent upon both the composition of the existing riparian stand and on future management actions. Field observations of stand type, seedling and understory tree density data, and published information on successional pathways for forest plant associations in the Colville National Forest (Williams et

al. 1995) were used to estimate long-term recruitment potential. Published soil studies (NRCS 1982) including woodland productivity data were also consulted. A long-term recruitment potential map (Map D-3) was generated assuming full fire suppression and no change in the distribution of land management activities.

The intention of assessing long-term recruitment trends and riparian stand succession is to better understand what factors might limit achieving good LWD recruitment. One possible use of this information is to assist managers interested in voluntary enhancement to estimate what future riparian conditions are possible. The long-term assessment assumes no major disturbance events will occur. In reality, disturbance events are common and they affect a forest stand's stage along a successional continuum. Unplanned disturbance events may include fire or disease. Managed harvest within a riparian area may affect the species composition through reducing forest canopy closure and thereby making conditions more favorable for shade intolerant species. Harvest may also target particular species and thereby alter species composition.

2.2.3 LWD Hazard Assessment

Geomorphic channel classifications provided from the channel module are associated with both LWD recruitment mechanisms and channel functional roles of LWD once the latter reaches the stream. For example, windthrow and bank undercutting are more prominent LWD recruitment mechanisms on unconfined channels with a seasonally wet floodplain. The channel geomorphology also influences the riparian vegetation as evidenced by brush vegetation on a wet floodplain contrasting to upland toe-slope conifer forests. Hazard calls were grouped accordingly by channel geomorphic group to recognize functional relationships.

Table D-4 is the matrix used for determining potential deliverability of an adverse effect on public resources due to a change in riparian condition. The riparian recruitment potential identifies the likelihood of the riparian stand being able to provide suitable LWD to the stream channel. The sensitivity of the stream channel to LWD must also be considered to determine if an adverse impact is probable with impaired LWD recruitment. Adequate amounts of functional LWD in the channel decrease the probability of delivering an impact to channel segments with moderate or high sensitivity, except where both recruitment potential is low and channel sensitivity is high. A high probability of an adverse impact is assumed in the latter case since there is likely to be a future interruption in the supply of LWD to the channel.

Table D-4 Probability of Hazard Delivery for LWD (WFPB 1996)

Near-Term Recruitment Potential Rating		Channel Sensitivity Rating		
	In-Channel LWD	LOW	MODERATE	HIGH
LOW	fair/good	L	M	H
	poor	L	H	H
MODERATE	fair/good	L	M	M
	poor	L	H	H
HIGH	fair/good	L	M	M
	poor	L	H	H

2.2.4 Modifications to Standard Methods

The methods for summarizing the distribution of riparian vegetation conditions were modified. Distribution frequencies based on stream length were calculated as a function of land management activity rather than channel segment. This approach provides a clearer depiction of how triggering mechanisms have affected current conditions. Riparian conditions are also summarized according to the general function of LWD in the stream; Table D-5 segregates fish-bearing and non-fish-bearing streams as well as channel segments according to the size of wood necessary to function.

Field data were used to test the assumption that 2 pieces per channel width of woody debris greater than 12 inches diameter are necessary to achieve good instream habitat conditions (Stream Channel/Fish Habitat Appendix E/F). The hazard assessments and riparian situations were modified to reflect that smaller wood and lesser amounts of wood are adequate for the smaller stream channels typical of this WAU.

Riparian channel units were grouped into riparian LWD function situations (Map D-6). RCUs within a situation group have similar conditions affecting both near and long-term recruitment.

The coding on the riparian condition map was modified for visual clarity on small format maps. On headwater segments, a single riparian timber condition determination and LWD recruitment impact call were recorded wherever possible in an effort to improve map legibility. In other words, if the timber condition was similar on both sides of a stream segment, then just one impact code line was drawn on the stream.

2.3 Results

2.3.1 Products

Riparian timber conditions are depicted on map D-1. Near-term LWD recruitment potential is shown on Map D-2a. Long-term recruitment potential (assuming full fire suppression) is shown on Map D-3. Map D-2b shows LWD hazard calls. Map D-6 depicts riparian LWD map units which were grouped by LWD recruitment situation. The cumulative length of each coding for riparian condition (type/size/density) is reported by channel groupings in Table D-5 and by associated land use in Table D-6. The lengths of riparian condition units (RCU) were computed from the GIS database (Map D-1). Ratings for recruitment potential for all RCUs are summarized in Worksheet D-2. Additional descriptive information for RCU's is provided in Worksheet D-4 and locations of numerated channel segments are shown on Map E-1/F-1 in the Stream Channel/Fish Habitat Assessment (Appendix E/F). Numeration of worksheets and maps is consistent with required products for this module (WFPB 1996). There is no Worksheet D-1 nor D-3. The required LWD work product Worksheet D-1 has been substituted for Table D-5 and Table D-6; the latter two tables summarize data by habitat function and land management effects.

2.3.2 Riparian Stand Conditions

Most of the riparian areas in the Onion Creek WAU can best be characterized as being part of the Western Hemlock/Cedar vegetation zone (Henderson et al 1989, 1992). A vegetation zone represents an area of land which has the potential to support the plant associations and all of the related successional series. Plant association groups (PAG) represent aggregates of tree, shrub, and herbaceous plant assemblages based on similarities in floristics, environment, and productivity. Western redcedar/queen cup beadlily (THPL/CLUN) and cedar/lady fern (THPL/ATFI) as characterized in Williams et al. (1995) are typical of moist riparian sites along the mainstem Onion Creek. In addition to redcedar, western larch and Douglas fir (PSME - *Pseudotsuga menziesii*) are the most important other seral species in this plant association. Grand fir (ABGR - *Abies grandis)* is shade tolerant and is also a major seral species; it is becoming more dominant due to the exclusion of fire. Engelmann spruce (PIEN - *Picea engelmannii*), a frost tolerant species, is found in cooler frost pockets along the mainstem, particularly along channel segment 8. It also possesses an interesting characteristic of allelopathy whereby it exudes chemicals into the soil which inhibit growth of other plants. Paper birch (BEPA - *Betula occidentalis*), quaking aspen (POTR - *Populus tremuloides*) and black cottonwood (POTR - *Populus trichocarpa)* occur in the mixed redcedar stands in the WAU. The wettest soils and areas closest to the streambank subject to flooding along the mainstem are often vegetated with thick shrubs. Western redcedar plant associations are also common along tributary drainages.

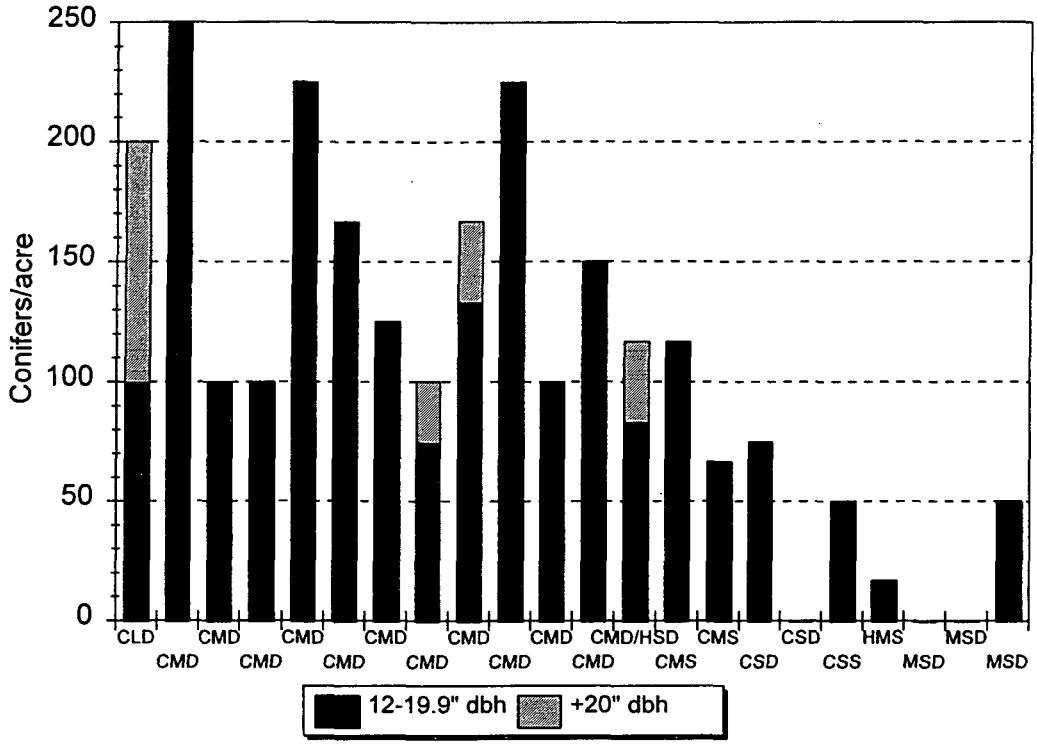
Western redcedar (*Thuja plicata*) can tolerate soil conditions which are both wetter and seasonally more drought prone than that favorable to growth of western hemlock (*Tsuga*

heterophylla). Hemlock plant associations mostly occur along tributaries with better drained soils and most often grow on the slopes adjacent to confined channels. Hemlock is not currently the dominant overstory species but its high shade tolerance will allow it to increase its dominance over time. The width of riparian area from which trees can be recruited to the channel is wider than true riparian vegetation zones; the latter being strongly influenced and dependent upon the wet stream environment. Much of the potential recruitment is from stands best characterized as upland forest.

Riparian stand stocking densities for measured sites are presented in Figure D-1. Stocking rates averaged 710 total trees per acre for dense riparian stands dominated by trees ≥12 inch dbh (sample of 12 stream segments and inclusive of all trees ≥ 1 in. dbh; St. Dev. = 274 trees/acre). The range of medium to large trees per acre in riparian stands classified as densely stocked was 100 to 250 trees per acre (average 155 trees/acre). The small plot size (1/50 acre for overstory) used in this reconnaissance survey may have overestimated tree density. The stocking densities reported in Figure D-1 were judged relative to overall stand density throughout the riparian unit, i.e., plot data may show a dense stocking within the plot but clumping of trees results in an overall qualitative judgement to identify the plot as sparsely stocked. Stands classified as sparsely stocked generally had less than 70 trees/acre.

Frequency distributions of riparian conditions were analyzed by cumulative stream length with each stream bank being tallied independently. The distribution of riparian conditions for streams in the basin are presented in Table D-5. More than one third of the streams in the basin have riparian areas densely stocked with medium and large conifers (> 70 trees per acre). Larger woody debris (≥12 inch diameter) is essential for instream habitat in moderately steep portions (2-8% gradient) of the mainstem Onion Creek and a few of the larger 4-12% gradient tributaries. Fifty percent of those stream segments known to be inhabited by salmonids or potentially fish-bearing and requiring LWD ≥ 12 inch in diameter are bordered by riparian stands densely stocked with medium and large conifers. Habitat can be expected to be maintained or improve based on a continuous supply of LWD being available.

Figure D-1 Riparian Stand Density
Onion Creek WAU



Smaller woody debris ≥ 8 inch diameter is stable and functions adequately to scour pools, provide cover, retain sediment and armor banks in nearly 90% of the streams in the WAU. The determination of the minimal size of woody debris needed for both function and stability was made in conjunction with the channels and fisheries analysts. A complete description of the analytical approach for determining wood size is provided in the Stream Channel/Fish Habitat Assessment (Appendix E/F). The small size of these streams allows smaller wood to function well. Provided there is a continuous supply of sufficient quantity of small debris and root strength is maintained for bank integrity, anticipated riparian management activities in the basin should not affect channel functions nor condition. Riparian vegetation and roots are important for maintaining channel integrity for all stream channels with direct connection to fish-bearing waters.

Recruitment potential was analyzed as a function of land management category determined from aerial photo analysis and field surveys (Table D-6). Sixty-three percent of the streambanks in the WAU are bordered by forested areas (inclusive of both industrial forest lands and forested private lands). Nearly half of these forested riparian areas have good near-term LWD recruitment potential. Non-forestry activities including agriculture, homesite development, and roads have altered forest conditions within or adjacent to riparian areas along approximately 28%

of the streambanks in the WAU. LWD recruitment potential is not adversely affected by these non-forestry activities when an adequate width buffer of densely stocked conifers is maintained along the streams. Both good near-term and long-term LWD recruitment potential can be achieved for all streams in the WAU except where non-forestry activities, naturally sparse stocking conditions, or wetlands preclude growth of densely stocked conifers within riparian areas. These limiting factors adversely affect recruitment potential for 16%, 2%, and 7% of the streambanks in the WAU, respectively.

Table D-5 Distribution of Riparian Condition Classes

Riparian Condition[1]	All Channel Segments	Mainstem Onion Creek (Seg 1-10)	All Fish-bearing Streams	Fish-bearing Streams Needing +12"dbh LWD	Total Length (ft)
CLD	1%	0%	1%	10%	94
CLS	0%	0%	0%	0%	0
CMD	34%	18%	34%	40%	311,670
CMD/HSD	1%	10%	1%	0%	9,070
CMD/MSS	1%	0%	1%	0%	5,540
CMS	12%	34%	10%	18%	109,790
CSD	24%	0%	25%	6%	210,800
CSS	6%	3%	6%	7%	57,850
HLD	0%	0%	0%	0%	0
HMD	1%	0%	1%	0%	10,520
HMS	0%	9%	1%	9%	8,770
HSD	0%	0%	0%	0%	0
HSS	5%	19%	4%	0%	46,660
MLD	0%	0%	0%	0%	0
MLS	0%	0%	0%	0%	0
MMD	1%	0%	1%	5%	7,420
MMS	0%	0%	0%	0%	3,240
MSD	7%	0%	9%	5%	65,380
MSS	2%	6%	1%	0%	21,710
No trees	4%	1%	3%	0%	32,940
Total Length	910,820	93,507	710,254	95,468	910,820

Frequency is based on stream length with each bank tallied independently.

[1]Riparian condition codes are defined in Table D-2.

Table D-6 Land Management Influence on LWD Recruitment Potential

Riparian Condition[1]	Percent of Streambank Length Affected								Near-term Recruitment Potential
	Forested		Agricultural/ Residential		Roads		Wetland		
	Length (ft)	%	Length	%	Length	%	Length	%	
CLD	9,440	2%	0		0		0		High
CLS	0		0		0		0		Mod
CMD	236,820	41%	34,920	17%	37,490	65%	2,450	3%	High
CMD/HSD	15,330	3%	1,330	1%	0		0		Mod
CMD/MSS	0		5,540	3%	0		0		Mod
CMS	36,400	6%	40,240	19%	6,390	11%	12,800	16%	Mod
CSD	141,900	24%	56,550	27%	0		12,350	15%	Low
CSS	43,540	7%	9,490	5%	2,140	4%	2,690	3%	Low
HLD	0		0		0		0		Mod
HMD	6,750	1%	3,770	2%	0		0		Mod
HMS	8,770	2%	0		0		0		Mod
HSD	0		0		0		0		Low
HSS	22,710	4%	22,710	11%	0		23,950	29%	Low
MLD	0		0		0		0		High
MLS	0		0		0		0		Mod
MMD	6,670	1%	2,850	1%	0		0		High
MMS	0		3,240	2%	0		0		Mod
MSD	33,380	6%	13,560	7%	8,420	15%	10,030	12%	Low
MSS	2,350		5,410	3%	2,840	5%	11,120	14%	Low
No trees	19,210	3%	7,160	3%	0		6,580	8%	Low
Total per Category	573,820	63%	200,380	22%	54,650	6%	81,970	9%	

Frequency is based on stream length with each bank tallied independently.
[1]Riparian condition codes are defined in Table D-2.

Recruitment mechanisms include windthrow and tree mortality due to disease and infestation. All LWD is recruited to the channels from the adjacent streambanks with downstream transport limited to mid to lower mainstem reaches; mean annual peak flows in the small channels are insufficient to transport LWD downstream. Smaller pieces of woody debris are more easily transported and can form jams which are effective at scouring pools and providing cover. Although not excessive, windthrow appears to be the primary recruitment mechanism along the mainstem, particularly in areas of seasonally wet soils. Where a floodplain has developed, the channel appears to be relatively stable in position within the floodplain. Neither bank undercutting nor lateral channel shifting are a significant recruitment mechanism throughout most of this WAU. Channel segments 4 and 5 along the mainstem were one of the few areas

where LWD is being recruited through bank erosion. If a more developed riparian forest canopy was present in channel segment 7, bank cutting would likely be a recruitment mechanism in this unconfined reach. Root rot was observed to be a prominent recruitment mechanism in several riparian channel segments; this condition was most evident in the Quinn's Meadow sub-basin. Other tree diseases also serve as recruitment mechanisms. Although western redcedars can survive for long periods with heart rot, this condition was evident in nearly all of the larger cedars in riparian areas and likely makes trees more prone to falling. Tree mortalities as evidenced by snags were relatively low in riparian stands not approaching late seral conditions. Therefore, many of the densely stocked stands of healthy, mature conifers lack a sufficient recruitment mechanism to deliver LWD to the channel in the near-term except in wet soils where moderate windthrow hazard occurs. Fire is not currently a primary recruitment mechanism and probably has historically not been a major LWD recruitment mechanism for most of this basin since stand replacing fires in moist riparian areas have been rare events. Breakage due to snow and wind are other recruitment mechanisms particularly for streams in which small wood and canopy litter function well.

2.3.3 Riparian LWD Function Situations (Map Units)

Riparian situations in the WAU were grouped into eight broad functional categories. Each riparian situation has been assigned a Map Unit number as shown on Map D-6. Table D-7 summarizes riparian conditions in each map unit and lists all RCUs affected.

Riparian Map Unit 1: Riparian areas with both good near-term and long-term LWD recruitment potential. Riparian stands are densely stocked with conifers at least 12 inches diameter at breast height (dbh). Channel segments are highly responsive to large woody debris which typically must be at least 12 inches in diameter to be functional. Currently there is adequate LWD in the channel for all channel segments within this map unit except channel segment 3 which is not sensitive to changes in LWD. Riparian map unit 1 accounts for 5% of all streambanks in the WAU. All RCUs in Map Unit 1 are fish-bearing.

Riparian Map Unit 2: Riparian areas with low to moderate near-term LWD recruitment potential and good long-term potential. Past land management practices (both forestry and more commonly non-forestry activities) have reduced the density of conifers ≥12 inch dbh growing within 75 feet of streams requiring larger wood for functional habitat. Near-term recruitment of suitable LWD is limited by the current average size of conifers growing in riparian areas but recruitment will improve with time as these riparian stands mature. Agricultural and homesite development adjacent to streams contributes 75% to this riparian situation (percentage based on streambank length). Selective harvest on private forested lands contributes 25% to this riparian situation. Map unit 2 accounts for 1% of the streambanks in the WAU.

Riparian Map Unit 3: Brushy streambank terraces with natural succession leading to dense conifer stands. Vegetation on the stream's floodplain is now mostly brush for an average width of 25 ft or more back from the streambank but conifer seedlings and/or saplings will eventually

become dominant and lead to good future LWD recruitment potential. Near-term LWD recruitment opportunities are limited to trees growing at the outer perimeter of the LWD recruitment zone. Floodplain soil types within this map unit include Chamokane silt loam. Brushy floodplain vegetation is primarily a result of past beaver activity causing floodplain widening and seasonal soil saturation in riparian channel units (RCU) 7-1 and 602-2. Past channel disturbance accounts for brush along RCU 507. Selective harvest has occurred within the riparian areas for all RCUs in this riparian map unit. Map unit 3 encompasses 5% of the streambanks.

Riparian Map Unit 4: Non-forested and Road impacted riparian areas. Agricultural and homesite development have reduced or eliminated the riparian width on one or both banks. The riparian width is also restricted where roads run parallel to the channel within 75 feet of the bankfull channel on one or both banks. Openings in the adjacent canopy and disturbance within the riparian area create a situation favorable to hardwood dominated riparian stands which reduces the recruitment potential of functional, longer lasting coniferous LWD. Impacted riparian areas which are adjacent to fields and pastures where soil mapping indicates conifer growth is not inherently restricted were attributed to agricultural or homesite impacts.

Active County and private roads affect riparian conditions in RCU 6R, 201-2R, 202-2, 501, 502, and 801-1. An inactive skid road reduces near-term recruitment potential in RCU 9-3L. Both roads and non-forestry activities impact riparian condition in RCU 201-1 and 801-2. Roads adversely affect riparian condition for a total of 6.3% of the streambank length for mapped channel segments in the WAU and agriculture or homesite development reduces recruitment potential from 9.2% of the streambanks. The stream has been channelized in RCUs 2 and 801-2 which severely impacts riparian condition.

Grazing impacts to riparian condition are most pronounced along channel segment 7. Grazing within the riparian area has recently been restricted by selective fencing in parts of channel segment 8. The riparian vegetation has dramatically responded through re-establishment of a closed, brushy canopy over the stream and conifer seedlings revegetating the fenced floodplain will lead toward good long-term recruitment potential.

Riparian Map Unit 5: Other naturally sparse riparian areas. Rocky soils or other non-wetland site conditions naturally limit stand density for 2% of riparian areas in the WAU.

Riparian Map Unit 6: Wetlands. Soil conditions on the stream's floodplain, particularly soil wetness, are favorable for brush and severely limit conifer growth. Conifers available for near or long-term LWD recruitment are primarily growing on the toe of the valley slopes. Wetland areas within agricultural areas were not assigned to this map unit when field observations and soil map data supported a conclusion that those areas are capable of supporting growth of dense coniferous or mixed stands. Other wetlands may also be reported in the Water Quality module; however, wet soil conditions in other riverine wetlands are not severe enough to restrict the

growth of an overstory tree canopy. Seven percent of the streambanks in the WAU are included in riparian map unit 6.

Riparian Map Unit 7: Riparian function met by small woody debris and vegetation roots. Smaller streams have less stream power and smaller pieces of woody debris (≥8 inches diameter) provide lasting function in the channel. Whereas small wood can be directly recruited to the stream, larger diameter trees typically span the channel without becoming incorporated into the channel bed. Riparian vegetation roots provide essential bank integrity. Large glacial lag boulders are found in many of the channel segments in this map unit. These boulders provide scour and channel complexity functions. Map unit 7 encompasses 62% of the streambanks in the WAU. Although small wood is adequate in nearly 90% of the streams in the WAU, many stream segments are grouped in another riparian map unit due to other factors limiting recruitment potential.

Riparian Map Unit 8: Conversion of brushy riparian vegetation requires vegetation management. Dense brush growing on streambanks and the floodplain prevents the re- establishment of conifers within the central portion of the LWD recruitment zone. Without vegetation management intervention, these areas are likely to remain vegetated in brush. Map unit 8 encompasses 2% of the streambanks in the WAU.

A riparian stand condition is the result of a complex interaction of species diversity, historical land management, site conditions, and climate. The riparian situations are not always geographically discrete and often overlap. Each bank of each RCU was, however, assigned to a single map unit to facilitate mapping and analysis. The riparian situation which was most limiting for LWD recruitment potential was assigned to each RCU streambank. For example, an area within an agricultural field may have wetland characteristics but the site is capable of growing trees if the agricultural activities did not impair forest growth. This RCU would be assigned to map unit 4 rather than map unit 6. Riparian areas where brush vegetation is the overriding factor impairing recruitment potential were assigned to either map unit 3 or 8. Channel segments for which small wood functions were only assigned to riparian map unit 7 if other factors did not limit tree growth potential.

Table D-7 Riparian LWD Map Units

Map Unit	Description	Riparian Condition Units	Riparian Condition Codes	Recruitment Potential		In-channel LWD	Presence of Brush/hard-woods	Comment
				Near Term	Long Term			
1	Good near and long term recruitment Potential	4-2, 5, 9-3L, 506, 601, 602-1, 602-3	CMD, MMD, MLD, CLD	H	H	Fair or Good	Minimal	
1b		3				Poor		
2	Low short term & High Long Term	505, 9-3R	CSD, MSD, CMS, MLS	L	H	Unknown	Moderate or less	
3	Natural succession of brush by conifers	4-1, 507, 602-2, 7-1	MSD, MMD CMD/HSD	LM	H	Good	floodplain	Conifer seedlings present. Chamokane and Manley soil
4a	Road impacts	6, 201-1, 501, 502, 801-1	CSS, CMS, CSD, HSD, HSS,MSS, MSD	L M	L M	Variable	Common	*Roads maintain brush* Fields Homesites Possible enhancement where Chamokane soil type
4b	Non-Forestry Impacts	2,7-2, 7-3, 8, 9-1, 9-2, 10, 50, 202-2, 205,306, 701-1, 701-3, 702-2, 702-4, 703, 801-1, 801-2, 904, 908,910						
5	Other Naturally sparse riparian	101, 905, 907	CMS	M	M	Poor	no	Maki soil type and rock bluffs
6	Wetlands	1, 52, 401, 709, 903, 203-2, 301, 402-1, 708-1, 712	MSD,HSD,HSS, CSS,CMSCMD	L	L	Poor	often permanent brush	Recruitment is only possible from perimeter. Bossburg and Saltese muck soils
7	Small LWD functions well	All tributary segments except 502, 503, 505, 506, 601, 602	Variable	M H	H		NA	Streambank roots and riparian vegetation important
8	Conversion necessary to reduce brush	509, 607, 705	conifers/ brush corridor	L M	Condi-tional	Good Fair	floodplain	Site specific assessment needed to determine feasible methods of conversion. Martella silt loam and Merkel stony loam

2.3.4 Long-term LWD Recruitment Potential

Past management history, fire history, soil type, and plant association community are primary determinants of long-term LWD recruitment potential. These factors influence stand species composition, stand age, and average tree size. Historical forestry activities have reduced the average stand age in the WAU but generally do not preclude good long-term LWD recruitment potential. Presently, harvest within riparian management zones on Type 1-3 streams under Forest Practices regulation is by selective harvest. In addition, riparian buffers of either young conifers or mixed age stands are typically left on perennial Type 4 streams. Harvest activities in approximately the last 25 years have generally left dense stands of conifers averaging 8 inch dbh or greater in riparian areas. Non-forestry activities along streams limit both near and long-term recruitment potential where the width of a riparian overstory is reduced or eliminated. Where not properly managed, grazing activity can also indefinitely maintain brushy vegetation which does not provide long-term LWD recruitment opportunities.

Fire History

The effects of fire on stand composition are most pronounced in the upper sub-basins where fires may have been more intense. Mid-slope stands are generally drier, and more wind-exposed, and may form a "thermal belt" which burns more intensely than lower slope positions (Arno and Davis 1980). Dense stands of lodgepole pine mixed with some western larch (*Larix occidentalis*) are characteristic of stands regenerating after intense fires. Western redcedar (*Thuja plicata*) and, less extensively, western hemlock (*Tsuga heterophylla*) dominate moister riparian areas within these lodgepole stands. Western redcedar will survive fires if any portion of the bole and cambium survive (Smith and Fishcer 1995). After stand replacing fires, western redcedar usually enters moist sites early in succession due to its prolific seed production. Faster growing Douglas fir also dominates within riparian "stringer stands" set among lodgepole pine hillslope stands. This type of mixed species stand is prevalent in the upper Onion Creek and Van Stone Mine sub-basins. The lodgepole pines growing on toe-slopes close to the streams are approaching their life expectancy and are being recruited to the channels as they die. Western redcedar, hemlock, and grand fir are either dominant or will succeed in these riparian segments. Grand fir is now an understory tree in much of the WAU; this more shade tolerant species will become more dominant with continued fire suppression.

In the past, riparian areas in this WAU have more commonly experienced slow, ground creeping fires due to the relatively high soil moisture. Redcedar plant associations growing along valley bottoms between drier forest slopes are less subject to intensive burning and thus create "stringers" or natural fire breaks. The fire return interval for low to moderate severity fires is 50 to 100 years for western redcedar riparian areas (Williams et al 1995). Stand replacing fires can be expected to occur on an interval of 150 to 500 years.

Shrub Growth on Floodplains

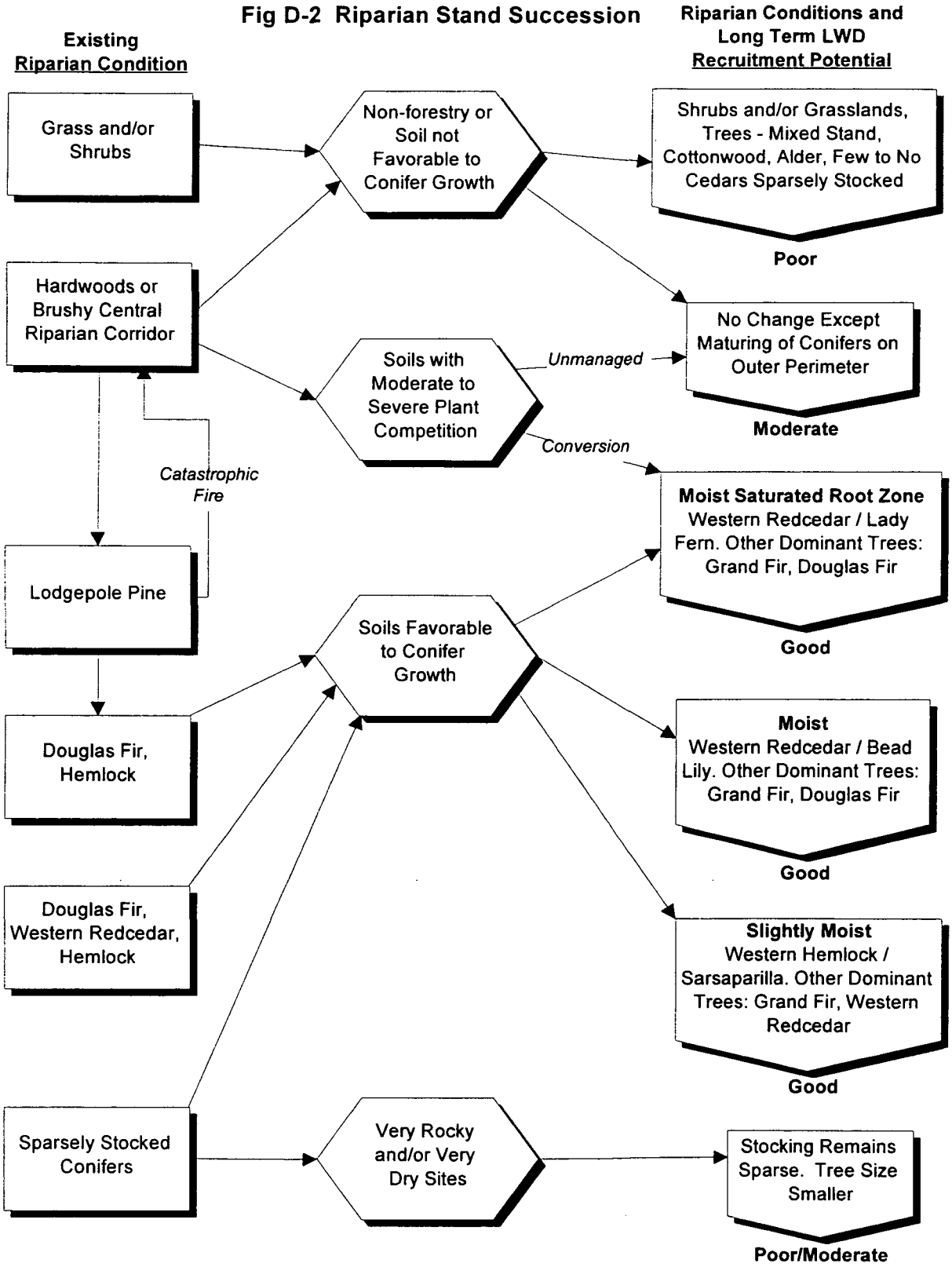
Brush vegetation dominates plant growth closer to streambanks on some of the channel segments with floodplain topography. The persistence of shrubs dominating riparian vegetation was observed to correspond closely with soil type and management. Soils with a seasonal or permanently high water table are most favorable to brush vegetation on the floodplain. Wetland soils including Bossburg muck, Saltese muck, and histosol soils found in association with Riparian Situation 6 do not support conifer growth and long-term recruitment potential is limited to any trees growing at the outer margin of the recruitment zone. Chewelah silt loams found as inclusions along RCU 7-2 and Peone silt loam (RCU 607) are also very wet soils more favorable to brush growth.

Past beaver activity along Onion Creek created conditions favorable for brush by increasing soil moisture. Ongoing beaver activity was not observed along the mainstem of Onion Creek but a resident reported beaver activity in channel segment 7 as recently as 1974. Beaver are currently active higher in the watershed maintaining brush dominated wetlands (segment 712). Floodplain soil type for Riparian Situation 3 is Chamokane silt loam; stumps of cedars and conifer seedlings found on the brushy floodplain indicate succession of brush by conifers leading to good long-term recruitment potential.

Long-term recruitment potential is limited by persistent brush growth on the floodplain for streams in riparian situation 8. Brush often becomes well established following canopy opening with fires, full harvest, or non-forestry related clearing. Invading shrubs and forbs draw heavily on the reserves of potassium in the soil and thereby initially out-compete conifer seedlings (pers. comm., D. Barron, consultant & retired SCS, Oct. 2, 1996). Potassium is essential for tree turgidity. Martella silt loams are formed in glacial lake sediments and are mantled with volcanic ash and loess (fine grained soil deposited by wind). Merkel stony loams are formed in glacial till with an admixture of volcanic ash in the upper part. The ash component maintains moister soil regimes and is favorable to brush. Unless brush is controlled, forest regeneration of redcedar, Douglas fir and western larch dominated stands on these two soil types may be delayed (NRCS 1982). Examples of this condition were observed in Quinn's Meadow sub-basin and the lower end of other tributary drainages. Wethy soils in segment 402 have moderate shrub competition when the canopy is opened but cedars will grow.

Figure D-2 shows the successional pathways and subsequent long-term recruitment potential for riparian stands in the Onion Creek WAU.

Fig D-2 Riparian Stand Succession



2.3.5 LWD Recruitment Model

VanSickle and Gregory (1990) proposed a geometric model to predict LWD recruitment rates. Sample plot data from field surveys were used to predict recruitment rates for selected riparian stands as a function of riparian zone width. The model calculates recruitment rate as a function of tree fall rates, probability of direction of fall for individual trees, and the spatial distribution of stand density.

Regional research is lacking for tree mortality rates and tree fall rates within riparian areas. The later and possibly both of these rates might be better defined as non-stochastic events. Probability of tree fall is often not randomly distributed spatially nor temporally. Recruitment from disturbance events may deliver many trees at once (windthrow storm) as compared to a steady rate of supply for individual pieces of LWD. Insect infestation leading to mortalities is also a non-stochastic recruitment process. For this assessment, a uniform and constant probability rate for tree fall was assumed in modeling recruitment. All trees growing immediately adjacent to the active channel were assumed to fall into the channel. Trees at distance from the channel were assumed to have a random probability of direction of fall. Hillslope topography and growth patterns of individual trees may cause this assumption to be invalid at specific sites.

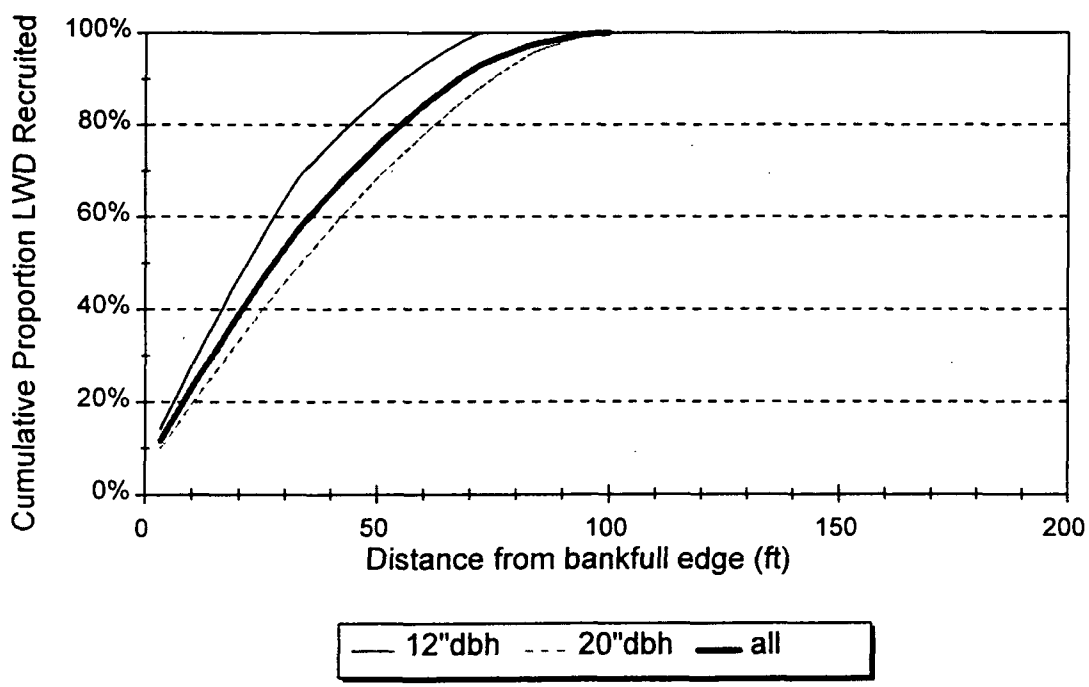
Recruitment for representative riparian conditions in the WAU were modeled to quantify recruitment as a function of distance from the channel. Riparian stand data from field measurements were used to assign stand densities for each 1.6 ft (0.5m) wide incremental partition of the riparian width. Tree height data both collected as part of this field effort and that reported in the literature were used in modeling LWD recruitment. It was assumed that the taper on the bole caused the top 20% of the tree height to be less than 12 inches in diameter and not effective for LWD. The Natural Resources Conservation Service (NRCS 1982) provides additional information on site indices (tree heights) for even aged, fully stocked timber stands at approximately 100 years age. The NRCS data is reported by tree species and soil type, and is based on a much larger sample size; thereby providing statistical validity. Williams et al. (1995) reports site index (height) and growth basal area by tree species within various plant associations or communities. Table D-8 lists site potential tree height data from various sources.

Table D-8 Site Potential Tree Heights

	Riparian Plot Data[1] Height (sample size)		NRCS (1982) Site Index	Williams et al. (1995) Site Index[3]
	12-19.9" dbh	≥ 20" dbh		
Douglas Fir	86 (12)	140 ft (3)	107 - 118[2]	64[4]
Western Red Cedar	66 (7)	95 ft (11)	NA	43[4]
Grand Fir	101 (7)	107 (3)	NA	81[5]
Western Larch	94 (6)	155 (2)	NA	65[4]
Western Hemlock	65 (3)		NA	69[5]
Lodgepole Pine	125 (1)		NA	65[4]

[1] Data from Onion Creek WAU; representative of tallest trees observed in the WAU
[2] SI is average measured height of dominant and co-dominant trees at 100 years age for Bonner and Chamokane soils, respectively.
[3] Colville National Forest (base years [stand age] = 50)
[4] Western red cedar/queencup beadlily (THPL/CLUN) plant association
[5] Western hemlock/sarsaparilla (TSHE/ARNU3) plant association

Fig D-3 LWD Recruitment
Late Seral Western Redcedar Riparian



Late seral conditions for a Western redcedar/queencup beadlily riparian plant association (Williams et al. 1995) with no brushy central corridor were modeled. Details for model input are provided in the supporting documentation to this module (Appendix D-3). Figure D-3 depicts LWD recruitment potential as a function of distance from the channel. Recruitment rates were normalized to account for the weakness of assumption in knowing the actual tree fall rate, i.e. recruitment is expressed as a percent rather than an established rate.

According to model results, 90% of the LWD recruitment is from trees growing within 67 ft of the bankfull channel and 75% of the recruitment is from within 50 feet. Actual recruitment rates may be even greater closer to the channel since windthrow and root rot mortality would be expected to be greater on the seasonally wetter soils of the floodplain or channel banks. The model assumed equal tree mortality and fall rates throughout the recruitment zone since site specific data are not available. The model results provide only a general guide but the model could be refined for site specific conditions. Model refinements may include: varying the probability and direction of tree fall for different portions of the riparian corridor; modeling a mixed age stand; and refining mortality rates.

The amount of LWD potentially recruited from a standard Riparian Management Zone (RMZ) as defined by Forest Practice Rules (WFPB 1995b: WAC 222-30-020(4) July 1995) was modeled. Standard rules for eastern Washington specify at least 24 trees/acre at ≥ 12 inch dbh must be left within an RMZ averaging 50 feet in width. A mortality rate of 7% per decade was assumed for this number of leave trees per streambank. Modeling a 50 ft wide RMZ for 1,000 ft of stream length (1.15 acres) yields an estimate of approximately four pieces LWD per decade potentially recruited from leave trees on both streambanks. Observations from other nearby watersheds documented LWD of conifer origin lasts at least 65 years in streams of similar size (Stimpson 1997). A total of 28 out of 48 leave trees ≥ 12 inch dbh are theoretically recruited to the channel during 70 years. This amount of LWD is the equivalent 0.3 pieces LWD per wetted channel width for an 11 ft wide stream (average wetted width of geomorphic channel groups 4 and 5). A rating of fair habitat was assigned to channel segments with at least 0.25 pieces LWD/wetted width. (See Stream Channel/Fish Habitat Assessment Appendix E/F.) In addition to the leave trees ≥ 12 inch dbh specified in standard forest practice rules, a minimum of 135 trees/acre ≥ 4 inch dbh must be left along gravel/cobble streams or 75 trees/acre along streams with a boulder/bedrock channel bed. Typical RMZs observed in the Onion Creek WAU which had been recently harvested had a predominance of conifers 8 - 12 inch dbh in addition to the larger diameter leave trees. Many of these trees would also be available for potential recruitment to the channel over a 70 year period during which their average diameter would increase. In summary, standard forest practice rules appear adequate to deliver sufficient LWD to Onion Creek except where other factors limit the stand density of riparian conifers.

Standard forest practice rules also specify all trees <12" dbh within the RMZ for fish-bearing streams are to be left standing. Tree breakage and recruitment from these smaller trees provide

suitable LWD to streams within Riparian LWD Map Unit 7 and other small stream channel segments where smaller wood is functional.

2.4 Confidence in Work Products

Confidence in the LWD work products is generally high in terms of providing the types of information required by the analysis procedure. Specifically, there is a high degree of confidence in species, size class and stocking condition assessments. Recent aerial photograph coverage (1992 app. 1:15,000 black and white) was available for nearly the entire Onion Creek WAU. Riparian conditions were verified for all of the Type 1-3 streams and a high proportion of all stream channel segments. There was a very high correlation between field based riparian condition calls and aerial photo assessments. Sixty-three percent of all riparian channel units were field visited. Plot data were collected for 34 out of the total 130 riparian channel units representing all of the various condition statements. Another 48 riparian channel units were reconnaissance surveyed. No indeterminate calls remained after field surveys. Confidence in measured riparian stand densities is moderate. Sample plot size was too small to accurately estimate stand density. A single tree counted in a 1/50 acre plot equates to 50 trees per acre. Relative values are comparable; however, since the sampling method was similar among riparian segments.

Confidence for the in-channel LWD data is high for those segments surveyed but extrapolation to other segments within the same channel group is limited since wood volumes are dependent upon a diversity of past land management activities as well as stream condition. The assessment team field surveyed nearly all of the channel segments where larger wood is required in the channel. Confidence is moderate to high that in-channel LWD amounts is at least fair for all RCUs in riparian map unit 7 where conifers are densely stocked. Smaller wood functions well in channels of this map unit so even small trees can provide suitable woody debris. Based on field observations, confidence is moderate to high that shrub roots and small LWD (≥8 inches diameter) can be functional in streams within Riparian Situation 7 for the purposes of pool scour, cover, sediment retention and bank armoring. The small size of these streams allows smaller wood to function well. Several riparian management zones (RMZ) selectively harvested according to standard rules were surveyed for Type 1-3 stream segments in riparian map unit 7. The recruitment potential for LWD ≥ 8 inch dbh was good in these recently harvested units.

Confidence is high that brushy streambanks identified in Riparian Map Unit 3 will naturally succeed to dense conifer stands. There is a good correspondence between soil mapping (NRCS 1982) suggesting conifer succession and the field observation of conifer seedlings. Stumps found in the brushy floodplain also confirmed conifers can grow in these locations. There is only low confidence that riparian segments in Map Unit 8 can be converted with control of brush. It was not possible to evaluate the site specific conditions and recommended treatments within this analysis.

Confidence in the model results for LWD recruitment as a function of distance from the water's edge is moderate. These results are only intended as a guide. Application of this model to predict actual recruitment rates would require additional field verification of assumptions for tree mortality. The model is also sensitive to tree heights and species composition as the latter affects average tree height. Model refinement during prescriptions is anticipated.

2.5 Habitat Enhancement Opportunities

- Vegetation management is possible for stream segments where soils are conducive to conifer growth but existing streambanks are brushy (Riparian Map Units 3, 4 and 8). The importance of shrub root strength and vegetation effects on bank integrity and flood energy dissipation require careful consideration. Where determined feasible and practicable, brush can be controlled and conifers planted. Monitoring potassium levels in the soil and timing nutrient supplementation to be favorable to conifer growth is advised. Riparian channel units in Map Unit 4 which have Chamokane loam soil have the greatest potential for reforestation (examples RCU 6R along road and RCU 8). Trees to plant in this situation include Douglas fir and grand fir. A silviculturalist should be consulted before attempting to convert brushy floodplains of Riparian Map Unit 8. Chewelah silt loam soils in RCU 7-2 may be seasonally too wet to support good conifer growth.

- Review and implement grazing management strategies for channel segment 7 and elsewhere noted in the causal mechanism reports. Management strategies which allow conifer seedlings to become established to a size resistant to trampling will aid riparian restoration in RCUs 7-1 and 7-2. Riparian vegetation on the streambanks in the lower portion of segment 8 is responding favorably to fencing exclosure. Numerous options other than fencing have been developed regionally. Working cooperatively with landowners is essential to finding successful voluntary solutions which meet both instream habitat concerns and provide continued grazing opportunities.

- LWD recruitment potential is impaired along channel segment 2 where the stream has been channelized. Pool habitat and spawning gravel for adfluvial kokanee and resident salmonids is degraded. Installation of log structures may not be effective in improving fish habitat unless the issue of channelization is also addressed. Working cooperatively with the landowner to address instream habitat concerns as well as potential flooding and possible shading effects to adjacent pastures is suggested.

- Installation of woody debris structures in the stream channel downstream of the mine could aid in restoration of habitat affected by past channel disturbances. Segments 502 and 503 have the greatest potential to benefit from installation of wood structures.

- Locating RMZ leave trees required by Forest Practices standard rules closer to the channel increases the probability of their naturally falling into the stream, especially if

leaning towards the stream. Managers are encouraged to voluntarily select leave trees accordingly.

2.6 Monitoring Recommendations

Monitoring plans should be incorporated into any enhancement activities. The effectiveness of instream structures in achieving habitat objectives should be evaluated at one and five years. Riparian vegetation management, where attempted, will require annual monitoring with possible maintenance until conifer saplings become well established.

The LWD recruitment model requires refinement and validation monitoring. Model refinement is better addressed on a regional level and is more appropriate for a T/F/W initiated research project. Since validation of modeled recruitment rates would require a long term monitoring plan implemented over several decades, a well coordinated regional approach has greater potential for generating meaningful results.

3.0 CANOPY CLOSURE AND STREAM TEMPERATURE

3.1 Introduction

Class AA water quality standards apply to all waters within the WAU. The standards establish a maximum instantaneous water temperature of 61.0°F (16.0°C). Incremental temperature increases resulting from non-point source activities shall not exceed 2.8°C or, in cases where water temperature naturally exceeds the standard, incremental changes shall not exceed 0.3°C.

Table D-9 identifies the canopy closure requirements to maintain water quality standards for maximum stream temperature as specified in the Watershed Analysis Manual Riparian Function (ver. 3.1). The shade requirement is determined by elevation; the latter is a reasonable substitute for air temperature. Air temperature is a primary factor in determining maximum daily stream temperature. Sullivan and others (1990) determined that percent canopy closure (shade) and elevation can be used in combination to determine water temperature relative to the State water quality standard for maximum temperature. Later work by other T/F/W cooperators revised this functional relationship for east of the Cascade crest. This approach offers a simple, map based approach to stream temperature assessment that is not dependent upon seasonal monitoring.

TABLE D-9 Default Riparian Target Canopy Closure Levels for Class AA Eastern Washington Streams (WFPB 1996)

Minimum Shade Category (%)	Elevation Zone (feet)
<10	>4450
10+	4200 - 4450
20+	4000 - 4200
30+	3800 - 4000
40+	3600 - 3800
50+	3350 - 3600
60+	3200 - 3350
70+	2900 - 3200
80+	2750 - 2900
90+	<2750

Target canopy closure levels used in this analysis were modified based on site specific data

3.2 Methods

3.2.1 General Approach

The level II functional assessment of riparian shade relies on the same methods as a level I assessment except that no indeterminate calls are made. Aerial photos (1992 1:14,00 to 1:16,400 black and white) were used to estimate canopy closure by stream segment. Segments with estimated canopy closure less than the target amount (Table D-11) were identified as high impacts or hazards. Field visits were made to all stream segments initially identified as indeterminate, and at least one site per sub-basin/ riparian condition that had a high impact rating for canopy closure. Field data collection consisted of taking shade measurements every 100 feet (30m) for up to 1,000 feet (305m) of a particular stream segment using a densiometer. Additional densiometer measurements (one every 50 feet) were made if warranted by high variability between sample sites within a single reach.

A rule of thumb that is supported by previous field studies (Caldwell and Doughty 1991) is that a Type 4 stream must contribute at least 20% of the flow to the downstream water to influence its temperature. Assuming complete mixing, the downstream water temperature equals the average

of the upstream contributing waters weighted proportionate to their flow. Type 4 streams estimated to contribute 20% or more of the total low flow in a downstream Type 3 were identified and impact calls made if existing shade was below the target level (Table D-11). Flow was estimated as a percentage of basin area unless direct field reconnaissance confirmed that the channel was dry or had a proportionately high percentage of the total downstream flow. Ephemeral streams were not considered susceptible to maximum temperature impacts. Streams which the Assessment Team determined fit the criteria for being potentially fish-bearing under the WDNR emergency rules (WFPB Nov. 14, 1996) were assigned a high hazard when the existing shade was below the target shade as defined in Table D-11.

Existing water temperature data within the WAU were reviewed. This data includes records from three continuous recording thermographs operated by Boise Cascade this past summer as well as data from other sources (Routh 1993; unpublished records Stevens County Conservation District; unpublished records Equinox Mine). Boise Cascade deployed three continuous recording hobo™ thermographs within the WAU. Monitoring sites were selected which approximately matched the elevation and shade criteria stated in Table D-9. Water temperatures were monitored from August 7, 1996 through September 19, 1996. Air temperatures and relative humidity were also monitored. Verification measurements of air and water temperature were made using a hand held mercury thermometer at the time of deployment and instrument retrieval.

3.2.2 Modification to Methods

Methods referenced in the Watershed Analysis Manual; Riparian Function (ver. 3.1) measure only overhead canopy. For this analysis, low brush and debris covering a stream were considered to be providing shade when no overhead canopy existed. Sullivan and others (1990) and Caldwell and Doughty (1991) observed that low brush can effectively regulate temperatures in small streams. Low brush was included in the field measurements of shade for this study.

Stream segments observed as dry during field work in early October were not given a high temperature hazard rating. Residents were also queried as to which stream segments are typically dry during mid to late summer. Maximum stream temperatures most often occur between mid-July and mid-August (Sullivan and others, 1990); a time when these channels would be dry.

All reliable maximum daily temperature data were analyzed by stepwise multiple regression to develop a predictive model specific to this WAU. Shade and elevation data were first tested for auto-correlation using a Durban Watson test (Chatterjee and Price 1977) which demonstrated these data variables were independent from one another. Shade and elevation data were then used in a multiple regression model to predict stream temperature. The descriptive statistics from this regression model were then used to generate alternate elevation and shade values necessary to meet Class AA water quality criteria for maximum temperature ($\leq$ 16.0°C) at a 90% confidence interval.

3.3 Results

3.3.1 Products

Canopy closure estimates are reported in Worksheet D-2 and Map D-4. Riparian segments along streams with a high probability of maximum water temperature not meeting State water quality criteria are reported in Map D-5. Supporting data are provided as an attachment to this module report.

3.3.2 Measured Water Temperatures

Thermograph data is summarized in Table D-10. Some of the data sources are from previous years with only water temperature provided. It was assumed that shade levels have not appreciably changed in the last few years for reaches sampled. Maximum water temperatures exceeded 61.0°F (16.0°C) for only two of the eleven sites monitored.

Table D-10 Maximum Recorded Water Temperatures for Onion Creek WAU

Stream Segment	Site	Temp °C	Elevation (ft)	Canopy Closure (%)	Date	Data Set
2	ON 2	17.2	1400	80	7/25/94	DOE/SSC 1996
9	SW-1	15.4	2560	55	7/94	Equinox
10	SW-4	17.2	2640	20	7/94, 10/94	Equinox
401	SW-2	13.0	2680	90	8/27/92	Equinox
401	SW-3	12.0	2760	90	8/29/91 6/12/92	Equinox
502	HB 1	14.0	2720	97	8/7/96- 9/19/96	Boise Cascade Corp.
506	HB 3	12.9	3238	100	8/7/96- 9/19/96	Boise Cascade Corp.
507	HB 2	12.5	3563	97	8/7/96- 8/19/96	Boise Cascade Corp.
507	SW-7	9.5	3800	100	8/27/95	Equinox
508	SW-8	11	3600	90	6/12/92	Equinox
601	SW-5	13.6	2680	94	7/94	Equinox

A stepwise multiple regression analysis yielded a significant relationship between the independent variables of elevation and shade and the dependent maximum stream temperature.

(Adjusted $R^2 = 0.843$; degrees of freedom = 10; mean standard error = 0.94817; variable assigned standard errors of 0.0004822 and 0.0131 for elevation and shade respectively.) The linear relationship for predicting maximum stream temperature at a given site *(I)* is:

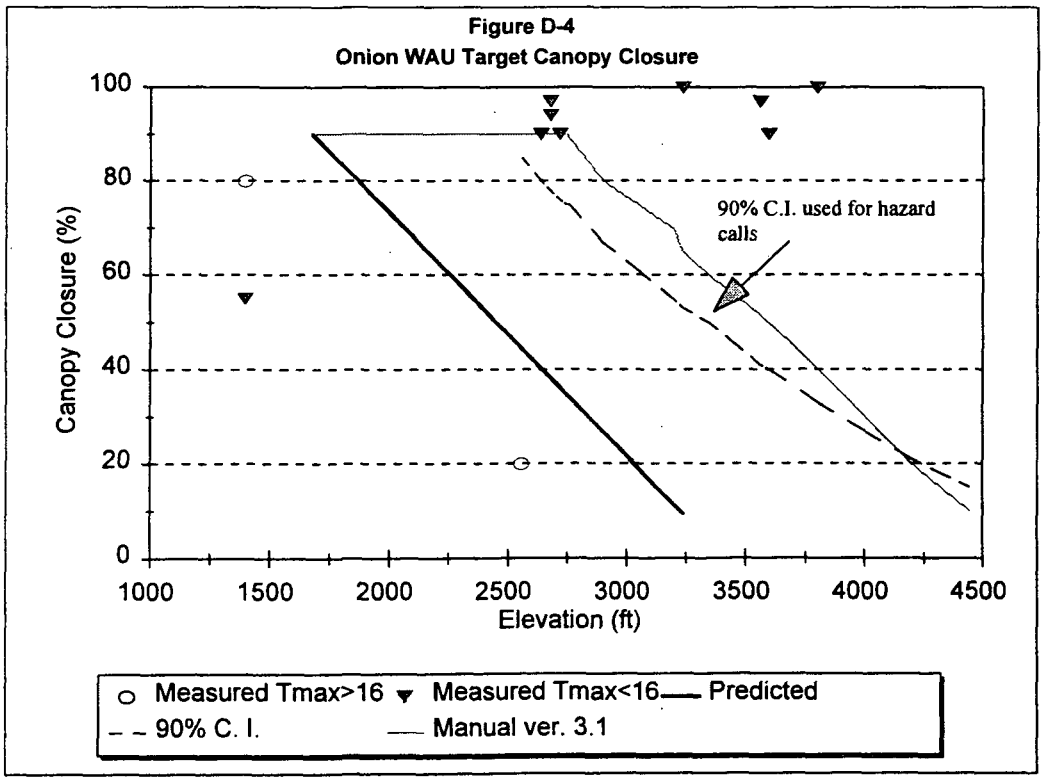
$$\text{Max Temp}_i(°C) = -0.00237*\text{Elevation}_i(\text{ft}) - 0.04585*\text{Shade}_i(\%) + 24.1077$$

The 90% confidence intervals were calculated and the upper bound was used to establish target shade levels in the WAU (Map D-4). This method represents a conservative approach at defining appropriate target shade levels. The sample size (data from 11 sties) is small and not spatially well distributed throughout the WAU. Use of the upper confidence bound for target shade levels errors on the side of protecting public resources. In other words, there is at least a 90% certainty that a stream segment with a minimum average canopy closure of the target level stated in Table D-11 will have a maximum summer temperature at or below 16 °C. Stream temperatures for locations below 2,300 feet; however, may exceed the standard even when the canopy is completely closed. The basin specific relationship including the 90% confidence interval is compared to the default target shade levels for eastern Washington in Figure D-4. Target shade levels used to map temperature hazards (Map D-5) are also provided in Table D-11.

Two factors account for the reduced shade needs compared to those recommended for eastern Washington. Maximum water temperatures and the diurnal temperature range for the thermograph data suggest cool groundwater inflow strongly influences summer temperatures. Numerous springs were observed throughout the WAU and the small channels are dominated by groundwater inflow. The WAU is located in the extreme northeastern corner of the state and the climate is influenced by cooler air masses moving down from Canadian mountain ranges.

TABLE D-11 Modified Riparian Target Canopy Closure Levels

Modified Minimum Shade Category (%)	Elevation Zone (feet)
<10%	>4450
15%	4200 - 4450
21%	4000 - 4200
27%	3800 - 4000
33%	3600 - 3800
40%	3350 - 3600
50%	3200 - 3350
55%	2900 - 3200
67%	2750 - 2900
75%	2440 - 2750
90%	2300 - 2240
100% or max. possible	<2300



3.3.3 Riparian Canopy Closure Situation Summaries

Three riparian function situations for canopy closure were defined. Situations resulting in a high hazard for canopy closure are noted on Map D-5. Hazard evaluations are based on the upper bound for the 90% confidence interval of the regression model discussed below in Section 3.3.3.

- Canopy Closure Map Unit 1: Naturally exceed Water Quality Standard. Riparian channel units in this map unit potentially exceed water quality standards for temperature due to higher air temperatures at lower elevations (< 2,300 ft) (Map Unit 1a) or naturally sparse shade for open water wetlands (Map Unit 1b). Although important for having a cooling effect on streams, even the maximum potential canopy closure with late seral forest conditions may not result in water quality standards being met. This map unit has been subdivided according to factors naturally limiting

- Canopy Closure Map Unit 2: Non- forestry related activities reduced canopy closure below target. Canopy closure on these fish-bearing stream segments has been reduced due to non-forestry activities including agriculture, home site development or roads located adjacent to the stream. Existing canopy closure is less than the target shade level resulting in a high hazard.

- Canopy Closure Map Unit 3: Non-fish-bearing streams capable of contributing to downstream temperature hazard. These non-fish-bearing streams potentially contribute at least 20% of the total downstream flow in a Type 3 stream and canopy reduction could presumably contribute to elevated temperatures in the downstream Type 3 water.

- Canopy Closure Map Unit 4: Minimum canopy closure target level met. These fish-bearing stream segments have adequate canopy closure to meet the designated Class AA water quality standard for temperature.

3.3.4 Contributing Activities

The following activities contribute to water temperatures exceeding the water quality standard in the Onion Creek WAU. Additional discussion of causative factors for individual RCU's is provided in Worksheet D-4. No situations were found where forest practices have reduced canopy closure below target levels along fish-bearing waters inclusive of streams potentially inhabited by fish as defined by emergency rules. Complete canopy removal during harvest has only occurred on three Type 4 non-fish-bearing streams having sufficient flow to adversely affect downstream water temperature for potentially fish-bearing waters. Twelve percent of the total stream length in the basin potentially experiences maximum temperatures in excess of water quality standards. The percentage of contributing activities stated below is greater than 100% since more than one factor may affect canopy closure within a stream segment.

Activities Contributing to Temperature Above 16°C	% of Hazard Attributed to Factor
• Streams naturally exceeds standard due to high air temperature and humidity (< 2,300 ft)	40%
• Wetlands with low canopy cover	27%
• Clearing of trees for agriculture and homesites reduced canopy overstory	14%
• Channelization of stream removed riparian canopy closure	9%
• Roads adjacent to the stream reduced canopy closure	6%
• Grazing reduces brush overhanging the stream which provides shade	18%
• Harvest of riparian trees along non fish-bearing Type 4 streams which contribute at least 20% of the low summer flow to downstream fish-bearing streams.	10%

Table D-12 High Temperature Hazard Segments and Contributing Activity

Riparian Condition Unit	Channel Group	Riparian Code		Canopy Closure (%)	Unit Length (ft)	Comment
		Left	Right			
Riparian Shade Situation 1a: Streams naturally exceeds Class AA water quality standards: Low Elevation						
1	1	-	-	0	603	no trees
2	2	HSS	HSS	80	5,153	channelized
3	3	CMD	CMD	92	1,039	
4-1	4	HMS	HMS	72	4,386	
4-2	4	CMD	CMD	93	2,275	
5	5	CMD	CMD	90	1,763	
6	4	CMD	CMS	70	4,252	road impact
7 - 1	2	CMD/HSD	CMD/HSD	90	4,533	
7 - 2	2	CMS	HSS	56	7,610	agricultural/grazing
7 - 3	2	MSS	MSS	40-70	2,703	agricultural/grazing
201 - 1	8	CMS	CMS	0-20	1,799	agricultural/homes
201-2	8	CMD	CMS	98	2,141	road impact
301 - 1	9	HSS	HSS	78	1,717	agricultural/homes

Table D-12 High Temperature Hazard Segments and Contributing Activity

Riparian Condition Unit	Channel Group	Riparian Code		Canopy Closure (%)	Unit Length (ft)	Comment
		Left	Right			
801-1	8	MSD	MSD	99	1,905	agricultural/homes
801-2	8	-	-	20-40	1,725	agricultural/homes
Riparian Shade Situation 1b: Naturally exceeds Class AA water quality standards: Wetlands						
52	6b	-	-	0	2,422	exempt stock pond
203 - 2	6b	CMD	CMD	0	1,622	
703	6b	-	-	0	265	
709	6a	CMS	CMS	20-40	2,316	
712 - 1	6a	CSD	CSD	60	2,362	
712 - 2	6a	CSS	CSS	0	1,346	
712 - 3	6a	MSS	MSS	0	5,559	selective harvest
903	6b	HSS	HSS	0-20	4,992	
904	6b	HSS	HSS	0-20	5,266	
908	6b	CMS	CMS	20-40	2,861	
Riparian Shade Situation 2: Non-Forestry activities reduced shade below target						
8	5	CMS	CMS	60	4,715	agricultural/homes
9 - 1	5	CMS	CMS	40-70	1,350	agricultural/homes
10	2	CMS	CMS	20	2,384	agricultural/homes
204	9	CMD	CMD	0	4,217	agricultural/homes
404	10a	CSD	CSD	20-40	4,880	channelized
701 - 1	8	HSS	HSS	20-40	2,398	wetland field
701 - 2	8	CMD	CMD	70-90	2,845	wetland field
701 - 3	8	CMS	CMS	0	1,535	wetland field
702 - 2	8	CMS	CMS	45	1,727	agricultural/homes
Riparian Shade Situation 3: Non-fish-bearing Type 4 stream contributing to downstream temperature hazard						
603 - 1	9	CSS	CSS	0-20	2,595	clearcut
710	9	CMS	CMS	0-20	4,168	clearcut
711	9	CSS		0-20	3,911	clearcut

3.4 Confidence in Canopy Closure and Stream Temperature Assessment

Confidence is high for the assessment of shade conditions throughout the basin. Field measurements of shade were made for a high proportion of the channel segments in the WAU. Aerial photos allowed comparisons between stream segments not visited and similar segments where direct shade measurements were made. Estimates of canopy closure from the photos corresponded well with field verification measurements except where shade was initially estimated at 20 - 40%. Canopy closure was verified in the field for these segments and brush proved effective at providing higher shade levels. Confidence is moderate that Type 4 and 5 streams identified as delivering downstream temperature impacts have sufficient flow volumes during critical summer months to significantly affect downstream water temperatures. Many, but not all, of these Type 4 streams were visited. Low flow conditions are highly site specific so extrapolation is limited. Confidence is also only moderate that stream segments assigned a high hazard due to the potential of fish presence under emergency rules actually have fish present in mid to late summer when high water temperatures are possible. The range of temperatures likely to occur in the WAU are not so high as to preclude fish use of a stream segment.

There is 90% confidence that the modified target levels for canopy closure will result in maximum water temperatures not exceeding the water quality standard. This represents a conservative approach to setting target levels. Substantially less shade may be adequate to still meet water quality standards as suggested by the regression line in Figure D-4.

3.5 Monitoring Recommendations

Additional monitoring is recommended to verify target canopy closure levels as modified in this analysis. Thermograph monitoring with more stations deployed would increase the sample size in re-analyzing the multi-regressions for temperature and independent variables of elevation and shade. A minimum of 15 sites is suggested using Table D-11 as a monitoring site selection guide. A range of elevation and canopy closure conditions should be included in the monitoring sites. Air temperature and relative humidity should also be monitored simultaneous with water temperature at hourly recording increments using calibrated, continuous recording thermographs. Even instantaneous single water temperature readings by a hand held mercury thermometer during afternoon hours of a hot summer day between July 15 and August 15 would provide usable data. Newly collected data can be combined with existing data from this report. Shade data should be collected concurrently with temperature monitoring. Sampling sites should have uniform canopy closure levels for a minimum of 1,000 ft upstream of the sampling site. Additional sampling may allow managers to set lower target shade levels according to the regression line with a far narrower confidence interval.

4.0 REFERENCES

Adams, T.A. and K. Sullivan. 1988. The Physics of Forest Stream Heating: A Simple Model. Weyerhaeuser Technical Report, Tacoma,Washington.

Agee, J.K. 1993. Fire Ecology of Pacific Northwest Forests. Island Press. Wash D.C.

Arno, S.F. and D.H. Davis. 1980. Fire history of western redcedar/hemlock forests in northern Idaho. USDA Forest Service, Gen Tech Rep. RM-81. Rocky Mountain Forest and Range Experiment Station. Ft. Collins, CO.

Bartholow, J. 1987. Temperature model technical note no. 6: Stream Reach Solar Model (SRSOLAR) ver. 1.4. USFWS. Ft. Collins, CO.

Caldwell, J.E. and K. Doughty. 1991. Evaluation of downstream temperature effects of type 4/5 waters. WA. Dept. of Natural Resources. TFW-WQ5-91-004. Olympia, WA.

Chance, D.A. and J. Chance. 1991. The Lumber Industry of Washington's Pend Oreille Valley: 1888 - 1941. Colville National Forest Contract 43-05G1-0-4600. Colville, WA.

Chatterjee, S. And B. Price. 1977. Regression Analysis by Example. Wiley Press. New York, NY.

Harlow, W.M., E.S. Harrar, and F.M. White. 1979. Textbook of dendrology. McGraw-Hill Book comopany, New York, NY. 510 pp.

Henderson, J.A., R.D. Lesher, D.H. Peter, and D.C. Shaw. 1992. Field guide to the forested plant associations of the Mt. Baker-Snoqualmie National Forest. USDA Forest Service. Gen Tech Rpt R6-ECOL-TP-028-91. Pacific Northwest Region. Portland, OR

Henderson, J.A., R.D. Lesher, D.H. Peter, and D.C. Shaw. 1989. Forested plant associations of the Olympic National Forest. USDA Forest Service. Gen Tech Rpt R6-ECOL-TP-001-88. Pacific Northwest Region. Portland, OR

Kovalchik, B. 1995. Draft Riparian Plant Associations for the Colville National Forest. Colville, WA.

McDade, M.H., F.J. Swanson, W.A. McKee, J.F. Franklin and J. Van Sickle. 1990. The source area for coarse woody debris in small streams in Western Oregon and Washington. MS thseis, Oregon State Univ. Corvallis, OR.

McIntosh, B.A., J.r. Sedell, J.E. Smith, R.C. Wissmar, S.e. Clarke, G.H. Reeves and L.A. Brown. 1993. Managment history of eastside ecosystems: changes in fish habitat over 50 years, 1935 to 1992. USDA Forest Service. PNW Research Station. Corvalis, OR.

Natural Resources Conservation Service (NRCS). 1982. Soil Survey of Stevens County, Washington. US Dept. Of Agriculture. Colville, WA

Rieman, B.E. and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. Gen. Tech. Rep. INT-302. Intermountain Research Station, US Forest Service.

Routh, J. 1993. Impact of lead-zinc mining on distribution of major and trace elements in water, sediment, and soil in VanStone Mine Stevens County, Washington. Masters Thesis. Eastern Wash. Univ.

Smith, J.K. and W.C. Fishcer. 1995. Fire ecology of the forest habitat types of northren Idaho [Review Draft]. USDA Forest Service, Intermountain Research Station, Ogden, UT.

Stimpson Lumber Company. 1997. Watershed Analysis Report for LeClerc Creek Watershed Administrative Unit, Pend Oreille County, WA. In press.

Sullivan, K. and T.A. Adams, 1988. The Physics of Stream Heating 2): An Analysis of Temperature Patterns in Stream Environments Based on Physical Principles and Field Data. Weyerhaeuser Technical Report.

Sullivan, K., J. Tooley, K. Doughty, J.E. Caldwell, and P. Knudsen, 1990. Evaluation of Prediction Models and Characterization of Stream Temperature Regimes in Washington. TFW-WQ-90-006. Olympia, WA.

Van Sickle, J. and S. Gregory. 1990. Modeling inputs of large woody debris to streams from falling trees. Oregon St. Univ. Corvallis, OR.

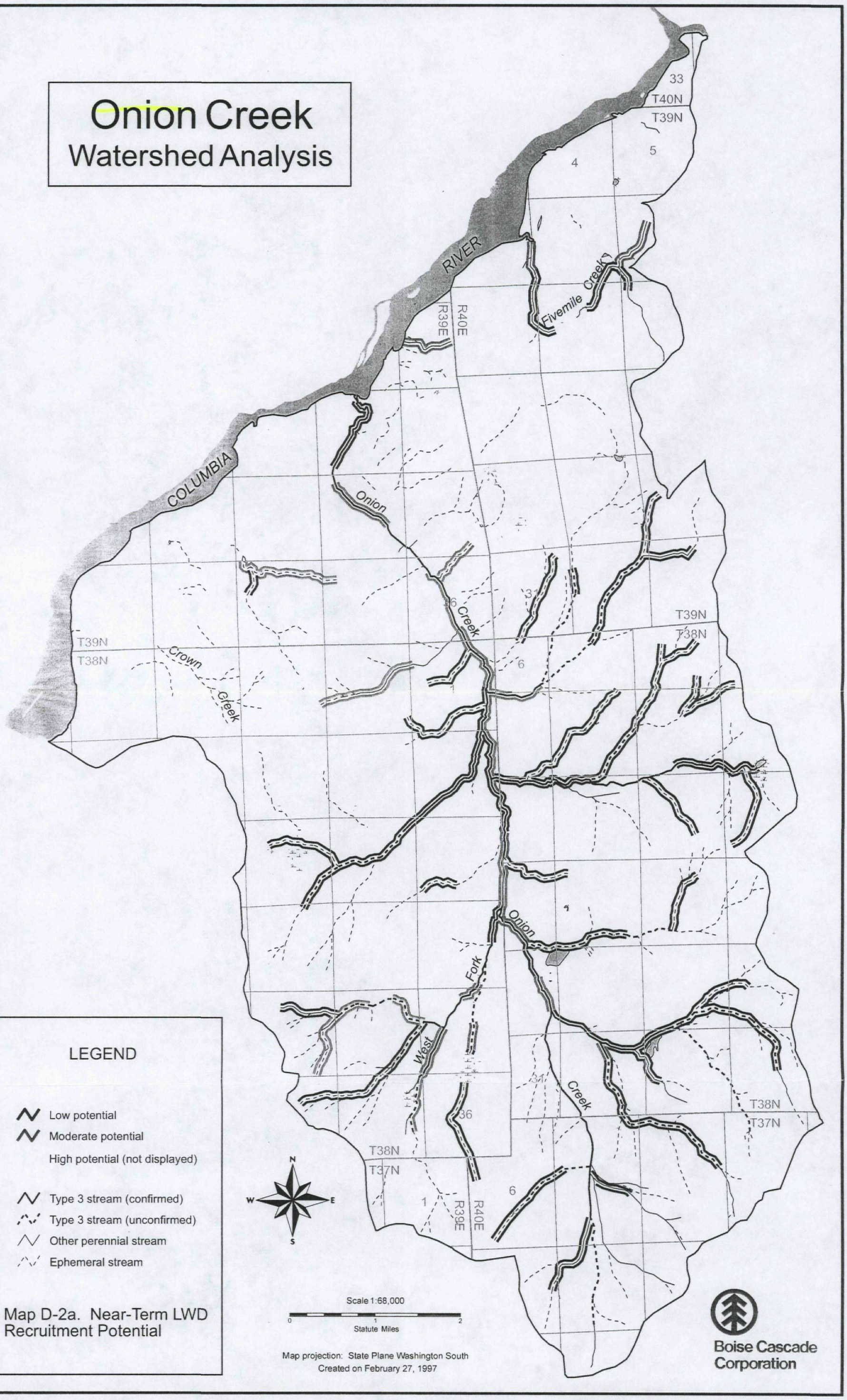
Washington Forest Practices Board (WFPB). 1995a. Board Manual: Standard Methodology for Conducting Watershed Analysis. Ver 3.0 November, 1995. Olympia, WA

Washington Forest Practices Board (WFPB). 1995b. Washington Forest Practices Act: Washington Administrative Code 222. July 1995.

Washington Forest Practices Board (WFPB). 1996. Riparian Function Module of the Board Manual: Standard Methodology for Conducting Watershed Analysis. Ver 3.1 February, 1996. Olympia, WA

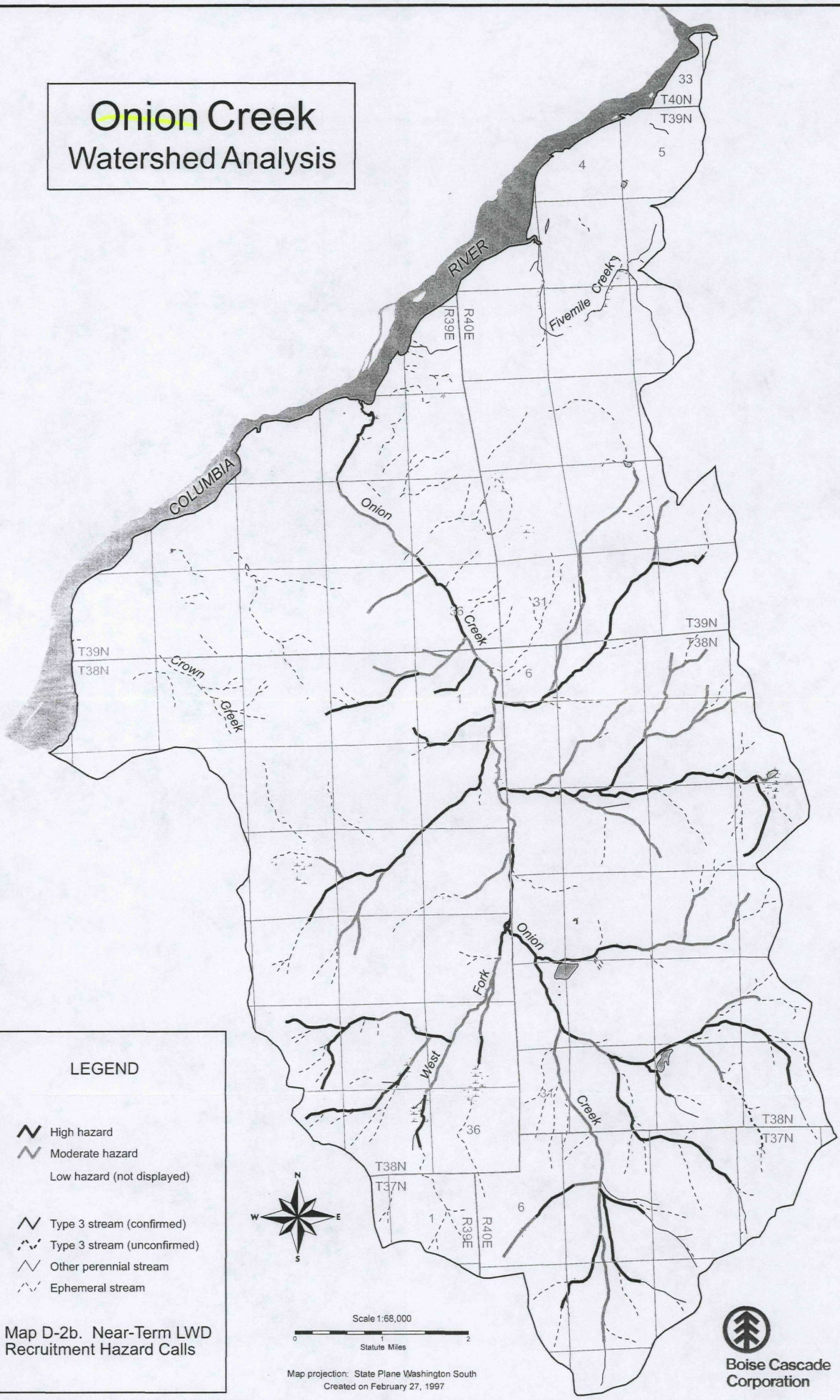
Williams, C.K., B. F. Kelley, B. G. Smith, and T.R. Lillybridge. 1995. Forested Plant Associations of the Colville National Forest. Gen. Tech. Rep. PNW-GTR-360. USDA Forest Service. Colville, WA.

Onion Creek
Watershed Analysis



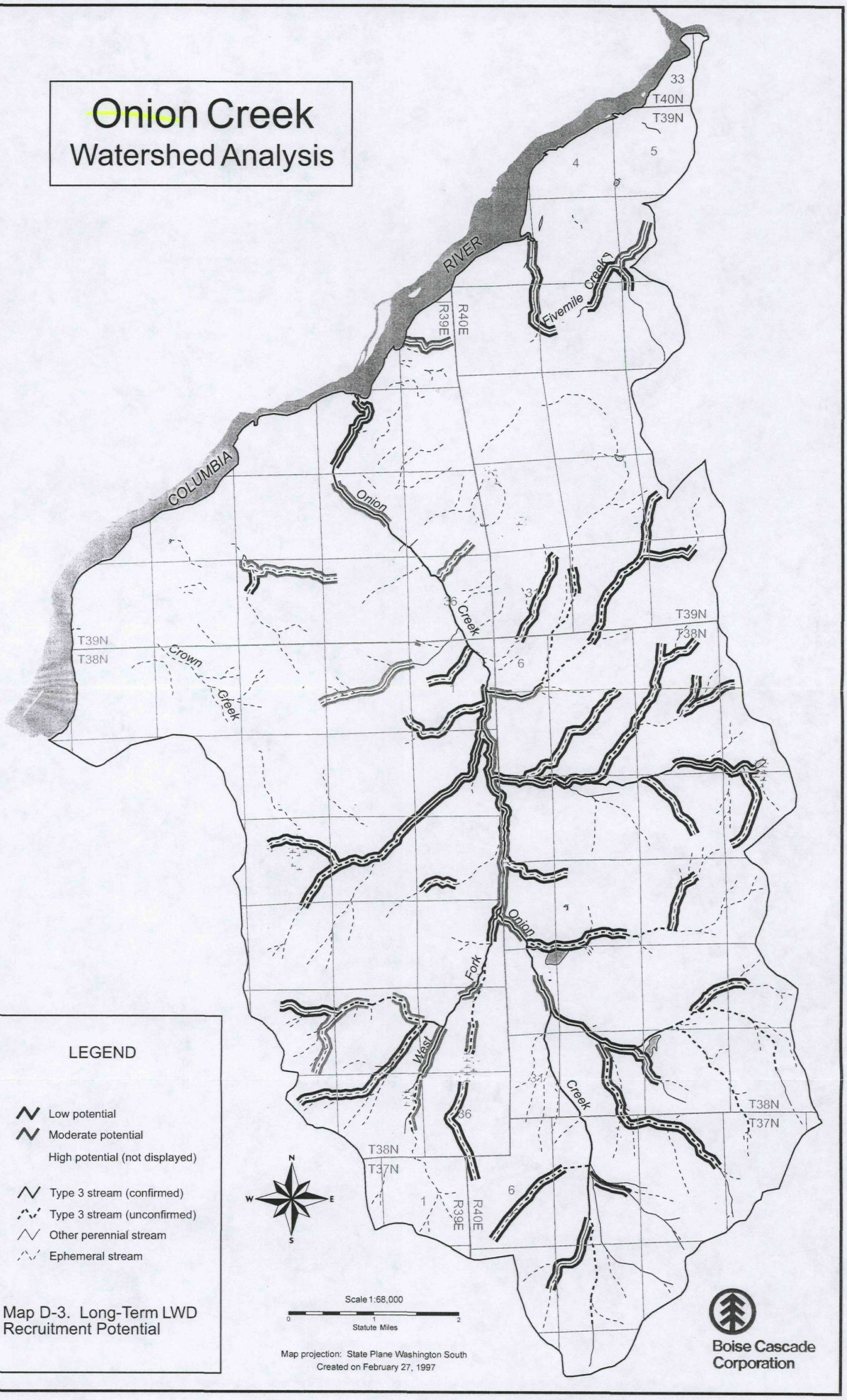
Map D-2a. Near-Term LWD Recruitment Potential

Onion Creek
Watershed Analysis



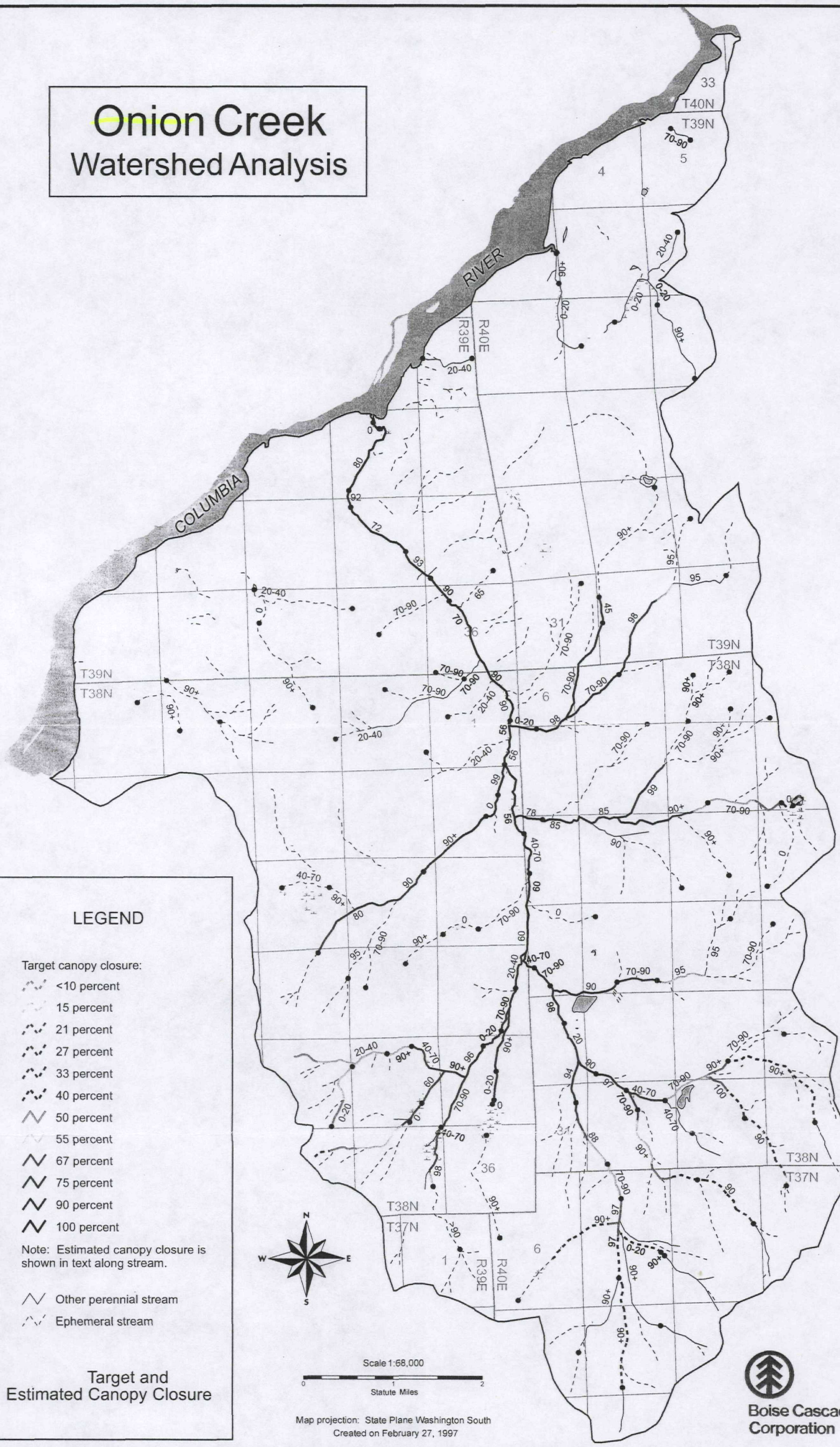
Map D-2b. Near-Term LWD Recruitment Hazard Calls

Onion Creek
Watershed Analysis

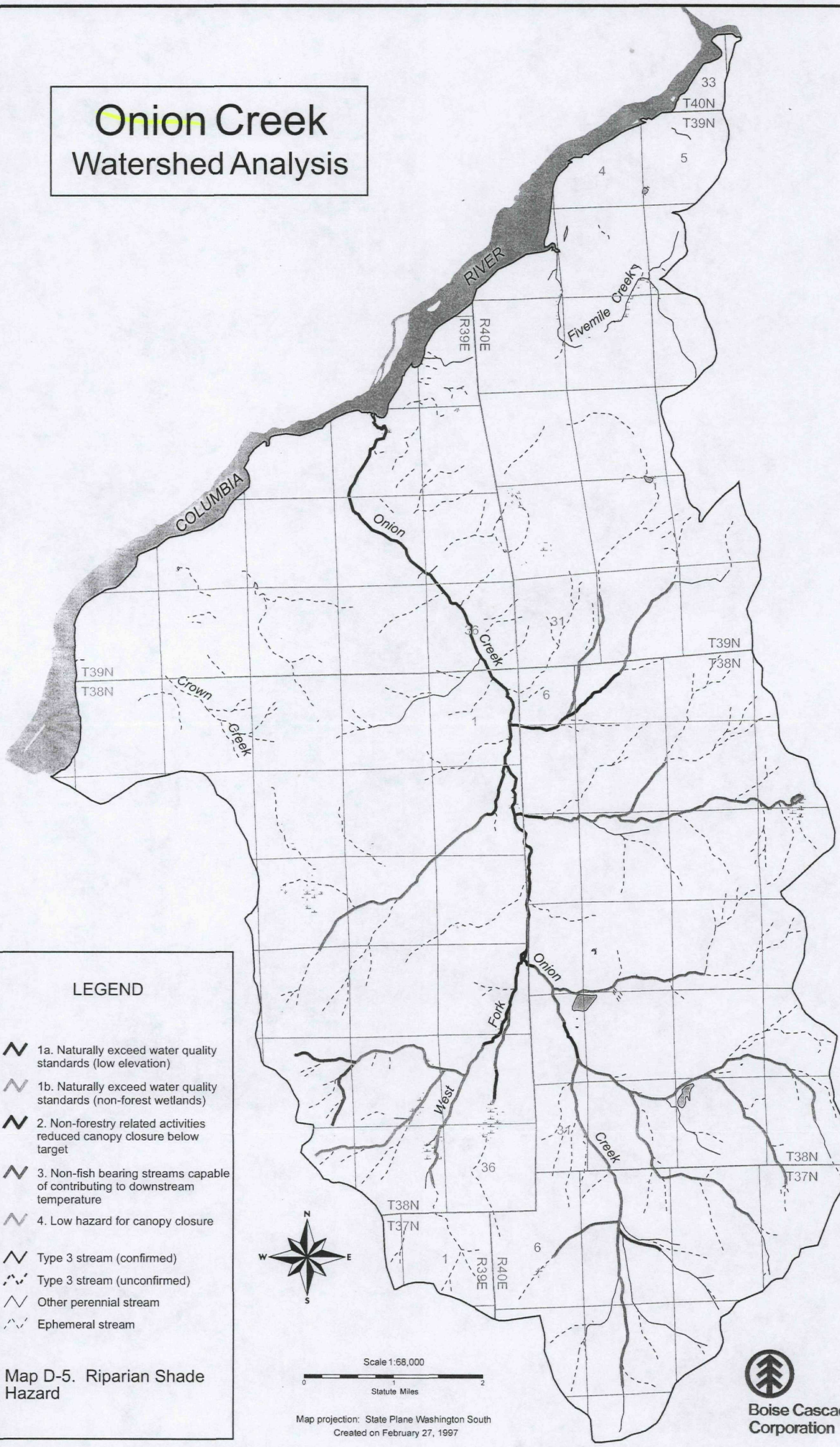


Map D-3. Long-Term LWD Recruitment Potential

Onion Creek
Watershed Analysis



Onion Creek
Watershed Analysis

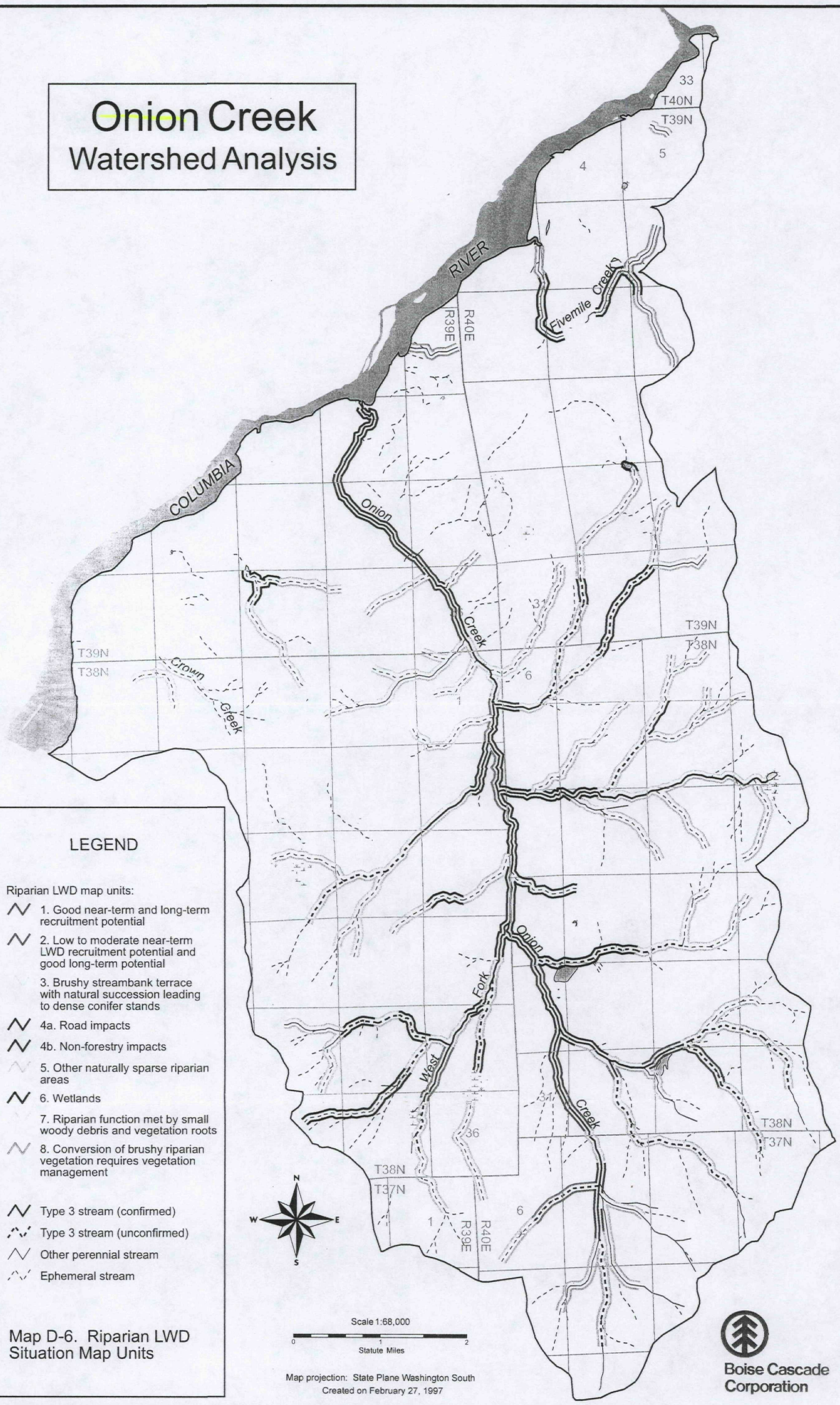


LEGEND

- 1a. Naturally exceed water quality standards (low elevation)
- 1b. Naturally exceed water quality standards (non-forest wetlands)
- 2. Non-forestry related activities reduced canopy closure below target
- 3. Non-fish bearing streams capable of contributing to downstream temperature
- 4. Low hazard for canopy closure
- Type 3 stream (confirmed)
- Type 3 stream (unconfirmed)
- Other perennial stream
- Ephemeral stream

Map D-5. Riparian Shade Hazard

Onion Creek
Watershed Analysis



Map D-6. Riparian LWD Situation Map Units

RIPARIAN SUPPORTING DATA

APPENDIX D-1
Worksheets

Worksheet D-2: Riparian Condition and LWD Recruitment Hazard Calls

				Left Bank (looking downstream)					Right Bank							
						Recruitment Potential					Recruitment Potential					
Riparian Condition Unit	Channel Geomorph Group	Channel Sensitivity	In-Channel LWD Rating	Riparian Code	Riparian Map Unit	Near Term	Long Term	LWD Recruit Call	Riparian Code	Riparian Map Unit	Near Term	Long Term	LWD Recruit Call	LWD Recruit Call	Canopy Closure (%)	Unit Length (ft)
1	1	L	**Poor**		6	low	low	low		6	low	low	low	low	0	603
2	2	M	**Poor**	HSS	4	low	low	high	HSS	4	low	low	high	high	80	5153
3	3	L	**Poor**	CMD	1	high	high	low	CMD	1	high	high	low	low	92	1039
4-1	4	H	**Good**	HMS	3	mod	high	mod	HMS	3	mod	high	mod	mod	72	4386
4-2	4	H	**Good**	CMD	1	high	high	mod	CMD	1	high	high	mod	mod	93	2275
5	5	H	NA	CMD	1	high	high	high	CMD	1	high	high	high	high	90	1763
6	4	H	NA	CMD	4	high	high	high	CMS	4	mod	high	high	high	70	4252
7 - 1	2	M	**Good**	CMD/HSD	3	mod	high	mod	CMD/HS	3	mod	high	mod	mod	90	4533
7 - 2	2	M	**Good**	CMS	4	mod	mod	mod	HSS	4	low	low	mod	mod	56	7610
7 - 3	2	M	**Good**	MSS	4	low	low	mod	MSS	4	low	low	mod	mod	40-70	2703
8	5	H	**Poor**	CMS	4	mod	mod	high	CMS	4	mod	mod	high	high	60	4715
9 - 1	5	H	NA	CMS	4	mod	mod	high	CMS	4	mod	mod	high	high	40-70	1350
9 - 2	5	H	NA	CMS	4	mod	mod	high	CMS	4	mod	mod	high	high	70-90	1448
9 - 3	5	H	NA	CMD	1	high	high	high	CSS	2	low	high	high	high	98	2540
10	2	M	NA	CMS	4	mod	mod	high	CMS	4	mod	mod	high	high	20	2384
50	10b	L	NA	CSS	4	low	low	low	CSS	4	low	low	low	low	0	4743
51	10a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	70-90	4303
52	6b	L	NA		6	low	low	low		6	low	low	low	low	0	2422
53	10b	L	Fair	CMD	7	high	high	low	CMD	7	high	high	low	low	90 +	2896
101	11b	L	NA	CMS	5	mod	mod	high	CMS	5	mod	mod	high	low	65	3287
102	10b	L	Fair	CMD	7	high	high	low	CMD	7	high	high	low	low	70-90	2926
103	10b	L	Fair	CSD	7	low	low	low	CSD	7	low	low	low	low	70-90	6083
104	10a	M	NA	CSS	7	low	low	high	CSS	7	low	low	high	high	20-40	6302
105	10a	M	NA	CSS	7	low	low	high	CSS	7	low	low	high	high	20-40	3825
106	11a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	low	70-90	4023
107	11a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	low	low	70-90	2913
108	11a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	low	mod	70-90	3069
109	11a	M	NA	CMS	7	mod	mod	high	CMS	7	mod	mod	low	low	20-40	6667
110	11a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	low	low	70-90	4641
201 - 1	8	H	NA	CMS	4	mod	mod	high	CMS	4	mod	mod	high	high	0-20	1799
201 - 2	8	H	NA	CMD	7	high	high	high	CMS	7	mod	mod	high	high	98	2141
202 - 1	8	H	**Fair**	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	70-90	6375
202 - 2	8	H	**Fair**	MMS	4	low	low	H	MMS	4	low	low	H	H	45	1622
202 - 3	8	H	**Fair**	CSD	7	low	low	H	CSD	7	low	low	H	H	70	
203 - 1	10a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	90+	8102
203 - 2	6b	L	NA	CMD	6	high	high	low	CMD	6	high	high	low	low	0	
204	9	H	NA	CMD	7	high	high	high	CMD	7	high	high	high	high	70-90	4217
205	8	H	**Fair**	CSD	4	low	low	H	CSD	4	low	low	H	H	98	6604
206	10a	M	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	mod	95	4209
207	9	H	NA	CSD	7	low	low	H	CSD	7	low	low	H	H	95	
301 - 1	9	H	NA	HSS	6	low	low	H	HSS	6	low	low	H	H	78	1717

RCUs with LWD data (counts or observations) are in bold

Worksheet D-2: Riparian Condition and LWD Recruitment Hazard Calls

				Left Bank (looking downstream)					Right Bank							
						Recruitment Potential					Recruitment Potential					
Riparian Condition Unit	Channel Geomorph Group	Channel Sensitivity	In-Channel LWD Rating	Riparian Code	Riparian Map Unit	Near Term	Long Term	LWD Recruit Call	Riparian Code	Riparian Map Unit	Near Term	Long Term	LWD Recruit Call	LWD Recruit Call	Canopy Closure (%)	Unit Length (ft)
301 - 2	9	H	NA	MSD	6	low	low	H	MSD	6	low	low	H	H	85	5017
302	10a	M	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	mod	70-90	8725
303	10a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	90	1922
304	10a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	90	5067
305	8	H	**Poor**	CSD	7	low	low	H	CSD	7	low	low	H	H	99	4391
306	10a	M	Fair	CSD	4	low	low	mod	CSD	4	low	low	mod	mod	70-90	3072
307	10a	M	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	mod	90+	5692
308	10a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	90+	3356
309	10a	M	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	mod	90+	2721
310	10a	M	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	mod	90+	3889
311 - 1	9	H	NA	CMD	7	high	high	high	CMD	7	high	high	high	high	90+	5938
311 - 2	9	H	NA	CSS	7	low	low	H	CSS	7	low	low	H	H	70-90	4878
312	11a	M	Fair	CSD	7	low	low	low	CSD	7	low	low	mod	low	90+	4976
313	10a	M	NA		7	low	low	high		7	low	low	high	high	0	5691
314	6a	M	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	mod	0	837
401	9	H	**Fair**	MSD	6	low	low	H	MSD	6	low	low	H	H	90	4208
402 - 1	8	H	NA	MSD	6	low	low	H	MSD	6	low	low	H	H	70-90	2421
402 - 2	8	H	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	95	2992
403	10a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	70-90	5940
404	10a	M	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	mod	95	4880
501	7	H	**Poor**	MSS	4	low	low	H	MSS	4	low	low	H	H	90	1419
502	8	H	**Good**	CMD	4	high	high	mod	CSS	4	low	low	mod	mod	97	2139
503	8	H	Fair	MSD	7	low	low	H	MSD	7	low	low	H	H	40-70	2453
504	10a	M	NA	CSS	7	low	low	high	CSS	7	low	low	high	high	40-70	2899
505	9	H	NA	CSD	2	low	high	H	CSD	2	low	high	H	H	70-90	2758
506	9	H	**Fair**	CMD	1	high	high	mod	CMD	1	high	high	mod	mod	100	3692
507	9	H	NA	MSD	3	low	high	H	MSD	3	low	high	H	H	90+	9302
508	10a	M	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	mod	70-90	4111
509	9	H	**Fair**	CMS	8	mod	mod	mod	CMS	8	mod	mod	mod	mod	70-90	1164
510 - 1	9	H	NA	CSD	7	low	low	H	CSD	7	low	low	H	H	90+	5326
510 - 2	9	H	NA	CSD	7	low	low	H	CSD	7	low	low	H	H	90+	1528
511	9	H	NA	CSD	7	low	low	H	CSD	7	low	low	H	H	90	4511
512	10b	L	Fair	CMD	7	high	high	low	CMD	7	high	high	low	low	90	4992
601	7	H	**Fair**	CMD	1	high	high	mod	CMD	1	high	high	mod	mod	94	2676
602 - 1	9	H	**Good**	CMD	1	high	high	mod	CMD	1	high	high	mod	mod	88	4286
602 - 2	9	H	NA	MMD	3	high	high	mod	MMD	3	high	high	mod	mod	70-90	2282
602 - 3	9	H	**Good**	CLD	1	high	high	mod	CLD	1	high	high	mod	mod	97	4718
603 - 1	9	H	NA	CSS	7	low	low	H	CSS	7	low	low	H	H	0-20	2595
603 - 2	9	H	NA	CMD	7	high	high	high	CMD	7	high	high	high	high	90+	295
604	9	H	NA	CMD	7	high	high	high	CMD	7	high	high	high	high	90+	6388
605	9	H	Good	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	90+	6709

RCUs with LWD data (counts or observations) are in bold

Worksheet D-2: Riparian Condition and LWD Recruitment Hazard Calls

				Left Bank (looking downstream)					Right Bank							
						Recruitment Potential					Recruitment Potential					
Riparian Condition Unit	Channel Geomorph Group	Channel Sensitivity	In-Channel LWD Rating	Riparian Code	Riparian Map Unit	Near Term	Long Term	LWD Recruit Call	Riparian Code	Riparian Map Unit	Near Term	Long Term	LWD Recruit Call	LWD Recruit Call	Canopy Closure (%)	Unit Length (ft)
606	9	H	NA	CSD	7	low	low	H	CSD	7	low	low	H	H	90+	5563
607-1	9	H	Fair	CMD	8	high	high	mod	CMD	8	high	high	mod	mod	90+	1610
607 - 2	9	H	Fair	CSD	8	low	low	H	CSD	8	low	low	H	H	90+	3101
608	10a	M	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	mod	90+	3215
701 - 1	8	H	Fair	HSS	4	low	low	H	HSS	4	low	low	H	H	20-40	2398
701 - 2	8	H	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	70-90	2845
701 - 3	8	H	Fair	CMS	4	mod	mod	mod	CMS	4	mod	mod	mod	mod	0-20	1535
701 - 4	8	H	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	96	2211
702 - 1	8	H	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	90+	3920
702 - 2	8	H	NA	CMS	4	mod	mod	high	CMS	4	mod	mod	high	high	0-20	1727
702 - 3	8	H	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	90+	
702 - 4	8	H	NA	CMS	4	mod	mod	high	CMS	4	mod	mod	high	high	0-20	
703	6b	L	NA		4	low	low	low		4	low	low	low	low	0	265
704	11b	L	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	low	90+	6755
705 - 1	7	H	Good	HMD	8	mod	mod	mod	HMD	8	mod	mod	mod	mod	70-90	3377
705 - 2	7	H	Good	CMS	2	mod	high	mod	CMD	1	high	high	mod	mod	40-70	391
706	6a	M	NA	CMS	7	mod	mod	high	CMD	7	high	high	high	high	98	2447
707	9	H	NA	CMD	7	high	high	high	CMD	7	high	high	high	high	90+	1332
708 - 1	8	H	NA	CMD/MSS	6	mod	mod	high	CMD/MS	6	mod	mod	high	high	40-70	2771
708 - 2	8	H	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	90+	1605
709	6a	M	NA	CMS	6	mod	mod	high	CMS	6	mod	mod	high	high	20-40	2316
710	9	H	NA	CMS	7	mod	mod	high	CMS	7	mod	mod	high	high	0-20	4168
711	9	H	Fair		7	low	low	H		7	low	low	H	H		3911
712 - 1	6a	M	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	mod	60	2362
712 - 2	6a	M	NA	CSS	6	low	low	high	CSS	6	low	low	high	high	0	1346
712 - 3	6a	M	NA	MSS	6	low	low	high	MSS	6	low	low	high	high	0	5559
801 - 1	8	H	NA	MSD	4	low	low	H	MSD	4	low	low	H	H	99	1905
801 - 2	8	H	Poor		4	low	low	H		4	low	low	H	H	0	1725
801 - 3	8	H	Fair	CSD	7	low	low	H	CSD	7	low	low	H	H	90+	5018
801 - 4	8	H	NA	MSS	7	low	low	H	MSD	7	low	low	H	H	90	2346
802	10a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	70-90	5828
803	8	H	Good	MSD	7	low	low	H	MSD	7	low	low	H	H	80	6213
804	10a	M	Fair	CSD	7	low	low	mod	CSD	7	low	low	mod	mod	90+	2096
805	6b	L	NA	CSD	7	low	low	low	CSD	7	low	low	low	low	40-70	2978
806	10a	M	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	95	2604
901	11b	L	Fair	MMD	7	high	high	mod	MMD	7	high	high	mod	low	70-9 0	1426
902	11a	M	Fair	HMD	7	mod	mod	low	HMD	7	mod	mod	low	low	90+	1883
903	6b	L	NA	HSS	6	low	low	low	HSS	6	low	low	low	low	0-20	4992
904	6b	L	NA	HSS	4	low	low	low	HSS	4	low	low	low	low	0-20	5266
905	11b	L	NA	CMS	5	mod	mod	high	CMS	5	mod	mod	high	low	20-40	3688
906	10b	L	Fair	CMD	7	high	high	low	CMD	7	high	high	low	low	90+	9167

RCUs with LWD data (counts or observations) are in bold

Worksheet D-2: Riparian Condition and LWD Recruitment Hazard Calls

				Left Bank (looking downstream)					Right Bank							
						Recruitment Potential					Recruitment Potential					
Riparian Condition Unit	Channel Geomorph Group	Channel Sensitivity	In-Channel LWD Rating	Riparian Code	Riparian Map Unit	Near Term	Long Term	LWD Recruit Call	Riparian Code	Riparian Map Unit	Near Term	Long Term	LWD Recruit Call	LWD Recruit Call	Canopy Closure (%)	Unit Length (ft)
907	10b	L	NA	CMS	5	mod	mod	low	CMS	5	mod	mod	low	low	20-40	3338
908	6b	L	NA	CMS	4	mod	mod	low	CMS	4	mod	mod	low	low	20-40	2861
909	10b	L	NA	CMS	7	mod	mod	low	CMS	7	mod	mod	low	low	20-40	4030
910	10b	L	NA		4	low	low	low		4	low	low	low	low	0	1855
911	11b	L	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	low	90+	6439
912	11b	L	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	mod	90+	4112
913	11b	L	Fair	CMD	7	high	high	mod	CMD	7	high	high	mod	low	90+	4411

RCUs with LWD data (counts or observations) are in bold

WORKSHEET D-4
Additional Information Riparian Condition Summary

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
1	B	0	0	•	•			No trees; Seasonally wet and does not support tree growth.
2	B	HSS	80	•	•			Agriculture - narrow strip of hardwoods along channel with few PIPO on R.B.
3	B	CMD	92	•	•		•	Patchy Hardwoods
4-1	B	HMS	72	•	•			Field areas interspersed with confier forest - some brush along stream banks. Historically harvested cedar stumps. Past beaver activity
4-2	B	CMD	93	•	•			Some brush and hardwoods along stream banks. Hardwoods succeeding to cedar. Windthrow is main recruitment mechanism.
5	B	CMD	90			•	•	Mixed age; slightly smaller trees on L.B. THPL PSME with LAOC indicating historically burned.
6	L	CMD	70					
6	R	CMS	70			•		Brush along channel. Mature conifers scattered and in patches along edge of 75 ft corridor. Roads on both banks affect riparian species composition and reduce LB recruitment potential.

[1]L=Left bank, R=Right Bank, B=Both banks [2]See Table 1 Appendix D for LWD codes
[3]Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
7 - 1	B	CMD HSD	90	•	•			Alder/brush in 25' wide floodplain L.B. Selective harvesting within RMZ but still sufficient >12"dbh conifers. Mixed age stand. 20 ft wide floodplain vegetated mostly with 4" alder but also cedar seedlings Left bank historically harvested as evidenced by cedar stumps. Soil creep on left bank hillslope causes recruitment as well as light windthrow.
7 - 2	L	CMS	56					
7 - 2	R	HSS	56	•	•			Agricultural/homes fields pasture on R.B. Cattle impacts to banks and vegetation; brushy, soil only limits conifers on RB; LB good recruitment potential from hillslope. Chewelah soil type; wet soil with high wind throw; not suitable for conifer.
7 - 3	B	MSS	40-70			•		Agricultural/homes fields/Residential. Some partial harvest. Cedar/spruce habitat. Light grazing with recent fencing. Left bank spruce 12"dbh with cedar at 8-11 in. dbh replacing shrubs.
8	B	CMS	60	•	•			Mixed age stand, agriculture impacts and recent selective harvesting by tractor. Some hardwoods. Landowner riparian enhancement efforts observed; floodplain replanted in conifer (blue spruce)
9 - 1	B	CMS	40-70			•		Agricultural/homes fields impacts
9 - 2	B	CMS	70-90			•		Agricultural/homes fields impacts

[1]L=Left bank, R=Right Bank, B=Both banks [2]See Table 1 Appendix D for LWD codes
[3]Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
9 - 3	L	CMD	98	•	•			Multi-age selective harvest; most trees 8 - 11 inch dbh parallel railroad grade (roadbed?) reduces RB density but revegetating with hemlock, douglas fir and cedar.
9 - 3	R	CSS						
10	B	CMS	20					Agricultural/homes fields impact; almost no riparian vegetation. Small section of CMD on LB.
50	B	CSS	0					Agricultural/homes fields; no riparian vegetation. Maybe small trees.
51	B	CMD	70-90					
52	B		0					Agricultural/homes fields; stream channelized and ponded. No riparian vegetation. Wetland.
53	B	CMD	90 +					Clumped multi-age stand is adequate for channel size.
101	B	CMS	65			•		Naturally open - south slope rocky.
102	B	CMD	70-90			•		Selective logging for 600' above road.
103	B	CSD	70-90					Selective logging; mixed age stand.
104	B	CSS	20-40			•		Selective logging; 8 - 11' conifer sparse.
105	B	CSS	20-40	•	•			Selective logging; sufficient seedlings and saplings to regenerate.
106	B	CMD	70-90			•		

[1]L=Left bank, R=Right Bank, B=Both banks [2]See Table 1 Appendix D for LWD codes
[3]Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
107	B	CMD	70-90			•		Mixed age.
108	B	CMD	70-90					
109	B	CMS	20-40					Selective logging.
110	B	CMD	70-90			•		Older selective logging.
201 - 1	B	CMS	0-20			•		Residential and road impacts; a few scattered trees.
201 - 2	L	CMD	98	•	•			Good conifer stand - some smaller trees mixed in.
201 - 2	R	CMS		•	•			Road is adjacent to stream channel.
202 - 1	B	CMD	70-90	•	•			Road is limiting some recruitment potential. floodplain and hillslope succeeding to ABGR/THPL. Root rot is main recruitment mechanism. Lodgepole pine dying out and recruiting to channel. Narrow floodplain with wet soil.
202 - 2	B	MMS	45			•		Home site and fields. Root rot killing PSME and PIEN.
202 - 3	B	CSD	70			•		Cedar 8 - 11" dbh selective harvest thinning.
203 - 1	B	CMD	90+			•		Stream bed used as road.
203 - 2	B	CMD						Pond partially dry.
204	B	CMD	70-90					Some selective harvesting.

[1]L=Left bank, R=Right Bank, B=Both banks [2]See Table 1 Appendix D for LWD codes
[3]Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
205	B	CSD	98	•	•			Some agricultural/homes fields/fields; densely stocked mixed age; 8 - 11" dbh PSME and ABGR. Hardwoods dying naturally due to age. Windthrow is main recruitment. Selective harvesting with narrow RMZ.
206	B	CSD	90+					Trees are clumped; selective logging.
207	B	CSD	90+					Trees are clumped; selective logging.
301 - 1	B	HSS	78		•	•		Agricultural/homes fields; brush along stream.
301 - 2	B	MSD	85		•	•		Agricultural/homes fields - Some Hardwoods; small pond; most trees 8 - 11" dbh.
302	B	CSD	70-90					
303	B	CMD	90		•	•		Patchy stands of small/medium conifers (plantation).
304	B	CMD	90		•	•		Channel dry 10/2/96; wide alluvial poorly defined channel but definitely flows most of year.
305	B	CSD	99	•	•			Multi-age stand. Recent harvest reduced size and density. Most trees 6-9" dbh
306	B	CSD	70-90			•		Agricultural/homes fields. Selective harvest; trees in clumps.
307	B	CSD	90+					
308	B	CMD	90+					
309	B	CSD	90+					Trees in clumps 8 - 11" dbh
310	B	CSD	90+					

[1]L=Left bank, R=Right Bank, B=Both banks [2]See Table 1 Appendix D for LWD codes
[3]Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
311 - 1	B	CMD	90+			•		Some over story 8 - 11"; THPL (Cedar rust infiltration) LAOC PSME.
311 - 2	B	CSS	70-90					Selective harvest.
312	B	CSD	90+					
313	B							No channel segment number on map.
314	B	CSD						Some open areas to edge of pond; selective cutting? Denser stand on east end of pond.
401	B	MSD	90	•	•			Some impact from road location. Some LAOC; historic burn. Mostly 8 - 11" dbh; PSME and THPL. Some PICO. 30% small POTR. Good seedling density of conifers will succeed to THPL/ABGR.
402 - 1	B	MSD	70-90			•		Agricultural/homes fields and wet soils at upper end. Plantings of conifers are becoming established but likely will remain mixed riparian stands through fields.
402 - 2	B	CMD	95	•	•			Well stocked multi-age stand
403	B	CMD	70-90					Channel
404	B	CSD	95	•	•			Soils limit lower end.
501	B	MSS	90	•	•			Dense small alders and 30% small conifer (PSME and THPL). Roads on both sides of stream limit recruitment (LB road not in use).
502	L	CMD	97	•	•			Mostly 8 - 11" dbh with 20% ≥ 12" dbh; mostly cedar with some PSME steep hill slope.

[1]L=Left bank, R=Right Bank, B=Both banks [2]See Table 1 Appendix D for LWD codes
[3]Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
502	R	CSS		•				Road limits riparian.
503	B	MSD	40-70					Small trees in flood plain; cleared for home site. Some larger trees on edge; alder and THPL.
504	B	CSS	40-70					Selective harvest; will become dense in time.
505	B	CSD	70-90			•		Some larger recruitable conifer on hill slope.
506	B	CMD	100	•	•			Selective harvesting.
507	B	MSD	90+			•		Good recruitable conifer on edge PSME POTR and THPL most conifer 8 - 11"dbh with many larger trees. Eventually POTR will be shaded out as RMZ recovers from harvest and past channel disturbances.
508	B	CSD	70-90					Patchy, selective harvest; some clumps close to 12".
509	B	CMS	70-90			•		Home site and selective harvest. Historic and recent harvest. Dense small alder with sparse medium conifers (THPL and PSME).
510 - 1	B	CSD	90+					Well stocked stand.
510 - 2	B	CSD	90+			•		Lodge-pole; densely stocked PSME and Larch.
511	B	CSD	90					
512	B	CMD	90					
601	B	CMD	94	•	•		•	Selective harvest

[1]L=Left bank, R=Right Bank, B=Both banks [2]See Table 1 Appendix D for LWD codes
[3]Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
602 - 1	B	CMD	88	•	•			Mixed age; selective harvest; PSME THPL 6 - 10" dbh.
602 - 2	B	MMD	70-90			•		Home site, historical selective harvest and past beaver activity.
602 - 3	B	CLD	97	•	•			Well stocked stand.
607- 1	B	CMD	90+			•		Dense stocking.
607 - 2	B	CSD	90+			•		Conifer are dominant but some hardwoods; a few over story trees.
603 - 1	B	CSS	0-20			•		Plantation; recent clearcut.
603 - 2	B	CMD	90+					
604	B	CMD	90+					Headwater type 5 streams.
605	B	CMD	90+					Headwater type 5 streams.
606	B	CSD	90+					Dense lodge-pole stand.
608	B	CSD	90+					
701 - 1	B	HSS	20-40			•		Agricultural/homes fields.
701 - 2	B	CMD	70-90			•		
701 - 3	B	CMS	0-20			•		Agricultural/homes fields.
701 - 4	B	CMD	96	•	•			Selective harvests for homesite.

[1]*L=Left bank, R=Right Bank, B=Both banks* [2]*See Table 1 Appendix D for LWD codes*
[3]*Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data*

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
702 - 1	B	CMD	90+			•		
702 - 2	B	CMS	0-20			•		Field.
702 - 3	B	CMD	90+			•		
702 - 4	B	CMS	0-20			•		Field.
703	B					•		Wetland Field.
704		CSD	90+					Dry channel road crossing. Poorly defined channel tight to moderate confined draw. Very slight channel expression gravelly, some large angular cobbles in soil.
705 - 1	B	HMD	70-90					No stereo coverage.
705 - 2	L	CMS	40-70					Selective logging.
705 - 2	R	CMD	40-70					Selective logging. 20 ft wide RMZ with larger conifer grades into small (8-11" dbh conifer)
706	L	CMS	98	•	•			
706	R	CMD		•	•			RMZ mixed-age; densely stocked some PSME and lodge-pole outside of RMZ but within 75'.
707	B	CMD	90+					

[1]L=Left bank, R=Right Bank, B=Both banks [2]See Table 1 Appendix D for LWD codes
[3]Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
708 - 1	B	CMD/ MSS	40-70					Small patches of trees along stream below farm. Some ponded water, dense stand of recruitable conifer along edge.
708 - 2	B	CMD	90+					Some selective harvest; patches of smaller trees.
709	B	CMS	20-40					Some selective harvest; beaver ponds; adjacent clearcut. PSME and ABGR most trees 8 - 11" dbh with some larger surrounding beaver pond.
710	B	CMS	0-20					Recent clearcut; a few trees left along channel.
711								
712 - 1	B	CSD	60					8 - 11" trees left from selective harvest.
712 - 2		CSS		•				Beaver pond wetlands.
712 - 3	B	MSS				•		Recent harvest; channel weakly defined. POTR and sparse medium conifers.
801 - 1	B	MSD	99	•	•			8 - 11" conifers; road impacting recruitment; small hardwoods.
801 - 2	B		0	•	•			Agricultural/homes fields; stream has been channelized along fence and road. No cover except grass.
801 - 3	B	CSD	90+			•		Dense stand; PICO, PSME, LAOC.
801 - 4	L	MSS	99	•	•			Selective cutting; buffer strip 25' wide on LB, wider on RB.
801 - 4	R	MSD		•				

[1]L=Left bank, R=Right Bank, B=Both banks [2]See Table 1 Appendix D for LWD codes
[3]Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
802	B	CMD	70-90			•		Small LWD functional, some selective harvest. Resident said flow is intermittent, flowing at road 10/01/96 spring fed just above. est. 20% conifers ≥ 12" dbh; some hardwoods.
803	B	MSD	80	•	•			Mostly smaller 8 - 11" dbh conifer with hardwoods. Spring board cedar stumps; recent selective harvest.
804	B	CSD	90+			•		Channel is dry but well defined, angular pea gravel substrates, PSME, PICO, LAOC very dense stocking.
805	B		40-70			•		drained wetland pasture
806	B	CMD	95			•		
901	B	MMD	70-9 0					
902	B	HMD	90+					
903	B	HSS	0-20					Canyon with wide flood plain; few trees. Grazing
904	B	HSS	0-20					Agricultural/homes fields.
905	B	CMS	20-40					Naturally open.
906	B	CMD	90+					Deep Canyon, dense conifer stand in bottom un- cut.
907	B	CMS	20-40					Selective logging, naturally sparse on bluffs above river.
908	B	CMS	20-40			•		Agricultural/homes fields impact; selective logging.

[1]L=Left bank, R=Right Bank, B=Both banks [2]See Table 1 Appendix D for LWD codes
[3]Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data

Riparian Segment	Bank[1]	LWD Code[2]	% Shade	Field Check[3] P	S	R	W	Comment
909	B	CMS	20-40					Selective logging.
910	B		0			•		Channel undefined
911	B	CMD	90+					Un-cut stand.
912	B	CMD	90+			•		Un-cut dense stocking.
913	B	CMD	90+			•		

[1]L=Left bank, R=Right Bank, B=Both banks [2]See Table 1 Appendix D for LWD codes
[3]Field codes: P = riparian plot data, s = shade data, R = reconnaissance, W = LWD data

APPENDIX D-2
Riparian Field Survey Data

Stream			Date			10/1/96
Seg	4		Analyst			KD
Bank	L		WAU			Onion
plot #	2	plot radius ovsty=16.7' seedlng=11.8'				
dist to channel (ft)						
Bnkfl channel width (ft)						
community	THPL, Yew					
slope			photo#			
aspect			%shade			
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
THPL				19.8
THPL				19.8

overstory tree tally

	species						
dbh (in)	THPL	POTR	PSME				trees/ac
1-2.9	6						300
3-7.9	5						250
8-11.9							
12-15.9		1					50
16-19.9	1						50
20-27.9							
28-31.9							
>32							
seedlings	15		1				800
trees/acre	2100	50	100				
disease?							
comments							

Stream			Date				10/1/96
Seg	4		Analyst				KD
Bank	L		WAU				Onion
plot #	1	plot radius ovsty=16.7' seeding=11.8'					
dist to channel (ft)		20					
Bnkfl channel width (ft)							
community	THPL Mixed terrace and slope						
slope			photo#				
aspect			%shade				92
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):	
THPL		107		21.6	Out of plot
PSME					

overstory tree tally

dbh (in)	THPL	PSME	POTR	TABR/ye			trees/ac
	species						
1-2.9	2			3			250
3-7.9	3	2		3			400
8-11.9	1	1					100
12-15.9	1	2	2				250
16-19.9		1					50
20-27.9							
28-31.9							
>32							
seedlings	2			1			150
trees/acre	550	300	100	400			
disease?							
comments							

Stream			Date			10/1/96
Seg	4		Analyst			KD
Bank	R		WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'				
dist to channel (ft)	22.5					
Bnkfl channel width (ft)	20					
community	Terrace THPL Yew, Alder shrubs					
slope	flat		photo#			
aspect		Oregon grape	%shade			
soil	silt loam	sedges				

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
THPL				

overstory tree tally

	species						
dbh (in)	THPL	TABR					trees/ac
1-2.9							
3-7.9		6					300
8-11.9	1						50
12-15.9	2						100
16-19.9	1						50
20-27.9							
28-31.9							
>32							
seedlings							
trees/acre	200	300					
disease?							
comments							

Stream			Date			9/30/96
Seg	4 - 1		Analyst			KD
Bank	R		WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'				
dist to channel (ft)		20				
Bnkfl channel width (ft)		28.5				
community	POTR White alder, Dogwood, Snowberry, Bent grass					
slope			photo#			
aspect			%shade			
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
THPL				17.2

overstory tree tally

species

dbh (in)	THPL	ALRH	POTR				trees/ac
1-2.9							
3-7.9		3	1				200
8-11.9							
12-15.9							
16-19.9	1						50
20-27.9							
28-31.9							
>32							
seedlings		8	1				450
trees/acre	50	950	150				

disease?

past beaver activity

historically harvested cedar stumps

Stream			Date			9/30/96
Seg	4 - 1		Analyst			KD
Bank	L		WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'				
dist to channel (ft)		25				
Bnkfl channel width (ft)						
community	Snowberry, Flood plain, Bent grass					
slope			photo#			
aspect			%shade			72
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

species

dbh (in)	POTR						trees/ac
1-2.9							
3-7.9	1						50
8-11.9	1						50
12-15.9							
16-19.9	1						50
20-27.9							
28-31.9							
>32							
seedlings	2						100
trees/acre	350						
disease?							
comments							

Stream			Date				
Seg	4 - 1		Analyst			KD	
Bank	L		WAU			Onion	
plot #	2	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community							
slope			photo#				
aspect			%shade				
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	THPL	POTR	ALRU				trees/ac
1-2.9							
3-7.9	1		1				100
8-11.9		2					100
12-15.9		1					50
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings		many					
trees/acre	50	150	50				
disease?							
comments							

Stream				Date			
Seg	4 - 2			Analyst			KD
Bank	R			WAU			Onion
plot #	1	plot radius ovsty=16.7' seeding=11.8'					
dist to channel (ft)		20					
Bnkfl channel width (ft)							
community							
slope				photo#			
aspect				%shade			93
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
THPL				18.1
POTR				15.2
THPL				18

overstory tree tally

species

dbh (in)	THPL	POTR					trees/ac
1-2.9							
3-7.9	6						300
8-11.9	2	2					200
12-15.9	1	2					150
16-19.9	2						100
20-27.9							
28-31.9							
>32							
seedlings	31						1550
trees/acre	3650	200					
disease?							
comments							

Stream				Date			
Seg	4 - 2			Analyst			KD
Bank	R			WAU			Onion
plot #	2	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community	Oregon Grape, Open floor, THPL, Ginger						
slope				photo#			
aspect				%shade			
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
THPL	88'			33.7
THPL	175@45dgs	140@20d		

overstory tree tally

species

dbh (in)	THPL						trees/ac
1-2.9							
3-7.9	8						400
8-11.9	2						100
12-15.9	2						100
16-19.9							
20-27.9							
28-31.9							
>32	1						50
seedlings	13						650
trees/acre	1950						
disease?							
comments							

Stream				Date			
Seg	4 - 2			Analyst			KD
Bank	L			WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community	Wild ginger, Trillium						
slope				photo#			
aspect		Open under story		%shade			
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
THPL		75		32
THPL		110		36
		est 12" dia		

overstory tree tally

	species						
dbh (in)	THPL	POTR					trees/ac
1-2.9							
3-7.9	2	2					200
8-11.9	1						50
12-15.9	3						150
16-19.9							
20-27.9							
28-31.9	1						50
>32							
seedlings	13						650
trees/acre	1650	100					

disease?

comments

Stream				Date			
Seg	7 - 1			Analyst			KD
Bank	R			WAU			Onion
plot #	1	plot radius ovsty=16.7' seeding=11.8'					
dist to channel (ft)		20					
Bnkfl channel width (ft)							
community	PMSE, THPL						
slope				photo#			
aspect				%shade			90
soil							

5 lrgst trees (not confined to plot)

spc:	H@ 12' dia	hieght (ft):		dbh (in):
PSME	50	95		19.2
THPL		96		28

overstory tree tally

dbh (in)	THPL	PSME	Alder				trees/ac
1-2.9	6		3				450
3-7.9							
8-11.9		4					200
12-15.9	1	1					100
16-19.9		1					50
20-27.9	1						50
28-31.9							
>32							
seedlings	3	4					350
trees/acre	700	700	150				
disease?							
comments							

Stream			Date				
Seg	7 - 1		Analyst			KD	
Bank	L		WAU			Onion	
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		35					
Bnkfl channel width (ft)							
community	Hillslope, vine maple, Little understory						
slope			photo#				
aspect		PSME, THPL	%shade				
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
PSME				25
THPL				18.5
PSME				15

overstory tree tally

species

dbh (in)	PSME	THPL					trees/ac
1-2.9	1	1					100
3-7.9	2	7					450
8-11.9	2						100
12-15.9	1						50
16-19.9		1					50
20-27.9	1						50
28-31.9							
>32							
seedlings							
trees/acre	350	450					
disease?							
comments							

Stream			Date			
Seg	7 - 1		Analyst			KD
Bank	L		WAU			Onion
plot #	2	plot radius ovsty=16.7' seeding=11.8'				
dist to channel (ft)						
Bnkfl channel width (ft)						
community	Flood plain, Alder, Gooseberry, Equestern Dogwood					
slope			photo#			
aspect			%shade			
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

species

dbh (in)	Alder	THPL	PSME				trees/ac
1-2.9	4	1					250
3-7.9	5						250
8-11.9							
12-15.9							
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings		3	2				250
trees/acre	450	350	200				
disease?							
comments							

Stream				Date			
Seg	7 - 2			Analyst			KD
Bank				WAU			Onion
plot #		plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community							
slope				photo#			
aspect				%shade			56
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)							trees/ac
1-2.9							
3-7.9							
8-11.9							
12-15.9							
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings							

trees/acre

disease?

comments

Stream			Date			
Seg	7 - 2		Analyst			KD
Bank	L		WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'				
dist to channel (ft)		20				
Bnkfl channel width (ft)						
community						
slope			photo#			
aspect			%shade			
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	PSME	ALCU					trees/ac
1-2.9		1					50
3-7.9							
8-11.9	1						50
12-15.9	3						150
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings	3						150
trees/acre	500	50					
disease?							
comments							

Stream				Date			
Seg	7 - 2			Analyst			KD
Bank	L			WAU			Onion
plot #	2	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		20					
Bnkfl channel width (ft)		1					
community	Hillslope, Snowberry, PSME, Oregon Grape						
slope		Slighlty rocky		photo#			
aspect		Silt loam		%shade			
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	PSME	THPL					trees/ac
1-2.9	1						50
3-7.9	4	1					250
8-11.9	3						150
12-15.9							
16-19.9	2						100
20-27.9							
28-31.9							
>32							
seedlings	6						300
trees/acre	1100	50					
disease?							
comments							

Stream			Date			
Seg	7 - 2		Analyst			KD
Bank			WAU			Onion
plot #		plot radius ovsty=16.7' seeding=11.8'				
dist to channel (ft)						
Bnkfl channel width (ft)						
community	Hillslope					
slope			photo#			
aspect			%shade			
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	PSME	POTR					trees/ac
1-2.9		1					50
3-7.9	2						100
8-11.9	1						50
12-15.9	2						100
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings	6						300
trees/acre	850	50					
disease?							
comments							

Stream			Date				10/4/96
Seg	8		Analyst				KD
Bank	R		WAU				Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		17					
Bnkfl channel width (ft)		13					
community	Flood plain, Grass, Spruce, Alder						
slope	Flat		photo#				
aspect			%shade				60
soil	Sand/silt						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
PSME		10		1.5

overstory tree tally

	species						
dbh (in)	Alder		PSME				trees/ac
1-2.9	3	3					300
3-7.9			1				50
8-11.9							
12-15.9							
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings							
trees/acre	150	150	50				
disease?							
comments							

Stream			Date				10/4/96
Seg	8		Analyst				WP
Bank	R		WAU				Onion
plot #	2	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community							
slope	0-2%		photo#				
aspect	W	Facing stream	%shade				
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
PSME		72		16.5
LAOC		80		14
LAOC		76		13
LAOC		78		14
LAOC		78		14

overstory tree tally

	species						
dbh (in)	PSME	LAOC					trees/ac
1-2.9							
3-7.9							
8-11.9							
12-15.9		1					50
16-19.9	1						50
20-27.9							
28-31.9							
>32							
seedlings							
trees/acre	50	50					
disease?							
comments							

Stream			Date				
Seg	8		Analyst			KD	
Bank	L		WAU			Onion	
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		35					
Bnkfl channel width (ft)		16					
community	Hillslope off f 18" wide flood plain						
slope	40		photo#				
aspect			%shade				
soil	Sand/loam						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
PSME				14.5

overstory tree tally

	species						
dbh (in)	PSME						trees/ac
1-2.9	3						150
3-7.9	3						150
8-11.9	1						50
12-15.9	1						50
16-19.9	1						50
20-27.9							
28-31.9							
>32							
seedlings	2						100
trees/acre	650						
disease?							
comments							

Stream			Date				
Seg	9-3		Analyst			KD	
Bank	R		WAU			Onion	
plot #		plot radius ovsty=16.7' seedling=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community							
slope			photo#				
aspect			%shade			98	
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	THPL	PSME					trees/ac
1-2.9	3						150
3-7.9							
8-11.9	1	2					150
12-15.9	1						50
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings	57	39					4800
trees/acre	5950	4000					
disease?							
comments	formerly seg 10-2						

Stream			Date				
Seg	9-3		Analyst			KD	
Bank	L		WAU			Onion	
plot #	2	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		25					
Bnkfl channel width (ft)							
community	Kinick knick, PMSE						
slope			photo#				
aspect			%shade				
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

species

dbh (in)	PMSE	THPL	POTR	TSHE			trees/ac
1-2.9	1	1	3				250
3-7.9	4	4		1			450
8-11.9	1	1					100
12-15.9							
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings	12	6		11			1450
trees/acre	1500	900	150	1150			
disease?							
comments	formerly seg 10-2						

Stream			Date			
Seg	9-3		Analyst			KD
Bank	L		WAU			Onion
plot #		plot radius ovsty=16.7' seedlng=11.8'				
dist to channel (ft)		20				
Bnkfl channel width (ft)						
community						
slope			photo#			
aspect			%shade			
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	TAPL	PSME	TSHE				trees/ac
1-2.9	4	1	1				300
3-7.9		1	1				100
8-11.9		1					50
12-15.9	4	1					250
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings	16	3	1				1000
trees/acre	2000	500	200				

disease?

comments formerly seg 10-2

Stream				Date			
Seg	601			Analyst			KD
Bank	L			WAU			Onion
plot #	1	plot radius ovsty=16.7' seedling=11.8'					
dist to channel (ft)		20					
Bnkfl channel width (ft)		9.2					
community	THPL, Flood plain						
slope				photo#			
aspect				%shade			94
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	THPL	TSAE	PSME				trees/ac
1-2.9	1						50
3-7.9	5	1					300
8-11.9	7	1	1				450
12-15.9	2						100
16-19.9	1						50
20-27.9							
28-31.9							
>32							
seedlings	14	3					850
trees/acre	2200	400	50				

disease?

comments formerly 11-2

Stream				Date			
Seg	601			Analyst			KD
Bank	R			WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		20					
Bnkfl channel width (ft)		6.5					
community	THPL, Oregon grape						
slope				photo#			
aspect				%shade			
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	THPL	TSHE	PSME	Alder			trees/ac
1-2.9	3			3			300
3-7.9	7	1		3			550
8-11.9	6		1				350
12-15.9	1						50
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings	12	12	4				1400
trees/acre	2050	1250	450	300			
disease?							
comments	formerly 11-2						

Stream				Date			10/4/96
Seg	201 - 2			Analyst			WP
Bank	L			WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		33					
Bnkfl channel width (ft)		10					
community	WRC, DF						
slope	0.72			photo#			
aspect	N			%shade			98
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
WRC		88		19
WRC		90		21
WRC		87		20
DF		83		15
DF		38		8

overstory tree tally

	species						
dbh (in)	PSME	WRC	NL				trees/ac
1-2.9		17					850
3-7.9		7	1				400
8-11.9	1						50
12-15.9							
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings		12					600
trees/acre	50	2400	50				
disease?							
comments							

Stream			Date			10/4/96
Seg	201 - 2		Analyst			KD
Bank	L		WAU			Onion
plot #	2	plot radius ovsty=16.7' seedling=11.8'				
dist to channel (ft)		20				
Bnkfl channel width (ft)		3.7				
community	PMSE, Steep slope, (THPL understory)					
slope			photo#			
aspect			%shade			
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
PIEN				
PSME				

overstory tree tally

species

dbh (in)	THPL	PSME	PIEN				trees/ac
1-2.9	8						400
3-7.9	6	2					400
8-11.9							
12-15.9	1	1	1				150
16-19.9	1						50
20-27.9							
28-31.9							
>32							
seedlings	0						
trees/acre	800	150	50				
disease?							
comments							

Stream				Date			
Seg	202 - 1			Analyst			WP
Bank	L			WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		35					
Bnkfl channel width (ft)							
community	GF/WRC						
slope	10			photo#			
aspect	N			%shade			
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):	
Lodgepole		125		18	dying
MF		82		18	
Birch		36		7	
WRC		40		10	
WRC		62		16	

overstory tree tally

species

dbh (in)	WRC	Birch	ABGR				trees/ac
1-2.9	2		4				300
3-7.9	3	1	2				300
8-11.9	1						50
12-15.9							
16-19.9			1				50
20-27.9							
28-31.9							
>32							
seedlings	9		12				1050
trees/acre	1200	50	1550				
disease?							
comments							

Stream			Date				
Seg	202 - 1		Analyst			KD	
Bank			WAU			Onion	
plot #	2	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		20					
Bnkfl channel width (ft)							
community	Plot center is at edge of flood plain						
slope			photo#				
aspect			%shade				
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
PSME		140		24
THPL		60		14

overstory tree tally

species

dbh (in)	PMSE	ABGR	THPL	POTR			trees/ac
1-2.9		2					100
3-7.9		5	1	2			400
8-11.9		1	1				100
12-15.9			2				100
16-19.9							
20-27.9	1						50
28-31.9							
>32							
seedlings		7	4				550
trees/acre	50	1100	600	100			
disease?							
comments							

Stream			Date				10/4/96
Seg	205		Analyst				WP
Bank	L		WAU				Onion
plot #	11	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		55					
Bnkfl channel width (ft)							
community							
slope	0.2%		photo#				
aspect	5		%shade				98
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
WRC		38		13
Birch	dead	66		13
Birch	dead	58		12
GF		140		17
WL		140-160		15

overstory tree tally

dbh (in)	species GF	WRC	HWDS				trees/ac
1-2.9	2	1	1				200
3-7.9	1		2				150
8-11.9							
12-15.9		1	2 (dead)				50
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings							
trees/acre	150	100	150				
disease?							
comments							

Stream			Date			
Seg	205		Analyst			KD
Bank			WAU			Onion
plot #		plot radius ovsty=16.7' seedlng=11.8'				
dist to channel (ft)						
Bnkfl channel width (ft)						
community						
slope			photo#			
aspect			%shade			
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
PSME				
POTR				

overstory tree tally

	species						
dbh (in)	ABGR	PSME	PILO	POTR	TSAE	Alder	trees/ac
1-2.9	3				1		200
3-7.9	8			1		2	550
8-11.9	2	1					150
12-15.9	1			1			100
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings							
trees/acre	700	50		100			
disease?							
comments							

Stream				Date			10/2/96
Seg	305			Analyst			KD
Bank	R			WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community	RZM buffr, PSME, Oregon grape						
slope				photo#			
aspect				%shade			99
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	PSME	ALRU	POTR	THPL			trees/ac
1-2.9							
3-7.9	4		1	1			300
8-11.9	3	1					200
12-15.9							
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings	4						200
trees/acre	750	50	50	50			
disease?							
comments							

Stream				Date			
Seg	401			Analyst			KD
Bank				WAU			Onion
plot #		plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community	PMSE, Snowberry, Grass, Oregon grape						
slope				photo#			
aspect				%shade			
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	PMSE	POTR	LHDL	ABGR	THPL		trees/ac
1-2.9							
3-7.9	6	2		2			500
8-11.9		1	1		1		150
12-15.9							
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings	1						50
trees/acre	400	150	50	100			
disease?							
comments	formerly 401-1						

Stream			Date				
Seg	402-2		Analyst			KD	
Bank			WAU			Onion	
plot #		plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		18					
Bnkfl channel width (ft)		5					
community	THPL, Lady fern, skunk cabbage, ginger						
slope			photo#				
aspect			%shade				
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
LHOC				16.3
THPL				14

overstory tree tally

species

dbh (in)	THPL	LAOC	PSME				trees/ac
1-2.9	6						300
3-7.9	4		5				450
8-11.9	3		1				200
12-15.9	3						150
16-19.9		2					100
20-27.9							
28-31.9							
>32							
seedlings							
trees/acre	800	100	300				
disease?							
comments	formerly 401-3						

Stream				Date			
Seg	502			Analyst			KD
Bank				WAU			Onion
plot #		plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community	Snow berry, PSME, PICO, Knick knick						
slope				photo#			
aspect		PICO, LAOC, PSME		%shade			97
soil		buffer strip					

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)							trees/ac
1-2.9							
3-7.9							
8-11.9							
12-15.9							
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings							

trees/acre

disease?

comments

Stream				Date			10/1/96
Seg	506			Analyst			KD
Bank	L			WAU			Onion
plot #	2	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		20					
Bnkfl channel width (ft)							
community							
slope				photo#			
aspect				%shade			100
soil		506 road abandoned and underlaid w/pipes					

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	THPL	PSME	ALRU	TSHE			trees/ac
1-2.9		2	1				150
3-7.9			3				150
8-11.9							
12-15.9		1					50
16-19.9	3						150
20-27.9							
28-31.9							
>32							
seedlings	8	5		1			700
trees/acre	950	650	200	100			

disease?

comments

Stream			Date			10/1/96
Seg	506		Analyst			KD
Bank	L		WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'				
dist to channel (ft)		20				
Bnkfl channel width (ft)		5				
community	THPL, Trillium, ??					
slope			photo#			
aspect			%shade			
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
THPL		95		19.6
PSME		100		19

overstory tree tally

	species						
dbh (in)	THPL	PSME	TSHE				trees/ac
1-2.9	2						100
3-7.9	3						150
8-11.9	1						50
12-15.9	2		1				150
16-19.9	1	1					100
20-27.9							
28-31.9							
>32							
seedlings	11	3					700
trees/acre	1550	350	50				
disease?							
comments							

Stream			Date			
Seg	602 - 1		Analyst			KD
Bank	L		WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'				
dist to channel (ft)						
Bnkfl channel width (ft)						
community	Salmonberry, THPL, TSHE, Alder					
slope			photo#			
aspect			%shade			
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

species

dbh (in)	THPL	TSHE	Birch	ALRU	ABGR	PMSE	trees/ac
1-2.9				4			200
3-7.9	1			1	1		150
8-11.9	1					1	100
12-15.9	2		1			1	200
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings	12	5			9	5	1550
trees/acre	1400	500	50	250			

disease?

comments formerly 601-1

Stream				Date			
Seg	602 - 3			Analyst			KD
Bank				WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community							
slope				photo#			
aspect				%shade			97
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
LAOC		160		20.8
ABGR		120		19.7
PSME		140		18
ABGR		95		16.7
ABGR		120		

overstory tree tally

species

dbh (in)	PSME	THPL	TSHE	LAOC			trees/ac
1-2.9	1						50
3-7.9	2		3				250
8-11.9	2						100
12-15.9	2						100
16-19.9							
20-27.9		1		1			100
28-31.9							
>32							
seedlings							
trees/acre	350	50	150	50			
disease?							
comments	formerly 601-3						

Stream				Date			
Seg	701 - 4			Analyst			KD
Bank	L			WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community							
slope				photo#			
aspect				%shade			98
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	PMSE	Alder	THPL				trees/ac
1-2.9							
3-7.9	1	1	3				250
8-11.9	1						50
12-15.9							
16-19.9	2						100
20-27.9							
28-31.9							
>32							
seedlings	12		6				900
trees/acre	1400	50	750				

disease?

comments

Stream			Date			10/2/96
Seg	706		Analyst			KD
Bank	R		WAU			Onion
plot #	1	plot radius ovsty=16.7' seedlng=11.8'				
dist to channel (ft)		25				
Bnkfl channel width (ft)						
community						
slope			photo#			
aspect			%shade			98
soil						

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	PMSE	THPL	POTR				trees/ac
1-2.9		1					50
3-7.9	3	4					350
8-11.9	1	2	1				200
12-15.9	2		1				150
16-19.9	1	1	1				150
20-27.9							
28-31.9							
>32							
seedlings		4					200
trees/acre	350	800	150				
disease?							
comments							

Stream			Date				
Seg	706		Analyst			KD	
Bank	L		WAU			Onion	
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community							
slope			photo#				
aspect			%shade				
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	THPL	PSME					trees/ac
1-2.9	1	5					300
3-7.9	4						200
8-11.9	3						150
12-15.9	2	1					150
16-19.9	1	1					100
20-27.9							
28-31.9							
>32							
seedlings	2	2					200
trees/acre	750	550					
disease?							
comments							

Stream				Date			
Seg	801 - 1			Analyst			KD
Bank	L			WAU			Onion
plot #		plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)	6 max	mostly 2.5					
community	Snowberry, ginger						
slope				photo#			
aspect				%shade			99
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):
THPL		100		24.9
PSME				

overstory tree tally

species

dbh (in)	PSME	THPL	LAOC				trees/ac
1-2.9	2						100
3-7.9	6						300
8-11.9	3	1					200
12-15.9	1		1				100
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings	1	1					100
trees/acre	700	150	50				
disease?							
comments							

Stream				Date			
Seg	801 - 1			Analyst			KD
Bank	R			WAU			Onion
plot #	2	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community							
slope				photo#			
aspect				%shade			
soil							

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	Alder	POTR					trees/ac
1-2.9							
3-7.9	18	3					1050
8-11.9							
12-15.9							
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings							
trees/acre	900	150					
disease?							
comments							

Stream			Date				
Seg	801 - 4		Analyst			KD	
Bank	L		WAU			Onion	
plot #	1	plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)		20					
Bnkfl channel width (ft)		4					
community	Snow berry, PSME, PICO, Knick knick						
slope			photo#				
aspect		PICO, LAOC, PSME	%shade				
soil		buffer strip					

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)	PSME	PICO	POTR				trees/ac
1-2.9	3		5				400
3-7.9	5		3				400
8-11.9	8	2					500
12-15.9							
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings							
trees/acre	800	100	400				

disease?

comments

Stream			Date				09/30/96
Seg	803		Analyst				KD
Bank			WAU				Onion
plot #		plot radius ovsty=16.7' seedlng=11.8'					
dist to channel (ft)							
Bnkfl channel width (ft)							
community	Snow berry, PSME, PICO, Knick knick						
slope			photo#				
aspect		PICO, LAOC, PSME	%shade				80
soil		buffer strip					

5 lrgst trees (not confined to plot)

spc:		hieght (ft):		dbh (in):

overstory tree tally

	species						
dbh (in)							trees/ac
1-2.9							
3-7.9							
8-11.9							
12-15.9							
16-19.9							
20-27.9							
28-31.9							
>32							
seedlings							

trees/acre

disease?

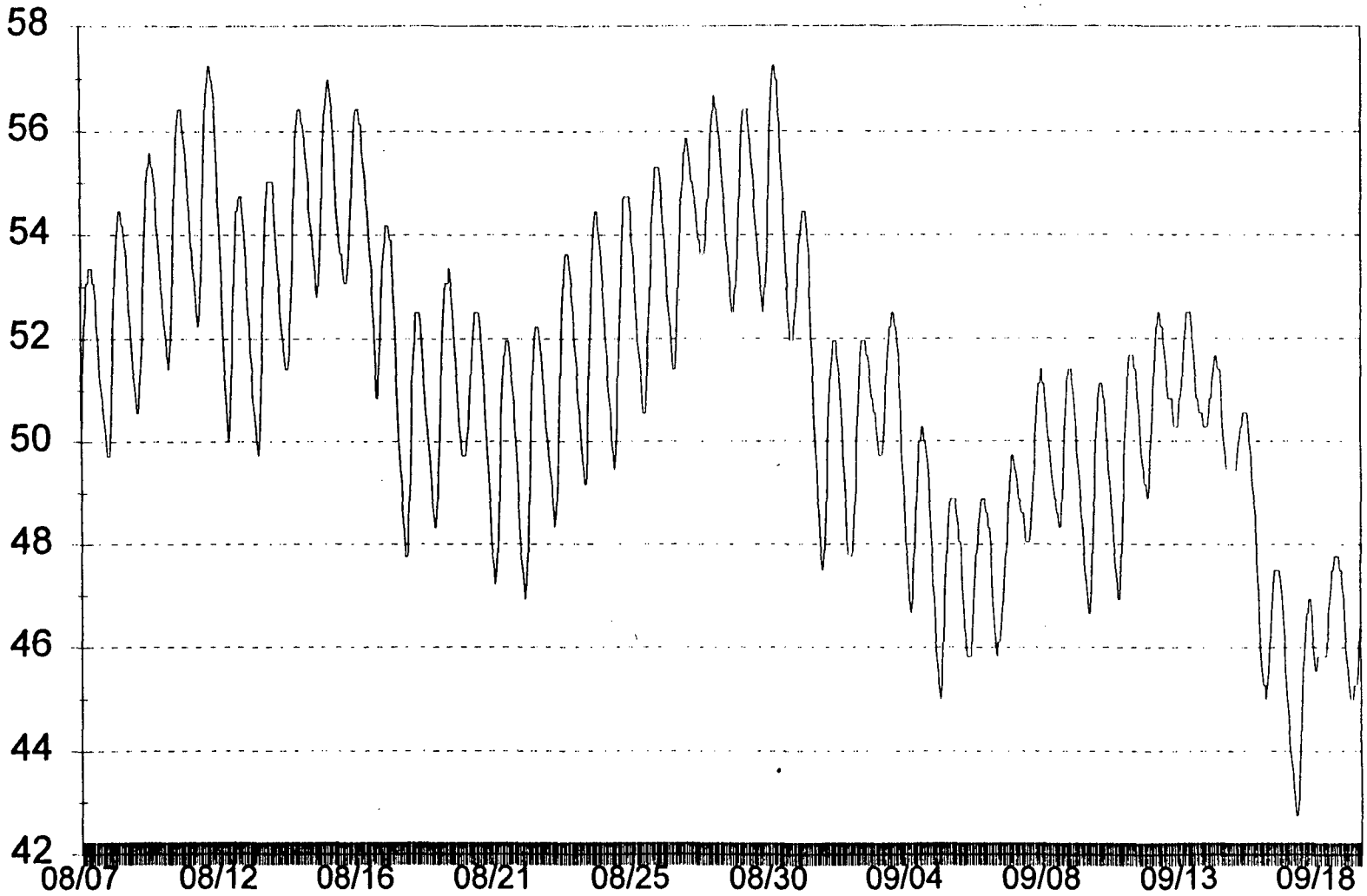
comments

HB 1 - 2720 ft Elevation RCU 502

Date	Min	Mean	Max
08/08/96	49.7	52.2	54.5
08/09/96	50.6	53.1	55.6
08/10/96	51.4	54.1	56.4
08/11/96	52.2	54.9	57.3
08/12/96	50.0	53.0	54.7
08/13/96	49.7	52.6	55.0
08/14/96	51.4	53.9	56.4
08/15/96	52.8	55.0	57.0
08/16/96	53.1	54.7	56.4
08/17/96	50.8	53.1	54.7
08/18/96	47.8	50.4	52.5
08/19/96	48.3	50.9	53.3
08/20/96	49.7	51.1	52.5
08/21/96	47.2	49.9	52.0
08/22/96	46.9	49.8	52.2
08/23/96	48.3	51.1	53.6
08/24/96	49.2	51.9	54.5
08/25/96	49.4	52.4	54.7
08/26/96	50.6	53.1	55.3
08/27/96	51.4	53.7	55.9
08/28/96	53.6	55.0	56.7
08/29/96	52.5	54.6	56.4
08/30/96	52.5	54.9	57.3
08/31/96	52.0	53.3	54.7
09/01/96	47.5	50.1	52.0
09/02/96	47.8	50.0	52.0
09/03/96	49.7	51.1	52.5
09/04/96	46.7	48.9	50.6
09/05/96	45.0	47.4	48.9
09/06/96	45.8	47.5	48.9
09/07/96	45.8	47.8	49.7
09/08/96	48.0	49.6	51.4
09/09/96	48.3	49.8	51.4
09/10/96	46.7	49.1	51.1
09/11/96	46.9	49.5	51.7
09/12/96	48.9	50.8	52.5
09/13/96	50.3	51.3	52.5
09/14/96	49.7	50.8	51.7
09/15/96	48.6	49.8	50.6
09/16/96	45.0	46.6	48.0
09/17/96	42.8	44.9	46.9
09/18/96	45.5	46.7	47.8

HB1-2720 ft Elevation Water Temp

Aug 7 - Sept 19, 1996

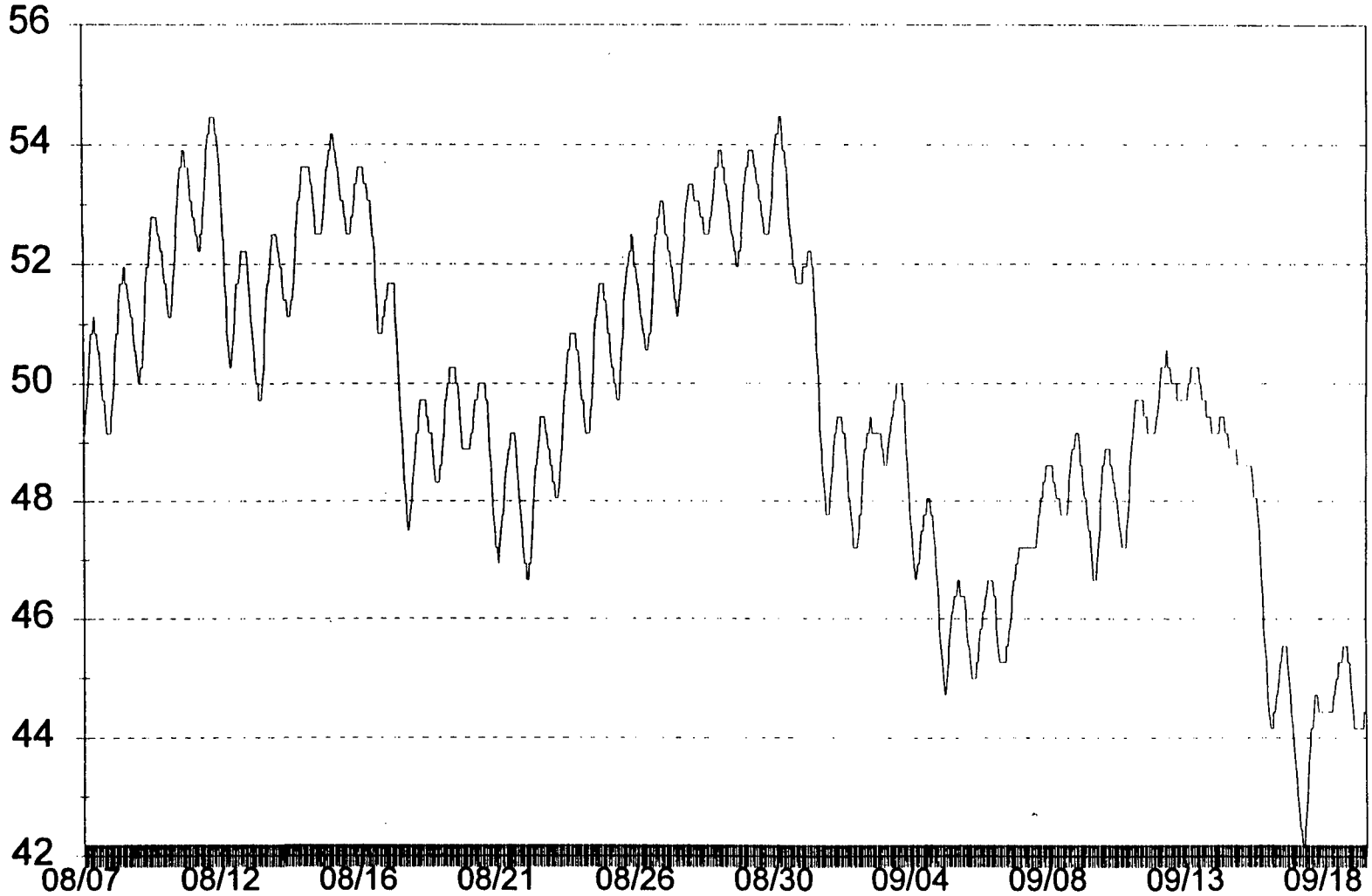


HB 2 - 3563 ft Elevation RCU 507

Date	Min	Mean	Min
08/08/96	49.2	50.4	52.0
08/09/96	50.0	51.4	52.8
08/10/96	51.1	52.4	53.9
08/11/96	52.2	53.4	54.5
08/12/96	50.3	51.8	53.9
08/13/96	49.7	51.1	52.5
08/14/96	51.1	52.3	53.6
08/15/96	52.5	53.3	54.2
08/16/96	52.5	53.1	53.6
08/17/96	50.8	51.7	53.1
08/18/96	47.5	48.9	50.3
08/19/96	48.3	49.3	50.3
08/20/96	48.9	49.5	50.0
08/21/96	46.9	48.3	49.7
08/22/96	46.7	48.1	49.4
08/23/96	48.0	49.4	50.8
08/24/96	49.2	50.4	51.7
08/25/96	49.7	51.0	52.5
08/26/96	50.6	51.8	53.1
08/27/96	51.1	52.3	53.3
08/28/96	52.5	53.1	53.9
08/29/96	52.0	53.0	53.9
08/30/96	52.5	53.4	54.5
08/31/96	51.1	52.0	53.6
09/01/96	47.8	48.9	50.6
09/02/96	47.2	48.3	49.4
09/03/96	48.6	49.3	50.0
09/04/96	46.7	47.7	49.2
09/05/96	44.7	46.0	47.2
09/06/96	45.0	45.9	46.7
09/07/96	45.3	46.1	47.2
09/08/96	47.2	47.8	48.6
09/09/96	47.8	48.4	49.2
09/10/96	46.7	47.9	48.9
09/11/96	47.2	48.4	49.7
09/12/96	49.2	49.7	50.6
09/13/96	49.7	50.0	50.3
09/14/96	48.9	49.3	49.7
09/15/96	47.2	48.4	48.9
09/16/96	44.2	45.1	46.7
09/17/96	42.2	43.6	44.7
09/18/96	44.4	44.9	45.5

HB2-3563 ft Elevation Water Temp

Aug 7 - Sept 19, 1996

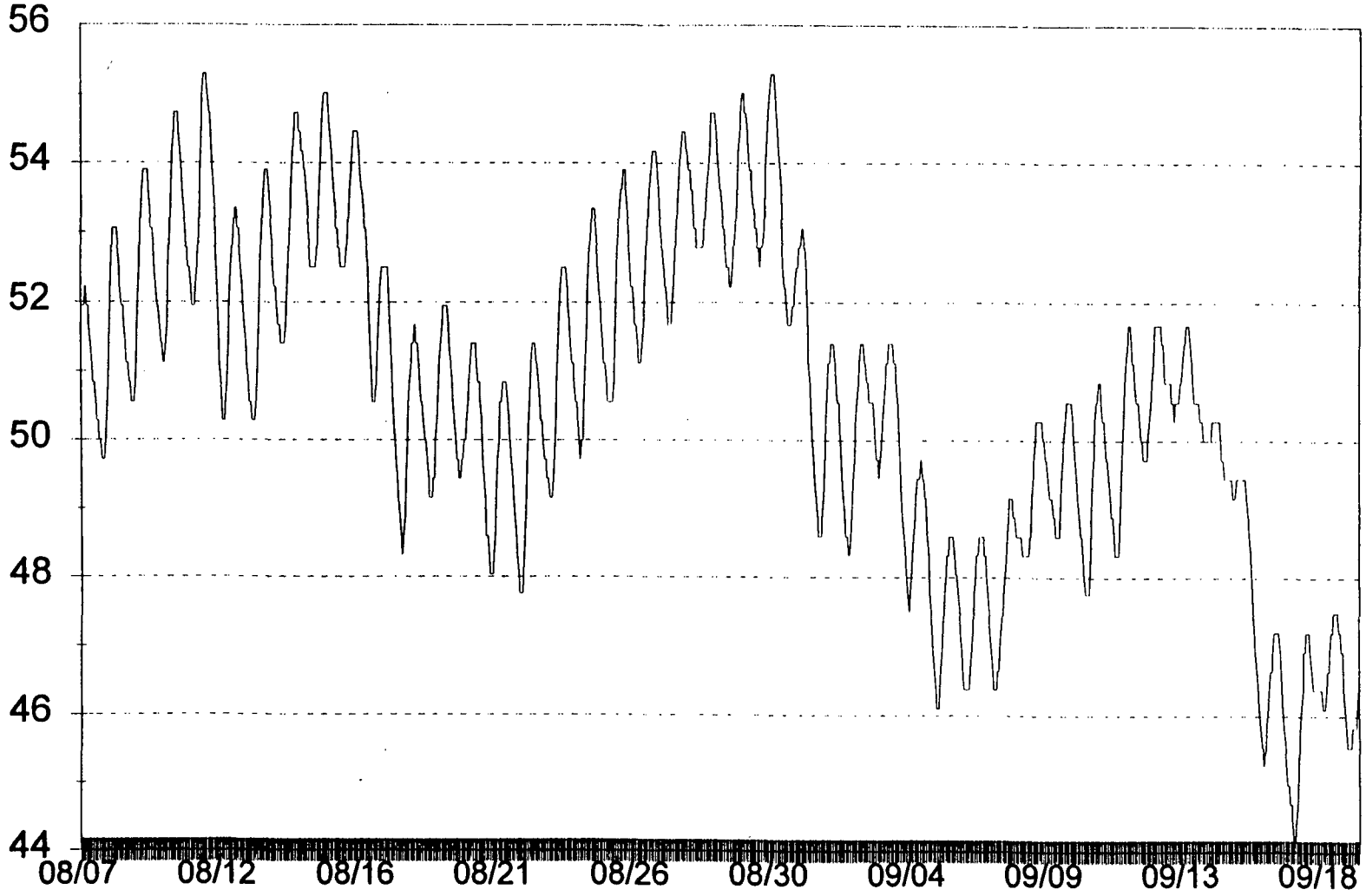


HB 3 - 3238 ft Elevation RCU 506

Date	Min	Mean	Max
08/08/96	49.7	51.3	53.1
08/09/96	50.6	52.2	53.9
08/10/96	51.1	52.9	54.7
08/11/96	52.0	53.5	55.3
08/12/96	50.3	52.1	53.6
08/13/96	50.3	52.0	53.9
08/14/96	51.4	52.9	54.7
08/15/96	52.5	53.7	55.0
08/16/96	52.5	53.4	54.5
08/17/96	50.6	52.0	53.3
08/18/96	48.3	50.2	51.7
08/19/96	49.2	50.6	52.0
08/20/96	49.4	50.5	51.4
08/21/96	48.0	49.6	50.8
08/22/96	47.8	49.6	51.4
08/23/96	49.2	50.8	52.5
08/24/96	49.7	51.6	53.3
08/25/96	50.6	52.1	53.9
08/26/96	51.1	52.6	54.2
08/27/96	51.7	53.1	54.5
08/28/96	52.8	53.6	54.7
08/29/96	52.2	53.6	55.0
08/30/96	52.5	53.9	55.3
08/31/96	51.1	52.3	53.6
09/01/96	48.6	50.1	51.4
09/02/96	48.3	50.0	51.4
09/03/96	49.4	50.6	51.4
09/04/96	47.5	48.9	50.0
09/05/96	46.1	47.5	48.6
09/06/96	46.4	47.5	48.6
09/07/96	46.4	47.7	49.2
09/08/96	48.3	49.2	50.3
09/09/96	48.6	49.6	50.6
09/10/96	47.8	49.3	50.8
09/11/96	48.3	49.9	51.7
09/12/96	49.7	50.7	51.7
09/13/96	50.3	50.9	51.7
09/14/96	49.7	50.2	50.6
09/15/96	47.5	49.1	49.4
09/16/96	45.3	46.5	47.2
09/17/96	44.2	45.7	47.2
09/18/96	46.1	46.8	47.5

HB3-3238 ft Elevation Water Temp

Aug 7 - Sept 19, 1996



APPENDIX D-3
LWD Recruitment Model Input

LWD RECRUITMENT MODEL

Watershed	Onion	Watershed	Onion	
subbasin		subbasin		
segment		segment		
01-Feb-97		01-Feb-97		
04:37:20 PM		04:37:20 PM		
Watershed	Onion	Watershed	Onion	
subbasin		subbasin		
segment		segment		
model run description	Late Seral	model run description	Late Seral	THPL full fire suppression

RESULTS		RESULTS		PSME	THPL	ABGR	Combined
Recruitment to channel		Recruitment to channel					
RMZ width (ft)	140	RMZ width (ft)	140				
12"pieces LWD/channel width/yr		12"pieces LWD/channel width/yr		0.0001	0.0000	0.0003	0.0004
20"pieces LWD/channel width/yr		20"pieces LWD/channel width/yr		0.0001	0.0003	0.0002	0.0006
Total functional LWD		Total functional LWD		0.0002	0.0003	0.0006	0.0011

INPUT DATA		INPUT DATA		
tree fall pattern	180	tree fall pattern	180	select probability tree fall pattern and enter value in cell b7 circle selection on print out random=180; partial bias=90; full bias=30

RIPARIAN STAND		RIPARIAN STAND						
species		species		PSME		THPL		ABGR
hieght @ 12"dbh (ft)		hieght @ 12"dbh (ft)		85		72		81
hieght @ 20"dbh (ft)		hieght @ 20"dbh (ft)		112		94		120
density@12" (trees/acre)		density@12" (trees/acre)		30		1		70
density@20" (trees/acre)		density@20" (trees/acre)		20		50		30
mortality@12" (%/yr)		mortality@12" (%/yr)		0.0015	0.0015	0.0015	0.0015	0.0015
mortality@20" (%/yr)		mortality@20" (%/yr)		0.0015	0.0015	0.0015	0.0015	0.0015
% of total tree hieght w/ diam >=12"		% of total tree hieght w/ diam >=12"		0.8				

CHANNEL		CHANNEL	
bankfull width (ft)	11	bankfull width (ft)	11
L	5.5	L	5.5
target lwd/bkfw	2	target lwd/bkfw	2

Model author: Kent Doughty, Cascades Environmental Services (360) 671-1150

APPENDIX E/F
STREAM CHANNEL AND FISH HABITAT ASSESSMENTS

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Permission to deviate from the standard format for the channel and fish habitat assessments for Onion Creek Watershed Administrative Unit was granted by Washington Department of Natural Resources, Forest Practices Division for the purpose of module development and assessment streamlining. Both the channel and fish habitat assessments were conducted in accordance with Version of 3.0 of the *Standard Methodology for Conducting Watershed Analysis*, Washington Forest Practices Board, November, 1995.

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Table E/F-1. Required Module Work Products and Comparable Products for Onion Creek.

Required Module Product	Onion Creek WA Channel Analysis Product	Location in this Report
Form E-1, Channel Segment Identification Worksheet	Same as required product	Back of report
Form E-2, Channel Disturbance Worksheet	Same as required product	Back of report
Form E-3, Field Site Selection Worksheet	Same as required product	Back of report
Form E-4, Channel Assessment Field Form *	Summarized on Form E-5. *Not required as part of final product, per Manual	Back of report
Form E-5, Segment Summary Sheet	Attributes from all sampled segments summarized on a single table labeled Form E-5	Back of report
Form E-6, Geomorphic Unit Description and Sensitivity Justification	Geomorphic unit sensitivity ratings summarized on a single table labeled Form E-6. Descriptions and justifications provided in text.	Section 4.0
Map E-1, Channel Segments	Map E-1/F-1 combined	Back of report
Map E-2, Channel Geomorphic Units	Map E-2	Back of report
Form F-2, Field Inventory Data	Form F-2, contains wood, habitat and pool data	Back of report
Form F-3, Field Data Summary and Habitat Diagnostic Calls	Form E-5 Data Summary Table E/F-4 Diagnostic Calls	Back of report Page
Form F-4, Fish Habitat Assessment Task Checklist	Similar form not required in Channel Module.	Completion statement at end of contents pg.
Map F-1, Fish Distribution	Map E-1/F-1 combined	Following references
Maps F-2 through F-5	Map E-1/F-1 combined	Following references

APPENDIX E/F. STREAM CHANNELS AND FISH HABITAT

1.0 INTRODUCTION

The Department of Natural Resources Forest Practices Division has granted one-time approval to the Onion Creek Assessment Team to combine into one analysis report both the Channel and Fish Habitat Assessment reports (Shaw, October, 1996). This format modification was attempted to ensure consistency of interpretive channel/fish results brought to the synthesis and prescription phases and to minimize the duplication of effort and work products. Level 2 assessment methods for both modules were used and standard or equivalent work products are supplied.

1.1 Channel Assessment Overview

The purpose of the channel assessment is to provide an understanding of the current and possible future states of channel conditions. The objectives are to develop information to establish:

- Which *channel segments are likely to respond similarly* to changes in the input factors of water, sediment, and wood.
- *Historical changes* in channel morphology to identify past and continuing natural processes and management-related impacts.
- The *current condition of channels* indicating the present status and potential direction of channel changes relative to the input factors.
- The *channel sensitivity or likely future response* relative to the input factors given the nature of the channel and its present condition.
- Channel processes influencing *habitat attributes* identified as important for fish or other aquatic organisms.

An important element of the assessment is to stratify the watershed into areas of similar condition and response, ultimately relating channel form and process to the terrain, geology, and disturbance history. This allows an assessment of channel conditions on a watershed scale and provides a basis for understanding the influence of changes in land management on channel conditions and processes and, therefore, aquatic resources.

The channel assessment is conducted using maps, aerial photographs, field observations, and other available data. In the text below, methods and results are described and related to the objectives above. Confidence in the analysis is addressed within each section or step, as required in the methods manual.

1.2 Fish Habitat Assessment Overview

The goal of the fish assessment is to locate accessible fish habitat in the watershed and to identify existing conditions and habitats of special concern. The objectives of the fish assessment are:

- Identify the *distribution and relative abundance* of salmonid fish species.
- Identify *historic trends in fish abundance* by stock.
- Determine *existing habitat conditions*.
- Evaluate distribution changes, abundance trends, and existing habitat conditions to *identify degraded habitats.*
- Evaluate *habitat utilization and habitat preference* information to identify high use areas and habitats of limited availability.

The fish habitat assessment is conducted using maps, available habitat and population survey information, field observations, and other available data. In the text below, methods and results are described and related to the objectives above. Confidence in the analysis is addressed within each section or step, as required in the methods manual.

2.0 STREAM CHANNEL ANALYSIS

2.1 Watershed Overview

This section offers an overview of the physiographic, geologic, and climatic factors shaping the Onion Creek stream system. Onion Creek is a fifth-order basin (Strahler classification; Strahler, 1957) joining the Columbia River on the left bank 14 miles downstream from the Canadian border. The Onion Creek WAU (Watershed Administrative Unit) includes 34,481 acres draining to Onion Creek and an additional 11,981 acres of sideslope drainage parallel to the Columbia River (Figure 2, main document). Maximum relief in the basin is 4,465 feet.

Bedrock geology includes marine metasedimentary rocks and granite (Figure 4, main document). The landforms of Onion Creek are shown in Figure A-1 (Appendix A) and are useful in the interpretation of both hillslope and channel processes. All of the Onion Creek WAU was overridden by Pleistocene continental ice which scoured the higher ridges and slopes, mantled sideslopes with till, and filled the valleys with deep glacial sediments. Areas of metamorphic rock form the higher elevation ridges on the southern and northern ends of the watershed. Subdued hills and the deeper glacial deposits are found in the middle portion of the basin underlain by granite.

The average annual precipitation is 22 inches of which 40 to 45 percent falls as snow. Spring snowmelt runoff is largely responsible for defining channel geometry. Runoff is shed quickly from the steeper ridges and sideslopes of exposed bedrock or shallow soils into the deep, glacial soils. Perennial streams are found in the mainstem and major tributaries valleys and where the smaller tributaries have sufficient drainage area. Only an estimated 37 percent of mapped streams flow perennially.

A steep, bedrock falls located about one mile from the mouth divides the upland area from the lower portion of the watershed that lies within the deeply-scoured Columbia River Valley. The portion of the WAU within the Columbia River Valley includes both glacially-scoured bedrock

sidewalls and glacial terraces at several elevations. Onion Creek below the falls flows through an alluvial fan-terrace complex. The lower 500 feet of Onion Creek is periodically flooded due to the fluctuating level of Lake Roosevelt. Of the numerous small tributaries draining the side slopes of the Columbia River, only Fivemile Creek south of Northport empties directly into Lake Roosevelt. The remaining tributaries flow subsurface upon discharging onto the terraces or quickly shed runoff from exposed bedrock slopes adjacent to the Columbia. Portions of a glaciofluvial terrace extend into Onion Creek above the falls.

Mass wasting occurs very infrequently within the WAU. Sources of sediment input to the channels are limited to bank erosion and surface erosion of the soils and alluvial floodplains and unpaved roads. Both the glacial till soils and residual granitic soils provide a source for abundant coarse sand found within many channel segments. Soils tend to be siltier in the northeast portion of the watershed in proximity to metasedimentary bedrock, trending to a higher sand content to the southwest where underlain by granite.

2.2 Methods

Methods employed for this level 2 assessment were those prescribed in version 3.0 of the Standard Methodology for Conducting Watershed Analysis (Washington Forest Practices Board, 1993). The majority of channel surveys were conducted with the fish module analyst, who collected the wood counts and pool frequency data.

A certain amount of duplication was found between forms E-4, E-5, and E-6. Formats for those products in this analysis differ slightly from the suggested formats in an effort to improve the efficiency of both the analysis and technical review. Table E/F-1 lists the forms required from the analysis in the methodology and the comparable products found in this analysis.

2.3 Channel Segments

Following a field reconnaissance of basin streams in early September, 1996, the first effort at characterizing channels began with partitioning them into segments based on gradient class and valley confinement. The combination of gradient and confinement provides a simple method to initially estimate response potential and can be done from either topographic maps, aerial photographs, or digital terrain data. This initial classification also helps in the selection of representative channel segments for field observation.

A total of 102 numbered channel segments were created for the Onion Creek watershed based on the channel reconnaissance, topographic maps, and 1992 aerial photographs. Segment breaks and and numbering were subsequently refined as a result of the field surveys (Section 4.0). A number of minor or ephemeral channels where not numbered, although a percentage of these were field checked. Channels originally mapped on the state hydrologic layer but found without a defined channel during field work were removed from the map. We anticipate that additional unnumbered segments may be removed from the water layer as these are field checked in the future. With the removal of the field checked non-channels, the drainage density within the WAU is 1.9 mi/mi^2.

Segment numbering provides a reference system also used in the riparian and fish habitat assessments and during the synthesis portion of the analysis. The mainstem channel segments of Onion Creek are numbered beginning with the number 1. Tributary systems are numbered beginning at the mouth of each creek using 3 digit numbers (Map E-1/F-1). Small tributaries draining middle mainstem side slopes were numbered 50 through 53. One segment was further subdivided following field work using the numbering sequence of the riparian analyst (801-4) to prevent renumbering existing data.

Segment breaks are approximate and were occasionally located coincident with tributary junctions to simplify mapping. Differences between segment breaks and fish use may represent either a channel change significant only to fish use, such as quantity of water, or an uncertainty in the exact map location of a change in channel morphology significant to fish use.

Form E-1 from the methods manual shows the initial distribution of channel segments by gradient and confinement classes. Unnumbered channel segments were tallied in the appropriate class. This display of channel segments is useful in selecting field sample locations representative of preliminary groupings of similar channel types. For the Onion Creek WAU, the presence or absence of perennial flow was an additional, overriding consideration in the final grouping of channel segments.

2.4 Historic Trends

A series of historical aerial photographs were examined for indicators of changes in channel conditions. Analysis from aerial photography offers a large-scale view of changes in channel morphology, such as channel widening, migration, and bar development or vegetation. The historical analysis also provides an indicator of past channel response and offers another means of focusing the field effort. The photograph series available for the Onion Creek WAU include:

1968 (1:22,580)
1980 (1:14,400)
1987 (~1:12,000)
1992 (~1:15,000)
1995 (1:214,025)

Trends in historic channel conditions were recorded on Form E-2, channel disturbance worksheet. Even under sparse and immature canopy in the 1968 photos, the majority of channels are not visible. Only those segments registering changes visible in the photographs or adjacent areas of potential land-use impacts are listed on Form E-2.

Channelization of approximately 3,000 feet of mainstem segment 2 near the mouth of Onion Creek is visible in the earliest photographs. The single tree-width of riparian vegetation appears to mature over time suggesting that the channelization may have occurred 10 to 20 years prior to 1968.

The singular channel disturbance event of note appears in the 1968 photographs in the immediate vicinity of the Van Stone Mine. A slope failure on the right bank opposite the upper tailings pond propagates down the channel and is visible as a bright, widened channel corridor all the way to the confluence of the West Fork of Onion Creek (includes segments 505, 503, 502, 501, 10, and 9). Regrowth of riparian vegetation occurs in succeeding photographs in these segments. From 1980 to 1987, however, gravel bars and bank erosion are visible in downstream, lower gradient segments 4 and 7. It is possible that sediment from the earlier disturbance is transporting through these more responsive channels 10+ years following that event. The disburbance may also be related to major storm or snowmelt runoff events. A portion of the upper-middle segment 7 channel is also accessible to cattle, which may contribute to the visible channel disturbance. A portion of this field surrounding the channel appears to have been fenced beginning in the earliest photos (1968).

From the photographs, agricultural activities and homesites appear concentrated in the mid to upper portion of the mainstem valley in proximity to the paved county road and where the glacial and valley terraces and gentle sideslopes are suitable for grazing and limited crop production. Between the 1968 and 1987 photos, there was a visible increase in the number of homesites within the watershed. Channels and wet swale areas are visible in the open, agricultural areas, but only localized evidence of erosion or disturbance aside from stock pond trenching was noted. Maintenance ditching of wet fields does not occur frequently or appear to promote long term erosion.

Forest harvest activities are evident in many portions of the WAU. Locations of potential channel disturbance include segment 602, where in 1980 it appears that logging occurred either in or immediately adjacent to the channel for some 3,000 feet and in the upper headwaters of the West Fork. The upper West Fork area experienced intensive, select harvest, and the skid trail density made it difficult to detect channels or the extent of any disburbance. A logging road in segment 203 also appears to displace that small channel for the distance to the headwater wetland.

A limited picture of changes in channel conditions over time in Onion Creek is provided by evaluation of aerial photography. Limiting factors include the short time period covered by the available photography (28 years), the small scale on the earliest and latest photos, and the small size of the majority of streams in the basin. Photos in the basin do not pre-date mining, forest harvest, or early agricultural activities, which limits the detection of major channel changes due to most land use activities. Because of the small size of these channels, the majority of channel disturbance visible from photographs is within the open areas. Confidence in detecting anything but large-scale channel disturbance from this portion of the analysis is low.

2.5 General Channel Conditions

Based on the preliminary analyses above and additional stream survey data, representative channel segments were observed in the field to evaluate current channel conditions. These included key features of the streambed, active channel, and flood plain attributes useful for interpreting channel condition and response potential. Interpretations of the reference segments were then

extrapolated to other segments similar in valley and landform where field surveys were not conducted.

Approximately 1.4 miles of stream were intensely surveyed as part of this analysis, primarily in the fish-bearing streams. Numerous reconnaisance surveys and spot checks were also conducted. Many of the field-verified segments were conducted by both the channel and fish habitat analysts. Other team analysts also contributed to observations of general channel characteristics. Overall, field surveys and observations of approximately 57 percent of the numbered channel segments were used in this analysis. Approximately 50 unnumbered channels were also field checked, and the majority of these were found to have no defined channel and removed from the channel map. Channel attributes from the surveys are summarized by segment in Form E-5 found at the end of this report.

Since the results of the field surveys were used to group segments into geomorphically similar units, a narrative discussion on channel condition interpretations is included in the description for each channel grouping found in Section 4.0 below. Some general statements regarding basin channel conditions are made here.

The first mile of Onion Creek below the fish barrier at the falls is accessible to spawning adfluvial species from Lake Roosevelt. The lower 500 feet of the stream is periodically flooded due to fluctuating lake levels. Above this point, the majority of channel has been straightened through a field and on either side of the cement box culvert under the state highway. The local conservation district apparently provided for the agricultural drainage by cabling logs into the banks along approximately 2,500 feet of channel. Installation of the cabled logs predates the earliest photos available to the assessment team, and could be as early as the mid 1930's. The plane bed morphology along this segment provides little structure necessary for the storing and sorting of spawning gravel and holding habitat.

Localized evidence of land use impacts to fish-bearing channels are found above the falls. A major disturbance occurred in the tributary adjacent to the Van Stone Mine due to an apparent tailings pipe-burst or associated slope failure prior to 1968. The channel immediately below this site remains a boulder cascade devoid of any functional wood in contrast to the step-pool morphology above. Mainstem segments 7 and 10 are point sources of extensive bank erosion and open canopy due to stream access to livestock. Both county and forest roads encroach upon channels with impacts ranging from a reduction in wood availability to sediment overloading in the small tributaries. Road dust from carbonate soils was found to cement the bed surface in segment 202 adjacent to a well-traveled, gravel county road. Harvest activities prior to 1980 along segment 602 has reduced wood recruitment along the left bank.

Wood is important for providing the majority of structure to mainstem and major tributary segments. The majority of these channels fall within a 2 to 4 percent gradient range, which are prone to establishing long riffles in the absence of wood. Overall, woody debris of a size sufficient to function in these channels currently appears to be in adequate supply with a corresponding area in pools (see Section 3.3.3). Within some of the more open areas, however,

wood is supplied by failed beaver dams and wood exhumed from the banks of former beaver ponds. This wood is limited in supply and in various stages of decomposition. Current beaver activity was observed by the team in just a few areas compared to widespread evidence of past activity. Additional structure is also provided by glacial lag boulders, particularly in the smaller tributaries.

Pool filling with fine sediment was inconsistent within segments. Coarse sand/fine gravel filling was found to a depth of 0.4 feet in 6 out of 16 pools in segment 4. The remaining pools had little if any filling. The bed surface of most fish-bearing segments was described as bi-modal due to the abundance of granitic coarse sand and fine gravel observed during the field surveys.

The fish habitat analyst noted very few patches of sorted spawning gravel in most reaches. In addition, the larger substrate particles in both the mainstem and tributaries were frequently found to be 40 to 50 percent embedded with the finer gravels, resulting in few interstitial spaces for winter refuge and rearing. These conditions exist in spite of relatively good habitat indices and wood loading. Several factors may contribute to this condition. These include an oversupply of a certain size-fraction of sediment within the channels, angularity of the coarse bedload, and the timing of field observations relative to periodic sediment flushing flows. The majority of parent material available within the stream system is composed of glacial till high in angular sand and small gravel of granitic origin which may currently, or naturally, be in oversupply relative to other size fractions. The sand/gravel was observed to compose a fair percentage of the mobile stream bed in addition to collecting in pools and velocity shadows. The coarser sediment component of the bed was also observed to be sub-angular, lending itself somewhat more to packing and requiring more stream energy for bed mobilization.

Field observations were conducted following a snow melt runoff event of 6 years or greater recurrence. When snow melt flows are contained within the banks (less than 1 year recurrence), sediment is scoured from the riffles and deposited in downstream pools. As flows approach or exceed bankfull, sediment is scoured from pools and redeposited in downstream riffles (Keller, 1971; Lisle, 1979). Subsequent lower flows will again move sediment from riffles to pools. In this manner, sediment that would have moved rapidly from the upland areas during last year's high snow melt runoff, could be conveyed and transported through the lower-gradient fish-bearing reaches. The unsorted sediment conditions observed may be the effect of transport of the pulse of sediment resulting from high flows. Alternatively, last year's high flows may imply that increased flushing flows are not likely to significantly affect the armoring problem

Few of the confined segments within the WAU are tightly confined within valley walls. Most have at least an additional channel width of floodplain along one or both banks. During high flow events, these small floodplains provide vegetated overflow areas that dissipate stream energy, reduce flood depths, and reduce scour in the main channel. Few channels within the WAU have defined alluvial rather than glacial terraces, indicating a rather stable post-glacial regime.

Debris flow does not appear to be an active process in this basin based on photo and field evidence, although dam break evidence was found in the steeper, confined mainstem segment 5.

Dam break associated with beaver dam failure was observed in segments 4 and 509 and in segment 7 where breaching is moderated by a wider floodplain.

Approximately 65 percent of the mapped channels within the WAU are ephemereal or intermittent. Glacial lag boulders eroded from the glacial soils provide the main roughness element in many of the observed intermittent and ephemeral channels. Forest canopy litter was also observed to function in these small channels along with roots of standing trees.

Grassy swales with no defined channel were removed from the stream layer. All or portions of these swales may in fact be wet during certain times of the year; however, surface runoff conditions are not sufficient for channel initiation. Segment 203 has a well-traveled road located within a former wet swale. The result has been a displacement of the absorption and filtering function of the swale. Former subsurface flow is now channelized into the road ditch, and both the road surface and the ditch drain directly into a stream channel. A high potential exists for increasing the sediment-contributing drainage area in this manner due to the number of non-surface draining swales within the WAU. Forest harvest activities have a high potential to contribute to this situation than other land uses due to the intensity of ground-based operations within areas of swale topography.

The distribution of land use within Onion Creek concentrates the commercial forestry activities within the headwater areas and the non-forestry activities within the valleys where the majority of fish-bearing streams are located. Out of approximately 46 miles of known fish and potential fish-bearing streams within the WAU, 33 miles (72 percent) flow through non-forest or small landownership (see Figure 2, Ownership Map).

Confidence in assessing current channel conditions within the fish-bearing mainstem and mainstem tributary channels is high due to the amount of field surveys and reconnaissance conducted. The emergency water typing rule invoked following the field work introduced uncertainty in extending the current Type 3 waters.

3.0 FISH HABITAT ANALYSIS

The fish habitat assessment for the Onion Creek Watershed used current and historical information to 1) identify fish species present in the watershed, 2) summarize the status of fish populations and fisheries management plans, 3) identify typical habitats and habitats of special concern, 4) discuss habitat conditions, and, 5) summarize vulnerability of various habitat types to changes in conditions that may be a result of forest practices.

This analysis consisted primarily of compiling and summarizing results of fish and habitat surveys completed in the watershed. Interviews were conducted with regional fisheries biologists familiar with the watershed fisheries. Field work consisted of visiting representative reaches throughout the watershed to verify results of previous survey work.

3.1 Fish Distribution and Population Trends

3.1.1 Available Information

Only two fish surveys have been conducted in the Onion Creek Watershed. In 1988, Washington Department of Fish and Wildlife conducted electro-shocking surveys in a reach below highway 21 and another reach above the falls (west half Sec 1, T38 R38). The reach below the falls was sampled in a joint project between Washington Department of Fish and Wildlife and the Colville Tribe in September 1991. All fish species sampled during these surveys are summarized in Table E/F-2. The fish collected at both sites in the WDFW survey were generally small, ranging in size from 3.0 to 9.7 inches, with a mean length of 6.3 inches. Brook trout are not native.

Stocking records were requested from Washington Department of Fish and Wildlife. There were no records prior to 1982 available. There are no records of any fish stocking occurring in the Onion Creek watershed between 1982 to the present. The presence of brook trout in the watershed indicates that stocking either by WDF or private parties has occurred sometime prior to 1982.

Table E/F-2. Fish sampled in 1988 & 1991 fish surveys conducted by Washington Department of Fish and Wildlife and the Colville Confederated Tribes.

Species sampled	1988 Numbers	1991 Numbers
below highway 21		
Kokanee, Oncorhynchus nerka		2*
Rainbow Trout, *Oncorhynchus gairdneri*	58	250*
Cutthroat Trout, *Salmo clarki*		?*
Brook Trout, *Salvelinus fontinalis*		2*
Bull Trout, *Salvelinus malma*		2*
Bluegill, *Lepomis macrochirus*	4	
Dace, *Rhinichthys spp.*	7	
Sculpins, *Cottus spp.*	4	
Northern Squawfish, *Ptychocheilus oregonensis*	2	
above Falls		
Rainbow Trout, *Oncorhynchus gairdneri*	38	
Brook Trout, *Salvelinus fontinalis*	4	

* there are data sheets missing from this survey, records of some species are based on conversations with R.LeCaire who was on the survey crew.

3.2 Distribution and Life History Requirements

This fisheries assessment focuses on instream habitat conditions influencing the growth and survival of kokanee salmon, brook trout, and rainbow trout. Other stream dwelling fish species are not addressed in this report. A waterfall approximately 100 feet tall is 1.2 miles upstream of the mouth of Onion Creek. This falls functions as a permanent barrier to fish passage in the watershed. The life history requirements of salmonids in the Onion Creek Watershed are summarized in Table E/F-3.

Table E/F-3: Simplified description of habitat preferences of key fish species found in the Onion Creek Watershed (Compiled from Behnke, 1992; McPhail and Murray, 1979; Meehan and others, 1992; Shepard et al., 1984; Wydoski & Whitney, 1979).

Species	Life History	Habitat Preferences	Timing
Rainbow	Spawning	0.2 - 1.6" gravel, redd sizes < 2 ft^2	April - May
	Incubation	No redd scouring or siltation	temp dependent, spring/summer
	Winter habitat	Pools, interstitial spaces in cobble/ gravel substrate	water temps. <4 °C
	Summer habitat	water temps. 13-21° C, food and escape cover (lethal temps. 26° C)	
Cutthroat Trout	Spawning	0.2-3.2" gravel, redd sizes 1-2 ft^2	Jan. - April
	Incubation	Stable clean substrate, usu. 50 - 100 days	temp. dependent
	Winter habitat	Pools, interstitial spaces in cobble/ gravel substrate	Water temps < 5°C
	Summer habitat	Pools & lateral habitats, food & escape cover (temps 10 -19° C, lethal 22.8° C)	Water temperatures > 5°C
Brook Trout	Spawning	0.1 - 1.6" gravel, redd sizes < 2 ft^2	late Sept. - Nov.
	Incubation	No redd scouring or siltation	Winter
	Winter habitat	Pools, interstitial spaces in cobble/ gravel substrate	water temps. < 4 °C
	Summer habitat	water temps. 10-19° C, food and escape cover (lethal temps. 25.3° C)	
Bull Trout	Spawning	loose gravels and cobble	primarily Sept.& Oct.
	Incubation	success increases with temperatures <10°C, optimum 2 to 4°C, stable substrate	September - April
	Winter habitat	Pools, interstitial spaces in cobble/ gravel substrate	Water temperatures < 5°C
	Summer habitat	temps 9 - 15° C, food and escape cover	Water temperatures > 5°C

Map E-1/F-1 illustrates the distribution of salmonid species occurring in the WAU. Additional maps illustrating zones of dominant species use or areas of special habitat concern (ie. summer rearing, winter rearing, spawning) were not produced for this analysis because species utilizing the watershed above the falls, rainbow trout and brook trout, utilize the entire stream network during all life history stages and do not typically segregate into specific areas. Below the falls, adfluvial

kokanee and bull trout have been recorded. These fish potentially utilize the entire lower reach for spawning and this area is identified on Map E-1/F-1.

On November 14, 1996, the Forest Practices Board adopted an emergency rule that redefines the physical parameters used to describe Type 3 waters. The new typing system is based on width, gradient and drainage area as follows: 1) Streams at least 3 feet wide and up to 16% gradient, or 2) Streams greater than 16% gradient draining an area of at least 175 acres. Any streams meeting these criteria are presumed to have fish and receive riparian protection unless fish absence is proven. Potential fish bearing reaches as defined by this new rule are also designated on Map E-1/F-1.

The Onion Creek WAU contains several small drainages which flow directly toward the Columbia River. Most of the drainages are ephemeral with low flows and no surface connections to the Columbia. Five Mile Creek, north of Onion Creek does have perennial flow. The outlet of this stream was visited during the field reconnaissance, and a very steep reach just below the highway appears to be a fish passage barrier. No additional habitat surveys were done in these segments.

3.2.1 Resident Native Fish Distribution

This portion of the Columbia River system was covered in ice during the last (Fraser) glaciation, and the current native fish faunas were attained through post-glacial dispersal from the main Columbia system (McPhail and Lindsey, 1986). The distribution pattern of bull trout is largely the result of headwater migrations and drainage crossover by stream capture following the retreat of the last continental ice sheet (Cavender, 1978). This suggests that bull trout and other native salmonids are species that survived glaciation only within refugia (Haas and McPhail, 1991). There are no portions of Onion Creek which are likely to have provided refuge during the glaciation and the presence of the falls near the mouth of Onion Creek would have prevented any fish from dispersing into the upper portion of Onion Creek from below. It is likely that Onion Creek did not support a native fish population, and that the rainbow trout (the only species observed which may have been a native) have been stocked.

3.2.2 Kokanee

Kokanee are landlocked sockeye salmon which occur in Lake Roosevelt. These fish are thought to have descended from a formerly anadromous population of Columbia River sockeye salmon (Groot and Margolis, 1991). Adults will migrate from Lake Roosevelt into stream reaches in the fall to spawn in tail out gravels of deep pools. After incubation the fry migrate into Lake Roosevelt to rear. Two kokanee were observed in the 1991 fish surveys. A trap was installed by the Colville Confederated Tribes in 1996 at the Highway 21 crossing to monitor kokanee and bull trout utilization of the lower reach. No fish were captured. Residents along the lower stream reach historically observed significant numbers of "red fish," which were probably kokanee or sockeye spawning in the lower reach of Onion Creek. Presence of kokanee in spawning condition was confirmed in 1991 (R. LeCaire, CCT, pers. comm., 1996). Kokanee populations in Lake Roosevelt have decreased in recent years. This decrease may be related to several factors. Sport

fishing for kokanee has increased significantly and over-fishing may be depleting stocks. In addition, water operations have decreased water levels during the egg incubation period which would dry out redds and result in decreased spawning success (R. LeCaire, CCT, pers. comm., 1996).

3.2.3 Rainbow Trout

An adfluvial population of rainbow trout is present in Lake Roosevelt which may be a remnant of the formerly anadromous steelhead population (Groot and Margolis, 1991). Adults enter tributary streams in the winter and spawning occurs in April and May. Juveniles may rear in streams for some months, although high flow events may flush rainbow fry into the lake. Rainbow trout have been collected in lower Onion Creek in samples collected by WDFW and the Colville Confederated Tribes. Fish which were collected were small, ranging in size from 3 to 9 inches. It is uncertain if these were resident or rearing adfluvial fish.

Resident rainbow trout occurring above the falls would also spawn in the early spring. Eggs will incubate during the high flow periods. Summer rearing habitat can be varied although rainbow trout will usually be associated with cover of some type. During the winter, cold temperatures keep fish relatively immobile. They prefer deep pools or areas with access to interstitial substrate spaces.

3.2.4 Cutthroat Trout

Cutthroat trout are resident in Lake Roosevelt and were observed in lower Onion Creek during the 1991 fish surveys. There are no records of cutthroat trout occurring above the falls, although small remnant populations may exist in headwater areas.

3.2.5 Bull Trout

Bull trout (*Salvelinus confluentus)* has been identified by Cavander (1978) as a distinct species of char unique to western North America. They are currently considered a Federal Category I (C1) species currently under consideration for listing by the U.S. Fish and Wildlife Service as a threatened or endangered species. The Service concluded that sufficient information on the biological vulnerability and threats to the species was available to support a warranted, but precluded, finding to list bull trout. This decision will be reviewed in June 1996.

Bull trout exhibit both resident and migratory life history forms (Rieman and McIntyre 1993). The presence of the waterfall in lower Onion Creek prevents any fish migrations. Bull trout which have been collected in lower Onion Creek are probably part of a fluvial population present in low densities in Lake Roosevelt. There are no records of bull trout occurring in the upper portion of the Onion Creek Watershed.

3.2.6 Eastern Brook Trout

Brook trout were observed throughout the Onion Creek drainage. Their habitat requirements for summer and winter rearing are similar to rainbow trout, although brook trout tolerate a wider range of conditions. Because they are tolerant of more diverse spawning and rearing habitat conditions, brook trout typically displace the native fish which may occur in a drainage.

3.3 Summary of Habitat Conditions

3.3.1 Field Surveys

Approximately 0.75 miles of stream were surveyed with data collected on all key habitat parameters for this analysis. Numerous spot checks and reconnaissance surveys were also conducted. The riparian analyst provided LWD counts from additional segments. Channel attributes from the surveys are summarized by segment in Form E-5 found at the end of this report along with sample field data collection forms.

3.3.2 Determination of Habitat Diagnostics

The Watershed Analysis Manual requires that comparisons be made between the existing conditions and a table of indices of resource condition which have been developed in the manual. This list of reference conditions was developed for habitat conditions in western Cascade streams and is not well suited for streams in the northeast portion of Washington. More appropriate indices of habitat condition were developed for this analysis. Selected habitat variables from habitat suitability index (HSI) models for brook trout, cutthroat trout, and rainbow trout were used as references (Raleigh, 1982; Hickman and Raleigh, 1982; and Raleigh et al., 1984). The habitat suitability curves were identical for all three species so only one set of parameters is developed for this analysis. Habitat variables from these models were matched with habitat parameters measured in the field. Habitat quality rankings were developed from the suitability curves (Table F-4).

Indices for LWD in the Watershed analysis manual were developed from information on streams in western Washington. To address conditions in eastern Washington streams several data sources were utilized. Montgomery et al. (1995) found LWD exerted a systematic influence on pool spacing in pool-riffle, forced pool-riffle, and plane bed morphologies. LWD also apparently decreases pool spacing (channel widths/pool) in step-pool channels. They found an inverse relationship between pool spacing and LWD frequency (pieces/m). Pool spacing declined significantly with increases in LWD frequency from 0 to 0.2 pieces/m, declined gradually with increases from 0.2 to 0.5 pieces/m, and declined very little with increases above 0.5 pieces/m.

Table E/F-4. Indices of resource conditions

	Habitat Quality Ranking		
Habitat Parameter (source)	**Poor**	**Fair**	**Good**
Percentage pool area (Raleigh et al. 1984)	<20% or > 70%	20 -30 %	30-70%
Pool depth & Cover Class (Based on Raleigh et al. 1984)	> 30 %, < 15cm deep and <30% LWD formed	> 30 %, >15cm deep and ≥30% LWD formed	> 60 %, > 60 cm deep and >60% LWD formed
Substrate (Washington Manual)	Sand or small gravel is sub-dominant in boulder or cobble dominant units (ie. Interstices filled)	Sand is sub-dominant in some units with cobble or boulder dominant (interstices reduced)	Sand or small gravel is rarely sub-dominant in any unit (interstices clear)
Gravel Availability (Washington Manual)	absent or infrequent		Frequent spawnable areas
LWD (Overton et al.1995, Martin 1996)	<0.2 pieces/cw	0.2-0.4 pieces/cw	>0.4 pieces/cw

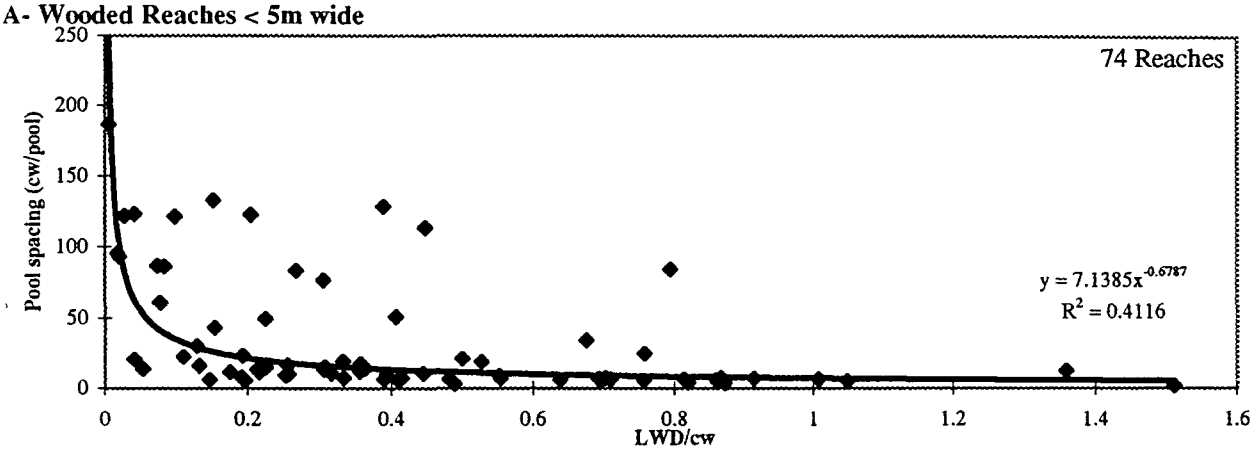
In the West Branch Watershed Analysis, Martin (1995) used data collected within the WAU to develop a watershed specific relationship between LWD and pool spacing. The criteria developed for West Branch WAU are as follows; Poor <0.2 pieces/cw, Fair 0.2-0.6 pieces/cw, and Good >0.6 pieces/cw. We did not sample enough stream reaches to develop a relationship specific to the Onion Creek Watershed. In order to test this relationship we took the Natural Conditions Database compiled by Intermountain Research Station (Overton et al., 1995) and plotted the relationship between LWD/cw (wetted) and pool spacing (wetted cw/pool). This database contains information from 196 stream reaches which occur in wilderness areas or areas which have not been subjected to extensive management activities, and therefore represents 'pristine' or undisturbed stream habitat conditions. This data was collected in the Salmon River Basin in central Idaho. The climatic, hydrologic, and geologic conditions in this area relatively similar to those in northeastern Washington. This analysis only included stream reaches which passed through forested areas and contained large woody debris. Since channel width strongly influences pool spacing in forest streams (Montgomery et. al., 1995), we plotted the relationship between LWD and pools based on wetted channel widths (Figure E-1b-1d).

The plots in Figure E/F-1a clearly illustrate an inverse relationship between LWD and pool spacing in streams less than 5 m wide. As the number of pieces of LWD increase, the space between pools decreases. There is no clear relationship in stream channels greater than 5 m. For stream channels less than 5 m wide, the greatest decrease in pool spacing is observed between 0 and 0.2 pieces of LWD per channel width. Between 0.2 to 0.4 pieces of LWD per channel width, some decrease in pool spacing is apparent, and the decreases level out with greater than 0.4 pieces of LWD per channel width.

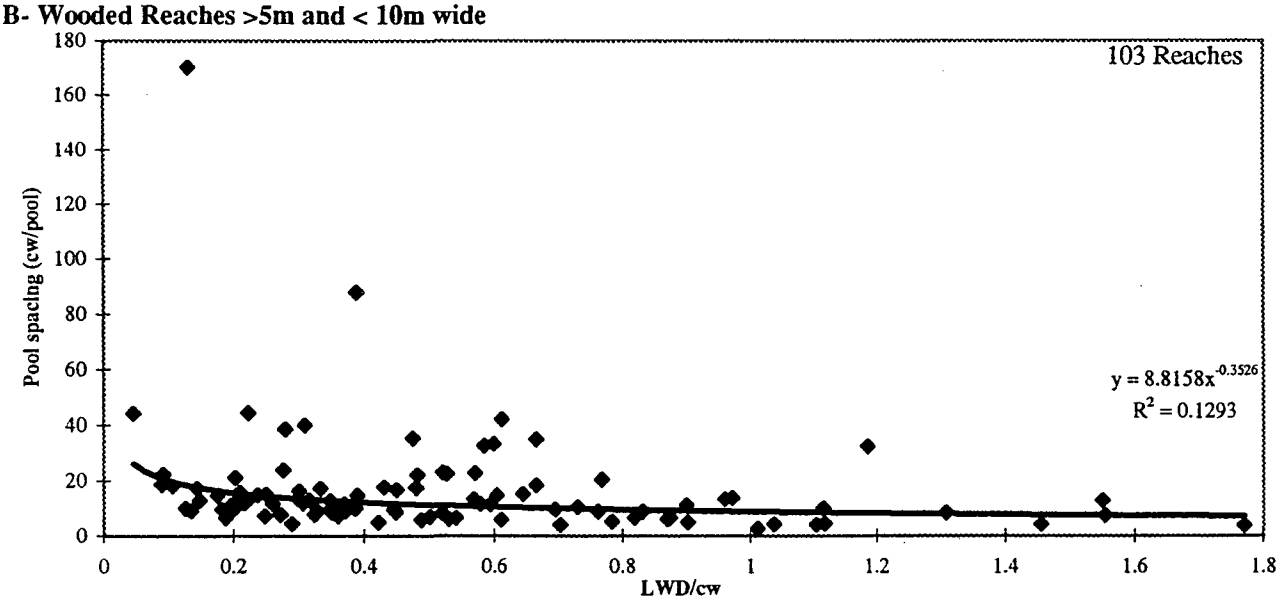
To further test this relationship, we plotted the data from streams less than 5 m wide by gradient and confinement classes (Rosgen designation) (Figures E/F 2a, b, c). These plots illustrate LWD has less influence on pool formation in higher gradient, confined streams and has a stronger influence on lower gradient, less confined streams.

Figure E/F-1: Relationship of LWD to pool spacing by stream size. Mainstem stream segments passing through forested areas containing lwd and pools (Natural Conditions database Overton et al. 1994).

A- Wooded Reaches < 5m wide



B- Wooded Reaches >5m and < 10m wide



C- Wooded Reaches >10m wide

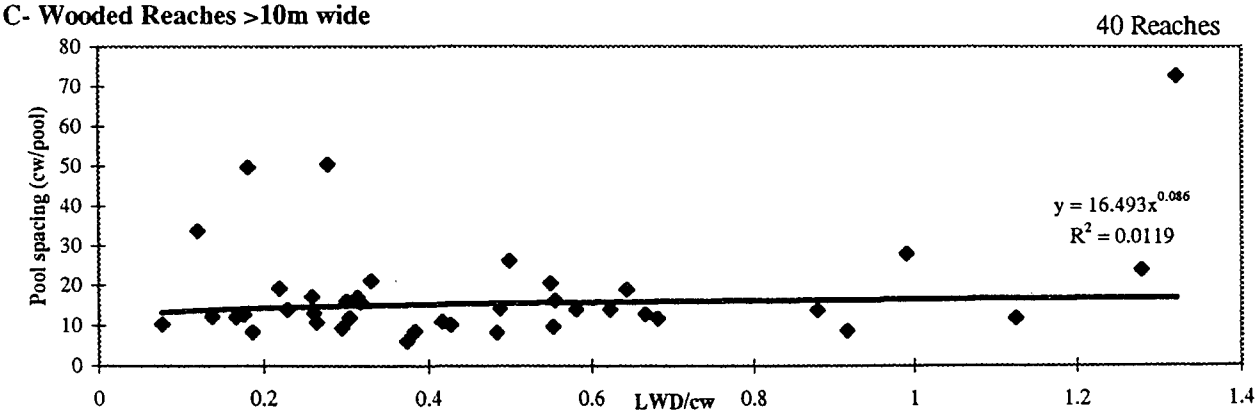
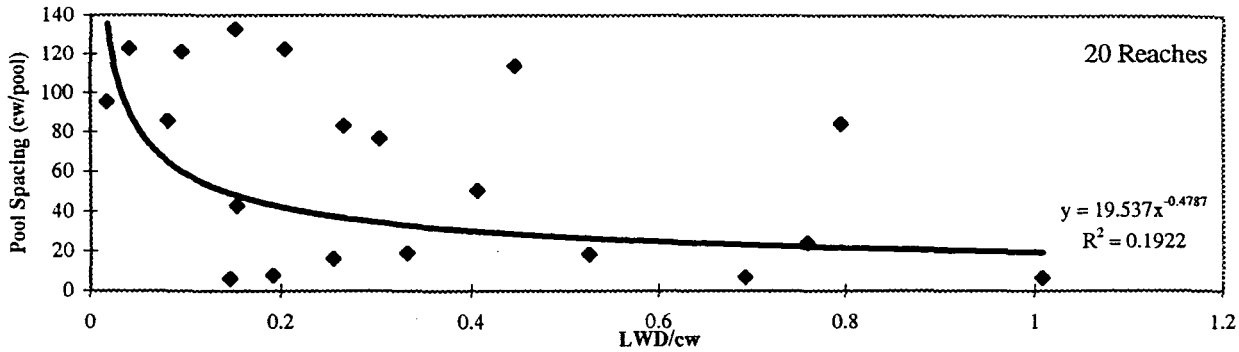
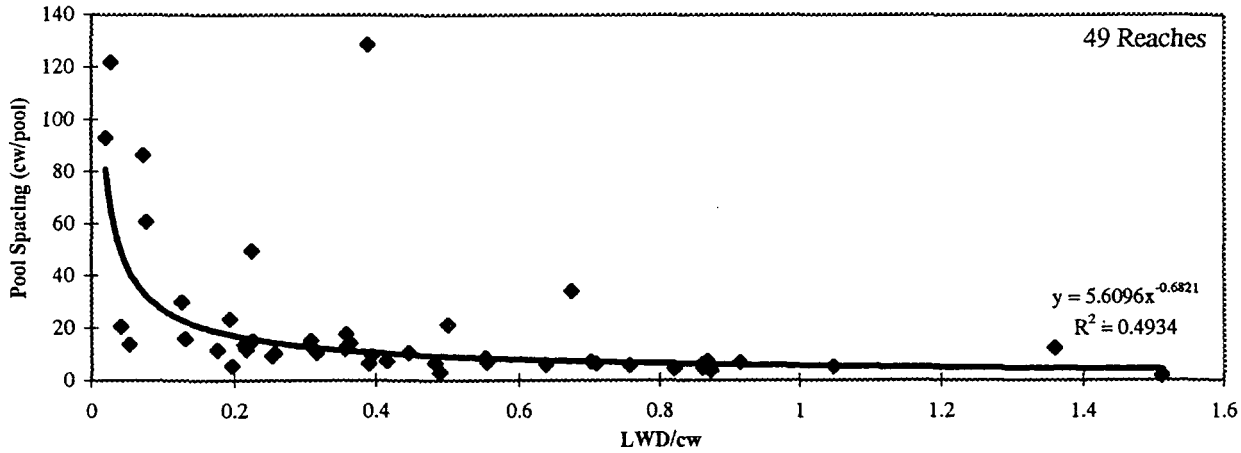


Figure E/F-2: Relationship of LWD to pool spacing by gradient and confinement classes (Rosgen Type). Mainstem stream segments passing through forested areas containing lwd and pools (Natural Conditions database Overton et al. 1994).

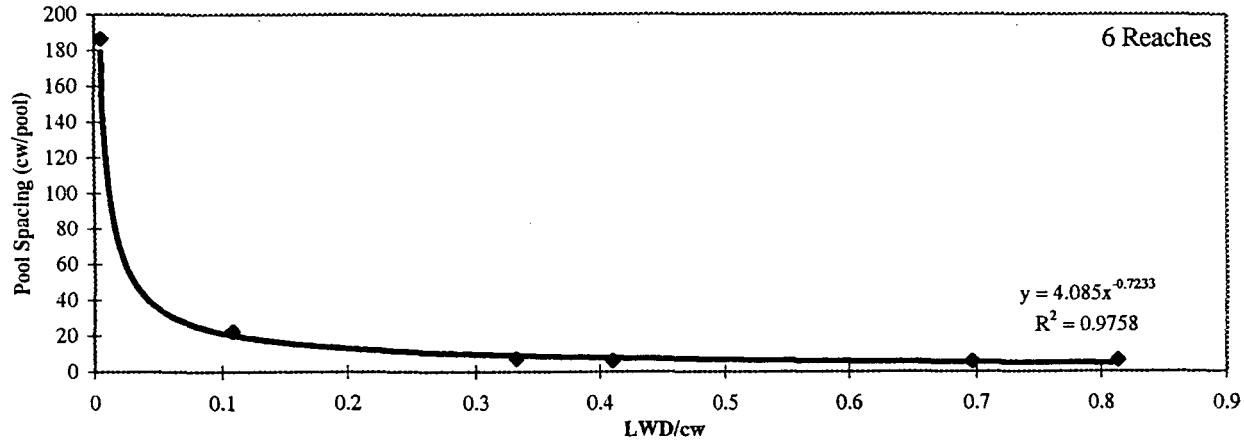
A- Wooded Reaches < 5m wide (Rosgen A, gradient 4-10%, confined)



B- Wooded Reaches < 5m wide (Rosgen B, gradient 2-4%, moderatly confined)



C- Wooded Reaches < 5m wide (Rosgen C, gradient <2%, unconfined)



Martin (1995) developed a similar relationship working with data from the West Branch Watershed with 13 data points. The LWD criteria developed for West Branch WAU were: Poor <0.2 pieces/cw, Fair 0.2-0.6 pieces/cw, and Good >0.6 pieces/cw. From the Natural Conditions Database, the criteria from West Branch appear conservative for streams less than 5 m wide but would be appropriate for streams between 5 and 10 m wide. Since the relationship developed from the Natural Conditions Database have a larger sample size and all streams in Onion Creek were less than 5 m wide, we applied the following criteria for our analysis: Poor <0.2 pieces/cw, Fair 0.2-0.4 pieces/cw, and Good >0.4 pieces/cw.

3.3.3 Habitat Condition Evaluation

Habitat conditions which were quantitatively sampled during the field visit are summarized in Form E-5 in the appendix of this section. The habitat diagnostics determined for key habitat parameters are summarized in Table E/F-5 (Form F-3).

3.4 Areas of Habitat Concern

Habitat conditions in the Onion Creek Watershed were variable. Following is a general discussion of key observations and concerns identified in the watershed.

3.4.1 Spawning Gravel \ Winter Rearing Habitat

The presence of fine sediment (particles < 0.6 cm) mixed with gravels, cobbles and boulders severely reduces the availability of winter rearing habitat by filling interstitial spaces which would be utilized as refuge. The mix of particle sizes reduces the quality of spawning habitat. Fish observed and sampled in the watershed were generally small and would be expected to spawn in smaller gravels (<1"). However, the observed mix of large and small particles reduces the ability of small fish to excavate redds.

The area of pool habitat and number of pools was good for almost all reaches sampled. However pools were not as deep as would be expected for optimal habitat.

3.4.2 Large Woody Debris

LWD numbers were generally fair to good. The distribution and function of LWD in segments 4, 5, 7, and 509 was influenced by previous beaver activity based on the presence of old beaver dams. In these reaches 'old' wood is being eroded out of stream banks indicating there has been a long history of beaver activity.

LWD appears to play a critical role in maintaining habitat conditions in the steeper tributary reaches. Segment 505 provides a graphic example of the function of LWD. Habitat conditions above a channel failure due to a pipe burst consist of deep step pools formed primarily by the interaction of LWD and boulders. Below the failure, limited LWD is present and has not become fixed in the channel. This segment is a boulder cascade with few pools and a shallow channel.

Table E/F-5 (Form F-3): Onion Creek Habitat Condition Evaluation.

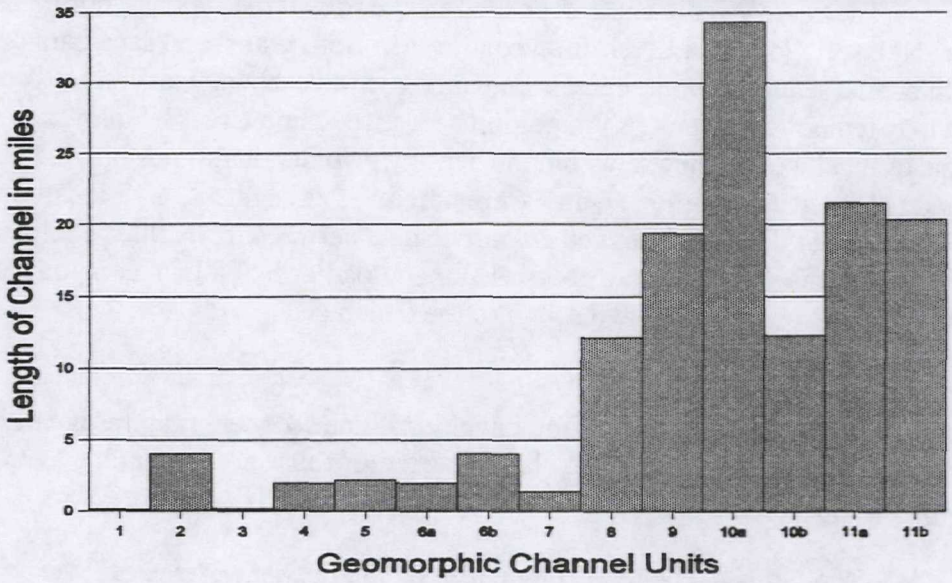
Segment Number (distance sampled)	% Pool Area	Pool depth (% pools > 15 cm / %> 60 cm) & Cover Class (% pools LWD formed)	Substrate (Winter Rearing)	Spawning Gravel Availability	LWD
1 (700 ft)	na[1]	na[1]	no spaces **Poor**	none **Poor**	0 **Poor**
2 - below hwy (730 ft)	21% **Fair**	89%>15cm/11%>60cm &~20%lwd(tree)formed (only 2 pools) **Poor**	no spaces **Poor**	very few patches **Poor**	.16 **Fair/ Poor**
2 - above hwy (415 ft)	11% **Poor**	100%>15cm&50%lwd formed (tree scour) **Fair/ Poor**	no spaces **Poor**	none **Poor**	0 **Poor**
3 (~200 ft)	?	**?**	spaces filled **Poor**	none **Poor**	low-none **Poor**
4 - above falls to beaver dam (590 ft)	52% **Good**	100%>15cm&53%lwd formed **Fair/Good**[3]	no spaces **Poor**	spawninggravels mixed with fines **Poor**	.99 **Good**
4 - open area above falls (170 ft)	15% **Fair**[2]	one pool in reach **Poor**	no spaces **Poor**	spawninggravels mixed with fines and cobbles **Poor**	1.5 **Good**
4 - above county road (408 ft - split channel 205 ft)	15% **Poor**	100%>15cm&~50%lwd formed **Fair**	no spaces **Poor**	spawninggravels mixed with fines and cobbles **Poor**	.84 **Good**
7 - lower (375 ft)	67% **Good**	82%>15cm/18%>60cm & 63% lwd formed **Fair**	no spaces **Poor**	patches of gravel in 3 of 15 units **Fair/Poor**	.74 **Good**
7 - mid with cattle (340 ft)	68% **Good**	100%>15cm&50%lwd formed **Fair**	no spaces **Poor**	one small patch of gravel **Poor**	.97 **Good**
305 (250 ft)					.14 **Poor**
501 (100 ft)					.02 **Poor**
502 (upper) (256 ft)	34% **Good**	100%>15cm&37%lwd formed **Fair**	spaces reduced **Fair**	small patches of gravel **Poor/Fair**	.79 **Good**
509 (600 ft)	?	100%>15cm&~40%lwd formed **Fair**	no spaces **Poor**	coarse sand near margins **Fair**	.13 **Poor**
601 (150 ft)					.37 **Fair**
602 (300 ft)	50% **Good**				1.3 **Good**
701- upper road x-ing (200 ft)					.23 **Fair**
705 (100 ft)					.90 **Good**

1 - Segment is within Lake Roosevelt influence

1- Segment pool area was 15%, with 35% glide

2- Segment exceeds criteria for wood formed pools but does not quite meet criteria for depths

Figure E/F-2. Lengths of stream by geomorphic channel unit.



1. Mouth of Onion Creek (<1%)

Description: This morphologic unit describes a single unique segment of the lower mainstem Onion Creek that is influenced by the raising and lowering of Lake Roosevelt. The gradient is less than 1 percent, and the dominant substrate is coarse sand. When the lake level is down, the bed morphology tends to long glides with occasional bank or bedformed, shallow pools. The channel has some terrace confinement of the left bank, but is generally unconfined. Sediment deposition patterns and particle sizes fluctuate with the changing daily and seasonal lake levels. As the lake level rises, the deposition of finer material occurs farther upstream. An observed medial bar was composed of a layer of gravel on the bottom, coarse sand in the middle and organic silt on the top. From tracks on the sand bars, this reach appears to be frequently utilized by the local wildlife.

Habitat Conditions: The habitat in this unit is influenced by variable lake levels and sediment deposition. The frequency of this variation is unknown. Habitat conditions are not stable for the duration of the spawning, egg incubation, and winter rearing periods (September to May). Therefore, the only function of this unit is as a migratory corridor to more stable reaches upstream.

Segments: *Field verified*: 1

Conditions and Response Potential:

Coarse Sediment: Both coarse and fine sediment deposit in this delta segment of the Columbia River. The coarser sediment is deposited further down the segment during higher stream flows and lower Columbia River flood conditions. Both gravel and sand bars develop. An increase in coarse sediment would temporarily increase the channel width and decrease the depth, which may temporarily block fish migration access to Onion Creek. Following deposition, the channel would reincise within the deposit. No distributary or braided channel pattern common to high sediment load deltas were noted in this segment. The location of this segment within the older delta/fan complex did not change between the earliest photos and the present. This could indicate a moderate coarse sediment load or that a high component of sediment load is mobile or suspendable through to the Columbia. *High sensitivity/vulnerability*

Fine Sediment: Due to the flucuating flood conditions, fine sediment may easily bury or fill the coarser gravels in areas where spawning has occurred or those areas that may have provided spawning opportunties for adfluvial species. *High sensitivity/vulnerability*

Peak Flow: The segment is directly influenced by the flucuating level of Lake Roosevelt, which may flood the segment during peak flow events and during periods of water storage. Overbank inundation of the immediate floodplain provides a low energy, backwater environment rather than the scour potential of concern in this rating. *Low sensitivity/vulnerability*

Large Woody Debris: Due to the periodic flooding in this unit, wood would not function to modify channel characteristics. Wet site conditions do not support tree growth. *Low sensitivity/ vulnerability*

Riparian Vegetation: The roots of wetland grasses and other vegetation provide the structure against erosion of the fine-textured streambank soils and help to limit the extent of channel widening. Little additional fish habitat is gained, however, as grass roots did not appear to promote bank undercutting here, the channel lacked cover and is too shallow to provide anything but a migration corridor during flood conditions. *High sensitivity*

Dam breaks: No dam break potential exists within this segment due to the extremely low gradient. This segment is buffered from the direct impact of upstream dam break by long lengths of low gradient segment 2 channel, which is currently very low in dam-forming wood. *Low sensitivity/vulnerability*

2. Mainstem , 1-2%, moderately confined to unconfined

Description: Unit 2 includes the lower-gradient channels of the mainstem of Onion Creek. These segments occur near the mouth of Onion Creek in an alluvial fan-terrace complex (segment

2), in the upper middle part of the watershed within a glacial outwash deposit (segment 7), and within a low-gradient reach of deep till soils (segment 10). The bed morphology is dominated by pools and riffles forced by wood and banks. The channels are moderately confined to unconfined within gentle valley slopes and terraces. Portions of segment 2 have been artificially incised and confined. A plane bed almost devoid of pools persists in segment 2 where channel straightening has occurred above and below the highway concrete box culvert and within an agricultural area apparently straightened to promote drainage 30+ years ago by the local conservation district. Cabled logs line both banks of the channel for approximately 2,500 feet upstream of the highway. The bed surface in the unchannelized section is composed of fine to coarse gravel, and large gravel and small cobbles dominate in the channelized portions of segment 2. Channel gradients are approximately 1 percent, but may be as high as 2 percent within the channelized area. Evidence of past beaver activity was found in segment 7 below an area maintained as cattle pasture. One channel-spanning impoundment, apparently for stock watering, was noted in segment 7. Livestock were also observed to have access to segment 10. Low flow discharge in segment 10 was measured at 1.4 cfs.

Habitat Conditions: The channelized portion of segment 2 has a uniform, shallow glide and riffle composition with virtually no pools or LWD to provide cover or refuge. This morphology is very poor fish habitat. The unchannelized segments currently sustained good to fair habitat conditions. Bank vegetation in segments 2 and 7 were generally dense grasses and shrubs providing cover, undercut banks, and leaf litter inputs. Pools were frequent and moderately deep. Suitable patches of spawning gravels for adfluvial fish (0.1 to 3.0 inches) were present in only small areas. Larger substrate particles were 40 to 50 percent embedded resulting in few interstitial spaces for winter refuge and rearing. LWD functions to form pools and cover and is lacking in segment 2.

Segments:	*Field verified:*	2, 7
	Reconnaissance:	10

Conditions and Response Potential:

Coarse Sediment: The Onion Creek sediment load is high in fine gravel/very coarse sand-size particles eroded from extensive glacial till deposits within the watershed. These particles constitute both the coarse fraction of the bed and deposit in pockets, velocity shelters, and overbanks as fines. Increases in coarse sediment, and this particle size in particular, have and will deposit on the bed, fill pools, and may overwhelm some wood structures. Coarse sediment deposited in an area of segment 10 was observed to cause multiple, shallow channels providing little habitat complexity. The fine gravels could provide good spawning habitat for resident fish; however, they were generally unsorted due in part to the high volume of fine gravel within the system. *High sensitivity/vulnerability*

Fine Sediment: As discussed above, gravels in this unit lacked sorting appropriate for good spawning. Increases in fines will contribute to this condition and fill interstial spaces of sorted

gravels. Pool filling by fines within the sampled segments was as high as 30 percent in segment 7 with access to cattle and very low in segment 2 below the highway. Pool filling increases with a higher sediment input, such as that available within the eroded cattle area, and with an increase in the number of pools. *High sensitivity/vulnerability*

Peak Flow: Peak flows are accommodated within the vegetated flood plain adjacent to most reaches. Some increase in bank erosion and rearrangement of woody debris would be expected with increases in peak flows. With adequate LWD and riparian root strength on the banks, impacts from peak flows would be moderate. *Moderate sensitivity/vulnerability*

Large Woody Debris: Lower pool surface area corresponds with lower wood counts in the survey data between segments 2 and 7 (see Form E-5). In the absence of wood, deep pools formed at the banks in segment 2 below the channelized reach. Plane bed morphology is dominant within the portion of segment 7 recovering from agricultural grazing. This channel did not have much sinuosity which could promote bank-formed pools without wood. LWD within segment 7 where cattle are grazed is old and decaying with little recruitment potential. *High sensitivity/vulnerability*

Riparian Vegetation: Tree roots are the observed primary sources of bank protection in unit 2 streams but is also supplied by LWD, wood buried in the banks, and less effectively by grass roots. Stream banks along the channelized portion of segment 2 are protected by cabled logs. A higher percentage of bank erosion occurs within unit 2 channels where livestock were observed to have access to the channels (segments 7 and 10) resulting in increased sediment supply, reduced wood recruitment, and reduced cover for fish. *High sensitivity/vulnerability*

Dam breaks: Dam break could occur within these channels from the breaching of beaver dams or impoundments. Due to low gradients and vegetated floodplains, the resulting flood wave would attenuate quickly. Localized bank erosion and channel rearrangement could result. *Moderate sensitivity/vulnerability*

3. Bedrock Falls (>20 %)

Description: This unit applies to segment 3, a bedrock falls located at the intersection of the uplands and the Columbia River terrace. The falls are carved from metalimestone and are precipitious, dropping near vertically for approximately 80 feet. Total drop over the 500 foot segment is approximately 160 feet, or an average gradient of 32 percent (measured from topographic map). The segment includes a lower gradient area at the base of the falls transitional to the segment below. A dam and old pump house located at the head of the falls allows very little transition in gradient between segment 4 above and the falls.

Habitat Conditions: This steep segment is a fish barrier and doesn't offer any habitat.

Segments: *Field verified*: 3

Conditions and Response Potential:

Coarse Sediment: All coarse sediment is transported through this segment, or held for a short time in pockets among the bedrock and boulders. *Low sensitivity/vulnerability*

Fine Sediment: Fine sediment is transported through this segment. *Low sensitivity/vulnerability*

Peak Flow: The bedrock banks and extremely steep gradient in this segment are essentially invulnerable to changes in peak flows. *Low sensitivity/vulnerability*

Large Woody Debris: Wood was not observed to be functioning in this segment. Recruitment immediately above the steep gorge is limited to wind throw and mortality, and breakage is likely to occur as trees drop into the steep, narrow bedrock channel. *Low sensitivity/vulnerability*

Dam breaks: Dams are unlikely to form or persist in this segment, and the steep gradient extremely limits ponding volume potential. *Low sensitivity/vulnerabiltiy*

Riparian Vegetation: Banks are bedrock. *Low sensitivity/vulnerability*

4. Mainstem, 2-4%, moderate to confined within terraces and sideslopes

Description: Mainstem segments 4 and 6 are included in this unit. Segment 4, located immediately upstream of the falls, is moderately confined within a deposit of glaciofluvial and alluvial sediments. Segment 6 is transitional between a higher gradient, confined channel below (segment 5, unit 5) and a lower gradient segment above (segment 7, unit 2). Confinement is generally moderate within valley sideslopes. Channel gradients in segment 4 are mainly in the 2 to 3 percent range and those in segment 6 are in the 3 to 4 percent range. Bed morphology is forced pool-riffle in the 2 percent gradient range, increasing to as much as 50 percent step-pool in the 3 to 4 percent gradient range. Even in the 4 percent range, measured bankfull widths in segment 4 are 2 to 4 times the low flow wetted width with side channel development, attributable mainly to the storage provided by abundant riparian wood over time. In the 2 percent range, bed surface particles were visually described as bi-modal consisting of cobble-coarse gravel and abundant small gravel-very coarse sand of a granitic source. The coarser textures are dominant in the 3 to 4 percent gradient range. A large, abandoned beaver dam complex observed in segment 4. Immediately above the dams, the channel is entrenched 3 to 4 feet into dominantly silty alluvial banks. Wood previously buried within the banks is being exhumed. This entrenched portion of segment 4 has a long glide associated with it, but channel sinuosity appears to be increasing as is evidenced by higher bank erosion in this reach.

Habitat Conditions: The segments within this unit currently sustain good to fair habitat conditions. Bank vegetation in segment 4 is generally shrubs and forbs which provide cover and leaf litter inputs. Pools are frequent and moderately deep. Suitable patches of sorted spawning gravels for smaller resident fish (0.1 to 1.0 inches) are virtually absent due to the mix of larger cobbles with coarse sands. The larger substrate particles are 40 to 50 percent embedded resulting in few interstitial spaces for winter refuge and rearing. LWD functions to form pools and cover.

Segments: *Field verified:* 4
Reconnaissance: 6

Conditions and Response Potential:

Coarse Sediment: The Onion Creek sediment load is high in fine gravel/very coarse sand-size particles eroded from extensive glacial till deposits within the watershed. These particles are found in the bed beneath the armor layer and deposit in pockets, velocity shelters, and overbank areas. Continuing levels or increases in this particle size range will contribute to bed fining and lack of spawning gravel sorting. The reaches immediately upstream also deliver medium-size gravel, so sources for larger particles are limited to bank erosion and extremely infrequent landslides within this immediate, lower portion of the watershed. Large increases in the larger particle sizes are unlikely, but could widen the bed and bury some pool-forming structures. This rating applies to the combined effect of the low potential for a change in the current large particle-size regime and the moderate effect of continuing high levels of the fine gravel and sand. *Moderate sensitivity/vulnerability*

Fine Sediment: Inconsistent filling of pools with the fine gravel/sand material was found in segment 4 where the pool counts were higher. Sand was found in 6 out of 16 pools up to a depth of 0.4 feet. The remaining pools had little if any sand/gravel filling. This size fraction also contributes to a lack of well-sorted gravel for spawning by filling interstitial spaces. *High sensitivity/vulnerability*

Peak Flow: Measured bankfull widths are 2.3 to 3.4 times wider than low flow wetted widths indicating the systems ability to accommodate peak flows in both the horizontal and vertical directions. Bankfull over wetted width is lower in the entrenched reach above the old beaver dams, and bank erosion here is higher as sinuosity continues to develop within the entrenchment. A recent high flow event in lower segment 4 deposited silt, sand and small woody debris onto a vegetated floodplain. If wood structures are stable, then the localized scour from peak flows will promote pool formation. *Moderate sensitivity/vulnerability*

Large Woody Debris: LWD greater than 12 inches dbh was the primary pool and step former in the surveyed segments. Wood also functions to armor banks and deposit and sort gravel. Long riffles and glides develop where wood is less abundant. Overall, LWD contributes significantly to holding, spawning, and cover habitat within these channels. *High sensitivity/vulnerability*

Riparian Vegetation: With the exception of the entrenched reach above the old beaver dams, bank erosion is low and found almost exclusively at the outside of bends. The roots of large trees are the primary erosion protection followed by LWD. Grass roots were somewhat effective in the entrenched reach, and some boulders were also functioning in the upper gradient range. The buried wood in the banks above the old beaver dams also provides protection against bank erosion. *High sensitivity/vulnerability*

Dam breaks: Dam break could occur within these channels from the breaching of beaver dams or impoundments. Due to low to moderate gradients and adequate vegetated overbank area, the resulting flood wave would attenuate quickly. Localized bank erosion and channel rearrangement could result. No channel damage was noted below the failed beaver dams in segment 4; however, the features have been abandoned for several decades or more. *Moderate sensitivity/vulnerability*

5. Mainstem, 4-8%, confined

Description: This unit includes the higher gradient channels of mainstem Onion Creek. Segment 5 is confined by bedrock hillslopes. Segments 8 and 9 are confined by incised till-covered footslopes. Bed morphology is mainly step pools with some long, lower-gradient forced pool reaches associated with the longer steps. A wood jam in segment 5 measures 30 feet wide, 25 feet long, and approximately 6 feet high. Bed roughness is also provided by boulders, with a visually bi-modal mobile bed consisting of cobbles and fine gravel. We measured a 2 cfs low flow discharge in segment 9. Less instream wood was observed in segments 8 and 9 than in segment 5.

Habitat Conditions: The segments within this unit were not quantitatively sampled. Segments 5, 8 and 9 were visited and qualitative observations were noted. Bank vegetation is dominated by dense shrubs and forbs providing cover and leaf litter inputs. Pool habitat is provided within step-pool complexes. Pools appear common and are moderately deep. Suitable patches of sorted spawning gravels for small resident fish (0.1 to 1.0 inches) are virtually absent due to the mix of larger cobbles with coarse sand. Larger substrate particles are present, and the small boulder piles provide some interstitial spaces for winter refuge and rearing. LWD functions to retain spawning gravel, form pools, and provide cover.

Segments: *Field verified*: 5, 9
Reconnaissance: *8*

Conditions and Response Potential:

Coarse Sediment: Coarse sediment deposits behind wood steps, but storage is limited due to steep gradients and valley confinement. Sources for larger particles are limited to bank erosion and extremely infrequent landslides within this lower portion of the watershed. Sources for the fine gravel fraction are abundant upstream. Substantial increases in the larger particle sizes are unlikely, but could temporarily widen the bed behind the steps and store in

small bars. Increases in the fine gravel fraction would contribute to the poor sorting and embedding of spawning gravels and winter rearing habitat in the step reaches, but much of it is easily mobilized during moderate flows. Boulders are not frequently mobile. *Moderate sensitivity/vulnerability*

Fine Sediment: Fines in the coarse sand size were found only locally in slack water areas and within some pools in the steps. As discussed in the coarse sediment section above, increases in this size sediment will contribute to filling of interstitial spaces within the step reaches and some pool filling. Much of this sediment is transported downstream during moderate to high flows. *Moderate sensitivity/vulnerability*

Peak Flow: Wood and debris jams form within this unit. The large debris jam described above along with a concentrated deposit of large wood above the high water margins in segment 5 provide evidence of the capacity of the stream to transport LWD through these segments. Peak flow increases may increase the mobility or redistribution of in-channel wood. Channel impacts were localized. *Moderate sensitivity/vulnerability*

Large Woody Debris: LWD is critical in providing the step-forming structure in these segments. Wood steps create scour pools, trap sediment usable for spawning, and provide cover. In the absence of wood, boulders will provide cascades and loosely organize in smaller steps, but the amount and complexity of habitat will be greatly diminished. *High sensitivity/vulnerability*

Riparian Vegetation: Bank erosion is low. Although protection from erosion is provided primarily by bedrock banks, boulders, and LWD, standing riparian trees aid in both log jam formation and attentuating dam break channel damage and do provide bank protection and pool scour in the lower gradient steps. *Moderate sensitivity/vulnerability*

Dam breaks: Evidence of the break up of a debris jam was observed in segment 5, although the impact was localized due to the trapping affect of standing riparian trees. No evidence of catastrophic or long runout damage was noted in the field or from photographs. *Moderate sensitivity/vulnerability*

6a. Tributary connected wetlands with potential access to fish

Description: This collection of very low-gradient segments (<1%) are found in the tributaries of Onion Creek in the valley bottoms or, in the case of Quinns Meadow (segment 314), on a gentle, till-buried ridge. These segments may include a short section of defined channel outlet. These features are topographically derived and are generally areas of springs. Segment 712 (and possibly 706 and 709) has a complex of beaver dams and ponds. It is questionable if segment 712 has a surface water outlet, but was included in this unit because of proximity to potential fish-bearing channels and possible seasonal access. Open water areas vary from 2 to 7 acres. All are

classified as non-forest wetlands (Water Quality assessment), and substrates are assumed to contain fines and organics.

Habitat Conditions: Without field verification, these segments are assumed to have seasonal access to fish. The outlet channel at Quinns Meadow was dry during field work in early October. These areas may provide refuge from high flows, and the wetland ponds could provide some rearing habitat.

Segments:	*Field verified:*	703, 903 (from 6b)
	Team notes:	314, 712
	Extrapolated:	706, 709

Conditions and Response Potential:

Coarse Sediment: Coarse sediment usually has deposited prior to reaching these low gradient segments or will deposit close to the source, which may diminish some wetland capacity but should not change the essential morphology. *Low sensitivity/vulnerability*

Fine Sediment: Wetlands are natural settling ponds for fine and suspended particles. A large increase in fines may significantly reduce the wetland volume over time and is dependent on the rate of background fine-filling, volume of the wetland, and volume of management-induced sedimentation. *Moderate sensitivity/vulnerability*

Peak Flow: Wetlands provide a low energy, backwater environment rather than the scour potential of concern in this rating. Peak flow increases will merely flood a larger area. *Low sensitivity/vulnerability*

Large Woody Debris: LWD provides no morphologic function except contributing to organic filling of the wetland. However, it could provide cover for fish. *Moderate vulnerability*

Riparian Vegetation: The amount of vegetation in and surrounding the wetland is a function of the ponded water depth and area. Wetland vegetation provides cover for fish. *Moderate vulnerability*

Dam breaks: Some of these wetland segments are controlled by beaver dams. Upon draining, the wetland size is greatly reduced and may return to a single, low-gradient channel. This is a natural cycle of wetland function. Both pre- and post-beaver dam conditions provide habitat for fish. *Low sensitivity/vulnerability*

6b. Tributary wetlands unconnected to fish streams

Description: The wetlands in this unit are similar to unit 6a but include only those low-gradient wetland features that are not directly accessible to fish, but have a surface water connection to the stream system of Onion Creek. For a complete listing of all wetland features in the WAU, refer to the Water Quality assessment. These segments function as sediment sinks between upslope sources and fish-bearing channels below. Segment 703 has been artificially drained with a road fill built through the middle of it and, according to the Steven County Soil Survey, segment 805 soils are drained as well. Artificial draining of headwater wetlands may contribute to lower summer flows or lower flows earlier in the year in the downstream channels. Segment 903 occupies a wet swale and is ponded just upstream of a road fill. Low flow outlets to these wetlands may be dry. Segment 904 occupies a depression on the Columbia River terrace with no surface outlet. Subsurface drainage from 904 is probably the spring source for segment 903.

Habitat Conditions: Wetlands in this unit were determined to have no direct access to fish or provided insufficient habitat conditions.

Segments: *Field verified*: 703, 903
Extrapolated: 52, seg. above 203, 805, 904, 808

Conditions and Response Potential:

Coarse Sediment: Coarse sediment usually has deposited prior to reaching these low gradient segments or will deposit close to the source, which may diminish some wetland capacity but should not change the essential morphology. *Low sensitivity*

Fine Sediment: Wetlands are natural settling ponds for fine and suspended particles. These low-gradient reaches provide sediment storage between upstream sources and fish-bearing streams where they are connected. *Low sensitivity*

Peak Flow: Wetlands provide a low energy, backwater environment rather than the scour potential of concern in this rating. Peak flow increases will merely flood a larger area. *Low sensitivity*

Large Woody Debris: LWD provides no morphologic function except contributing to organic filling of the wetland. *Low sensitivity*

Riparian Vegetation: The biologic function of wetland vegetation is considered within the Water Quality assessment. *Low sensitivity*

Dam breaks: Some of these wetland segments are controlled by beaver dams. Upon draining, the wetland size is greatly reduced and may return to a single, low-gradient channel. This is a natural cycle of wetland function. *Low sensitivity*

7. Tributary, 1-2%, moderately confined

Description: Unit 7 includes the low gradient, moderately confined perennial tributary segments. These are similar to the mainstem unit 2 segments, but are separated because of their smaller size. Measured bankfull widths vary from 5 to 10 feet. Channels are moderately confined within gentle swale or terrace topography within the larger valley. Forced pool-riffle bed morphology is dominant. Glacial lag boulders were observed by the riparian analyst to provide some structure in segment 705. Bed particle sizes are in the coarse gravel range, with a large component of the very coarse granitic sand. The upper to mid-portion of segment 601 appears recently disturbed as the channel is wide and shallow (10 feet wide by approximately 0.3 feet deep), lacks much structural integrity and has recent and extensive overbank silt deposits. Plane bed topography dominates this disturbed portion. Discharge measured at the lower end of 501 was 0.9 cfs, and 0.4 cfs at the lower end of 601. As the flow in 601 appears larger in volume further up in the segment, flow is probably immergent in the lower part. A local swimming hole had been created below the county road crossing on segment 501, and the structure appears temporary. Segment 501 and adjacent segments appear bright and disturbed in the 1968 photos due to an apparent tailings pipe/slope failure upstream.

Habitat Conditions: Segments 501, 601, and 701 were visited and qualitative observations were noted and LWD counts were taken. Bank vegetation is composed of alder, shrubs, and grasses which provide cover and leaf litter inputs. Pool habitat was not evaluated. Substrates are a mix of coarse gravel and coarse sands with some glacial lag boulders which provide some structure and potential winter rearing habitat in segment 705. LWD is the primary pool forming element and is lacking in segments 501 and 601.

Segments: *Field verified*: 501, 601
Team notes: 705

Conditions and Response Potential:

Coarse Sediment: An oversupply of coarse sediment would overwhelm these small channels, burying wood and other structures, filling pools, cause widening and shallowing of the bed, and may cause subsurface flow during low flow conditions. Overbank gravels were observed above the road crossing on segment 501. *High sensitivity/vulnerability*

Fine Sediment: These low energy channels will tend to store fines in both the bed and pools. Low flows were measured at less than 1 cfs in segments 501 and 601. There is a high component of coarse sand within the mobile bed. Extensive overbank silt was noted in mid-segment 601. *High sensitivity/vulnerability*

Peak Flow: The effect of increases in peak flows is highly dependent on the condition of other channel elements. With stable LWD and adequate riparian vegetation, some channel reorganization and bank erosion would be expected; however, flows should be

accommodated within the larger vegetated floodplain. Since peak flows should be overbank, little additional depth and velocity within the channel should be expected. Where bank vegetation has been removed, channel widening, shallowing, and bed coarsening would be expected. *Moderate sensitivity/vulnerability*

Large Woody Debris: LWD appears critical to the structural complexity of these channels. Wood is the main pool-forming element. Where wood is lacking in segment 601, the bed widens, shallows, and becomes a long riffle. LWD also contributes to bank protection. Local residents living along the stream may remove wood in segment 501 in order to enhance visibility, access, and drainage. *High sensitivity/vulnerability*

Riparian Vegetation: Alder and shrub roots are the main bank protection and create undercut banks that provide fish cover and holding. Clay banks observed in lower segment 601 are resistent to erosion and promote pool development. *High sensitivity/vulnerability*

Dam breaks: No beaver dams were observed in the field, although it is probable beaver occur in these areas. Due to low gradients and vegetated floodplains, the resulting flood wave from a dam break would attenuate quickly. Localized bank erosion and channel rearrangement could result. *Moderate sensitivity/vulnerability*

8. Tributary, 2-4%, moderately confined

Description: Unit 8 includes perennial tributary segments slightly higher in gradient than unit 7. These are small channels with bankfull widths between 3 and 6 feet in the surveyed and sampled segments. Segments 502 and 503 are exceptions with measured bankfull widths between 8 and 14 feet. A moderate valley confinement is provided by till-covered sideslopes. Segments 202 and 502 are more constrained by roads parallel to the channels. Many of the surveyed and observed segments contain boulders in the bed assumed to be infrequently mobile and eroded from the glacial till soils. The mobile bed consists of coarse sand and fine gravel of granitic origin. Bed textures in the wider segments contained cobbles in addition to the gravel and sand, although the coarser bed in segments 502 and 503 may also be a function of disturbance originating upstream along with the road bed confinement. Gradients range from 2 to 4 percent, but segments 202 and 305 have gradients as high as 6 to 8 percent. These segments are included in this unit because bed textures are more similar to other segments in unit 8 than unit 9. The dominant bed morphology is pools and riffles forced by wood, boulders, and banks. Wood and boulder step pools and plane beds were also observed. The lag boulders help to trap small debris jams observed in segments 201 and lower 701, but were also found to suspend wood in upper segment 701. Lacking wood, unit 8 channels retain enough structure from boulders to retain some pool forming and sediment trapping capability. A low flow discharge of 0.6 cfs was measured in segment 701.

Habitat Conditions: Segment 502 was the only segment where habitat conditions were quantitatively sampled. Habitat conditions are generally fair to good. Bank vegetation consisted

of shrubs and forbs which provide cover and leaf litter inputs. Pools are frequent and moderately deep. Suitable patches of sorted spawning gravels for small resident fish (0.1 to 1.0 inches) are present on channel margins. Groups of brook trout indicated spawning may be taking place in this area. Larger substrate particles were 40 to 50 percent embedded resulting in few interstitial spaces for winter refuge and rearing. LWD functions to form pools and cover. Segments 701 and 801 had bank vegetation consisting of young hardwoods and conifer and grass which provides undercut banks. In some reaches the grass choked out the channels. Sediment conditions were dominated by sand and coarse gravels. LWD in channel is fair in mid-segment 701. In some cases, LWD was suspended over the small channels limiting LWD function and inputs.

Segments:	*Field verified*:	202, 502, 503, 801, 701
	Reconnaissance:	201, 205, 305, 402, 702, 803
	Extrapolated:	708

Conditions and Response Potential:

Coarse Sediment: The beds are composed of fine gravel and sand in the smaller channels, and cobble sand/gravel in the wider channels. An oversupply of the coarser sediment would overwhelm these small channels, burying wood and other structures, filling pools, and cause widening and shallowing of the bed. *High sensitivity/vulnerability*

Fine Sediment: Since the bed textures are high in sand-size fines, additional inputs will have a similar effect as in coarse sediment above. Airborne silt from the adjacent road dust was found to cement the gravel bed in segment 202. Angular and flat slate gravel lends to packing of the bed as well. *High sensitivity/vulnerability*

Peak Flow: The effect of increases in peak flows is highly dependent on the condition of other channel elements. With stable LWD and adequate riparian vegetation, some channel reorganization and bank erosion would be expected; however, flows should be accommodated within the larger vegetated floodplain. Since peak flows apread horizontally overbank, little additional depth and velocity within the channel should be expected. Under disturbed conditions where bank vegetation has been removed, channel widening and shallowing, bed coarsening, and bed scour would be expected. *Moderate sensitivity/vulnerability*

Large Woody Debris: Unit 8 channels differ from unit 7 channels primarily in that most of unit 8 channels will retain some structure from boulders in the absence of wood in the system. During low flows, however, the streams flow around rather than over the boulders. LWD was observed to contribute to the structural complexity of these channels by forming small steps and scour pools, trapping and sorting gravel, protecting banks, and providing cover habitat. Where wood and boulders are lacking in segment 502, the bed widens, shallows, and becomes a long riffle. *High sensitivity/vulnerability*

Riparian Vegetation: The roots of riparian vegetation are the primary sources of bank protection in the observed segments. Wood and boulders provide secondary protection. Where riaprian shade is lacking in segments 701 and 702, the channels are choked with grasses. *High sensitivity/vulnerability*

Dam breaks: No beaver dams were observed in the field checked segments, although it is probable for beaver to use these areas. Due to low gradients and vegetated floodplains, a flood wave resulting from failure of aa small impoundment would attenuate quickly. Localized bank erosion and channel rearrangement could result. *Moderate sensitivity/vulnerability*

9. Tributary, 4-12%, confined

Description: Unit 9 includes perennial tributary segments within a broad range of 4 to 12 percent gradients. All of these segments have a dominant step-pool morphology and developed within deep, glacial till or terrace soils in midslope to footslope locations. Valleys are generally confined, although some gentle swale topography allows for more moderate confinement. Measured bankfull channel widths are highly variable between 3 and 11 feet and locally higher. Short sections of low-gradient reaches were found in segments 311 and 510. Breached beaver dams were found in segments 509 and 510. Man-made impoundments are also found within this unit in segments 301 and 509, and others may also exist. Boulders and wood steps provide the step structure, and the mobile bed consists mainly of fine to coarse gravel and small cobble. Perennial flow may originate from springs at the upper ends of some of these segments (607, 311, 207).

Variants: Segment 204 was dry during early October field work, but is included in this unit because a well-defined channel and water in segment 205 upstream suggest this segment flows on a regular basis and fish may have seasonal access. Segment 512 drains shallow soils on bedrock slopes and has gradients in the 6 to 20 percent range. It is included in this unit because of perennial flow confirmed during field surveys, and meets the criteria for new Type 3 water typing.

Habitat Conditions: The extension of the defined fish-bearing streams from the FPB emergency rule includes a number of unit 9 segments. As a result, a number of roads previously crossing Type 4 and 5 streams may now be potential fish barriers.

Fish (brook trout) observations were more common in segment 509 and 505 than any other segments visited. Habitat conditions are generally fair to good and varied depending on gradient. In segment 509, bank vegetation consists of shrubs and forbs which provide cover and leaf litter inputs. Pools are frequent and moderately deep. Suitable patches of sorted spawning gravels (0.1 to 1.0 inch) are present in patches on channel margins. Groups of brook trout suggested spawning may be taking place in this area. Larger substrate particles are 40 to 50 percent embedded resulting in few interstitial spaces for winter refuge and rearing. LWD functions to form pools and cover. LWD function and supply appears to be influenced by dam break flooding

associated with upstream beaver dam complexes. Segment 505 is a higher gradient step-pool complex. Pools, spawning gravels and general fish habitat are maintained by the presence of LWD.

Segments:	*Field verified*:	509, 505
	Reconnaissance:	204, 301, 311, 401, 506, 507, lower 510, 602
	Team notes:	204, 207, 311, 401, 506, 512, 602, 603, 604, 605, 607
	Extrapolated:	upper 510, 511, 606, 707, 710, 711

Conditions and Response Potential:

Coarse Sediment: Although these segments contain steep streams, the mobile bed is mainly in the large to small gravel range. This is a function of the sediment load, the small size and energy of the streams, and the step morphology which will tend to store smaller particles in the low gradient steps. Very coarse sand and fine gravel is also a major component of the local till soils and is carried in the bed. Increases in coarse sediment would temporarily fill pools. However, it would take an extreme volume of this material, as observed in segment 506 above the Section 28 road crossing, to cause significant or long term changes. *Moderate sensitivity/vulnerability*

Fine Sediment: Fines less than 2 mm were not observed to be overly abundant on the bed of these small, steep streams, although overbank silt deposits were noted above the road fill in 507. Some pools have patches of fine gravel that, when sorted or clean, make appropriate-sized spawning gravel for the small resident fish. An increase in fines less than 2 mm, however, may fill the interstitial spaces in these small gravels. *Moderate sensitivity/vulnerability*

Peak Flow: Peak flows are currently accommodated within the banks and limited floodplain available in these confined channels. Some additional bank erosion, overbank deposits, and pool scour may be expected with peak flow increases over the range of flows under undisturbed conditions. Overbank silt deposits were noted in segments 507 and 510 in the lower gradient steps. Most wood and boulder roughness would continue to function to dissipate energy and provide refuge habitat at high flows. *Moderate sensitivity/vulnerability*

Large Woody Debris: Segment 505 provides a dramatic example of channel changes in the lack of LWD in unit 9. Bed morphology is step pool immediately above an assumed pipeline burst visible in the 1968 photos that heavily gullied a slope above the stream, while immediately below is a boulder cascade reach. The step-pool features provide scour pools for fish holding and pocket gravels for spawning. Fish habitat is greatly reduced in the absence of LWD. Segments 602 and 505 have larger channels due to a larger drainage area and/or flow, and the observed functional wood size was larger than in the smaller channels. Wood is particularly critical in segment 602 where the source soils appear to be lacking in boulders. *High sensitivity/vulnerability*

Riparian Vegetation: Although there are boulders and wood within these small streams, field notes on segments 204, 401, 505, and 602 indicate that tree roots are primary or secondary factors in controlling bank erosion. Streamside riparian trees also provide roughness upon which wood steps may form and is important for maintaining the habitat diversity in these steep streams. *High sensitivity/vulnerability*

Dam breaks: Since beaver dams and impoundments are located within these channels, the potential for dam break exists. Evidence of dam break was found in segment 509 where extensive, localized downcutting and bank erosion had occurred. It was unclear whether this event was related to an upstream beaver dam breach, as channel manipulation was also evident in the immediate area. No photographic or field evidence was found to indicate that these processes occur frequently or affect extensive lengths of the channel. *Moderate sensitivity/vulnerability*

10a. Tributary, 4-12%, midslope ephemeral or intermittent streams connected to Type 3 streams, moderately confined to confined

Description: Unit 10a channels include a variety of ephemeral or intermittent streams draining midslope locations underlain by deep glacial till. Gradients are in the moderate to moderately steep range of 4 to 12 percent. The majority of these segments have defined channels indicating surface flow for some part of the year. Portions of these segments may have ill-defined channels or wet swales where surface flow is intermittent. Channels are moderately confined in swales or confined by moderate gradient slopes. Bankfull channel widths vary from less than 1 foot to 3 to 4 feet. Bed morphologies include plane bed, step pool, and forced pool-riffle. Mobile bed textures include medium to fine gravel, sand and silt. Some channels contain boulders eroded from the adjacent till soils.

Segment 203 is essentially a road ditch. It is doubtful that this channel contained much surface flow prior to construction of the road grade within this narrow swale. The result has been a displacement of the absorption and filtering function of the swale. Both the road surface and the ditch drain directly into a stream channel.

Habitat Conditions: These channels lack sufficient flow to provide suitable habitat for fish.

Segments: *Reconnaissance*: 203, 304, 306, 508, 802, 804
Extrapolated: 51, 104, 105, 206, 302, 303, 307, 308, 309, 310, 313, 403, 404, 504, 608, 801-4, 806, and 36 unnumbered segments

Conditions and Response Potential:

Coarse Sediment: Since these channels are not fish-bearing, their main function is to store and meter sediment out to downstream reaches. Coarse sediment will deposit behind

obstructions. Coarse sediment above medium-sized gravel may not be transported by these streams. Segments 304 and 804 below road outfall has extensive deposits of fine gravel and fines in the dry bed. *Low sensitivity*

Fine Sediment: Fine sediment of all size fractions are found on the dry channel beds. During higher flows, many of the smaller fines will transport through. *Low sensitivity*

Peak Flow: Peak flow increases in these small streams may occur from increases in road runoff. These small channels could widen and erode to accommodate the added flow. The extent of erosion is dependent on the amount of flow obstructions and riparian vegetation. With sufficient flow obstructions from forest litter, wood, or riparian roots and vegetation, erosion may be minimal. *Moderate sensitivity*

Large Woody Debris: Woody debris traps sediment and reduces flow energy, and therefore erosion. The roots of standing trees and falling branches are more likely to function within these small channels than entire downed trees. *Moderate sensitivity*

Riparian Vegetation: Roads can add relatively significant ncreases in channel forming runoff to these small channels (see Peak Flow). Tree roots, standing shrubs, forbes and grasses all function to prevent bank ersoion, which mitigates downstream sediment delivery to fish-bearing streams. A certain amount of storage capacity is also provided by obstructions in the lower gradient channels. *High sensitivity*

Dam breaks: These small channels with seasonal flow are unlikely to form significant obstructions. Beaver dams were not noted in the field checked segments. *Low sensitivity*

10b. Tributary, 4-12%, midslope ephemeral or intermittent streams unconnected to Type 3 streams, moderately confined to confined

Description: Unit 10b channels differ from 10a channels only in that they do not have a surface water connection to the fish-bearing streams. Segments 902, 909 and 910 terminate in unconnected wetlands. Segments 50, 102, 103 and other unnumbered segments have no apparent surface connection with the mainstem at their terminal ends.

Habitat Conditions: These channels lack sufficient flow to provide suitable habitat for fish and are not accessible from fish-bearing streams.

Segments: *Reconnaissance*: 102, unnumbered segment in NE4 of NW4 Sec 14 T38R39
Extrapolated: 50, 53, 103, 906, 907, 909, 910, and 15 unnumbered segments

Conditions and Response Potential:

Coarse Sediment: These channels are seasonal conduits for runoff and will transport and store coarse sediment. In channel and downstream impacts from increases in coarse sediment are of no consequence to fish habitat or water quality. *Low sensitivity*

Fine Sediment: These channels are seasonal conduits for runoff and will transport and store fine sediment. In channel and downstream impacts from increases in fines sediment are of no consequence to fish habitat or water quality. *Low sensitivity*

Peak Flow: Peak flow increases from increases in road runoff may increase erosion in these small streams; however, there are no impacts to fish or water quality. *Low sensitivity*

Large Woody Debris: Wood and forest litter provide obstructions for sediment storage and dissipation of flow energy, but are not essential in maintaining fish-habitat or water quality. Other off-site impacts to private property downstream may need to be considered. *Low sensitivity*

Riparian Vegetation: Roads located in swales or displacing ephemeral channels were observed to reduce the absorption and filtering function of the soils and vegetation, and have the potential to establish a surface water connection to fish bearing streams. *Moderate sensitivity*

Dam breaks: These small channels with seasonal flow are unlikely to form significant obstructions. Beaver dams were not noted in the field checked segments. *Low sensitivity*

11a. Ephemeral or intermittent headwater channels, connected to Type 3 streams

Description: Channels in the headwater-connected unit originate on the steeper upper basin slopes underlain by bedrock at shallow to moderate depths (0 to 40 inches). Many of these small drainages flow through the deeper till and terrace soils at the foot slopes and flow subsurface. These channels are generally not spring-fed or have insufficient flow to create a perennial stream. Some may flow intermittently in the low-flow months before going subsurface. Others receive runoff only during snow melt periods. Unnumbered channels above segments 507, 603, 604, and 605 may have perennial flow. Channel gradients are 20 percent or greater, but include the lower gradient downstream portions of these channels, generally no less than 8 percent. Most have a small, but defined channel created mainly by snow melt runoff in the spring. Measured bankfull channel widths ranged from less than 2 feet to 4 feet.

Variations: Although shown on the soils map to drain deep, till-covered slopes, segments 106 and 109 are included in this unit due to gradients steeper than those generally found in unit 9. Segment 109 was also found to be flowing during early October field work.

Habitat Conditions: Channels in this unit may occasionally be utilized by fish but are generally not suitable for fish due to lack of perennial flow and steep gradients.

Segments: *Field Reconnaissance*: 107, 108, 109, 902, segment above 207, NE4 Sec 34 T38R40

Extrapolated: 106, 110, 312, and 40 unnumbered segments. Many similarly located and mapped channels were found to have no defined channel when field checked, and were removed from the channel map. Unfield checked segments of unit 11a are shown by a dashed line on Map E-1.

Conditions and Response Potential:

Coarse Sediment: Coarse sediment will deposit behind obstructions. These small, steep streams are transporting mainly gravel and sand. *Low sensitivity*

Fine Sediment: Mainly sand and silt-size fines were found on the dry channel beds. During higher flows, many of the smaller fines will transport through. *Low sensitivity*

Peak Flow: Peak flow increases in these small streams may occur from increases in road runoff. These small channels could widen and erode to accommodate the added flow. The extent of erosion is dependent on the amount of flow obstructions and riparian vegetation. With sufficient flow obstructions from forest litter, wood, or riparian roots and vegetation, erosion may be minimal. *Moderate sensitivity*

Large Woody Debris: Woody debris traps sediment and reduces flow energy, and therefore erosion. Boulders, roots of standing trees, and falling branches are more likely to function within these small channels than entire downed trees. *Moderate sensitivity*

Riparian Vegetation: Tree and shrub roots function along with boulders and wood to prevent bank ersion important for mitigating downstream sediment delivery to fish-bearing streams. *Moderate sensitivity*

Dam breaks: No field or photographic evidence of dam break or debris flow activity was noted in these steep channels. *Low sensitivity*

11b. Ephemeral or intermittent headwater channels, unconnected to Type 3 streams

Description: Channels in the headwater-disconnected unit originate on the upper basin steeper slopes underlain by bedrock at shallow to moderate depths (0 to 40 inches). Most of these small drainages flow through the deeper till and terrace soils at the foot slopes and flow subsurface or pond in disconnected wetlands. Channel gradients are generally greater than 20 percent, but include the lower gradient downstream portions of these channels. These channels are generally

not spring-fed or have insufficient flow to create a perennial stream. Some may flow intermittently before going subsurface. Most have a small, but defined channel created mainly by snow melt runoff in the spring. Measured channel widths ranged from 2 to 5 feet.

Habitat Conditions: Channels in this unit are not suitable for fish due to lack of perennial flow, gradients greater than 20 percent, and are unconnected to any fish-bearing streams.

Segments: *Field verified*: 101, 704, 713, 901, unnumbered segment in Sec 25 T39R39.
Extrapolated: 905, 911, 912, 913, and 33 unnumbered segments. Many similarly located and mapped channels were found to have no defined channel when field checked and were removed from the channel map.

Conditions and Response Potential:

Coarse Sediment: These channels are seasonal conduits for runoff and will transport and temporarily store gravel and cobble-size coarse sediment. In-channel and downstream impacts from increases in coarse sediment are of no consequence to fish habitat or water quality. Other off-site impacts, such as culvert plugging and fill gullying downstream, may need to be considered. *Low sensitivity*

Fine Sediment: These channels are seasonal conduits for runoff and will transport and store fine sediment. In-channel and downstream impacts from increases in fines sediment are of no consequence to fish habitat or water quality. *Low sensitivity*

Peak Flow: Peak flow increases from increases in road runoff may increase erosion in these small streams; however, there are no impacts to fish or water quality. Other off-site impacts to private property downstream may need to be considered. *Low sensitivity*

Large Woody Debris: Wood and forest litter provide obstructions that limit erosion, but are not essential in maintaining fish-habitat or water quality in these unconnected streams. *Low sensitivity*

Riparian Vegetation: Tree and shrub roots function along with boulders and wood to prevent bank ersoion and can create obstructions for sediment storage and energy dissipation, but is not contributing to the maintenance of fish-habitat or water quality in these unconnected streams. *Low sensitivity*

Dam breaks: No field or photographic evidence of dam break or debris flow activity was noted in these steep channels. *Low sensitivity*

5.0 MONITORING RECOMMENDATIONS

1. The extended fish distribution based on the new channel definitions in the FPB emergency rule has not been field verified. The capacity of these small stream channels to support fish is uncertain. Fish surveys would help test the validity of this new rule. In addition, the presence of native bull trout, or cutthroat in the Onion Creek WAU has not been documented. We have suggested it is unlikely native bull trout or cutthroat occur in the Onion Creek WAU because of the glacial history of the watershed and the barrier falls near the mouth. However, there has been extremely limited fish surveys and more extensive surveys would help to verify this assertion.

2. Potential fish barriers have not been field checked at road crossings on the channel segments extended as type 3 under the emergency rule. A determination of potential fish use in these segments may reduce the list of crossings to check for barriers.

3. Since there is uncertainty regarding the cause for a lack of sorted spawning gravel in Onion Creek, baseline data on bed particle composition is recommended in those reaches noted as lacking. Repeat measurements are recommended following major floods, large drought cyles, and major or local channel changes resulting from either disturbance events or enhancement. Additional data collected may include the angularity and lithology of medium-gravel size and larger particles. Analysis of data will quantify the abundance of certain particle sizes, the influence of local sediment sources, and effects of the flow regime on sediment size and distribution.

6.0 REFERENCES

Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society Monograph 6.

Cavander, T.M. 1978. Taxonomy and distribution of the bull trout, *Salvelinus confluentus* (Suckley) from the American Northwest. Calif. Fish and Game 3:139-174.

Coho, Carol, and Burges, Stephen J., 1993, Dam-break floods in low order mountain channels of the Pacific Northwest, Department of Civil Engineering, University of Washington, Water Resources Series Technical Report No. 138, 68 p.

Groot C. and L. Margolis 1991. Pacific Salmon Life Histories. UBC Press. Vancouver. BC. 564 pp.

Haas G. R. and J. D. McPhail 1991. Systematics and distributions of dolly varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) in North America. Can J Fish Aquat Sci. Vol 48: 2191-2211.

Hickman, T. and R.F. Raleigh. 1982. Habitat suitability index models: cutthroat trout. US Department of the Interior, Fish and Wildlife Service FWS/ OBS-82/10.5.

Keller, E.A., 1971, Areal sorting of bedload material: the hypothesis of velocity reversal. Geological Society of Ameria Bulletin 82, pp 753-756.

Lisle, T., 1979. A sorting mechanism for a riffle-pool sequence. Geological Society of America Bulletin, Part II, 90, pp 1142-1157.

McPhail, J.D. and C.B.Murray. 1979. The early life history and ecology of Dolly Varden (Salvelinus malma) in the upper arrow Lakes. Department of Zoology and Institute of Animal Resources, University of British Columbia, Vancouver, British Columbia.

McPhail, J.D. and C.C. Lindsey. 1986. Zoogeography of the freshwater fishes of Cascadia (The Columbia system and rivers north to the Stikine) p 615-637. *In* C.H. Houcutt and E. O. Wiley (ed.) The zoogeography of North American freshwater fishes. John Wiley and Sons, New York, NY. 866 p.

Meehan, W.R., editor. 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19.

Montgomery, D.R., J. M. Buffington, R.D. Smith, K.M. Schimdt, and G. Pess. 1995. Pool spacing in forest channels. Water Resources Research 31:1097-1105.

Overton C.K., J.D. McIntyre, R. Armstrong, S.L. Whitwell and K.A.Duncan.1995. User's guide to fish habitat: Descriptions that represent natural conditions in the Salmon River Basin, Idaho. USDA Forest Service Intermountain Research Station Gen. Tech. Rept. INT-GTR-322.

Raleigh, R. F. 1982. Habitat suitability index models: brook trout. US Department of the Interior, Fish and Wildlife Service FWS/ OBS-82/10.6.

Raleigh, R. F., T. F. Hickman, R.C. Solomon, and P. C. Nelson. 1984. Habitat suitability index models: rainbow trout. US Department of the Interior, Fish and Wildlife Service FWS/ OBS-82/10.24.

Rieman, B.E. and J.D.McIntyre. 1993. Demographic and habitat requirements of bull trout. United States Forest Service, Intermountain Research Station, General Technical Report INT-302, Boise, Idaho.

Selby, M.J., 1982, Hillslope Materials and Processes, Oxford University Press, New York, 264 p.

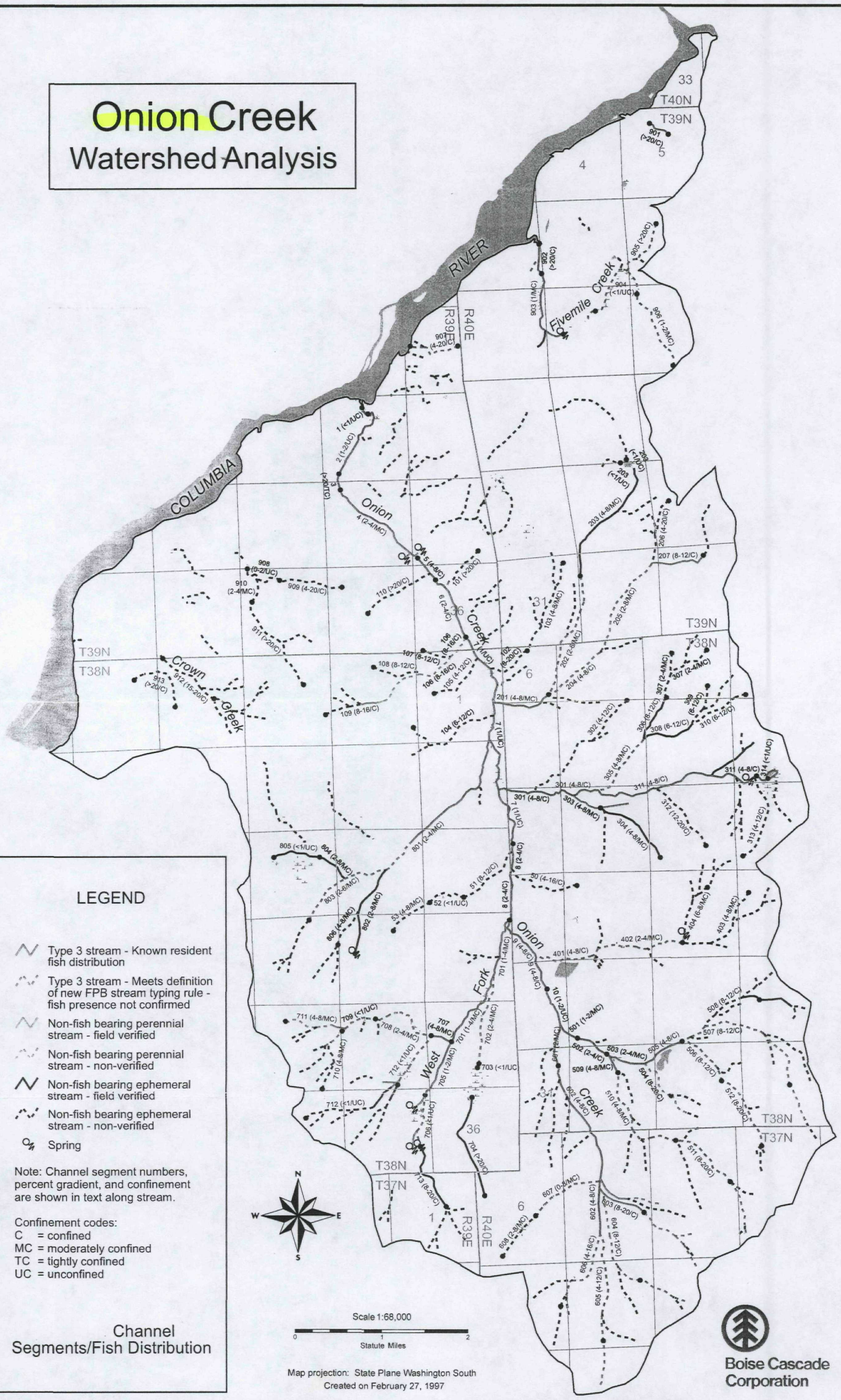
Shepard, B. K. Pratt, P. Graham.1984. Life histories of westslope cutthroat and bull trout in the upper Flathead River basin, Montana. Kalispell, MY: Montana Department of Fish, Wildlife and Parks. 85p.

Strahler, A., 1957, Quantitative analysis of watershed geomorphology, *Trans. Amer. Geophy.U.*, 38, pp. 913-920.

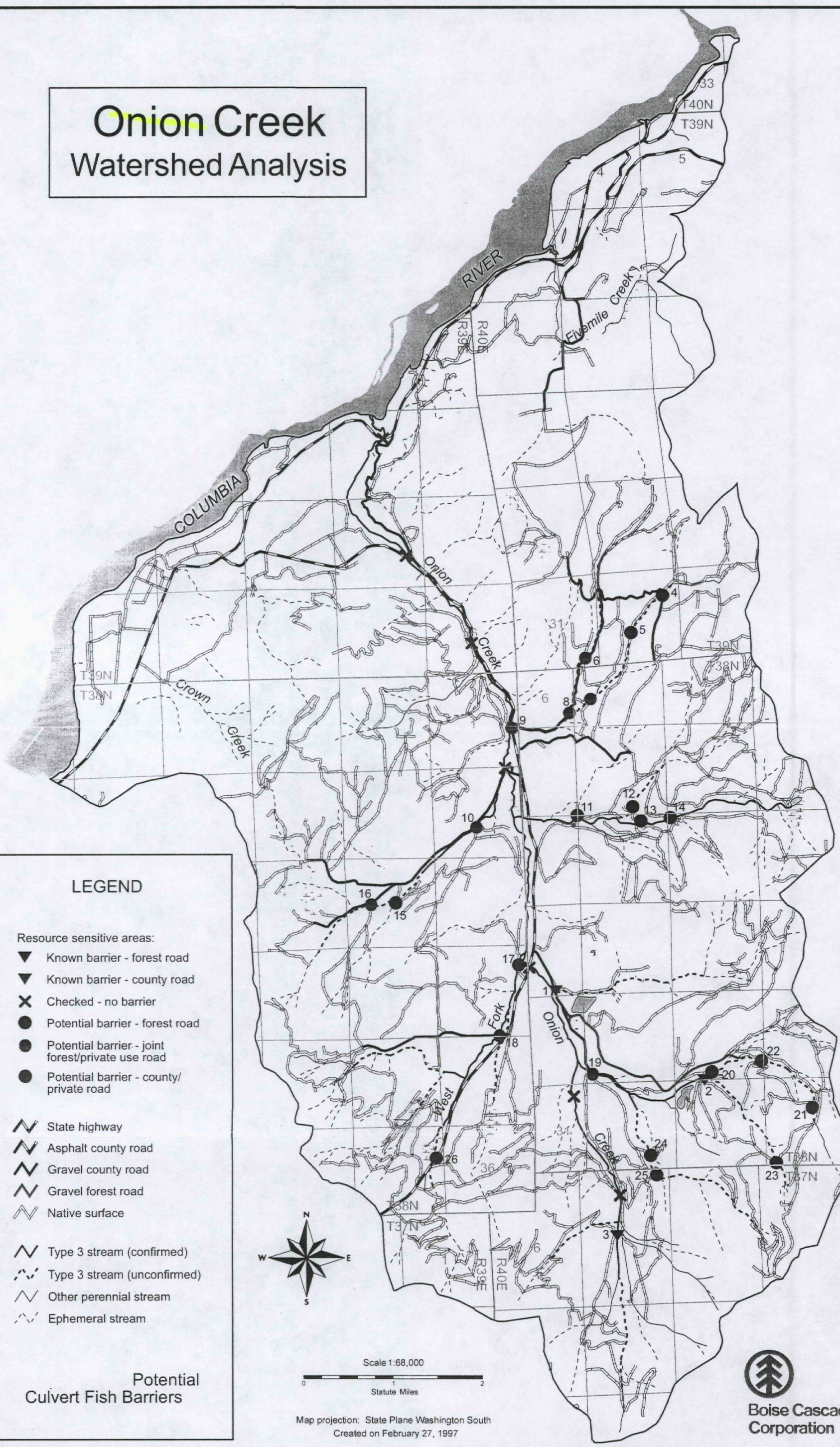
Washington Forest Practices Board, 1995, Board Manual: Standard methodology for conducting watershed analysis. Version 3.0.

Wydoski, R.S. and R.R.Whitney 1979. Inland Fishes of Washington.University of Washington Press. 219 p.

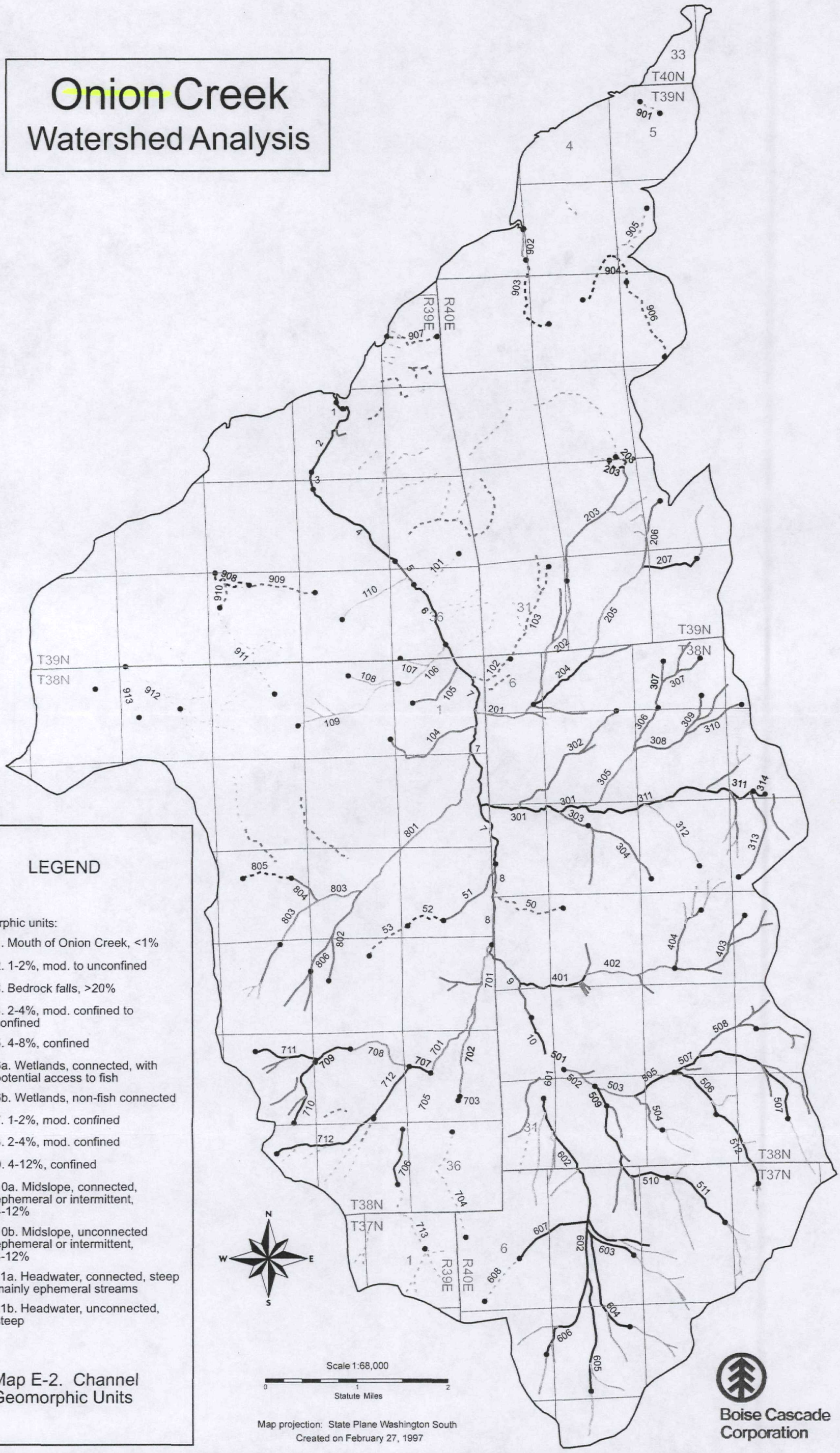
Onion Creek
Watershed Analysis



Onion Creek
Watershed Analysis



Onion Creek
Watershed Analysis



Map E-2. Channel Geomorphic Units

Table E/F-6. Channel response potential ratings to changes in input variables for grave-bedded streams.

Rating	Coarse Sediment	Fine Sediment	Peak Flows	LWD	Riparian vegetation	Dam Break
High	Significant increase in channel width, bed aggradation, and/or bar development expected with moderate to high or temporary increases in coarse sediment. Burial of roughness elements. Bed material size and pool volumes would be reduced. Conversion from/to pool-riffle to plane-bed or braided channel types could occur.	Large accumulations of fines, such as deep mounds in pools, as bars along channel margins, and deep deposits in particle interstices expected.	Significant increase in bedload transport, depth of scour and/or bank erosion expected. Coarsening of streambed and channel widening or incision, depending on channel confinement and gradient.	Critical for forming pools, trapping sediment, creating scour that cleanses gravel and/or dissipating stream energy via steps and deflection	Critical in providing root strength for stream-bank stability, energy dissipation during overbank flood flows, and/or reductions of energy and travel distance of debris torrents.	Catastrophic damage to channel including removal of structural wood or concentration of boulders; bank erosion and channel widening; bed coarsening; riparian damage.
Moderate	A minor adjustment in channel width, depth of scour, median bed particle size, bar development and/or pool volume expected. A very large, persistent increase required to trigger significant changes in channel morphology.	Minor accumulations of a thin film of fine sediment expected within sheltered areas, such as backwater pools, channel margins. A very large, persistent increase required to result in loss of pool volume or embeddedness.	Minor increase in bedload transport, depth of scour, median bed particle size, and/or bank erosion.. Very large increase required before a significant change in channel width or depth. May result in increase landsliding from inner gorge slopes.	Contributes to pool formation, sediment trapping, formation of steps and gravel cleansing, but other roughness elements, such as boulders are also available.	Contributes to stream bank stability and/or energy dissipation of overbank flows and debris torrents. Other elements of bank protection available.	Dam break affects localized areas only. Riparian mainly intact; wood on channel margins. Gradient & confinement such to limit ponded volume and attentuate effects quickly.
Low	Sediment temporarily stored, then transported downstream. Little or no change in channel morphlogy expected.	Increased fine sediment inputs would be transported through segment. Temporary storage of fines occur only in sheltered areas.	Little or no change in channel morphology expected. Simple expansion of flow rather than physical channel adjustment.	Not a primary roughness element. When present, does not significantly contribute to pool formations, sediment trapping, step formation, or gravel cleansing scour. Found on channel margins or gravel bars in larger streams.	Not essential for stability nor functioning to dissipate energy of overbank flows and debris torrents.	Due to gradient or valley confinement, dams do not form or attenuate rapidly when breached. Includes segments buffered from upstream dam break processes.

FORM E-1. SEGMENT IDENTIFICATION WORKSHEET

SEDIMENT	DISCHARGE	WOOD	CATASTROPHIC EVENTS
FS – Fine Sediment Deposition CS - Coarse Sediment Deposition	SC - Scour Depth SF - Scour Frequency BE - Bank Erosion	WL - Wood Loss WA - Wood Accumulation	DFS - Debris Flow Scour DFD - Debris Flow Deposition DB - Dam Break Flood

	<1.0 Pool-Riffle	1.0 - 2.0 Pool-Riffle, Plane-Bed	2.0 - 4.0 Plane-Bed, Forced Pool-Riffle	4.0 - 8.0 Step-Pool	8.0 - 20.0 Cascade	> 20.0 Colluvial
VW > 4CW UNCONFINED	1, 52, 314, 703 706, 709, 712 805, 904 908	708, 7, 2 10,				
2CW < VW < 4CW MODERATELY CONFINED		703, 501, 705 106, 601	701, 803, 806 6, 8, 502, 4, 307, 402, 503, 702, 708, 801 710, 801-4, 𝍸	404, 303, 608, 53 103, 201, 202, 203, 304, 305 403, 507, 510, 607 707, 710, 711, 205 802, 804, 𝍸 𝍸 II	I	
VW < 2CW CONFINED				105, 302, 313 605, 5, 9, 204 301, 311, 401, 505, 602, IIII	206, 907, 909, 50 102, 504, 511, 512 603, 606, 106, 109 312, 104, 308, 309 310, 51, 107, 108 207, 306, 506, 507, 508, 604 713 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸	101, 110, 704 901, 902, 905 911, 912, 913 3 𝍸 𝍸 𝍸 IIII 𝍸 𝍸 𝍸 II

VALLEY GRADIENT AND TYPICAL CHANNEL BED MORPHOLOGY

Channel Response Seg. No.	Δ Channel Width	Aerial Photo Year	Disturbance or Recovery Indicators:
1		1968	photos missing
	0	1980	Mouth of Onion Cr. influenced by Columbia R. lake levels.
2		1968	photos missing
	+	1980	Lowest end near seg. 1 lighter on both banks, but strip of green veg. where channel is - could be a vegetation change. Channel is straightened above state hway.
	+	1987	Bright banks and lg. bar below hiway.
	-	1992	Channel visible below hiway in open field, but exposed soil/gravel limited to outside bends. Single line of veg along channelized portion appears to mature over time.
3		1968	photos missing
	0	to 1992	Steep, falls segment. No change over time.
4	0	1968	Channel not visible but riparian area looks sparse, open on upper end.
	+	1980	Somewhat bright, 1 large right bank bar and side channel visible at lower end of cleared area.
	+	1987	Channel open, bright.
	-	1992	Channel still visible through sparse canopy but no bright bars.
5	+	1987	Some riparian opening not evident in earlier photos, but doesn't look recent. Channel visible intermittently, but riparian filling in.
	-	1992	Channel no longer visible through canopy.
7	0	1968	Open channel not visible. Upper end of seg. within wooded area open around riparian area. No ponding visible. Poss. beaver, wetland, or riparian harvest. Pasture/field maintained on r. bank for ~1 mi above cty. road.
	+	1980	Moderate channel disturbance visible between bottom of seg & trib 104. Brush cover only thru here. Some bank erosion or gravel bars visible in field above cty rd and in area of seg. 201. Seg. low gradient, sinuous.
	0	1987	Meanders, bars still intermittently visible.
	-	1992	Good canopy closure in lower seg. where not in fields. Fenced area channel highly visible contrasted with very light colored surrounding field in May flight line, Aug. flight line shows dark against mowed neighboring field.
8	0	1980	Partial cut activity evident. Lower end of seg. visible above homesite, riparian cleared for ~1,000 ft.
9	+	1968	Confined channel visible and bright above county rd crossing. See note in seg. 505.
	-	1980	Riparian closure.
10	+	1968	Channel open, bright for entire length through open field. See note in seg. 505.
	+/-	1980	Generally recovered from '68. Narrow band of intermittent riparian veg. Some disturbance on banks, could be livestock access. Left bank ditch drains field into stream.
	0	1987	No change
	-	1992	Riparian veg. getting thicker. Less ground disturbance visible.

Channel Response Seg. No.	Δ Channel Width	Aerial Photo Year	Disturbance or Recovery Indicators:
50	0	1968	Large, open wet area. Stream prob. ephemeral, exists solely within an open agricultural area therefore visible. No obvious signs of erosion.
	+/-	1980	Occasional bright spot in banks. Open field, barely channelized flow appears to come & go.
52	0	1968	Large wet area in middle of open field. Standing water visible.
	+	1980	New homesite on edge of wet area & stock pond excavated. No disturbance downstream.
	+	1987	Drainage ditches visible. At least one new homesite on edge of field.
unnumb. off seg. 4, Sec 25	0	1968	Skid trail up draw.
201	0	1968	County road parallels channel for entire length.
202	0	1968	County road parallels channel for entire length. Portions may go into wet swales
203	0	1968	Road up narrow draw. Channel defined by early yarding up swale?
205	0	1980	Impoundment visible in cleared homesite area.
301	0	1968	2 stream impoundments visible.
	+	1987	Exposed soil around upper pond. May be from flucuating water level.
	+	1992	Bottom pond appears drained. No downstream disturbance.
501	+	1968	Major channel disturbance originates on slope opposite upper tailings pond in seg. 505. Total lack of riparian veg. in 501 may be from surrounding agricultural clearning.
	-	1980	Channel & riparian veg recovering. Stream obvious by riparian veg but barely visible.
	0	1987	No change. Narrow riparian through field.
502	+	1968	Major channel disturbance originates on slope opposite upper tailings pond in seg. 505. Hard to tell is lack of riparian veg. is from upstream event, harvest or adjacent road in narrow valley.
	-	1980	Riparian veg recovering, channel barely visible.
	-	1987	Riparian filling in.
503	+	1968	Major channel disturbance originates on slope opposite upper tailings pond. Major channel widening in 505 and 503.
	+/-	1980	~100 sq ft disturbed area in/adjacent to channel. Remaining channel recovering w/riparian revegetating.
	-	1987	Canopy filling in. Somewhat sparse near homesite.
505	+	1968	Major channel disturbance originates on slope opposite upper tailings pond. Major channel widening in 505 and 503.
	-	1980	Channel and riparian recovering. Some bright spots still visible. Upper tailings pile appears to drain directly to channel.
	-	1987	Channel not visible.

Channel Response Seg. No.	Δ Channel Width	Aerial Photo Year	Disturbance or Recovery Indicators:
506	0	1968	Road in or closely paralleling mid-segment channel.
509	0 +	1968 1980	2 impoundments visible. Sparse riparian - beaver? Only one pond visible, but no evidence of dam-break.
601	+	1987	New homesite next to stream. Some riparian clearing and pond?
602	+ –	1980 to 1992	Looks like skid trail up channel for ~3,000 ft in area of partial cut. Canopy closure over time.
701	0 +	1968 1987	Impoundment visible below county road. Left bank exposed where pond used to be. Pond drained?
703	0 + +	1968 1987 1992	Wetland. Stock pond dug in downstream end near bldgs. Fainst pattern of ditching. Ditching patterns well-defined. New road through middle of wetland. Ditching looks improved.
705	0	1968	Ponded water visible in several spots - beaver ponds?
709-713+ unnumb. segments 709	? 0	1980 1992	Intensive, select harvest in secs. 27, 26, 34, 35. Skid trail density makes it hard to see where channels should be or extent of any disturbance. Series of ponds, beaver? Most visible in these photos, but appear earlier.
801	+ +	1980 1987	Channel through field with no riparian veg, new open impoundment near house appears to have diverted flow in/out. Channel bright, open at next driveway crossing above pond. Could be powerline disturbance/brushing/installation.
805	0	1968 1992	Open field, darker areas indicate wet swales, pattern of ditching but no bright eroding areas visible. Ditching of field obvious (May photos). Some soil disturbance in field.
902	0	1980	Lowest reach near mouth used as fish habitat accessible from Columbia R?
903	0	1968 1980 1992	Farm road or dirt track appears to parallel stream between cty rd crossings. Stream occupies a wet swale with shrub/grass veg. Parallel road no longer looks used - greening up.

Form E-3. Field Site Selection Worksheet, Onion Creek WAU

Segment Chosen	Rationale
1	Verify upstream extent of lake level influence on Onion Creek.
2	Only habitat segment accessible to kokanee. Upstream portion historically channelized.
3	Find upstream and downstream boundaries of steep falls segment. Fish barrier.
4	Mainstem, fish-bearing. Low gradient segment upstream of falls shows disturbance in photos.
5	Mainstem, fish bearing. High gradient segment with some evidence of stream disturbance. Look for dams.
7	Mainstem, fish bearing. Long, low gradient segment with multiple land uses, perhaps evidence of beaver. Some erosion and bars evident.
8/9	Higher gradient, mainstem segments similar perhaps to segment 6. Seg. 9 upstream of major tributary confluence, and shows disturbance from 1968 upstream event in segment 505.
10	Low gradient segment responding to upstream disturbance, agricultural/residential land uses.
101, 102 & unnumb.	Field check as many first-order tributaries to the mainstem as practical. Verify surface flow, perennial/ephemeral status.
201-203	Check upper limit to type 3 at end of 201. Check impacts of county road parallel to stream in 202, and location and impacts to channel in relation to road in 203.
205	Check upper limit to perennial streams in this tributary system.
300 tributary	Other than mid-stream impoundments, channels not visible in photos but fish use extends to headwater wetland at Quinn's meadow. Check channel conditions, quality of fish habitat and approx. volume of flow. Determine as many perennial streams as practical.
400 tributary	Currently no type 3 streams but could support fish. Check on reasons for lack of fish typing and habitat potential.
501	Check channel condition following upstream 1968 event.
502	Check channel conditions following upstream 1968 event. Road also closely parallels channel. Check impacts.
503	Check channel conditions following upstraem 1968 event.

Segment Chosen	Rationale
505	Find initiation location to 1968 event. Compare upstream conditions with immediately downstream.
509	Check nature of impoundments and potential for fish use. Currently not typed for fish.
601	This tributary system is labeled as mainstem Onion Creek, but may be equal in drainage size and flow to the 500 tributary (Van Stone Mine trib).
602	In channel yarding possible from earlier photos. Check channel conditions.
Upper 600 trib	Check upper fish limit and habitat conditions. Check seasonal flow of 1st and 2nd order tributaries and channel geometry, etc.
701	West Fork Onon Creek. Check size and channel characteristics.
Valley bottom 700 segs.	Sample valley bottom segments in West Fork. A number of wetland areas appear on photos. Mainly an agricultural/residential area.
Hillslope 700 segs.	Sample small streams draining the slopes to the West Fork Onion Creek. Upland slopes intensely harvested prior to 1980. Check channel conditions and fish use. Presently not mapped as type 3.
801	Long segment with no tributaries, fish typing ends prior to confluence with upper tributaries. Check upper fish limit and lower channel/habitat potential.
upper 800 segs.	Drainage density noticably lower in this part of watershed. Check for channel presence, seasonal flow, channel conditions where access allows.
901, 907-913	Sample tributaries draining toward Columbia River but have no surface flow connections mapped.
902	Steep terrace scarp segment of Five Mile Cr. with drianage to Columbia R. Check if highway/roads block upstream fish passage.
903	Upper Five Mile Creek. Check channel conditions. Drains high terrace surface with source at visible spring.

Form E-5. Field survey segment summary for Onion Creek WAU.

Seg. No.	Geomorph Channel Unit	Length Sampled (ft.)	Channel Gradient	Valley Confine-ment	Bed Morph-ology	Wetted width/ bankful width/(ft)	Substrate dom/sub-dom	Pools % surf area	LWD per bankful channel width	Fine Sediment	% Banks Eroding / Bank Protection	Pool-Forming Elements
Field	Surveyed	Segments										
1	1	700	<1%	unconf.	free pool-rif	variable, backwtr of Lk. Roosevlt	c. sand/ gravel & organics	visual - low	0	abundant -when lake floods, sand deposits	ht. 1.5' silt banks 20-50% erod / grass roots	bed forms, left bank terrace
2 below hiway	2	730	1%	unconf.	75% forced & 25% free pool-rif	12.2 ww 14.2 bfw	gravel / sand & cobble	21 %	0.32 bfw	local accum. No V* to meas.	~15% erod./ some clay banks, grass & few trees	mainly terrace banks, some roots
2 above hiway	2	415	1-2%	unconf. artificial straightn	80% plane bed	15.7 ww 21.7 bfw	cobble & sand / gravel	11 %	0	coarse sand part of bedload	very low / logs wired to banks	1 - banks 1 - tree roots 1 bldr pocket
3	3	observed ~200	>20%	tightly confined	bedrock	not measured	bedrock / boulder	not measur ed	low to none	very low	0 / bedrock banks	cataracts, scour pools
4 above falls to beaver dam	4	1,311 habitat unit meas 590'	2-3%	mod. confined	forced pool riffle	11.5 ww 26.1 bfw	bi-modal cob-gravel & c. sand	52 % avg res depth= 0.95'	3.1 bfw 0.99 ww	inconsistent pool filling, sand in 6/16 pools, some sand to 0.4'	low ~10% eroding / tree roots & wood protect alluvial bank	LWD, roots, some bldr pools
4 open area	4	170	1-2%	entrench 3-4' banks	forced pool riffle	17.5 ww 25.3 bfw	cob-gravel / sand	15 % glide= 35%	2.23 bfw 1.5 ww wood exhumd	local accum & in patches	20-30% / buried wood tree roots, grasses	banks,
4 above cty rd	4	408 split chnl for 205'	2-4%	mod. confined	forced p-f 50% step pool 50	9.5 ww 32.8 bfw	cob/gravel / sand	15 %	2.9 bfw 0.84 ww	local accum & in patches	<10% / tree roots, wood, bldrs	LWD >12"

Seg No.	Geomorph Channel Unit	Length Sampled (ft.)	Channel Gradient	Valley Confine-ment	Bed Morph-ology	Wetted width/ bankful width/(ft)	Substrate dom/sub-dom	Pools % surf area	LWD per bankful channel width	Fine Sediment	% Banks Eroding / Bank Protection	Pool-Forming Elements
5	5	200	4 % 8% in steps	confined	step pool / forced pool		bimodal= cob-bldr / gravel sand			patches in eddies	low to none / bedrock, wood & boulders	log jam, boulders evidence of dam break
7 lower	2	375	≤1%	mod confined	forced pool rif 60% / free pool rif	12.7 ww 43.1 bfw	bimodal= gravel & sand	67 % avg res depth 0.89'	2.5 bfw 0.74 ww past beaver activity	on bed in patches, below bed armor very high in coarse sand	5-10% est./ wood, beaver sticks	logs 8-12" undercut & meander banks
7 mid w/cattle	2	340	~ 1%	unconfin w/ local entrench ment	forced pool riffle	14.3 ww 20.0 bfw	gravel & sand high sand content in substrate	68 % avg res depth 0.79'	1.3 bfw 0.97 ww old wood decaying little new recruitmt	up to 30% pool filling, extends in strands on riffles	70 % est. banks 3-4 ft. / wood in banks, roots, minor clay	1.7' logs, roots in banks & old beaver dam, dammed impoundment
.7 mid cattle exclude	2	~400	~ 1%	unconfin mod entrench ditched?	plane bed	ww & bfw 10-12 ft	gravel and sand, some lag boulders			local in shelters & some strands	10% est. / grass & shrubs	low pool #s / banks & exhumed wood in bank
502 upper	8	256	2-4 %	confined by road on r bank	forced pool rif 80%, step pl	7.8 ww 11.4 bfw	cobble / sand	34 % avg res depth 0.77'	1.2 bfw 0.79 ww sm diam wood not function	1 pool w/sand, interstitial in riffles	low / dom. tree roots then wood, bldrs	rootwads & boulders, 1 pool from live roots
502 lower frm rip. notes	8	700 includes 200' of 501	~ 2 %		plane bed w/few pools	7.65 ww 13.7 bfw			0.04 bfw 2 pieces			

Seg No.	Geomorph Channel Unit	Length Sampled (ft.)	Channel Gradient	Valley Confine-ment	Bed Morph-ology	Wetted width/ bankful width/(ft)	Substrate dom/sub-dom	Pools % surf area	LWD per bankful channel width	Fine Sediment	% Banks Eroding / Bank Protection	Pool-Forming Elements
503	8	525	2 %	mod confined	forced p-r 50% step-pl 50%	5.9 ww 8.0 bfw	bi-modal cobble / sand & gravel		few	patchy in some pools, interstitial in riffles	low / tree roots	lag boulders, roots & bldrs in banks
509	9	600	6-8%	mod confined	step pool	4.7 ww 13.1 bfw	lg gravel-sm cobble / sand & sm gravel	5 pool/ 3 riffle in 153' 1' max depth	0.36 bfw 0.13 ww avg 1.4' diam	patches in pools, in shelters in rif	locally 30% due to dam break upstm	LWD 1-1.8' diam,undercut banks, bldrs, manmd pond, old beaver dm
801	8	100+	2-4 %	mod confined	forced pool rif	3.25 ww 5.8 bfw intermit flow in Sec 14	sm grav / sand occasional muck		low, sm pieces function	bed is coarse sand	low / banks undercut - tree-grass roots, bldrs	undercut banks, small wood
Field	Recon	Surveys										
unnumb T39R39 Sec.25	11b	75'		swale	seep & wet soil	ill-defined	duff	na	na	na	na	
101	11b	100'			no chnl at road	no sign surface runoff					gullied in glacial seds below ditch culvert	
6	4	200	4 %	confined	forced pool rif & step pool	8.35 ww Q=4.3cfs 0.34' d	cobble / gravel & sand				low	
10	2	600	1-2 %	mod confined to unconf	forced pool rif	8.7 ww 0.43" wd Q=1.40 cfs	coarse gravel / sand & cobble			local unconf sed deposit, livestock access	~ 20 % + headward gully eros / tree roots,	undercut banks, roots, some wood

Seg. No.	Geomorph Channel Unit	Length Sampled (ft.)	Channel Gradient	Valley Confine-ment	Bed Morph-ology	Wetted width/ bankful width/(ft)	Substrate dom/sub-dom	Pools % surf area	LWD per bankful channel width	Fine Sediment	% Banks Eroding / Bank Protection	Pool-Forming Elements
102	10b	100		grassy swale		may flow further upslope						
201	8	50	4 %	mod confine	forced pool rif sm steps	2.7 ww 3.9 bfw 0.2' wd	gravel-sand/ cobble & sm bldr structure			sand in bedload	low / shrub, tree & grass roots protect grass chokes where open	limbs, debris form small steps
202	8	intermitnt observtns along entire seg	2-6 %	mod confined, road confines in places	plane bed, forced p-r, steps	2.0 ww 5.0 bfw 0.2 wd	sand & sm gravel , silt			fine bed text, fine cement on bed prob from road dust		
203	10a	3,000	~ 4 %	mod confined by road	plane bed	0.0 ww 2.0 bfw dry chnl max .5' d	sm ang. arg. gravel armor / silt below	na	none	fine silt bed below armor	50%, chnl in road ditch	no flow
204	9	100	~ 4 %	confined	steps	0.0 ww 4.0 bfw dry chnl	coarse argillite gravel / sand	na	large log	dry chnl w/ some sand on bed	low / many roots holding banks	no flow, bldrs and log steps
205	8	100	~ 4 %	mod confined in swale	step pool	2.0 ww 2.7 bfw	fine granitic gravel/lag boulders		big wood rotting stumps	bed is v. fine gravel	low / LWD, veg. roots	big wood, stumps in bank; flows around bldrs
9	5	~1,500	4-8 % locally 2-4%	confined	step pools, forced pool	8.3 ww Q=2.0cfs 0.62' d	cobble-boulder / gravel-sand			locally in eddies	low / boulder banks, tree roots	boulders, suspended LWD can supplement

Seg No.	Geomorph Channel Unit	Length Sampled (ft.)	Channel Gradient	Valley Confine-ment	Bed Morph-ology	Wetted width/ bankful width/(ft)	Substrate dom/sub-dom	Pools % surf area	LWD per bankful channel width	Fine Sediment	% Banks Eroding / Bank Protection	Pool-Forming Elements
701 lower	8	300	~ 4%	mod confined	plane bed, steps & forced pool	4.0 ww 4.7 bfw Q=0.6cfs 0.27' d	fines & sm gravel / lag boulders		sm wood jams	bedload is mainly fines	10-20% / bldrs, grass roots, shrubs	debris jams, history of stream modific. lower 701
701 upper rd xing	8	200	1-2% some ponding above road	mod confined in swale	plane bed,forc pool-rif grass choked	4.4 ww 4.7 bfw 3-4 ww 0.4' d	sand & sm gravel lag bldrs		0.23 bfw 0.23 ww	sand in bed	low to none, chnl grass choked where no shade	boulders, banks, roots in banks, lwd suspended on boulders
702	8	200	1-2 %	mod confined	forced pool rif	3-4' ww	sm. gravel & sand			sand in bed	low / brush, grass	flows under live tree roots, roots in banks
703 drained wetland	6b	200	<1 %	unconf	plane bed	2.0 ww 2.0 bfw 1.5 bfd	fines			fine bed	low / grass roots line ditched seg	few to no pools, no prob fish use
705 riparian notes	7	100				5.0 ww 5.25 bfw	coarse sand & sm gravel		0.94 bfw 0.90 ww	bed is coarse sand	tree roots	lwd, undercut banks
713	12	300	6-8%	confined	steps	0.0 ww 5.0 bfw 1.5 bfd	moss, gravel / local scour to cobbles			in patches on dry bed	no estimate	no flow
401 above rd xing	9		~ 2-3% above rd 6-8% upstrm	mod confined to confined	step pool, some forced	3.5 ww 5-6' bfw 0.2' d	fine gravel & sand/ sm cobble	max depth 0.6'		fine gravel & sand bed	low / grass, shrubs, alder tree roots	sm wood, lag boulders, old wood road xing

Seg. No.	Geomorph Channel Unit	Length Sampled (ft.)	Channel Gradient	Valley Confine-ment	Bed Morph-ology	Wetted width/ bankful width/(ft)	Substrate dom/sub-dom	Pools % surf area	LWD per bankful channel width	Fine Sediment	% Banks Eroding / Bank Protection	Pool-Forming Elements
402 upper (frm kd notes)	8	275	~ 2 %		forced pool rif, flows btwn bldrs	2.0 ww 3-5' bfw	sand & v fine gravel / lag boulders	max pool depth 0.5'	0.74 mainly suspend	sandy substrate, sm wood traps		boulders
501	7	100	1-2%	mod terrace confined	forced pool riffle	5.4 ww 0.32' d Q=0.91 cfs	lg gravel / sand & fines		0.04 bfw 0.02 ww		~20% /	roots in banks, some wood
505	9	200	~ 4%	confined	step pool, bldr cascade	no meas	gravel / boulders			in eddies only	low / bldrs & roots	LWD
507 above road fill	9	50	4-8% some ponding above fill	confined	step pool	3.0 ww	gravel / sand			sand in bed, some silt overbank dep	low / LWD, bldrs	LWD steps
601	7	150	2%	mod confined	forced pool rif, plane bed	3.6 ww 8.2 bfw 0.43' d at Q=0.40 cfs	coarse gravel - sand		0.79 bfw 0.37 ww	fines in shelters, extensive overbank silt at upper rd xing	10-15% / alder, brush, grass roots, clay banks	wood, clay banks, roots
602	9	100 300-ripar.	4-6 %	confined some mod conf	steps, forced pool rif	7.9 ww 11 bfw	coarse gravel sm cobble	est. 50%	1.54 bfw 1.3 ww		est 10 % / LWD, tree roots	wood mainly (12-16") trees in banks
901 subs out behind mill	11b	100	steep above rd, <1% below	confined	steps, plane bed	2.0 ww	drops silt in low gradient			silt bed below road	no estimate	no data

Seg No.	Geomorph Channel Unit	Length Sampled (ft.)	Channel Gradient	Valley Confine-ment	Bed Morph-ology	Wetted width/ bankful width/(ft)	Substrate dom/sub-dom	Pools % surf area	LWD per bankful channel width	Fine Sediment	% Banks Eroding / Bank Protection	Pool-Forming Elements
902 above side rd	11a	50	1 % behind rd fill	mod conf	steps, plane bed		gravel / silt			silt deposits behind road fill	no est.	water ponded behind fill
903 at 2 sites	6b	300	generally < 1 %	mod conf in swale	plane bed	2-3 ww 0.2' wd	fines / some gravel in lower seg			fines deposit in low gradient chnl	low to none, choked w/grass where open	water ponds behind rd xings
unnumb NE4 NW4 S14 T38R39	10b	100	wet swale	mod conf in swale	no defined channel		fines exposed where cattle use			fines where exposed	exposed soil where heavy cattle use	little to no surface flow
803	8	150	~ 2 %	confined in swale	forced pool rif	5.0 ww 5-6' bfw 1-2' bfd	mobile bed med gravel & sand			some sand in mobile bed	low / LWD, roots. Banks undercut	channel carved in/around old down wood
804	10a	150	4-8 %	confined	step pool	0.0 ww 3-4' bfw dry chnl	gravel-sand mobile/ bldrs stable			fines piled up & downstrm of road		
301 below impdmt	9	50	4-8 %	confined	bldr step pool	5-6' ww	gravel mobile bed			impoundmt immed. above traps		boulder steps, LWD
304	10a	50	2-6%	mod confined in swale	plane bed, forced pool rif	0.0 ww dry chnl				large deposit of fines below road in swale		

Seg No.	Geomorph Channel Unit	Length Sampled (ft.)	Channel Gradient	Valley Confine-ment	Bed Morph-ology	Wetted width/ bankful width/(ft)	Substrate dom/sub-dom	Pools % surf area	LWD per bankful channel width	Fine Sediment	% Banks Eroding / Bank Protection	Pool-Forming Elements
305	8	250	4-8 %	mod confined		1.7 ww 4.7 bfw - but variable	angular sand & v fine gravel		0.34 bfw 0.14 ww	mobile bed is coarse sand, lwd stores sed.	low / grass roots, some lwd	LWD 0.3 to 0.9' diam.
311	9	100	4-8%	confined	step pool	2.5 ww 0.2' wd 5.5' bfw hi as 30' above culvert	med-fine gravel & sand			sand in mobile bed	low / wood-some buried, tree roots, bldrs	sm wood, tree roots, banks, boulders
Misc.	observatns	from	team									
314 outlet Quinns meadow	6a		< 1%	uncon-fined		0.0 ww 5' bfw	very fine sm gravel/ organics			fine gravel sand bed / organics frm wetland		
311 below meadow	9	approx 1 mi below Quinns M.		spring at wetland		30.0 ww						
107	11a	at road crossing				no channel	duff					
108	11a	at road crossing				no channel	duff					
109	11a	at road crossing	~ 15 %			<2.0 bfw spring 50' above road	sand sm gravel					
207	9	adjacent to road				2-3' bfw 0.7 bfd	sand gravel					

Seg. No.	Geomorph Channel Unit	Length Sampled (ft.)	Channel Gradient	Valley Confine-ment	Bed Morph-ology	Wetted width/ bankful width/(ft)	Substrate dom/sub-dom	Pools % surf area	LWD per bankful channel width	Fine Sediment	% Banks Eroding / Bank Protection	Pool-Forming Elements
segment above 207	11a	at upper road crossing				0.0 ww <2.0 bfw dry chnl	sand silt					
303	10a	at rd xing				flowing <2' bfw						
304	10a	at lower rd crossing				defined chnl but dry						
305	8					3.0 bfw	gravel / cobble					
306	10a					0.0 ww <1.0 bfw dry chnl	silt					
506 above lower rd xing	9	~ 250				4.5 ww 6.0 bfw		0.25' avg depth				culvert barrier if fish below road
512 Sec 34 rd xing	11a					ww not meas. 4.0 bfw	cob / gravel					
508 Sec 27 rd xing	10a					dry channel	1' diam plugged culvert					
603	9					>3.0 bfw						
604	9					<2.0 bfw						
605	9					>3.0 bfw						

Seg No.	Geomorph Channel Unit	Length Sampled (ft.)	Channel Gradient	Valley Confine-ment	Bed Morph-ology	Wetted width/ bankful width/(ft)	Substrate dom/sub-dom	Pools % surf area	LWD per bankful channel width	Fine Sediment	% Banks Eroding / Bank Protection	Pool-Forming Elements
607	9				area of many springs, wet ground	4.0 ww 10 bfw intermit at middle rd xing	sm cobble gravel					
704 below lower rd xing	11b				no defined chnl	intermit flow on forest floor, dry above rd						
712	6a		< 1 %		wetland, resident says no surface drain	unknown						
802	10a					spring upper; intermit lower	seepy, muck					
NE4 Sec 34 T38R40	11a					dry channel						

Form E-6. Geomorphic channel unit sensitivities / fish habitat vulnerabilities to changes in input variables (L=low; M=moderate; H=high).

Geomorphic Channel Unit	Numbered Segments	Coarse Sediment	Fine Sediment	Peak Flows	In-stream LWD	Live Standing Riparian Veg.	Dam break
MAINSTEM SEGMENTS							
1. Mouth of Onion Creek, < 1%	1	H	H	L	L	H	L
2. 1-2%, mod. to unconfined	2, 7, 10	H	H	M	H	H	M
3. Bedrock falls, > 20%	3	L	L	L	L	L	L
4. 2-4 %, mod. confined to confined	4, 6	M	H	M	H	H	M
5. 4-8%, hillslope confined	5, 8, 9	M	M	M	H	M	M
TRIBUTARIES							
6a. Wetlands, connected, with potential access to fish	314, 706, 709, 712	L	M	L	M	M	L
6b. Wetlands, non-fish connected	52, above 203, 703, 805, 903, 904, 908	L	L	L	L	L	L
7. 1-2 % mod. confined,broad valley	501, 601, 705	H	H	M	H	H	M
8. 2-4 %, mod. confined, trib. valley	201, 202, 205, 305, 402, 502, 503, 701, 702, 708, 801, 803	H	H	M	H	H	M
9. 4-12%, confined, tributary valley	fish: 204, 301, 311, 401, 505, 506, 507, 509, 510, 511, 512, 602, 605, 607, 707, non-fish: 207, 603, 604, 606, 710, 711	M	M	M	H	H	M
10a. Midslope, connected, ephemeral or intermittent, 4-12%	51, 104, 105, 203, 206, 302, 303, 304, 306, 307, 308, 309, 310, 313, 403, 404, 504, 508, 608, 801-4, 802, 804, 806	L	L	M	M	H	L
10b. Midslope, unconnected ephemeral or intermittent, 4-12%	50, 53, 102, 103, 906, 907, 909, 910	L	L	L	L	M	L
11a. Headwater, connected, steep mainly ephemeral streams	106, 107, 108, 109, 110, 312, 902	L	L	M	M	M	L
11b. Headwater, unconnected, steep streams	101, 704, 713, 901, 905, 911, 912, 913	L	L	L	L	L	L

FORM F-2. Habitat Survey Data

Segment #: 2 below hwy

Distance Sampled: 730

Unit#	Distance	Unit length	Unit Typ	pool type	wetted widt	bf width	pool tail	pool depth	% Embedded	%spawning	LWD pieces	LWD jams
1	219	219	riffle		16	18			60	0	4	
2	243	24	pool		15		0.4	1.8	60	0		
3	261	18	pool		8		0.6	1	70	0		
4	277	16	glide		6				60	0	1	
5	295	18	pool		11.4		0.8	1.4	70	20	3	
6	401	106	riffle		15					0		
7	412	11	pool		12		0.45	1.5	70	0		
8	449	37	glide		10		0.4	1.1	60	0		
9	461	12	riffle		8				60	0		
10	476	15	pool		10.5		0.45	1.8	50	0		
11	527	51	pool		8		0.5	1.2	40	0		
12	570	43	pool	tree	12		0.5	2.2		0	2	
13	661	91	riffle		18				10	10		
14	670	9	pool		12		1	1	20	0		
15	730	60	glide		9	13			40	5	1	
		730										

Notes: channel appears to have been straghteded thru first unit
shallow undercuts with overhanging grass approx. 5% cover
bugs common despite limited interstitial space
unit 8 1' undercut
unit 10 1.3' undercut
unit 12 formed by collapsed bank with alder tree
spawning gravels are mostly small pea gravels
unit 15 wood included downed alder with roots holding lwd pieces

FORM F-2. Habitat Survey Data

Segment #: 2 upstream of highway bridge

Distance Sampled: 415

Unit#	Distance	Unit length	Unit Type	pool type	wetted width	bf width	pool tail	pool depth	% Embedded	%spawning	LWD pieces	LWD jams
1	201	201	riffle		15.7	21.7				0	0	0
2	231	30	pool	tree scour			0.4	1		0	0	0
3	398	167	riffle							0	0	0
4	415	17	pool	scour			0.6	1.2		0	0	0
		415										

notes: Channel straighteded by logs cabled into banks for most of segment
unit 2 - 1 pocket pool

Segment #:4 just above falls

Distance Sampled: 590

Unit#	Distance	Unit length	Unit Type	pool type	wetted width	bf width	pool tail	pool depth	% Embedded	%spawning	LWD pieces	LWD jams
1	30	30	wood pool		16.5			1.3	75	0	3	0
2	58	28	riffle		10.8	41			40	0	3	2
3	81	23	pool		12		0.4	1.1	70	0	1	1
4	98	17	wood pool		14		0.3	0.85	70	0	2	0
5	120	22	dam wood		15		0.1	1.3	60	0	0	0
6	131	11	wood pool		15		0.2	1.6	0	0	0	1
7	139	8	wood pool		15		0.2	1	0	0	0	0
8	246	107	riffle		15				0	0	11	0
9	260	14	wood pool		12		0.4	1.5	0	0	2	0
10	280	20	riffle		8				0	0	0	1
11	287	7	wood pool				0.6	1.2	70	0	0	1
12	313	26	riffle		12				50	0	1	0
13	328	15	roots pool		10		0.4	1.8	60	0	1	0
14	353	25	riffle		12				50	0	0	1
15	386	33	pool		13		0.4	1.1		0	0	0
16	428	42	step pools		10				60	0	2	0
17	434	6	pool		15		0.7	1.7	60	0	1	0
18	440	6	pool		12		0.7	1.7	60	0	1	0
19	461	21	riffle		10					0	1	0
20	477	16	pool		12		0.6	1	50	0	1	0
21	484	7	wood pool		15		0.5	1.3		0	0	1
22	493	9	riffle		10				50	0	0	1
23	522	29	pool		15		0.1	1.4	100	0	1	1
24	568	46	riffle		18					0	2	0
25	590	22	pool		16.3		0.2	1.9	50	0	0	2
		590									33	12

Notes: debris jam spans units 6&7 pools under jam were not sampled
Unit 5 pieces of wood embedded in gravel bar
units #&$ has some suitable spawning size particles (2-10mm) mixed lots smaller fines
its 11, 13, 15, 21,25 sandy
it 23 all sand
no spawning substrate observed

FORM F-2. Habitat Survey Data

Segment #:4 flat area above falls

Distance Sampled: 170

Unit#	Distance	Unit length	Unit Type	pool type	wetted width	bf width	pool tail	pool depth	% Embedded	%spawning	LWD pieces	LWD jams
1	35	35	riffle		17				40	5	6	
2	90	55	glide		17.5	25.3			30	0	3	1
3	120	30	pool		14		0.4	1.8	50	sand	2	
4	170	50	riffle		15				varied	0	2	
		170										

notes: substrate mixed; not well sorted suitable size spawning gravels are present but are mixed with large and small particles

Segment #:4 new seg. above road Distance Sampled: 407

Unit#	Distance	Unit length	Unit Type	pool type	wetted width	bf width	pool tail	pool depth	% Embedded	%spawning	LWD pieces	LWD jams
1	15	15	pool		9.5	32.8	0.8	1	50	sandy	0	0
2	67	52	riffle		10				high	0	5	0
3	74	7	pool		12		0.5	1	50	0	1	0
4	113	39	riffle		split				40	0	3	1
5	123	10	pool		9		0.3	1.5	50	0	1	0
6	150	27	boulder pool		8		0.2	1.3	high	0	3	0
7	202	52	riffle		10					0	6	0
8	407	205	riffle		7					0	16	0

Notes: large gravel debris dam behind old cedar tree

Units 7&8 - split channel left channel 3 pools; rt channel 7 pools 1.5,1.4, .8, .8, .9, .9, .9, unit 8 large gravel bar/jam wood buried

FORM F-2. Habitat Survey Data

Segment #: 7 Distance Sampled: 340'

Unit#	Distance	Unit length	Unit Typ	pool type	wetted widt	bf width	pool tail	pool depth	% Embedded	%spawning	LWD pieces	LWD jams
1	11	11	r	riffle					60	0	0	0
2	25	14	p	bedrock			0.6	0.9	50	0	0	0
3	34	9	p	bank			0.1	0.8	60	0	1	0
4	34	0	p	wood			0.5	1.2	60	5	3	0
5	54	20	r	riffle							0	0
6	69	15	p	bank			0.3	1	60	0	0	2
7	81	12	r	riffle							0	0
8	92	11	p	bank	13	20	0.5	1.1	40	10	2	0
9	115	23	r	riffle							0	0
10	139	24	p	bank/tree	15		0.3	1.3	60	0	3	0
11	146	7	r	riffle							0	0
12	156	10	p	bank/tree	15		0.4	1.2			1	0
13	179	23	p	wood			0.4	1.7			1	0
14	215	36	p	tree			0.4	1.4			2	0
15	227	12	r	riffle						10	0	0
16	245	18	p	bank			0.3	1.1		0	2	0
17	280	35	p	bank/wood			0.4	1.9		5	2	1
18	296	16	p	bank/woo	15		0.7	1.5		0	0	1
19	308	12	p	bank/woo	17		0.7	1.4		5	1	0
20	331	23	r	riffle	8						0	0
21	340	9	p	wood			0.7	1.3		0	0	1
Notes:		340									18	5

Pools 3&4 are adjacent pools
unit 2 fines to .1'
unit 4 fine sed draping
unit 8 tail out embedded
unit 10 tail out embedded
unit 14 spawning gravels in tail, fines in pool; undercut bank
unit 17 .6' avg fines in pool, old beaver dam?
unit 21 sandy subs in pool
all wood old, old trees embedded in b only 3-4 fish observations, bugs were few (some cases not many crawling around)
stream above fence grassy banks, very straight channel, not many deeper pools, general lack of undercut/ overhanging banks and deep pools

FORM F-2. Habitat Survey Data

Segment #: 7 lower part along road

Distance Sample 374

Unit#	Distance	Unit length	Unit Typ	pool type	wetted widt	bf width	pool tail	pool depth	% Embedded	%spawning	LWD pieces	LWD jams
1	16	16	r	riffle	11.7	37			60		3	
2	19	3	pw	wood			0.5	1	60	0	1	
3	38	19	pw	wood	9.4		0.7	1.2	60	0	2	
4	87	49	g	glide	9.5					0	0	1
5	96	9	b	bank	11		0.9	1.4	60	0	0	
6	105	9	b	bank	12		0.4	2.1	60	5	2	
7	126	21	b	bank	10		0.8	1.5	60	5	0	
8	140	14	w	wood	11		0.6	2	60	0	0	
9	151	11	w	wood	11		0.4	1.1	60	0	2	
10	176	25	r	riffle	16.4	65.5			40	5	0	
11	212	36	b	bank	16.5		0.3	1.1	60	0	5	
12	238	26	w	wood	16.5		0.4	1.4	40	10	2	
13	275	37	r	riffle	17				35	10	0	
14	303	28	w	wood			0.5	1.6		10	1	1
15	374	71	w	wood	14	26.8		1.6			0	1
		374										

Notes: unit 2 fines in patches .4'deep
unit 5 sand deposited on side not filling depth
unit 7 few fines
unit 8 lots fines
unit 10 spawning gravel at end of riffle
unit 12 spawning gravel at tail out
unit 14 spawning gravel at tail out
unit 15; .7' fines in plunge pool; 3 pools associated with old beaver dam& lg log dam, plunge & wood scour
gravels better sorted
bugs common
rainbows observed
some undercut banks under heavy grass growth
not as many large substrate particles

FORM F-2. Habitat Survey Data

Segment #: 502 Van Stone Trib. Distance Sampled: 256

Unit#	Distance	Unit length	Unit Typ	pool type	wetted widt	bf width	pool tail	pool depth	% Embedded	%spawning	LWD pieces	LWD jams
1	19	19	riffle							0	3	0
2	24	5	pool				0.3	0.8	40	5	0	0
3	50	26	riffle		6.6						3	0
4	55	5	boulder pool				0.5	0.6	50	0	0	0
5	75	20	riffle							0	3	0
6	106	31	boulder pool				0.4	1	60	5	2	0
7	196	90	riffle		7.4	8.4					4	0
8	212	16	bank pool				0.2	1.2	40	5	2	0
9	225	13	riffle								0	0
10	238	13	step pool wood				0.3	1.8	0		0	1
11	248	10	riffle-cascade rocks								1	0
12	252	4	dam pool wood				0.5	0.9	0		1	0
13	256	4	dam pool wood		9.3	14.3	0.1	1.4	0		1	0
		256										

Notes: Unit 2 spawning gravels on margin
Unit 6 spawning gravels coarse sand in tailout
Unit 8 spaning on margin
mossy banks not as much grassy overhang
some pocket pools none very deep brook trout observed
some nice small spawning gravels in patches

FORM F-2. Habitat Survey Data
Segment 406/509
wetted width = 44
8 Units

5 pools	depth	tail
step	0.7	
step	0.8	0.3
undercut,	0.55	0.25
bank	1	
bank	1	
3 riffles		

sampled 153' stopped at brick?
disturbed channel
lots of fish 20+ brook trout
possibly spawning
numerous evidence of beaver ponds
wood function dependent on dam breaks
spawning substrate appears to be coarse sand along channel margins <5% in patches
bugs are common, appear to be less than downstream, some worm tubes present

Segment 505 - near old slide
brook trout present
lots of wood, deep pools sorted seds above slide
below slide scoured rocky & steep

Segment 2 - below Highway

Unit #	Diameter	Type	Zone	Function
1	4 to 8"	unknown	bankfull	none
1	4 to 8"	unknown	bankfull	none
1	4 to 8"	unknown	bankfull	none
1	4 to 8"	unknown	bankfull	none
5	4 to 8"	unknown	bankfull	none
6	4 to 8"	unknown	bankfull	none
6	4 to 8"	unknown	bankfull	none
6	4 to 8"	unknown	bankfull	none
12	4 to 8"	unknown	bankfull	none
12	4 to 8"	unknown	bankfull	none
15	4 to 8"	hardwoo	wetted	pool scour

Segment 2 - Above highway no LWD

FORM F-2. Habitat Survey Data
Segment 4: Above Falls

	Unit #	Diameter	Type	Zone	Function
1	1	4 to 8"	hardwoo	suspende	none
2	1	12 to 19.9"	conifer	suspende	scour
3	1	4 to 8"	hardwoo	bankfull	none
4	2	12 to 19.9"	conifer	wetted	none
5	2	4 to 8"	unknown	wetted	deposition
6	2	4 to 8"	unknown	wetted	deposition
7	2	jam	mixed	wetted	deposition
8	2	jam	mixed	bankfull	deposition
9	3	12 to 19.9"	hardwoo	bankfull	deposition
10	3	sm jam	hardwoo	bankfull	deposition
11	4	12 to 19.9"	unknown	bankfull	dam pool
12	4	12 to 19.9"	unknown	bankfull	scour
13	6	med jam	mixed	bankfull	scour / deposition
14	8	> 20"	unknown	suspende	none
15	8	8 to 11.9"	unknown	bankfull	none
16	8	8 to 11.9"	unknown	bankfull	none
17	8	8 to 11.9"	unknown	bankfull	none
18	8	8 to 11.9"	unknown	bankfull	none
19	8	8 to 11.9"	unknown	bankfull	none
20	8	8 to 11.9"	unknown	wetted	scour
21	8	8 to 11.9"	unknown	wetted	bank armor
22	8	8 to 11.9"	unknown	wetted	bank armor
23	8	8 to 11.9"	unknown	wetted	bank armor
24	8	8 to 11.9"	unknown	wetted	bank armor
25	9	8 to 11.9"	unknown	wetted	bank armor
26	9	8 to 11.9"	unknown	wetted	bank armor
27	10	lg jam	mixed	wetted	deposition
28	11	sm jam	mixed	wetted	deposition
29	12	4 to 8"	conifer	bankfull	none
30	13	root wad	conifer	wetted	scour
31	14	sm jam	mixed	wetted	deposition
32	16	> 20"	unknown	suspende	none
33	16	4 to 8"	unknown	wetted	bank armor
34	17	4 to 8"	unknown	bankfull	none
35	18	12 to 19.9"	unknown	wetted	bank armor
36	19	4 to 8"	unknown	bankfull	none
37	20	4 to 8"	hardwoo	wetted	deposition
38	21	jam	mixed	wetted	deposition /pool scour
39	22	sm jam	mixed	wetted	deposition
40	23	4 to 8"	hardwoo	bankfull	bank armor
41	23	jam	unknown	wetted	deposition
42	24	12 to 19.9"	unknown	bankfull	bank armor
43	24	4 to 8"	unknown	bankfull	bank armor
44	25	sm jam	unknown	bankfull	bank armor
45	25	sm jam	unknown	wetted	scour

FORM F-2. Habitat Survey Data
Segment 4: Open area

Unit #	Diameter	Type	Zone	Function
1	4 to 12"	unknown	wetted	bank armor
1	4 to 12"	unknown	wetted	bank armor
1	8 to 11.9"	unknown	bankfull	none
1	12 to 19.9"	unknown	bankfull	none
1	12 to 19.9"	unknown	bankfull	none
1	12 to 19.9"	unknown	bankfull	none
2	4 to 12"	unknown	wetted	none
2	4 to 12"	unknown	wetted	none
2	4 to 12"	unknown	wetted	none
2	sm jam	unknown	wetted	scour
3	4 to 12"	unknown	wetted	bank armor
3	4 to 12"	unknown	wetted	bank armor
4	>20"	unknown	bankfull	scour
5	8 to 11.9"	unknown	wetted	deposition
5	8 to 11.9"	unknown	wetted	deposition

FORM F-2. Habitat Survey Data
Segment 4: Above Road

Unit #	Diameter	Type	Zone	Function
2	4 to 8"	unknown	bankfull	none
2	8 to 11.9"	unknown	bankfull	none
2	8 to 11.9"	unknown	bankfull	none
2	>20"	conifer	suspend	none
2	4 to 8"	unknown	bankfull	none
3	4 to 8"	unknown	wetted	none
4	4 to 8"	hardwood	suspend	none
4	jam	mixed	wetted	deposition
4	jam	mixed	wetted	bank armor
4	12 to 19.	conifer	bankfull	scour
5	8 to 11.9"	conifer	wetted	scour
6	12 to 19.	conifer	wetted	scour
6	12 to 19.	conifer	wetted	deposition
6	>20"	conifer	wetted	bank armor
7	>20"	conifer	suspend	none
7	12 to 19.	conifer	wetted	bank armor
7	12 to 19.	conifer	suspend	none
7	12 to 19.	conifer	suspend	none
7	12 to 19.	conifer	suspend	none
7	sm jam	conifer	wetted	scour
8	8 to 11.9"	conifer	suspend	scour
8	8 to 11.9"	conifer	suspend	none
8	>20"	conifer	wetted	deposition
8	>20"	conifer	wetted	deposition
8	8 to 11.9"	conifer	wetted	scour
8	8 to 11.9"	conifer	wetted	scour
8	12 to 19.	conifer	wetted	deposition
8	12 to 19.	conifer	wetted	pool scour
8	>20"	unknown	wetted	pool scour
8	4 to 8"	hardwood	wetted	scour
8	4 to 8"	unknown	wetted	scour
8	4 to 8"	unknown	wetted	?
8	4 to 8"	unknown	wetted	?
8	4 to 8"	unknown	wetted	?
8	12 to 19.	unknown	wetted	?
8	jam	mixed	wetted	deposition

FORM F-2. Habitat Survey Data
Segment 7

Unit #	Diameter	Type	Zone	Function
3	12 to 19.	c	wetted	pool scour
4	4 to 8"	uk	wetted	bank armor
4	12 to 19.	uk	wetted	scour
4	8 to 11.9"	uk	wetted	scour
6	sm jam	uk	wetted	scour
6	med jam	uk	bankfull	bank armor
8	4 to 8"	uk	bankfull	scour
8	4 to 8"	uk	bankfull	scour
10	8 to 11.9"	uk	wetted	none
10	8 to 11.9"	h	wetted	pool scour
10	8 to 11.9"	uk	wetted	deposition
13	8 to 11.9"	uk	wetted	none
14	>20"	uk	wetted	pool scour
15	8 to 11.9"	uk	wetted	deposition
15	8 to 11.9"	uk	wetted	bank armor
16	12 to 19.	uk	wetted	bank armor
16	4 to 8"	uk	wetted	bank armor
17	8 to 11.9"	uk	wetted	scour
17	4 to 8"	h	wetted	none
17	sm jam	uk	wetted	pool scour
18	med jam	uk	wetted	pool scour
19	>20"	uk	wetted	pool scour
21	sm jam	h	wetted	pool scour

FORM F-2. Habitat Survey Data
Segment 7 - along road

Unit #	Diameter	Type	Zone	Function
1	4-8"	u	wetted	bank armor
1	4-8"	u	wetted	bank armor
1	4-8"	u	wetted	bank armor
2	4-8"	h	wetted	pool scour
3	>20"	c	wetted	pool scour
3	4-8"	u	bankfull	none
4	4-8"	u	wetted	bank armor
6	8-11.9"	u	wetted	bank armor
6	4-8"	u	wetted	pocket scour
7	sm jam	u	wetted	pocket scour
9	8-11.9"	u	wetted	pocket scour
9	4-8"	u	wetted	none
11	12 -19.9"	u	wetted	pocket scour
11	4-8"	u	wetted	pocket scour
11	4-8"	u	bankfull	none
11	4-8"	u	wetted	pocket scour
11	4-8"	h	wetted	pocket scour
12	8-11.9"	u	wetted	pool scour
12	8-11.9"	u	wetted	pool scour
14	mjam	u	wetted	pool scour
14	8-11.9"	u	wetted	none
15	mjam	u	wetted	dam

FORM F-2. Habitat Survey Data
Segment 502

Unit #	Diameter	Type	Zone	Function
1	8-11"	u	wetted	bank armoring
1	4-8"	u	wetted	bank armoring
1	4-8"	h	suspend	none
3	4-8"	h	wetted	scour
3	4-8"	h	wetted	scour
3	4-8"	h	suspend	none
3	4-8"	h	suspend	none
3	4-8"	h	suspend	none
3	4-8"	h	suspend	none
3	4-8"	u	bankfull	bank armoring
3	8-11"	c	suspend	none
5	4-8"	h	suspend	none
5	12-19.9"	u	wetted	bank/deposdition bar
5	8-11"	h	bankfull	bank armoring
6	8-11"	h	suspend	none
6	8-11"	h	bankfull	none
7	4-8"	u	bankfull	bank armoring
7	12-19.9"	u	wetted	deposition
7	>20"	c	wetted	bank -roots
7	4-8"	u	bankfull	none
8	4-8"	u	bankfull	none
8	4-8"	u	bankfull	none
10	SM JAM	u	wetted	pool scour
11	12-19.9"	c-root	wetted	scour
12	8-11"	c	wetted	dam pool/ scour
13	12-19.9"	c	wetted	dam pool

APPENDIX G
WATER QUALITY

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Appendix

Appendix gg-1. SCCD and Equinox Water Quality Data

The Water Quality module assessment for the Onion Creek Watershed Administrative Unit was conducted in accordance with draft version 1.0 of the Water Quality Module of the Washington Forest Practice Board *Standard Methodology for Conducting Watershed Analysis*, November, 1996. This version was printed after the field work was conducted and consequently, sufficient field data was not collected for a Level 2 assessment. For these cases, Level 1 assessment vulnerability calls were applied.

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_____ _____

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APPENDIX G. WATER QUALITY

1.0 INTRODUCTION

This module investigates the water quality of stream channels, wetlands and lakes within the watershed. Many of the wetlands in the Onion Creek WAU function to store and regulate the water flow in tributaries to Onion Creek. Water is stored as surface and ground water and enters the stream channels directly or as ground water inflow. Wetlands also function as filters to trap fine sediment from entering the stream channels. Small wetlands (<3 acres) are vulnerable to increases in temperature and sediment inputs. Warm water from the wetlands can enter the stream channels and affect downstream resources. Sediment entering wetlands can reduce the ability of the wetland to store water and additional sediment.

Wetland soils are rich with nutrients and organic material making them attractive for conversion to pasture or growing crops. Aerial photos give evidence that a number of wetlands in the Onion Creek WAU have been converted to agriculture. The wetlands have been ditched and drained into stream channels decreasing their ability to function as water storage and sediment traps.

Several water quality parameters discussed in the draft water quality module are addressed within other modules of this watershed analysis. Specifically, stream temperature and canopy closure is discussed in the Riparian Function Report (Appendix I). Sediment issues are addressed in the Mass Wasting, Surface Erosion and Stream Channels/Fish Habitat reports (Appendices A, B and E/F). Therefore, these parameters are only briefly discussed in this module report.

Onion Creek is listed as a Class AA stream and generally meets Washington state water quality standards listed in Table G-1.

Table G-1. Standards for Class AA Streams.

Water Quality Parameter	Class AA Standard	Addressed in Module
Temperature	Not to exceed 16°C	Yes
Nutrients; Nitrogen, Phosphorous	Washington drinking water standards	Yes
Dissolved Oxygen	To exceed 9.5 mg/l	Yes
pH	Within 8.5 - 6.5	Yes
Dissolved Organic Matter	None	No
Turbidity	Not to exceed 5 NTU over background	No
Accretion; Fine Sediment		Channels Module
Fecal Coliform Bacteria	Not to exceed 50 colonies/100 ml	No
Toxic Chemicals	Washington drinking water standards	If specific conditions exist

1.1 Current Water Quality Conditions

Water quality of Onion Creek is currently being monitored by two organizations. In compliance with their permit for mining operations, Equinox Resources Inc.(Equinox), present owner of the Van Stone Mine, monitors water quality at seven surface water sites and one ground water site. These sites are near the mine and mine tailings ponds. The Stevens County Conservation District (SCCD) monitors water quality in the main channel of Onion Creek near the mouth, directly upstream of Highway 25, in stream segment 2. Table G-2 lists the water quality parameters tested with each sample. Appendix gg-1 contains water quality data collected by Equinox and SCCD. In addition, to these ongoing studies, a former graduate student of Eastern Washington University studied the fate of trace elements from the Van Stone Mine.

The water quality monitoring data indicate that Onion Creek meets the Class AA standards with exceptions during low flow periods in late summer and fall. With warm air temperature and low flow the water temperature has exceeded 16°C and fecal coliform bacteria has exceeded 50 colonies/100 ml. The fecal coliform bacteria may be contributed from live stock having direct access to the stream or from failing and poorly designed septic systems. The Van Stone Mine, located in the head waters of the WAU, has contributed trace metals, including lead and zinc, into Onion Creek. Although the concentrations of trace metals are above background levels during normal flow conditions, they are below safe EPA drinking water standards (Routh 1993).

Table G-2. Existing Water Quality Data

Parameter	Equinox	SCCD
Discharge	No	Yes
Temperature	Yes	Yes
Dissolved Oxygen	Yes	Yes
pH	Yes	Yes
Specific conductivity	Yes	Yes
Turbidity	Yes	Yes
Total suspended solids	Yes	Yes
Total dissolved solids	Yes	Yes
Fecal coliform bacteria	No	Yes
Chloride	Yes	Yes
Sulfate	Yes	Yes
Nitrate	Yes	Yes
Ammonia Nitrogen	No	Yes
TKN	No	Yes
Soluble reactive phosphorus	No	Yes
Total phosphorous	No	Yes
Alkalinity	No	Yes
Bicarbonate	No	Yes
Carbonate	No	Yes
Trace metals	Yes	Yes

1.2 Critical Questions

Critical questions addressed in the water quality module include:

- What water bodies occur in the watershed and where are they located?
- What are the likely responses of the water body parameters (temperature, sediment, pH concentration of nutrients and DO) to potential changes in input variables?
- What is the vulnerability of each water body to potential changes in input variables
- What do current water quality conditions or changes from past conditions indicate about

the determination of vulnerability of the water bodies?

- If a water body is found to be vulnerable to an input, e.g. sediment, nutrients, heat, or organic matter, is there sufficient information available in the watershed analysis assessment reports to identify sources and to establish sensitivity to those inputs?

1.3 Assumptions

The following assumptions were used in development of the draft version of the water quality module and were applicable to the Onion Creek watershed analysis.

- Assessment methods apply to all surface waters of the state.
- State and federal surface water and drinking water quality standards identify important water quality characteristics.
- Changes in input variables (sediment, wood, heat energy, and water quality and chemicals) to each water body of concern can result in changes in water quality and changes in the level of support to beneficial uses.
- Water quality parameters vary significantly in both short-term time and in space.
- Water bodies differ in their functional characteristics. These characteristics determine the beneficial uses of the water body and its vulnerability to changes in input variables.
- A variety of land use activities, as well as natural processes, can cause changes in water quality. The presence of land uses other than forest management can have significant effects on water quality that may not be fully characterized in the watershed analysis.
- The current condition of a water body represents its response to past and current watershed processes. Current condition and past changes are indicators of the potential of the water body to be influenced by watershed processes and land use activities.

2.0 METHODS

The water quality assessment of Onion Creek was conducted using a draft version 1.0 of the water quality module (WFPB 1996). The draft module was printed after the field work was completed. Consequently, data collected during the field visit are not adequate for a Level 2 assessment.

Level 2 assessments generally require collecting specific field data for the resource in question and Level 1 assessments rely on existing data such as aerial photos and soil maps. At the time of field observations, the draft Water Quality procedures manual was not available and data requirements for Level 2 assessment were not known and consequently, not collected. Therefore, several water quality parameters were assessed with Level 1 procedures.

2.1 Water Body Identification

Wetlands were identified and described in the Onion Creek WAU by analysis of: 1) USGS maps; 2) NRCS soils maps (1982); 3) National Wetland Inventory (NWI) map; 4) 1992 black and white aerial photographs (1:14,000-1:16,500 scale) and; 5) field verification. Wetlands identified on aerial photographs were plotted on the NWI map and digitized on the Water Body Location and Vulnerability Map G-1. Wetlands were described from aerial photo analysis and field verification of selected sites. Field verification of location, size, canopy closure, inlet and outlet channel connection to tributaries and Onion Creek was conducted in October, 1996. Wetlands were numbered to be consistent with the stream channel segments. Form G-1 lists wetlands identified in this analysis, their classification and vulnerability to temperature and sediment.

2.2 Response and Vulnerability to Inputs

The response of water bodies to inputs was determined using Level 1 assessment in Standard Methodologies for Conducting Watershed Analysis Draft Version 1.0 (WFPB 1996) except as modified for specific wetlands. Level 1 standard assessments are conservative and results tend toward high vulnerability calls. Modifications to vulnerability calls were made when supporting information justified the changes. The modifications are noted in the tables and texts.

2.2.1 Temperature

Stream channel vulnerability to temperature is addressed in the Canopy Closure and Stream Temperature section of the Riparian Functions module report. Canopy closure and view to sky of the Onion Creek channel will not be discussed in this Water Quality module report.

Temperature vulnerability of wetlands and lakes were determined with Level 1 assessment methods. Wetlands with a surface area of 3 acres or less have a high vulnerability to temperature, wetlands between 3 and 10 acres have a moderate vulnerability and wetlands larger than 10 acres have a low vulnerability. Form G-1 lists the wetlands and vulnerability to temperature and sediment.

Temperature vulnerability calls of wetlands which are seasonally dry were modified by assessing the depth of the water table. Wetlands with water tables deeper than 15 inches have a low vulnerability, wetlands with water table 8-15 inches have moderate vulnerability and water tables less than 8 inches have a high vulnerability (WFPB 1996). Water table depths were determined with soil descriptions in the Stevens County Soil Survey (NRCS 1982).

2.2.2 Sediment

Vulnerability of a wetland to sediment accumulation is based the probability of sediment being routed to the wetland and the effectiveness of the wetland to store the sediment. Table G-2 lists

the standard assessments of wetland probability to receive sediment, effectiveness in storing sediment and vulnerability to sediment input.

Table G-3. Level 1 Assessment for Vulnerability to Sediment Input

Wetland Classification	Probability of Receiving Sediment	Effectiveness for Storage	Vulnerability to Sediment
Riverine valley connected	High	Moderate	High
Riverine valley unconnected	Moderate	Moderate	Moderate
Depressional connected	Low	High	Moderate
Depressional unconnected	Low	High	Moderate
Slope connected	Low	Low	Low
Slope unconnected	Low	Moderate	Low
Lacustrine fringe	Low	Moderate	Low

2.2.3 Nutrients

Nutrient vulnerability assessment is dependent of the vulnerability of receiving waters to inputs of nitrogen and phosphorus. Lake Roosevelt is the receiving water of the Onion Creek WAU and has a low vulnerability to nutrient enrichment due to the size, depth and rate of water exchange. Silver Crown Lake is an isolated water body in the WAU which has no apparent inlet or outlet. This lake may be vulnerable to nutrient enrichment, however nutrients would be carried by surface drainage and ground water flow; determination of inputs from these sources is outside of the scope of this analysis.

2.2.4 Dissolved Oxygen

The concentration of Dissolved Oxygen (DO) is dependent on water temperature, biochemical oxygen demand, re-aeration of the stream channel and elevation. Level 1 assessment procedures were followed to identify stream segments with high and moderate vulnerabilities to low DO concentrations. Stream segments were identified where stream gradient was less than 2% with unconfined channel and open canopy cover. These stream segments may have elevated water temperatures which would decrease DO concentration and low gradient stream segments with unconfined channels do not promote aeration.

2.2.5 pH

All streams and water bodies are assumed to have low vulnerability to pH and generally, forest practices have little affect however, pH may vary with discharge and biochemical oxygen

demand (McDonald et al. 1991). Analysis of the existing Onion Creek water quality data was conducted to identify possible patterns and relationships.

2.3 Modifications to Methods

Methods used in the Onion Creek Water Quality assessment followed the Level 1 assessment standards of the Draft Version 1.0 (WFPB 1996). Because the Draft Version 1.0 was made available after the field work had been completed, much of the collected data was not adequate for a Level 2 analysis. However, existing water quality data and field observations from accompanying modules provided sufficient information to modify some of the Level 1 vulnerability calls.

Because Onion Creek is a relatively small stream, the view to the sky methodology was not necessary. The Canopy Closure and Stream Temperature methods in the Riparian Function module were adequate to quantitatively assess temperature vulnerability of Onion Creek. Temperature vulnerability of depressional wetlands connected to stream channels by surface water were assessed by Level 1 assessment methods.

Changes of water body conditions due to past land management was not assessed so, determination of vulnerabilities of the water bodies by their response to land management was not evaluated. Vulnerabilities of water bodies were generally, determined by Level 1 protocol.

The assessment of responses and vulnerabilities of wetlands unconnected to stream channels is not necessary. Unconnected wetlands do not have a surface water connection to stream channels so sediment and water cannot be delivered to public resources. Ground water inflow provided from the unconnected wetlands will be cooled by soil at depth. Parton and Logan (1981) found that soil below 8 inches (20 cm) maintained a stable temperature near the average daily air temperature. In the Onion Creek WAU the average daily air temperature in July and August is unlikely to exceed 16°C.

The Water Body Map G-1 has been combined with other map products from the draft module for convenience and because of the few vulnerabilities of water bodies in this watershed. The combined map G-1 includes: Map G-3 (temperature), Map G-4 (sediment), and Map G-6 (DO and pH). Boise Cascade Corporation provided a land ownership map, shown in Figure 3 of the main report, which substitutes for the Land Use Map G-2. Though Figure 3 does not specifically identify land use, land ownership implies how the land is managed.

3.0 RESULTS and DISCUSSION

3.1 Wetlands

Wetlands and water bodies identified in the Onion Creek WAU are shown on Map G-1 and listed

on Form G-1. Vulnerability of each wetland to temperature and sediment is also listed on Form G-1. Several wetlands in this WAU have been impacted by agricultural practices. Wetland outlet channels have been modified by ditching for drainage of the wetlands. These activities have likely reduced ground water recharge and altered the timing of runoff to receiving surface waters.

Most wetlands were identified from analysis of aerial photographs, NWI map and Stevens County Soils map. Forested wetlands are not easily distinguished on aerial photos and their number may have been underestimated. There was a good correlation between the aerial photographs and the NWI and soils maps with the location of wetlands.

Wetlands identified in the Onion Creek WAU fall into three wetland hydrographic units (WHU). Sixteen wetlands occur in the riverine valley connected by surface water flow to main channel flow, 19 wetlands occur in depressional topography connected to the main channel, and 11 wetlands occur in depressional topography with no surface water connection to channels. The riverine valley connected wetlands are treated as riparian units on the stream segments and temperature vulnerability of these wetlands are discussed in the Riparian Condition Module. Depressional connected wetlands occur as either headwaters or in line with stream segments and contribute directly to stream flow. Depressional connected wetlands of three acres or less have a high vulnerability to temperature by standard assessment. Table G-4 lists the depressional connected wetlands in the Onion Creek WAU that have a high or moderate vulnerability to temperature, fish bearing status, canopy closure of downstream channel segments and target shade level of downstream channel segments.

Table G-4. Temperature Vulnerability in Depressional Connected Wetlands

Wetland Number	Temp Vulnerability	Fish Bearing Status	Downstream Canopy Closure	Target Shade
301a	High	Fish Bearing	78%	100%
301b	High	non-Fish Bearing	85%	100%
606	High	non-Fish Bearing	90%+	27%
710	High	non-Fish Bearing	20-40%	55%
903b	High	non-Fish Bearing	20-90%	100%
903c	Moderate	non-Fish Bearing	90%+	100%

Wetlands 301a and 301b are stock ponds which were either created in the stream channel or enhanced from existing wetlands connected with stream segment 301, a fish bearing stream segment. However, stock ponds are allowed as an existing beneficial use by Washington state water quality standards provided that no further degradation to water quality is allowed to occur.

Surface water from wetlands 301b, 606, 710, 903b and 903c do not discharge directly into fish

bearing channel segments and therefore, deliverability of warm water to fish bearing channels from these wetlands is low.

Depressional unconnected wetlands are not connected with stream channels by a surface outlet. Increased water temperature from these wetlands will not affect water temperature in any stream segments. The default temperature vulnerability call for depressional unconnected wetlands is moderate however, there is no hazard of deliverability of warm water to a public resources.

Wetland Management Zone (WMZ) buffer widths described in the Forest Practices Board Manual WAC 222-30-020 (WFPB 1993) are designed to protect wetland functions and wildlife habitat forested wetlands. Non-forested wetlands on forestry lands are also protected by harvest methods described in the Forest Practices Board Manual WAC 222-30-020 (WFPB 1993). Standard forest practice rules are adequate to protect wetlands in the Onion Creek WAU.

3.2 Sediment

An increase of sediment in wetlands can decrease the ability of a wetland to trap more sediment, store water and buffer peak stream flow. Vulnerability of wetlands to sediment is based on the probability of a wetland to receive sediment and the effectiveness of storing sediment. Table G-5 lists the Level 1 assessment vulnerability calls for each wetland hydrogeomorphic subclass.

Table G-5. Level 1 Assessment Vulnerability Calls for Sediment Input

Wetland Hydrogeomorphic Subclass	Probability of Sediment Input	Effectiveness of Storing Sediment	Vulnerability to Sediment Input
Riverine valley connected	High	Moderate	High
Riverine valley unconnected	Moderate	Moderate	Moderate
Depressional connected	Low	High	Moderate
Depressional unconnected	Low	High	Moderate
Slope connected	Low	Low	Low
Slope unconnected	Low	Moderate	Low

Wetland vulnerability calls for sediment were determined by Level 1 assessment. Results are listed on Form G-1 (attached). Table G-6 lists the wetlands that have a high vulnerability to sediment as well as sediment contribution and deliverability from road surface erosion. Estimates of sediment input to wetlands was provided by the surface erosion analyst and is based on estimated erosion rates and measured contributing area of road. All wetlands listed are riverine valley wetlands connected to stream channels by surface water flow. These wetlands have a high vulnerability to sediment input. However, deliverability of sediment is generally low and sediment contribution from mass wasting is essentially absent from the Onion Creek WAU.

Table G-6. Sediment Input to Wetlands from Road Erosion

Wetland	Vulnerability to Sediment	Sediment Input from Roads (tons/yr)	Deliverability
1	High	1,512	High
2	High	1,300	High
7	High	1,259	High
507	High	0	Low
607a	High	1	Low
607b	High	0	Low
608	High	0	Low
701-1	High	55	Moderate
701-2a	High	26	Moderate
701-2b	High	26	Moderate
701-3	High	0	Low
702	High	0	Low
706	High	0	Low
708	High	0	Low
709	High	0	Low
712	High	0	Low
903a	High	1	Low

Wetland 1 is associated with the flood hazard area periodically flooded by Lake Roosevelt. Wetlands 2, and 7 are associated with stream channels and flood hazard areas and periodically receive overbank deposits of sediment. A function of these wetlands is to store the sediment input. The Level 1 vulnerability call for these wetlands is high for sediment input, and deliverability of sediment to these wetlands is high. Sediment input into these wetlands and channel segments are discussed in the Surface Erosion Report and Stream Channels/Fish Habitat Report (Appendices B and E/F respectively).

Wetlands 701-1, 701-2a, and 701-2b have a high vulnerability to sediment input with moderate deliverability (Table G-6). These wetlands are associated with stream segment 701 which also has a high vulnerability to sediment input. Causal Mechanisms Report #5 for channel 701 discusses sediment inputs to these areas. The remaining wetlands listed in Table G-6 have a high

vulnerability to sediment input but, have a low deliverability of sediment.

3.3 Nutrients

Lake Roosevelt is the receiving water of the Onion Creek WAU and has a low vulnerability to nutrient inputs due its large volume, depth and the short water residence time in the lake. Since the receiving water has a low vulnerability to nutrient input, Level 1 assessment vulnerability of Onion Creek and tributaries is low.

Wetlands have natural high concentrations of organic material and nutrients, therefore, inputs from changes from forest practices do not harm wetland processes. Wetlands are not considered vulnerable to nutrient inputs.

3.4 Dissolved Oxygen

The concentration of dissolved oxygen (DO) must exceed 9.5 mg/l to meet Washington State class AA standards. However, gas saturation and atmospheric pressure decrease with elevation. DO saturation at 1,450 ft above mean sea level, the elevation of Onion Creek at State High 25, at 16°C is less than the Class AA standards. The background DO concentrations may naturally fall below Class AA standards.

The Level 1 vulnerability assessment identified four stream segments of the main steam of Onion Creek with gradients of 1% to 2% or less with unconfined channels. Stream depths in unconfined channels are generally shallow with gravel and fine sediment and water velocity is low. Re-aeration in these channels is low and vulnerability to low dissolved oxygen concentration is high. Table G-7 lists the stream segments identified with low gradient and unconfined channels with occurrence of low dissolved oxygen concentrations.

Table G-7. Dissolved Oxygen Vulnerability

Stream Segment	Gradient (%)	Confinement	Wetted Depth (ft)	Wetted Width (ft)	Velocity (ft/sec)	Vulnerability to Dissolved Oxygen
1	<1	Unconfined				High
2	1 - 2	Unconfined	0.6		0.65	Moderate
7	1	Unconfined				Moderate [1]
10	1 - 2	Unconfined	0.51	8.7	0.40	High

1. Professional judgement based on shade condition, gradient and channel roughness.

Depth, width and velocity data were not available for stream segments 1 and 7. Vulnerability calls were based on canopy cover conditions, gradient and channel conditions including pool

depth and pool:riffle ratio. Stream segment 1 is a low gradient, unconfined channel with an open canopy. Depth and velocity is directly influenced by the water level of Lake Roosevelt. Level 1 vulnerability assessment for DO is high for stream segment 1. Stream segment 7 has a low gradient with about 68% of surface area in pools with average residual depths of 0.4 ft and 0.5 ft, lower and middle section respectively. Large woody debris contributes to channel roughness in this segment which also decreases water velocity. In addition, cattle are allowed to graze in this area which may contribute organic material to the stream leading to decreased DO concentration.

SCCD recorded a low DO concentration of 9 mg/L at 10:34 am, September 18, 1995 near the mouth of Onion Creek in stream segment 2. This measurement is associated with a low flow measurement of 1.3 cfs and a high fecal coliform concentration of 64 colonies/100 ml.

Existing DO concentration data measured by Equinox Resources is suspect. Reported DO concentrations range from 4.5 to 43. Assuming units of milligrams per liter, the lower range of 4.5 mg/L is excessively low for mountain streams and 43 mg/l is about four times the saturation concentration of DO. Because of this extreme variation of recorded observation, this data set was not used for this analysis.

3.5 pH

The existing water quality data shows that pH measurements are within standards for class AA waters (6.5 - 8.5). However, pH measurements below 6.5 were recorded at three sites on August 27, 1992 by Equinox Resources Inc. (Appendix gg-1). There were no unusual rain events, and no other supporting data to suggest a cause for the low pH, so these measurements were treated as an error in the data set.

pH is generally assumed to be unchanged by most forest practices and runoff has little impact to streams because of the buffering capacity of the soil (McDonald et. al. 1991). It is unlikely that forest practices in the Onion Creek WAU will affect the pH of Onion Creek. However, pH may be affected if a large volume of the Van Stone mine tailings entered Onion Creek. A study of water quality parameters of a stream that received runoff from coal mine tailings during a rain storm event found that pH temporarily fell to levels harmful to fish, invertebrates and algae (Wangsness 1982). The Van Stone Mine tailings consists primarily of sulfates, sulfides and carbonates that rapidly oxidize in oxygenated water (Routh 1993). If a catastrophic event occurred where the tailings pond was breached and entered Onion Creek, the pH might fall below the class AA standard of 6.5. Below 6.5 salmonid egg production, hatching success and emergence of some aquatic insects decline (McDonald et. al. 1991). In addition, chemical reactions may lower DO concentration. Trace metals may be redissolved into the water column at low pH levels (Routh and Ikramuddin 1996) and some trace metals have harmful affects on aquatic biota. Such an event would occur over a short time period of a few hours but, could have long term affects on the aquatic community (Wangsness 1982).

To avoid the catastrophic event described above, it is important that surface water runoff should not be concentrated near the Van Stone Mine or the tailing ponds. Anecdotal reports of past failures of the tailings pipes and ponds suggest that Onion Creek has had catastrophic inputs from the mine tailings. Whether these events have had a chronic affect on Onion Creek is beyond the scope of this analysis.

3.6 Van Stone Mine

The Van Stone Mine has operated intermittently since 1926 when large lead and zinc deposits were discovered. Milled wastes are stored at two mine tailing ponds in the east fork Onion Creek drainage. The tailings contain a number of trace metals including: aluminum, arsenic, barium, calcium, cadmium, chromium, copper, iron, potassium, magnesium, manganese, molybdenum, sodium, nickel, lead, antimony, selenium, vanadium and zinc. Routh and Ikramuddin (1996) concluded that the high pH due to calcium carbonate dissolution in Onion Creek and the presence of metal oxides resulted in the formation of insoluble trace metal complexes which precipitate or adsorb to sediments in the upper reaches of Onion Creek downstream of the mine wastes. Although the concentration of lead and zinc are above background levels, water quality meets EPA regulatory standards. Routh's study was conducted during low discharge conditions and trace metal concentrations may be affected by changes in runoff and sediment scouring events (Routh and Ikramuddin 1996).

3.7 Forest Chemicals

Application of fertilizer, herbicides and pesticides is regulated by Washington Forest Practices Board WAC 222-38 (WFPB 1993). Forest chemicals are not allowed to be applied to wetlands or open water. Aerial application of fertilizer and pesticide must provide a buffer of 200 ft around residences and 100 ft around agriculture lands. Aerial application must provide a 25 ft buffer strip on either side of Type A and B wetlands and all typed streams except Type 4 and 5 with no surface water at the time of application. Within the buffer zones, hand application of fertilizer and pesticides must be targeted and not allowed to enter surface water. Herbicides must not be allowed to enter Type A and B wetlands and all typed streams except type 4 and 5 with no surface water at the time of application.

A recent study was conducted in Oregon to investigate herbicide residue in forest streams used by fish and for domestic water supply. Samples were collected approximately 24 hours after the herbicide application and no detection of herbicides was found in 43 out of 52 samples (83%). The remaining 17 samples had detection levels below standards for human health risks (ODF 1992). This study recommended buffer strips of 60 feet on Class I waters (streams and water bodies significant for fisheries, recreation or domestic use and corresponds to Washington's Type 1, and 2 streams) to control excessive drift or over spray onto surface water. Herbicides are used in forests to prepare areas for replanting, controlling undesirable vegetation, and to control noxious weeds. Herbicides are also used on utility right of ways.

The following herbicides may be used in the Onion Creek WAU:

Roundup, and Accord (products of Mansanto Co. 1-800-332-3111);
Arsenal (product of American Cyanamid Co.1-201-835-3100);
Glyfos (product of Cheminova, 1-800-548-6113);
Tordon 22K and Curtail (products of DowElanco, 1-503-829-4933);
Pronone (product of Pro-serve Inc. 1-901-332-7052);
Amine 4 (product of Wilbur-Ellis 1-800-424-9300).

Information about the specific herbicides may be obtained from the manufacturer and in the extensive Environmental Impact Statement (EIS): Vegetation Treatment on BLM Lands in Thirteen Western States (BLM 1991). The EIS studied the effects of using several herbicides including the above, on the human and natural environments. The study determined that members of the public are not at risk where the herbicides are applied as directed by the manufacturers and by BLM policy.

4.0 CONFIDENCE IN WATER QUALITY ASSESSMENT

Confidence in the water quality assessment and vulnerability calls is moderate. Much of this assessment was based on Level 1 analysis protocol because the field work was conducted prior to the printing of the draft version 1.0 Water Quality Module and did not meet the requirements for a Level 2 assessment. Level 1 vulnerability calls are conservative and modifications to calls were based on conservative judgement.

Confidence is good that non-forested wetlands were accurately identified from the use of aerial photos, NWI maps and Stevens County Soils maps. Forested wetlands could not be accurately identified from the aerial photos. Only a few wetlands could be visited in the field to verify the accuracy of the Onion Creek WAU base map and soils maps.

Confidence is high for existing water quality data collected by the SCCD because of their strict quality control standards. Data collected by Equinox Resources is not subject to the same standards applied to the SCCD data and must be interpreted with caution.

Confidence is high that water quality conditions of water bodies identified in this assessment will be protected by compliance with standard Forest Practice Rules. These rules apply to areas where forests are managed but does not apply to non-forest land management such as agriculture and private residences.

5.0 MONITORING RECOMMENDATIONS

Continued water quality monitoring of the Onion Creek WAU is recommended to identify the contribution of water quality effects from the Van Stone Mine, agriculture, residential development and forest practices. To ensure accuracy and validity of water quality data, collection methods employed by Equinox Resources should be required to meet the same standards of quality control as applied by the SCCD. Without quality control checks, water quality data are not valid. In addition, samples should be taken during the period of extreme rainfall and runoff event. During "normal" periods, mine tailing sediments are contained and trace metals adsorbed to sediment particles. During a rain storm event runoff from the tailing ponds or harvest units may enter Onion Creek and have an acute impact with long term effects. In addition, monitoring the assemblages of aquatic macroinvertebrates may help to assess the chronic effects of inputs such as the Van Stone Mine.

6.0 LITERATURE CITED

BLM. 1991. Final environmental impact statement: Vegetation treatment on BLM lands in thirteen western states. Bureau of Land Management. Casper, WY

Caldwell, J.E., K. Doughty, and K. Sullivan. 1991. Evaluation of downstream temperature effects of type 4/5 waters. WA Dept. Of Natural Resources. TFW-WQ5-91-004. Olympia, WA.

MacDonald, L.H., A.W. Smart and R.C. Wissmar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the pacific northwest and Alaska. EPA 910/9-91-001. Seattle, WA

Natural Resources Conservation Service (NRCS). 1982. Soil survey of Stevens County, Washington. US Dept. Of Agriculture. Colville, WA.

Oregon Department of Forestry (ODF) 1992. Forest herbicide application water sampling study. Forest Practices Program, ODF, Salem, OR

Parton, W.J. and J.A. Logan. 1981. A model for diurnal variation in soil and air temperature. Agric. Meteorol., 23:205-216

Routh, J. 1993. Impact of lead-zinc mining on distribution of major and trace elements in water, sediment, and soil in Van Stone Mine Stevens County, Washington. Masters Thesis. Eastern Washington University.

Routh, J. and M. Ikranuddin. 1996. Trace-element geochemistry of Onion Creek near Van Stone lead-zinc mine (Washington, USA)-Chemical analysis and geochemical modeling. Chemical Geology. Accepted Jan 18, 1996 to be published.

Wangsness, D.J. 1982. Reconnaissance of stream biota and physical and chemical water quality in areas of selected land use in the coal mining region, southwestern Indiana, 1979-1980. USGS open-file report 82-566. Indianapolis, IN.

Washington Forest Practices Board (WFPB). 1993. Board Manual: Washington Forest Practices Rules - WAC 222. WA Dept. of Natural Resources. Olympia, WA

Washington Forest Practices Board (WFPB). 1995. Board Manual: Standard Methodology for Conducting Watershed Analysis. Version 3.0 November, 1995. WA Dept. of Natural Resources. Olympia, WA

Washington Forest Practices Board (WFPB). 1996. Draft water quality module: Standard Methodology for Conducting Watershed Analysis. November, 1996. WA Dept. of Natural Resources. Olympia, WA

PROJECT DATA SUMMARY

Project : **San Pedro Garnet**

Deposit : Andradite Garnet

Location : Santa Fe County 35 miles Northeast of Albuquerque, New Mexico, USA

Access : By road

Royalstar Interest : 100%

Other Participants : None

Deal : Initial payment of US$50,000 and S$15,636/month to a total of US$1.22 m

NSR Royalties : 1.5% "net royalty" to a maximum of US$ 1.5 m to Mr. John Young plus a 5% "net cash operating royalty" to Noramco Mining Corp.

Operator : San Pedro Mining Corporation (Royalstar)

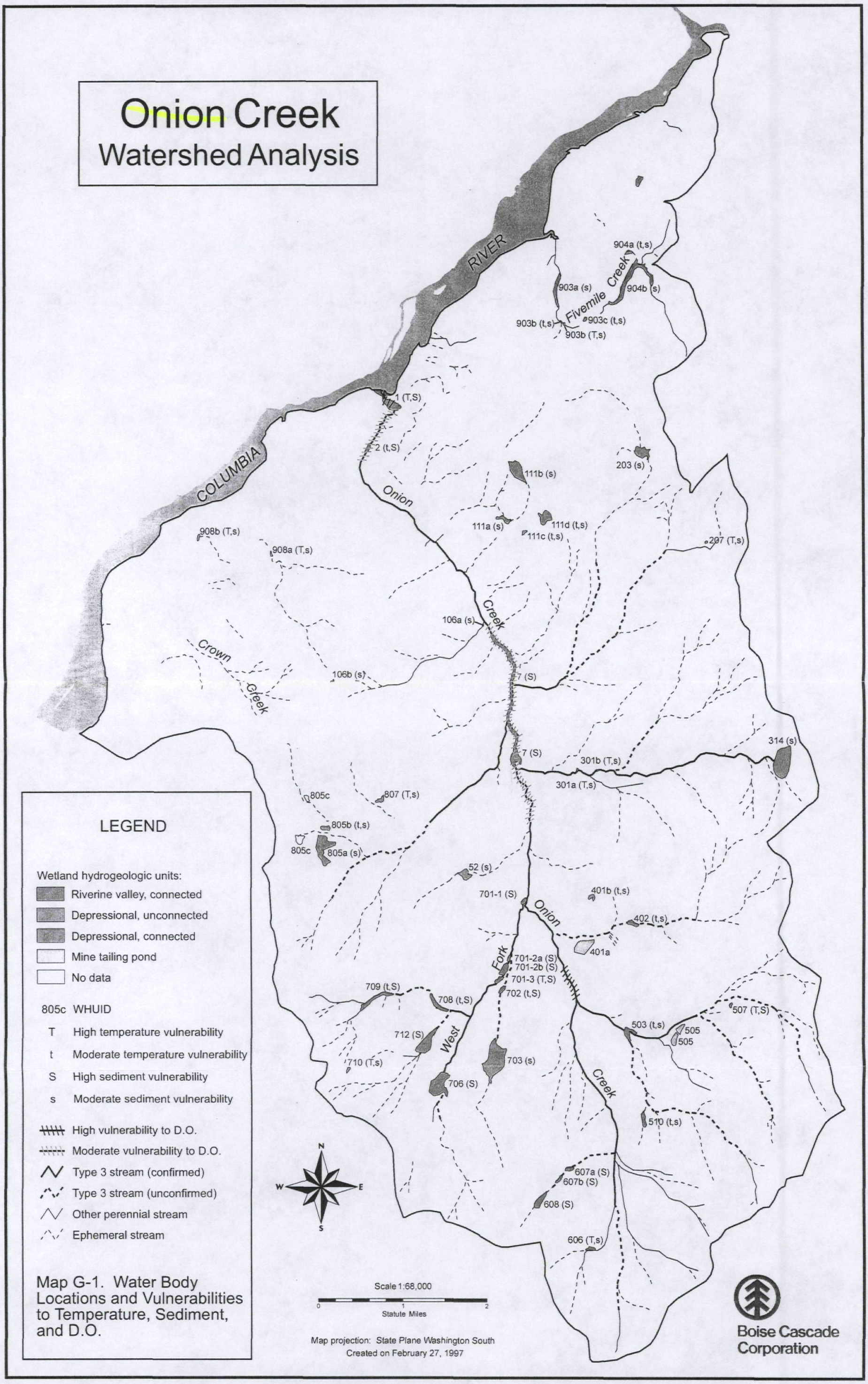
Land : ± 450 acres

Commitments : See legal opinion

Geological Concept : Multiple, thick, shallow-dipping garnets-sturn (garnetite) horizons.

Accomplishments to Date : Inferred resources, preliminary metallurgical testing to open-pit mining and milling. Various operating and environmental permits in place. Limited product (as abrasive) testing.

Onion Creek
Watershed Analysis



Map G-1. Water Body Locations and Vulnerabilities to Temperature, Sediment, and D.O.

Form G-1. Wetland and Water body Assessment Worksheet.

Wetland Location Stream Segment	Wetland Hydrogeomorphic Unit (WHU)	Wetland Class/Type	Wetland Area (acres)	Open Water Area (acres)	Field Check	Approx Max Depth (feet)	Input Variable	Vulnerability Call (Std assessment)	Comments
1	Riverine Valley, Connected	Non-forested Type B	15	Onion Creek	✓	3	Temp Sediment	High High	Below Highway 25, flood plain of Columbia River
2	Riverine Valley, Connected	Non-forested Type B	3	Onion Creek		3	Temp Sediment	Moderate High	In Onion Creek flood plain
7	Riverine Valley, Connected	Non-forested Type B	48	Onion Creek	✓	3	Temp Sediment	Low High	In Onion Creek flood plain
52	Depressional, Connected	Non-forested Type A	15	1.5			Temp Sediment	Low Moderate	Headwater wetland drained into stock pond
106 a	Depressional, Connected	Non-forested Type A	1	Seasonal			Temp Sediment	Low Moderate	
106 b	Depressional, Unconnected	Non-forested Type A	1	1		>6	Temp Sediment	Low Moderate	Small lake on top of hill ,Section 3
111 a	Depressional, Connected	Non-forested Type A	14	Seasonal			Temp Sediment	Low Moderate	In line with Stream segment 111
111 b	Depressional, Connected	Non-forested Type A	16	Seasonal			Temp Sediment	Low Moderate	Headwater to Stream segment 111
111 c	Depressional, Unconnected	Non-forested Type A	1	Seasonal			Temp Sediment	Moderate 1 Moderate	
111 d	Depressional, Unconnected	Non-forested Type A	4	Seasonal			Temp Sediment	Moderate Moderate	
203	Depressional, Connected	Non-forested Type A	17	4.5			Temp Sediment	Low Moderate	Headwater to Stream segment 203 Bodie Meadow wetland

Form G-1. Wetland and Water body Assessment Worksheet.

Wetland Location Stream Segment	Wetland Hydrogeomorphic Unit (WHU)	Wetland Class/Type	Wetland Area (acres)	Open Water Area (acres)	Field Check	Approx Max Depth (feet)	Input Variable	Vulnerability Call (Std assessment)	Comments
207	Depressional, Unconnected	Non-forested Type A	1.5	Seasonal			Temp Sediment	High Moderate	
301 a	Depressional, Connected	Non-forested Type A	1	0.8	✓		Temp Sediment	High Moderate	Stock Pond
301 b	Depressional, Connected	Non-forested Type A	1.5	1	✓		Temp Sediment	High Moderate	Stock Pond
314	Depressional, Connected	Non-forested Type A	12	7	✓	>6	Temp Sediment	Low Moderate	Headwater to Stream segment 314, no flow on field visit. Quinn's Meadow wetland
401 a	Mine Tailings Pond	Non-forested Type A	35	15	✓	>6	Temp Sediment	Low Not applicable	Lower Tailings Pond
401 b	Depressional, Unconnected	Non-forested Type A	1.5	.5	✓		Temp Sediment	Moderate 1 Moderate	
402	Depressional, Connected	Forested	3	Seasonal	✓		Temp Sediment	Moderate Moderate	
503	Depressional, Connected	Non-forested Type A	3	0.5			Temp Sediment	Moderate Moderate	
505	Mine Tailings	Non-forested Type A	15		✓		Temp Sediment	Low Not applicable	Upper Tailings Ponds
507	Riverine Valley, Connected	Non-forested Type A	0.5	0.5			Temp Sediment	High High	Mine impoundment pond

Form G-1. Wetland and Water body Assessment Worksheet.

Wetland Location Stream Segment	Wetland Hydrogeomorphic Unit (WHU)	Wetland Class/Type	Wetland Area (acres)	Open Water Area (acres)	Field Check	Approx Max Depth (feet)	Input Variable	Vulnerability Call (Std assessment)	Comments
510	Depressional, Connected	Non-forested Type B	3	Seasonal			Temp Sediment	Moderate Moderate	Pasture or open field
606	Depressional, Connected	Non-forested Type A	1	Seasonal			Temp Sediment	High Moderate	
607 a	Riverine Valley, Connected	Non-forested Type A	0.5	Onion Creek	✓	1	Temp Sediment	Low 2 High	
607 b	Riverine Valley, Connected	Non-forested Type B	0.5	Onion Creek	✓	1	Temp Sediment	Low 2 High	
608	Riverine Valley, Connected	Non-forested Type A	1	Seasonal	✓	0.5	Temp Sediment	Low 2 High	Headwater of stream segment 607
701 - 1	Riverine Valley, Connected	Non-forested Type B	1.5	0	✓	1	Temp Sediment	Low 1 High	Spring in pasture on side of creek at confluence of Onion and West Fork
701 - 2a	Riverine Valley, Connected	Non-forested Type	0.5	Onion	✓	0.5	Temp	Low 2	

APPENDIX gg-1

WATER QUALITY DATA

Collected by

Stevens County Conservation District

and

Equinox Resources, Inc.

Stevens County Conservation District

WATER QUALITY DATA FROM LABORATORY ANALYSIS OF MONTHLY SAMPLES COLLECTED DURING THE 1994-1995 WATER QUALITY MONITORING PORTION OF THE UPPER COLUMBIA RIVER WATERSHED RANKING PROJECT

STATION: ON2	ONION CREEK						
DATE	NO3+NO2-N	NH3-N	SRP	TP	TURBIDITY	TSS	FECAL COLIFORM
	mg / L	mg / L	µg / l	µg / l	NTU	mg / L	# colonies / 100 ml
6/27/94	0.19	0.01	47	76	3.1	14	170
7/25/94	0.15	0.02	49	51	1.5	**2**	220
8/8/94	0.14	**0.01**	42	43	0.6	**2**	99
9/6/94	0.09	**0.01**	39	46	0.5	**2**	44
9/19/94	0.07	0.02	38	38	0.2	**2**	28
10/3/94	0.08	**0.01**	32	32	0.3	**2**	17
10/17/94	0.09	**0.01**	38	38	0.5	**2**	5
11/14/94	0.07	0.03	28	32	0.3	**2**	5
12/12/94	0.09	**0.01**	41	41	0.6	**2**	2
12/12/94D	0.22	**0.01**	34	36	0.5	**2**	6
1/9/95	NS	NS	NS	NS	NS	NS	NS
2/6/95	0.21	0.04	29	37	0.8	4	8
3/13/95	0.36	0.01	40	146	18	110	14
4/3/95	0.24	0.04	25	66	5.7	20	8
4/18/95	0.2	0.03	29	69	5.4	24	8
5/1/95	0.14	0.02	14	40	3.3	14	6
5/15/95	0.1	**0.01**	13	50	5.7	30	30
6/13/95	0.15	0.03	25	49	2.1	12	18
9/18/95	0.13	0.09	37	40	0.7	**2**	4
10/16/95	0.17	0.08	27	38	0.7	**2**	64
4/15/96	0.22	0.01	26	90	10	51	37
5/13/96	0.22	**0.01**	27	66	6.3	28	30
5/13/96D	0.23	**0.01**	26	72	5.4	33	30
MAX.	0.36	0.09	49	146	18	110	220
MIN.	0.07	0.01	13	32	0.2	2	2
MEDIAN	0.15	0.01	30.5	44.5	1.15	3	17.5
MEAN	0.16	0.02	32.1	54.4	3.3	16.5	18.1
ST. DEV.	0.07	0.02	9.2	25.4	4.2	24.4	NA
NO3+NO2-N - Nitrate plus nitrite - nitrogen					mg/L - Milligrams per liter		
NH3-N - Ammonia - nitrogen					µg/L - Micrograms per liter		
SRP - Soluble reactive phosphorus					TP - Total phosphorus		
TSS - Total suspended solids					NTU - Nephelometric turbidity units		
TURBIDITY - Class AA Standard - Shall not exceed 5 NTU over background							
FECAL COLIFORM - Class AA Standard - Not exceed geometric mean of 50/100 ml							
BOLD NUMBERS DENOTE MEASUREMENTS BELOW THE DETECTION LIMIT							

Stevens County Conservation District

WATER QUALITY DATA GATHERED IN THE FIELD DURING THE 1994-1995 WATER QUALITY MONITORING PORTION OF THE UPPER COLUMBIA RIVER WATERSHED RANKING PROJECT

STATION: ON2			ONION CREEK					
DATE	TIME	TEMP.	D.O.	COND.	pH	FLOW		
		Deg. C	mg/L	µS/cm		cfs		
6/27/94	7:45AM	10.7	10.7	406	8.6	8.6		
7/25/94	7:12AM	17.2	10.2	467	8.3	1.9		
8/8/94	7:50AM	15	10	484	8.6	1.4		
9/6/94	8:00AM	9	15.4	474	8.4	1.7		
9/19/94	8:25AM	9.3	12	498	8.4	1.2		
10/3/94	7:40AM	6	9.8	489	8.4	1.8		
10/17/94	7:30AM	4.6	11.9	466	8.4	2.1		
11/14/94	7:00AM	1.8	13	438	8.4	2.9		
12/12/94	8:00AM	0.3	13	434	8.4	2.8		
1/9/95	7:45AM	NS	NS	NS	NS	NS	Frozen	
2/6/95	9:25AM	2.1	13.1	342	8.2	7.3		
3/13/95	9:30AM	3.6	NS	205	8	46.7		
4/3/95	8:20AM	2.8	13.6	321	8.2	40.1		
4/18/95	8:30AM	4.2	12.4	300	8.2	38.4		
5/1/95	9:45AM	5.5	12.2	267	8.6	32.7		
5/15/95	8:05AM	9.3	9.6	212	8.2	46.4		
6/13/95	12:20PM	11.4	10.6	310	8.4	16.4		
9/18/95	10:34AM	11	9	467	8.6	1.3		
10/16/95	9:30AM	6.9	11.5	435	8.2	2.9		
4/15/96	10:00AM	4.7	12.4	262	8.3	51.1		
5/13/96	9:10AM	7.2	11.4	327	8.4	41.0		
MAX.		17.2	15.4	498	8.6	51.1		
MIN.		0.3	9	205	8	1.2		
MEDIAN		6.5	11.9	420	8.4	5.1		
MEAN		7.1	11.7	380	8.4	17.4		
ST. DEV.		4.4	1.6	96	0.2	18.9		
DEG. C - Degrees Celsius				mg/L - Milligrams per liter				
COND. -Specific Conductivity				µS/cm - MicroSiemens per centimeter				
TEMP. - Temperature: Class AA Standard - Shall not exceed 16 Deg. C								
D.O. - Dissolve oxygen: Class AA Standard - Shall Exceed 9.5 mg/L								
pH - Class AA Standard - Within the range of 6.5 to 8.5								
CFS - Cubic feet per second								

WATER QUALITY DATA FROM LABORATORY ANALYSIS OF QUARTERLY SAMPLES COLLECTED DURING THE 1994-1995 WATER QUALITY MONITORING PORTION OF THE UPPER COLUMBIA RIVER WATERSHED RANKING PROJECT

STATION: ON2		ONION CREEK								
PARAMETER	UNITS	8/9/94	11/14/94	2/6/95	5/15/95			MAX	MIN	AVE
TKN	mg/L	0.11	0.14	0.15	0.22			0.22	0.11	0.16
T.ALK.	me/L	4.18	3.99	3.10	1.82			4.18	1.82	3.27
HCO3	me/L	4.14	3.99	3.10	1.82			4.14	1.82	3.26
CO3	me/L	0.04	<0.01	<0.01	<0.01					
CALCIUM	me/L	3.62	3.48	2.8	1.52			3.62	1.52	2.86
CHLORIDE	me/L	0.04	0.04	0.04	0.03			0.04	0.03	0.04
SULFATE	me/L	1.40	1.24	0.73	0.50			1.40	0.50	0.97
SILVER	µg/L	<1	<1	<1	<1					
ARSENIC	µg/L	2	2	1	1			2	1	1.5
BERYLLIUM	µg/L	<1	<1	<1	<1					
CADMIUM	µg/L	<1	<1	<1	<1					
CHROMIUM	µg/L	1	1	1	1			1	1	1
COPPER	µg/L	<1	<1	<1	2					
IRON	µg/L	14	13	14	292			292	13	83.3
MERCURY	µg/L	<0.5	<0.5	<0.5	<0.5					
MANGANESE	µg/L	2	2	4	24			24	2	8.0
NICKEL	µg/L	1	1	1	<1			1	1	1
LEAD	µg/L	<1	<1	<1	5					
ANTIMONY	µg/L	<1	<1	<1	<1					
SELENIUM	µg/L	<5	<5	<5	<5					
THALLIUM	µg/L	<1	<1	<1	<1					
ZINC	µg/L	3	4	10	35			35	3	13.0
POTASSIUM	mg/L	2.85	2.72	1.95	1.48			2.85	1.48	2.25
MAGNESIUM	mg/L	20.4	19.8	14.9	6.93			20.4	6.93	15.5
SODIUM	mg/L	7.2	7.25	4.95	3.22			7.25	3.22	5.66
HARDNESS	mg/L	250	246	190	108			250	108	199

METALS AND CYANIDE RESULTS OF SEDIMENT SAMPLING CONDUCTED ON OCTOBER 16, 1995; UPPER COLUMBIA RIVER WATERSHED RANKING PROJECT; STEVENS COUNTY CONSERVATION DISTRICT

	PN1	ON2	DP3	DP3 DUP	CD4	GD5	SP6	SQ7	CN8	FT9	FM10
CYANIDE	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SILVER	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
ARSENIC	5.0	1.2	0.6	0.5	3.7	4.0	5.5	5.3	5.3	5.2	3.3
BERYLLIUM	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CADMIUM	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.6	<0.2	<0.2	<0.2
CHROMIUM	9.7	3.1	5.1	4.9	11.6	18.1	20.9	23.5	31.2	29.3	12.6
COPPER	23.4	5.6	2.8	4.6	8.2	9.6	10.5	14.7	10.9	9.2	10.1
MERCURY	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
NICKEL	8.4	2.7	4.4	4.0	11.7	10.5	18.1	28.8	23.7	17.3	18.4
LEAD	5.8	11.7	7.8	8.6	12.0	12.7	7.2	5.2	5.1	5.4	5.9
ANTIMONY	2.7	<1.8	<1.8	<1.8	2.1	2.9	5.0	6.2	6.1	5.4	3.9
SELENIUM	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
THALLIUM	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
ZINC	39.4	62.6	29.6	37.6	69.8	38.1	34.5	178.0	46.2	50.1	36.4
ALL RESULTS ARE EXPRESSED IN MILLIGRAMS PER KILOGRAM (mg/kg) WHICH ARE SYNONOMOUS WITH PARTS PER MILLION (ppm)											

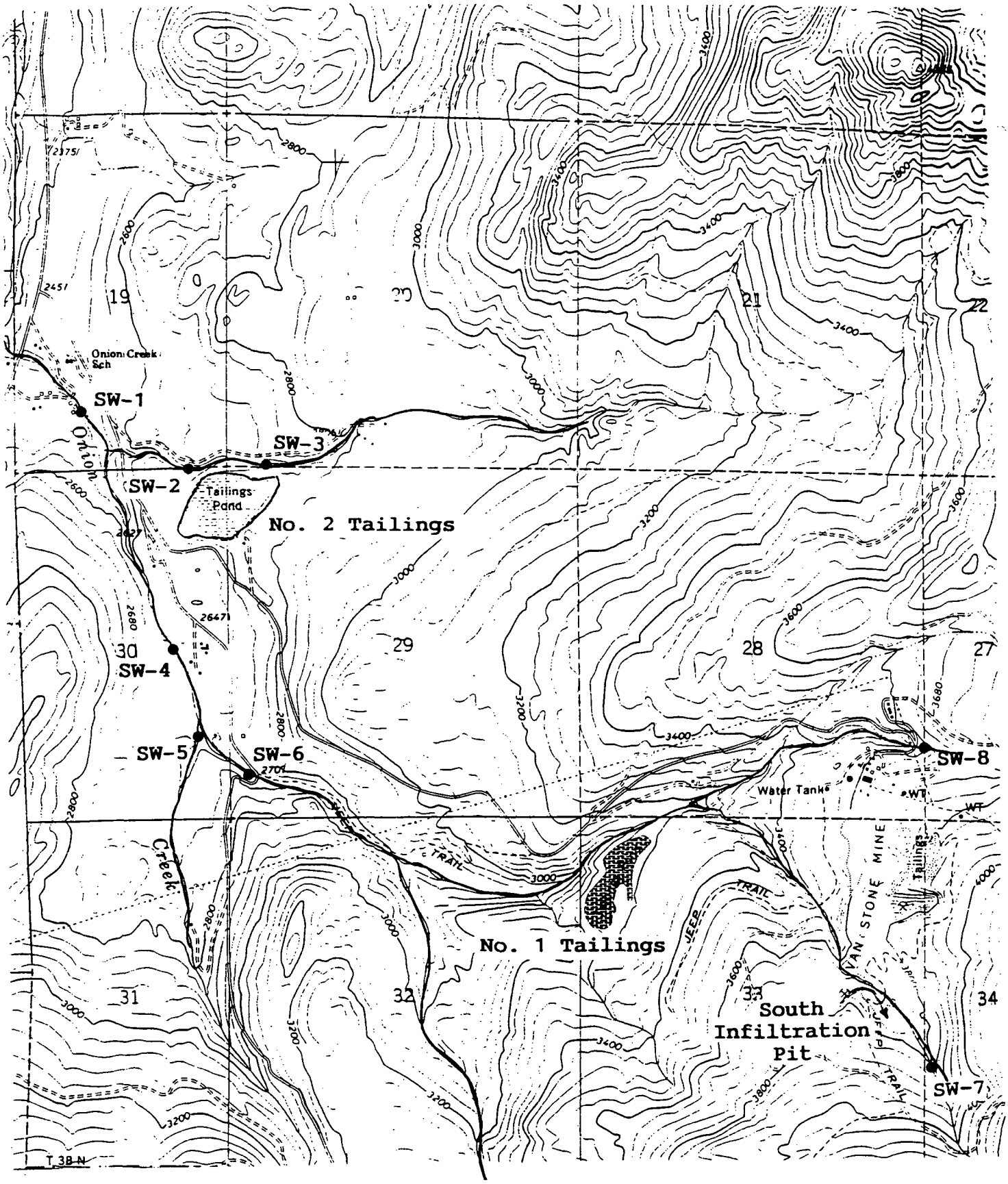


Figure 1. Location of sampling sites for Equinox Resources, Inc. Water Quality Monitoring.

Van Stone Mine

Equinox Resources, Inc.

RECEIVED
JAN - 7 1993

SUMMARY OF WATER QUALITY DATA
1991 - 1992

Sample Name: 1 SW
Sample Location: West Fork Onion Creek

Report Date: Jan - 6 - 93

FIELD & WATER QUALITY DATA	1991											1992					
	1/24	2/28	3/28	4/18	5/16	6/13	7/17	8/29	9/24	10/22	11/12	3/19	6/12	8/27	9/24	10/29	11/30
Temp. (C)	1	1	2	3	6	8	11	12	9.5	2	3	4	12	13	9.50	5.00	1.00
pH	8.06	8.14	7.36	6.94	7.04	6.96	6.73	6.65	7.05	7.88	7.35	7.52	7.13	6.74	7.06	7.47	7.34
Spec. Cond.(1)	332	347	390	250	160	270	310	380	402	430	438	272	405	492	502	431	421
Turbidity(2)	NA	NA	NA	NA	NA	9.8	5	2.5	0.42	0.24	0.81	4.4	0.35	0.92	0.85	0.14	0.39
Tot. Susp. Solids	3	6	<1	6	12 14	28	8	150 150	4	1	4	10	2	<1	4.00	7.00	4.00
Tot. Dislv. Solids	210	720	10	150	100	180	190	250	260	120	130	110	180	180	280	24	60
Dissolved Oxy.	NA	NA	NA	NA	NA	NA	4.7	32	24	24	24	20	12	21	10.00	8.50	7.10
Chloride	<1 <1	<1 <1	<1	1	1.2	2.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.20	<1
Sulfate	37	30	32	25	9.3	17	21	40	52	49	50	20	38	100	73.00	54.00	61.00
Nitrate	0.112	0.194	0.198	0.249	0.065	0.23	0.68	0.91	0.77	0.31	0.22	0.24	0.23	0.29	1.00	1.40	1.10
WATER CHEMISTRY -EPA METHOD 200.7																	
Antimony	NA	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Arsenic	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.03	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Calcium	48	41	44	34	21	30	44	45	56	53	41	29	49	65	73.00	76.00	56.00
Cadmium	0.0002	0.002	0.0004	0.0006	0.0004	0.0006	<0.002	<0.0005	<0.0005	<0.0005	0.2	0.0004	<0.002	<0.002	<0.002	<0.002	0.0002
Iron	<0.01	0.04	0.14	0.47	0.54	<0.01	0.25	<0.01	0.01	<0.01	0.03	0.16	0.03	0.15	0.10	0.06	0.05
Mercury	0.0003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.01	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Magnesium	11	10	10	8	4.1	7.2	9	11	14	13	11	6.2	12	18	20.00	19.00	14.00
Manganese	0.006	0.018	<0.002	0.009	0.009	0.016	0.015	0.006	0.009	0.018	0.008	0.012	0.007	0.01	0.02	0.008	0.006
Sodium	4.6	5.1	6	4.8	2.4	3	3.6	5.4	5.1	4.7	3.2	2.4	4.5	20	6.90	7.50	5.20
Nickel	<0.01	<0.01	<0.01	0.02	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ad	0.011	0.006	0.005	0.01	0.01	0.068	0.02	0.002	<0.001	0.003	0.006	0.004	0.004	0.002	0.00	0.004	0.002
ilicon	NA	NA	NA	NA	NA	7.5	8.9	<0.1	3	6.6	6.8	6.2	9.2	9.7	11.00	11.00	9.00
Silver	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.091	0.109	0.116 0.116	0.12	0.092	0.15	0.057	0.018	0.033	0.029	0.05	0.056	0.067	0.047	0.06	0.078	0.064

Van Stone Mine

Equinox Resources, Inc.

SUMMARY OF WATER QUALITY DATA
1991 - 1992

Sample Name: 2 SW
Sample Location: Unnamed Creek

Report Date: Jan - 6- 93

FIELD & WATER QUALITY DATA	1991											1992					
	1/24	2/28	3/28	4/18	5/16	6/13	7/17	8/29	9/24	10/22	11/12	3/19	6/12	8/27	9/24	10/29	11/30
Temp. (C)	1	1	2	2	7	7	11	12	9	2.5	2.5	3	12	13	10	5	0
pH	7.97	7.9	7.14	7.08	6.96	7.07	6.77	6.65	7.07	7.35	7.22	7.37	7.00	6.49	6.85	7.07	6.87
Spec. Cond.(1)	397	378	430	340	230	230	230	350	606	533	362	344	442	621	563	606	478
Turbidity(2)	NA	NA	NA	NA	NA	18	9.2	3.3	1.2	0.65	1.3	6.9	1.4	2.8	0.96	0.35	2.6
Tot. Susp. Solids	110	30	2	14	13	21	11	4	<1	3	1	1	2	6	2	2	110
Tot. Dislv. Solids	260	210	18	160	200	210	190	250	270	220	170	160	270	220	340	290	76
Dissolved Oxy.	NA	NA	NA	NA	NA	NA	18	31	10	26	19	43	24	23	9	9.3	17
Chloride	<1	1	<1	1.6	1.3	3	<1	1.2	<1	1.2	<1	<1	<1	2.3	<1	<1	<1
Sulfate	8	72	68	2.3	29	19	21	48	85	110	56	50	100	190	140	110	110
Nitrate	0.177	69 0.295	0.239	0.198	30 0.058	0.037	0.48	0.012	0.033	<0.01	0.041	0.2	0.07	0.03	0.036	<0.01	1.1
WATER CHEMISTRY -EPA METHOD 200.7																	
Sb	NA	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
As	0.004	0.002	<0.001	0.002	0.001	<0.001	<0.03	0.002	0.002	0.002	0.002	<0.001	<0.001	0.003	0.003	0.002	0.002
Ca	49	41	36	24	23	15	25	34	43	46	39	32	55	73	75	68	54
Cd	0.0012	0.0007	0.0002	0.0003	<0.0002	<0.0005	<0.002	<0.0005	<0.0005	<0.0005	0.053	0.0009	<0.002	<0.002	<0.002	<0.002	0.0005
Fe	1.1	<0.01	0.3	0.21	0.54	0.79	0.86	0.19	0.08	<0.01	0.03	0.71	0.15	0.14	0.13	0.08	0.29
Hg	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.01	<0.0002	0.0003	<0.0002	<0.0002	<0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Mg	19	15	12	6.6	6.8	4.7	6.6	11	15	18	14	11	19	29	29	24	20
Mn	1.58	0.036	<0.002	0.023	0.044	0.045	0.058	0.03	0.069	0.08	0.043	0.039	0.08	0.17	0.17	0.093	0.16
Na	11	13	10	9.5	8.8	6.4	8.4	11	11	6.9	9.7	9.9	14	24	17	16	12
Ni	<0.01	0.02	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pb	0.03	0.015	0.006	0.006	0.007	0.005	<0.02	0.0002	0.002	0.004	<0.001	<0.001	0.004	0.001	0.001	0.006	0.012
Si	NA	NA	NA	NA	NA	16	18	2.4	9.5	13	16	19	20	18	19	19	16
Ag	0.004	0.002	<0.001	0.002	0.001	<0.001	<0.03	0.002	0.002	0.002	0.002	<0.001	<0.001	<0.01	<0.01	<0.01	<0.01
Zn	0.167	0.13	0.033	0.07	<0.002	0.01	0.055	0.003	0.004	0.006	0.005	0.028	0.024	0.015	0.045	0.035	0.1

Van Stone Mine

Equinox Resources, Inc.

SUMMARY OF WATER QUALITY DATA
1991 - 1992

Sample Name: 3 SW
Sample Location: Unnamed Creek

Report Date: Jan - 6 - 93

FIELD & WATER QUALITY DATA	1991											1992					
	1/24	2/28	3/28	4/18	5/16	6/13	7/17	8/29	9/24	10/22	11/12	3/19	6/12	8/27	9/24	10/29	11/30
Temp. (C)	1	1	2	2	7	8	11	12	9	2.5	2.5	3	12	11	10	4.5	0
pH	8.04	7.67	7.31	7.07	7.1	7.27	6.79	6.9	7.36	8.01	6.95	7.19	6.94	6.72	6.9	7.31	7.02
Spec. Cond.(1)	224	325	240	190	210	230	230	290	268	252	218	191	335	305	295	253	247
Turbidity(2)	NA	NA	NA	NA	NA	16	11	17	1	0.86	2.9	7.9	2	1.1	1.2	0.44	1.9
Tot. Susp. Solids	61	12	26	8	9	17	9	29	1	<1	12	1	5	83	2	5	16
Tot. Dislv. Solids	120	230	110	160	170	190	170	170	170	120	94	120	150	160	170	140	12
Dissolved Oxy.	NA	NA	NA	NA	NA	NA	7.9	18	13	30	32	24	18	21	NA	11	20
Chloride	<1	1	<1	5.8	1.2	2.6	<1	<1	<1	1.1	<1	<1	<1	<1	<1	<1	<1
Sulfate	14	15	15	16	12	10	16	11	13	14	17	15	13	12	12	14	16
Nitrate	0.166	0.326	0.338	16 0.18	0.057	0.034	1.6	<0.01	0.18	0.026	0.13	0.29	0.03	0.06	<0.01	<0.01	0.11
WATER CHEMISTRY -EPA METHOD 200.7																	
Antimony	NA	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Arsenic	0.002	0.002	0.002	0.001	0.002	0.001	<0.03	0.002	0.002	0.003	0.002	0.002	0.005	0.001	0.003	0.001	0.003
Calcium	28	27	28	20	20	14	21	25	28	29	24	22	31	35	42	32	34
Cadmium	<0.0002	<0.0002	0.0002	0.0004	0.0003	<0.0005	<0.002	<0.0005	<0.0005	<0.0005	0.091	0.0000	<0.002	<0.002	<0.002	<0.002	0.0004
Iron	<0.01	<0.01	0.26	0.83	0.68	0.78	0.89	0.27	0.23	<0.01	0.02	0.99	0.35	0.46	0.15	0.65	0.54
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.01	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Magnesium	6	6.1	6.3	4	4.3	3.4	4.1	5.5	6.2	6.5	5.8	5	6.5	7.3	8.2	6.7	7.3
Manganese	0.02	<0.002	<0.009	0.019	0.032	0.038	0.055	0.009	0.034	0.038	0.022	0.02	0.045	0.18	0.036	0.026	0.087
Sodium	10	12	11	9.1	8.9	6.7	7.7	10	11	5.4	9	8.9	13	16	16	13	12
Nickel	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	0.005	0.003	0.008	0.009	0.007	0.004	>0.02	0.002	0.001	0.002	0.007	<0.001	0.005	0.003	0.001	0.003	0.012
Silicon	NA	NA	NA	NA	NA	17	18	3.6	8.6	14	17	19	21	19	21	18	18
Silver	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	>0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.033	<0.002	0.064	0.07	0.092	0.032	0.012	0.015	<0.002	<0.002	0.012	0.012	0.02	0.011	0.007	0.009	0.13

Van Stone Mine

Equinox Resources, Inc.

SUMMARY OF WATER QUALITY DATA
1991 - 1992

Sample Name: 4 SW
Sample Location: West Fork Onion Creek

Report Date: Jan- 6- 93

FIELD & WATER QUALITY DATA	1991											1992					
	1/24	2/28	3/28	4/18	5/16	6/13	7/17	8/29	9/24	10/22	11/12	3/19	6/12	8/27	9/24	10/29	11/30
Temp. (C)	1	2	3	3	6	8	11	12	10	3	4	4.5	13	14	9.5	6	1.5
pH	8.11	8.09	7.58	7.08	7.07	7.52	6.95	7.19	7.32	7.06	7.51	7.48	7.29	6.26	7.22	7.63	7.49
Spec. Cond.(1)	308	300	310	250	160	260	340	420	361	399	338	229	310	469	443	407	324
Turbidity(2)	NA	NA	NA	NA	NA	8.5	2.2	0.79 0.79	0.24	0.17	1.3	2.9	0.33	0.4	0.71	0.13	0.55
Tot. Susp. Solids	6	14 16	<1 <1	6	11	28	4	1	3	<1	4	12	3	<1	2	<1	4
ot. Dislv. Solids	200	170 180	180 190	140	100	180	200	240 240	220	160	52	86	170	150	250	220	52
Dissolved Oxy.	NA	NA	NA	NA	NA	NA	8.6	25	16	20	17	NA	16	27	11	10	12
Chloride	<1	<1	<1	<1	<1	1.8	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sulfate	23 22	25	25	18	7.5	17	17	29	41	38	41	16	36	92	58	44	48
Nitrate	0.08	0.188	0.154 0.159	0.178	0.06	0.24	0.79	1.1	0.61	0.24	0.26	0.24	0.25	0.52	1.1	1.4	1.3
WATER CHEMISTRY -EPA METHOD 200.7																	
Antimony	NA	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
Calcium	44	39	40	33	19	27	47	47	48	47	44	27	49	67	72	65	58
Cadmium	0.0002	<0.0002	0.0002	0.0006	0.0002	<0.0005	<0.002	<0.0005	<0.0005	<0.0005	<0.001	0.0006	<0.002	<0.002	<0.002	<0.002	0.0003
Iron	<0.01	<0.01	0.06	0.34	0.11	<0.01	0.13	0.05	0.01	<0.01	<0.01	0.16	0.06	0.1	0.06	0.29	0.03
Mercury	0.0004	<0.0002	0.0004	<0.0002	<0.0002	<0.0002	<0.01	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Magneseium	9.3	8.8	9.3	6.9	3.3	6.1	8.9	11	12	12	11	5.6	11	18	19	16	15
Manganese	0.009	<0.002	<0.002	0.007	0.006	0.007	0.008	0.006	0.003	0.007	0.007	0.022	0.012	0.015	0.011	0.007	0.004
Sodium	3.5	4.5	3.9	4.3	1.8	2.1	3	4.5	4.6	3.3	3	2.7	4	10	5.4	5.3	4.2
ckel	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ad	0.006	0.002	0.003	0.014	0.008	0.023	<0.02	0.002	0.002	0.002	0.01	0.014	0.007	0.004	0.003	0.002	0.002
Silicon	NA	NA	NA	NA	NA	5	7.7	<0.1	2.2	5.4	7.2	6	8.3	9.6	10	9.3	9.1
Silver	NA	NA	NA	NA	NA	<.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.079	<0.002	0.047	0.18	0.032	0.057	0.039	0.032	0.018	0.02	0.063	0.059	0.087	0.056	0.059	0.078	0.072

Van Stone Mine

Equinox Resources, Inc.

SUMMARY OF WATER QUALITY DATA
1991 - 1992

Sample Name: 5 SW
Sample Location: East Fork Onion Creek

Report Date: Jan- 6 -93

FIELD & WATER QUALITY DATA	1991					1992					
	7/17	8/29	9/24	10/22	11/12	3/19	6/12	8/27	9/24	10/29	11/30
Temp. (C)	11	12	9	3	2.5	4.5	12	12	9.5	5.25	1
pH	7.11	7.43	7.36	8.05	7.48	7.41	7.37	6.38	7.04	7.8	7.21
Spec. Cond.(1)	270	290	291	289	262	145	350	324	235	249	258
Turbidity(2)	1.1	59	0.07	0.19	0.67	0.99	1.9	2.2	0.75	0.11	0.22
Tot. Susp. Solids	<1	34	26	<1	<1	2	6	2	<1	1	1
Tot. Dislv. Solids	160	170	160	110	54	70	200	150	130	110	3
Dissolved Oxy.	5.3	NA	19	NA	17	29	9.7	25	21	13	9.9
Chloride	<1	<1	<1	<1	<1	<1	1.1	<1	<1	<1	<1
Sulfate	3.8	<10	10	<10	<10	5.6	63	4.7	5.2	5.4	5.4
Nitrate	0.55	<0.01	<0.01	5.3	0.063	0.065	0.57	0.03	0.013	<0.01	0.18
WATER CHEMISTRY -EPA METHOD 200.7											
Antimony	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<.02
Arsenic	<0.03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	0.001
Calcium	44	40	40	36	32	19	51	40	48	40	37
Cadmium	<0.002	<0.0005	<0.0005	<0.0005	0.057	<0.0002	<0.002	<0.002	<0.002	<0.002	0.0002
Iron	0.04	0.03	0.05	<0.01	<0.01	0.07	0.06	0.01	0.02	0.03	0.02
Mercury	<0.01	<0.0002	<0.0002	<0.0002	<0.0002	<0.002	<0.0002	0.0012	<0.0002	<0.0002	<.0002
Magnesium	5	5.2	5.4	4.8	4.5	2.8	15	5.2	5.9	5.1	4.8
Manganese	<0.002	<0.002	0.004	0.008	<0.002	0.003	0.008	0.029	0.003	<0.002	<0.002
Sodium	2	3.4	2.6	1.8	1.4	1.2	4.1	7.2	2.3	2.4	3.2
Nickel	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	<0.02	0.001	0.002	0.011	0.003	<0.001	0.006	0.002	<0.001	<0.001	0.002
Silicon	6.6	<0.1	1.5	4.5	5.4	4.7	8.7	7.7	8.5	7.4	7
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.015	0.01	<0.002	<0.002	0.002	0.017	0.12	0.007	0.007	0.03	0.01

Van Stone Mine

Equinox Resources, Inc.

SUMMARY OF WATER QUALITY DATA
1991

Sample Name: 6 SW
Sample Location: West Fork Onion Creek

Report Date: Jan- 6 - 93

FIELD & WATER QUALITY DATA	1991											1992					
	1/24	2/28	3/28	4/18	5/16	6/13	7/17	8/29	9/24	10/22	11/12	3/19	6/12	8/27	9/24	10/29	11/30
Temp. (C)	1	2	2	3	6	8	11	12	9.5	3	2.5	4.5	13	12	9.5	5	1
pH	8.16	8.12	7.31	7.01	7.15	7.61	7.37	7.4	7.41	8.08	7.67	7.4	7.33	6.29	7.03	7.7	7.24
Spec. Cond.(1)	331	320	240	300	170	290	390	470	474	446	362	252	228	559	511	426	384
Turbidity(2)	NA	NA	NA	NA	NA	19	46	200	0.28	0.21	2.4	3.4	0.14	0.8	0.48	0.15	0.49
Tot. Susp. Solids	3	18	<1	22	16	63	31	2	<1	9	25	11	1	<1	2	<1	3
Tot. Dislv. Solids	230	200	210	180	110	200	250	330	330	250	50	140	110	280	300	280	81
Dissolved Oxy.	NA	NA	NA	NA	NA	NA	6.3	NA	23	18	5.4	28	12	26	14	14	13
Chloride	<1	<1	<1	<1	<1	1.8	<1	1.1	<1	1	<1	<1	<1	<1	<1	1	<1
Sulfate	40	43	49	<1 35	14	35	67	72	100	77	38	35	6.3	160	110	77	91
Nitrate	0.07	0.243	0.373	33 0.369 0.361	0.105	0.47	0.69	2.1	1.7	0.56	0.41	0.55	0.29	1.1	2.1	2.4	2.5
WATER CHEMISTRY -EPA METHOD 200.7																	
Antimony	NA	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.001	<0.02	0.02	<0.02	<0.02
Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	0.001
Calcium	44	39	49	34	23	26	55	53	62	58	44	38	41	73	82	76	69
Cadmium	0.0003	0.0002	0.0005	0.0003	<0.0002	0.0009	<0.002	0.0006	<0.0005	<0.0005	0.307	0.0005	0.004	0.003	<0.002	<0.002	0.0009
Iron	0.05	<0.01	0.33	<0.01	0.03	<0.01	1.3	0.08	<0.01	<0.01	<0.01	0.22	<0.01	0.01	0.03	0.04	0.04
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.01	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Magnesium	12	12	15	9.2	5.8	8.3	18	18	20	18	14	9.9	5	27	30	25	23
Manganese	0.008	<0.002	<0.002	0.008	0.01	0.017	0.047	0.006	0.003	0.012	0.01	0.025	<0.002	0.003	0.02	0.004	0.008
Sodium	3.5	4.5	4.9	4.3	2.8	2.3	4	5.4	8.7	4.3	3.6	2.9	2.4	9.2	6.5	7.2	5.6
ickel	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	0.006	0.005	0.005	0.015	0.003	0.1	0.08	0.003	0.002	0.004	0.009	0.005	0.002	<0.001	0.004	0.003	0.004
Silicon	NA	NA	NA	NA	NA	<0.01	11	<0.1	2.6	6.5	7.4	7.5	7.6	9.6	11	11	10
Silver	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.128	<0.002	0.173	0.11	0.038	0.21	0.31	0.12	0.05	0.052	0.078	0.092	0.015	0.081	0.095	0.11	0.15

Van Stone Mine

Equinox Resources, Inc.

SUMMARY OF WATER QUALITY DATA
1991 - 1992

Sample Name: 7 SW
Sample Location: Middle Fork Onion Creek

Report Date: Jan - 6 - 93

FIELD & WATER QUALITY DATA	1991											1992					
	1/24	2/28	3/28	4/18	5/16	6/13	7/17	8/29	9/24	10/22	11/12	3/19	6/12	8/27	9/24	10/29	11/30
Temp. (C)	0.5	2	2	3	6	5	8	9	7.5	3	2.5	1	9	9.5	8	4	1
pH	7.5 7.53	8.09	7.39	7.11	7.02	6.63	6.79	6.61	6.9	7.58	7.13	6.77	7.07	6.77	6.68	6.89	7.05
Spec. Cond.(1)	85	207	220	210	160	190	190	190	180	148	199	240	148	165	142	163	204
Turbidity(2)	NA	NA	NA	NA	NA	2.3	1	4.5	0.17	0.35	0.34	2.3	0.55	0.5	1.1	0.14	0.43
Tot. Susp. Solids	38	10	4	10	1	2	1	20	1	<1	2	2	2	1	5	4	3
Tot. Dislv. Solids	16 22	110	98	120	100	140	130	160	98	68	44	110	72	100	82	76	<1
Dissolved Oxy.	NA	NA	NA	NA	NA	NA	15	20	14	10	22	22	34	31	NA	18	14
Chloride	<1	<1	<1	<1	<1	1.6	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sulfate	<1	2.7	<1 3.3	3.9	<1 <3.	4.5	<1	<10	<10	<10	<10	4.5	4.3	10	<1	3.1	<1
Nitrate	0.015	0.018 0.029	0.096	0.047	0.029	0.011	0.95	0.01	<0.01	0.47	0.34	0.04	<0.01	<0.01	<0.01	5.6	0.08
WATER CHEMISTRY -EPA METHOD 200.7																	
Antimony	NA	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Calcium	14	30	82	29	21	14	29	26	23	20	23	33	22	21	25	26	25
Cadmium	<0.0002	<0.0002	0.0003	0.0004	<0.0002	<0.0005	<0.002	<0.0005	0.0008	<0.0005	0.61	0.0002	<0.002	<0.002	<0.02	<0.002	0.0002
Iron	0.48	<0.01	0.19	0.94	0.04	<0.01	0.15	0.05	<0.01	<0.01	<0.01	0.15	0.04	0.04	0.2	0.39	0.04
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.01	<0.0002	0.0017	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0009
Magnesium	2	6.4	6.5	5.5	3.5	2.8	4.9	5.5	4.6	4.4	4.7	6.5	4	3.8	4.6	4.7	4.7
Manganese	0.037	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002	0.002	0.01	<0.002	0.004	0.003	<0.002	0.02	0.003	0.002
Sodium	12	3.1	2.4	2.9	1.8	0.7	1.5	7.9	1.7	1.9	1.8	1.8	1.8	5.3	1.7	2.4	1.9
'ickel	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	0.007	0.002	0.007	0.011	0.007	0.003	<0.02	<0.001	<0.001	0.003	0.003	0.003	0.003	<0.001	0.006	0.002	0.002
Silicon	NA	NA	NA	NA	NA	2.7	5.6	<0.1	1.3	3.6	5.2	0.6	6.1	5.8	6.8	6.6	6.1
Silver	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.018	<0.002	0.08	0.07	<0.002	<0.002	0.03	0.017	<0.002	0.002	0.003	0.026	0.043	0.008	0.069	0.021	0.03

_.. Stone Mine

Equinox Resources, Inc.

SUMMARY OF WATER QUALITY DATA
1991 - 1992

Sample Name: 8 SW
Sample Location: Creek Near Mine House

Report Date: Jan - 6- 93

FIELD & WATER QUALITY DATA	1991					1992					
	7/17	8/29	9/24	10/22	11/12	3/19	6\12	8/27	9/24	10/29	11/30
Temp. (C)	10	10	8	3	2	3	11	10	8.5	4	0
pH	6.66	6.64	7.19	7.48	6.93	6.5	6.95	6.9	6.84	7.27	6.8
Spec. Cond.(1)	190	280	335	690	343	251	286	433	380	404	356
Turbidity(2)	2.5	0.98	3.9	0.87	1.5	3.6	0.32	1.1	0.98	0.1	0.89
Tot. Susp. Solids	6	58	34	25	3	1	2	2	27	7	10
Tot. Dislv. Solids	130	190	210	250	120	130	120	190	210	200	31
Dissolved Oxy.	NA	NA	19	22	16	17	18	21	9.5	6.8	7.6
Chloride	<1	<1	<1	8.4	<1	<1	<1	<1	<1	1.2	<1
Sulfate	3.7	<10	12	110	17	17	6.4	1.8	2.8	18	18
Nitrate	5.2	<10 0.75	0.27	3.2	0.94	15	2.8	3.8	2.8	2.2	3.2
WATER CHEMISTRY -EPA METHOD 200.7											
Antimony	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Arsenic	<0.03	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Calcium	26	36	41	64	44	27	28	58	67	66	59
Cadmium	<0.002	<0.0005	<0.0005	<0.0005	0.07	0.0000	<0.002	<0.002	<0.002	<0.002	0.0004
Iron	0.17	0.18	0.1	<0.01	<0.01	0.48	0.02	0.36	0.08	0.14	0.02
Mercury	<0.01	<0.0002	0.0012	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Magnesium	5	8.5	10	18	12	6.6	6.1	13	15	15	14
Manganese	0.005	0.005	0.007	0.015	<0.002	0.011	<0.002	0.049	0.14	0.005	0.005
Sodium	2.4	9.1	4.6	5.3	4.3	3.6	3.9	9.5	6.7	7.2	5.6
Nickel	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	<0.02	<0.001	0.002	0.007	0.001	<0.001	0.002	0.12	0.001	0.007	<0.001
Silicon	8.7	<0.01	3.4	5.8	7.4	11	7.7	11	11	10	10
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.022	0.013	<0.002	0.01	0.002	0.031	0.013	0.046	0.029	0.025	0.031

Van Stone Mine

Equinox Resources, Inc.

SUMMARY OF WATER QUALITY DATA
1991 - 1992

Sample Name: 1 GW
Sample Location: Northwest Corner of Containment Dike

Report Date: Jan - 6 - 93

FIELD & WATER QUALITY DATA	1991											1992				
	1/24	2/28	3/28	4/18	5/16	6/13	7/17	8/29	9/24	10/22	11/12	3/19	6/12	8/27	9/24	10/29
Temp. (C)	NA	5	5	7	10	9	10	10	11.5	7.5	7.5	4	11	6	9	8
pH	NA	8.22	6.85	6.77	6.77	6.56	6.73	6.79	6.88	7.11	6.55	7.52	6.67	6.19	6.55	6.87
Spec. Cond.(1)	NA	1294	1460	1480	1530	1540	1560	1560	1525	1512	1471	1499	1507	1561	1544	1512
Turbidity(2)	NA	NA	NA	NA	NA	99	83	340	3.8	51	130	400	0.65	180	410	210
usp. Solids	NA	1100	56	120 130	340	190	180	63	300	86	59	1200	540	340	1100	450
ot. Dislv. Solids	NA	1100	780	1100 1100	1200	1300	1300	1300	1200	1000	1200	1100	1100	1000	1200	1200
ot. Organ. Carb.	NA	NA	NA <0.005	NA 0.006	NA	10	25	<0.05	32	12	30	5.5	12	3.7	<1	3.2
Chloride	NA	3.6	3.8	4.2	5.6	6.8	4 4	4.9 4.9	4.2	5.2	2.7	3.1	7.8	5.6	3.6	5.5
Sulfate	NA	570	540 540	580	670	680	740 740	620	880	720	500	820	760	840	590	720
Nitrate	NA	0.074	0.153	0.125	0.074 0.073	0.094	4.2 4.2	0.089 0.089	0.11	0.061	0.19	0.11	0.08	0.029	0.08	0.045
WATER CHEMISTRY -EPA METHOD 200.7																
Antimony	NA	NA	NA	NA	NA	<0.02	NA	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Arsenic	NA	<0.001	<0.001	0.001	0.001	0.002	NA	<0.001	0.002	<0.001	0.001	0.002	0.001	0.001	0.003	0.003
Calcium	NA	87	160	140	190	150	190	170	210	160	190	220	210	230	250	210
Cadmium	NA	0.0003	0.0012	0.0021	0.003	0.0022	NA	0.0022	<0.000	0.0016	1.76	0.005	<0.002	<0.002	<0.002	<0.002
Iron	NA	<0.01	0.64	0.89	0.73	5.1	3.4	0.11	3.4	3.2	2.8	20	5.7	4.2	3.3	8.2
ercury	NA	<0.0002	<0.0002	<0.000	<0.0002	<0.0002	<0.01	<0.0002	0.0004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
agnesium	NA	91	100	90	110	95	120	110	130	100	120	130	120	120	150	120
Manganese	NA	0.025	0.01	0.057	0.088	0.17	0.15	0.003	0.19	0.15	0.22	0.66	0.34	0.29	0.3	0.28
Sodium	NA	16	15	15	18	14	18	15	20	12	16	21	21	28	27	23
Nickel	NA	<0.01	<0.01	<0.01	<0.01	<0.01	NA	<0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
Lead	NA	0.012	0.014	0.071	0.057	0.072	NA	0.006	0.12	0.076	0.16	0.16	0.096	0.008	0.13	0.13
Silicon	NA	NA	NA	NA	NA	17	15	5.1	11	10	9.4	35	22	27	21	24
Silver	NA	NA	NA	NA	NA	<0.01	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	NA	<0.002 <0.002	0.084	0.18	0.368	0.31	NA	0.16	0.5	0.2	0.16	0.78	0.42	0.39	0.48	0.38

\ . Stone Mine

Equinox Resources, Inc.

SUMMARY OF WATER QUALITY DATA
1991 - 1992

Sample Name: 2 GW
Sample Location: 2nd Well at Tailings

Report Date: Jan - 6 - 93

FIELD & WATER QUALITY DATA	1991					1992					
	7/17	8/29	9/24	10/22	11/12	3/19	6/12	8/27	9/24	10/29	11/30
Temp. (C)	10	11	12	7	10	NA	11	NA	NA	NA	NA
pH	6.81	6.89	7.02	7.57	7.23	NA	7.05	NA	NA	NA	NA
Spec. Cond.(1)	680	850	833	741	722	NA	741	NA	NA	NA	NA
Turbidity(2)	88	300	3.4	21	64	NA	35	NA	NA	NA	NA
Tot. Susp. Solids	190	430	310	81	280	NA	410	NA	NA	NA	NA
Tot. Dislv. Solids	460	550	520	510	420	NA	450	NA	NA	NA	NA
Tot. Organ. Carb.	460 NA	1.2	34	36	32	NA	11	NA	NA	NA	NA
Chloride	3.1	4.9	4.4	5.7	3.2	NA	6.4	NA	NA	NA	NA
Sulfate	120	180	240	190	130	NA	210	NA	NA	NA	NA
Nitrate	0.36	0.37	0.32	8.3	0.13	NA	0.26	NA	NA	NA	NA
WATER CHEMISTRY -EPA METHOD 200.7											
Antimony	<0.02	<0.02	<0.02	<0.02	<0.02	NA	<0.02	NA	NA	NA	NA
Arsenic	2.6	0.002	0.004	0.003	0.003	NA	0.001	NA	NA	NA	NA
Calcium	120	120	140	83	110	NA	120	NA	NA	NA	NA
Cadmium	0.005	0.0007	<0.0005	0.0011	2.87	NA	0.003	NA	NA	NA	NA
Iron	2	0.18	2.3	0.55	1.1	NA	1.9	NA	NA	NA	NA
Mercury	<0.01	<0.0002	<0.0002	<0.0002	<0.0002	NA	<0.0002	NA	NA	NA	NA
Magnesium	34	26	37	22	16	NA	29	NA	NA	NA	NA
Manganese	0.14	0.022	0.13	0.051	0.081	NA	0.097	NA	NA	NA	NA
Sodium	19	14	18	11	16	NA	19	NA	NA	NA	NA
Nickel	<0.01	<0.01	<0.01	<0.01	<0.01	NA	<0.01	NA	NA	NA	NA
Lead	0.08	0.002	0.074	0.049	0.11	NA	0.011	NA	NA	NA	NA
Silicon	20	9.2	15	15	13	NA	15	NA	NA	NA	NA
Silver	<0.01	<0.01	<0.01	<0.01	<0.02	NA	<0.01	NA	NA	NA	NA
Zinc	0.32	0.046	0.31	0.11	0.39	NA	0.51	NA	NA	NA	NA

Equinox Resources, Inc.
Van Stone Mine
Water Quality Data

		Van Stone Mine				
		Summary of Water Quality Data				
Name	**1 SW**					
Location	**West Fork Onion Creek**					
Field & Water	1994				**1995**	
Quality Data		July	October		**January**	**April**
Temp.(c)		15.4	10.7		2.4	4.9
pH		8.46	8.35		8.46	8.44
Spec. Cond.(1)		286	378		322	202
Turbidity(2)		0.45	0.25		0.40	3.6
Tot. Susp. Solids		4	4		2	7
Tot. Dislv. Solids		150	280		150	130
Dissolved Oxy.		9	4.5		13	6.5
Chloride		<1	<1		1	<1
Sulfate		35	56		41	11
Nitrate		0.1	0.14		0.14	0.064
Water Chemistry-EPA Method 200.7						
Antimony		<.02	<.02		<0.02	<0.02
Arsenic		<.001	0.001		0.001	0.001
Calcium		42	47		42	37
Cadmium		0.00005	0.0002		0.00016	0.00016
Iron		0.05	0.02		0.06	0.29
Mercury		<.01	<.01		<0.0002	<0.0002
Magnesium		8.8	12		9.1	6.5
Manganese		0.007	0.003		0.003	0.011
Sodium		3.5	4.2		3.2	2.9
Nickel		<.01	<.01		<0.01	<0.01
Lead		0.001	0.006		0.008	0.003
Silicon		8.3	8.3		7.3	9.0
Silver		<.01	<.01		<0.01	<0.01
Zinc		0.024	0.007		0.048	0.042

		Van Stone Mine				
		Summary of Water Quality Data				
Name	**2 SW**					
Location	**Unnamed Creek**					
Field & Water	1994			**1995**		
Quality Data		July	October	**January**	**April**	
Temp.(c)		12	9.1	1.6	3	
pH		8.3	8.14	8.09	8.29	
Spec. Cond.(1)		287	512	343	149.2	
Turbidity(2)		2.4	0.48	1.2	15	
Tot. Susp. Solids		8	2	2	12	
Tot. Dislv. Solids		230	350	200	130	
Dissolved Oxy.		7.2	5	7.1	9.5	
Chloride		<1	<1	1.8	1.1	
Sulfate		42	110	71	17	
Nitrate		0.05	<.05	0.13	0.031	
Water Chemistry-EPA Method 200.7						
Antimony		<.02	<.02	<0.02	<0.02	
Arsenic		<.001	0.002	0.002	0.002	
Calcium		33	50	43	16	
Cadmium		0.00018	0.00015	0.00018	0.00017	
Iron		0.39	0.09	0.23	1.9	
Mercury		<.01	<.01	<0.0002	<0.0002	
Magnesium		11	21	16	4.1	
Manganese		0.051	0.1	0.046	0.065	
Sodium		10	11	12	6.5	
Nickel		<.01	<.01	<0.01	<0.01	
Lead		0.003	0.005	0.002	0.003	
Silicon		19	15	16	19	
Silver		<.01	<.01	<0.01	<0.01	
Zinc		0.007	<.002	0.016	0.044	0

Equinox Resources, Inc.
Van Stone Mine
Water Quality Data

		Van Stone Mine			
		Summary of Water Quality Data			
Name	**3 SW**				
Location	**Unnamed Creek**				
Field & Water	1994			**1995**	
Quality Data		July	October	**January**	**April**
Temp.(c)		11	8.9	2.2	3.7
pH		8.34	8.31	8.32	8.25
Spec. Cond.(1)		189.3	230	199	117.8
Turbidity(2)		2.6	1	2.3	14
Tot. Susp. Solids		3	2	5	11
Tot. Dislv. Solids		180	180	150	120
Dissolved Oxy.		6.7	7.2	9.3	6.9
Chloride		<1	<1	<1	1
Sulfate		14	1	16	10
Nitrate		0.05	<.05	0.14	0.03
Water Chemistry-EPA Method 200.7					
Antimony		<.02	<.02	>0.02	<0.02
Arsenic		0.002	0.002	0.001	0.002
Calcium		25	28	25	14
Cadmium		0.00011	0.00016	0.00111	0.00008
Iron		0.41	0.15	0.42	2
Mercury		<.01	<.01	<0.002	<0.0002
Magnesium		5	5.8	5.1	3.1
Manganese		0.032	0.053	0.048	0.054
Sodium		9.9	10	9.6	6.4
Nickel		<.01	<.01	<0.01	0.02
Lead		0.002	0.006	0.018	0.002
Silicon		19	16	15	20
Silver		0.058	<.01	<0.01	<0.01
Zinc		0.008	<.002	0.027	0.022

Equinox Resources, Inc.
Van Stone Mine
Water Quality Data

		Van Stone Mine			
		Summary of Water Quality Data			
Name	**4 SW**				
Location	**West Fork Onion Creek**				
Field & Water	1994			**1995**	
Quality Data		July	October	**January**	**April**
Temp.(c)		17.2	17.2	0.7	3.1
pH		8.47	8.3	8.36	8.35
Spec. Cond.(1)		277	313	260	215
Turbidity(2)		0.45	0.48	0.29	2.2
Tot. Susp. Solids		12	2	3	4
Tot. Dislv. Solids		200	240	150	120
Dissolved Oxy.		10	6.4	9.8	5.9
Chloride		<1	<1	<1	<1
Sulfate		41	51	34	15
Nitrate		0.08	0.09	0.14	0.061
Water Chemistry-EPA Method 200.7					
Antimony		<.02	<.02	<0.02	<0.02
Arsenic		<.001	0.001	0.001	0.002
Calcium		44	44	38	40
Cadmium		0.00019	0.00018	0.00012	0.00014
Iron		0.42	0.03	0.04	0.14
Mercury		<.01	<.01	<0.0002	<0.0002
Magnesium		8.8	10	8.1	6.8
Manganese		0.006	0.044	0.003	0.007
Sodium		2.9	3.2	2.4	2.2
Nickel		<.01	<.01	<0.01	<0.01
Lead		0.001	0.005	0.002	0.002
Silicon		8.2	7.7	6.3	8.1
Silver		<.01	<.01	<0.01	<0.01
Zinc		0.032	0.02	0.041	0.04

Equinox Resources, Inc.
Van Stone Mine
Water Quality Data

	Van Stone Mine			
	Summary of Water Quality Data			
Name	**5 SW**			
Location	**East Fork Onion Creek**			
Field & Water	1994		**1995**	
Quality Data	July	October	**January**	**April**
Temp.(c)	13	10.3	0.01	2.4
pH	8.46	8.45	8.54	8.55
Spec. Cond.(1)	206	202	161	199.5
Turbidity(2)	0.25	0.15	0.23	1.4
Tot. Susp. Solids	5	2	1	4
Tot. Dislv. Solids	130	140	82	120
Dissolved Oxy.	7.8	8	8.7	7.5
Chloride	<1	<1	<1	<1
Sulfate	4.2	76	3.1	<1
Nitrate	<.05	<.05	<0.01	0.046
Water Chemistry-EPA Method 200.7				
Antimony	<.02	<.02	<0.02	<0.02
Arsenic	<.001	<.001	<0.001	0.001
Calcium	31	34	24	34
Cadmium	0.00004	0.00093	0.00014	0.00014
Iron	0.02	0.04	0.03	0.05
Mercury	<.01	<.01	<0.0002	<0.0002
Magnesium	3.9	4.3	3.5	4
Manganese	<.002	0.044	<0.002	0.004
Sodium	1.8	1.8	1.4	1.7
Nickel	<.01	<.01	<0.01	<0.01
Lead	0.001	0.025	0.002	0.001
Silicon	6.4	6.7	5.2	6.5
Silver	<.01	<.01	<0.01	<0.01
Zinc	0.003	0.012	0.013	0.01

Equinox Resources, Inc.
Van Stone Mine
Water Quality Data

		Van Stone Mine				
		Summary of Water Quality Data				
Name	**6 SW**					
Location	**West Fork Onion Creek**					
Field & Water	1994				**1995**	
Quality Data		July	October		**January**	**April**
Temp.(c)		13.6	8.2		2.0	2.4
pH		8.48	8.37		8.63	8.54
Spec. Cond.(1)		334	390		395	245
Turbidity(2)		0.39	0.16		0.25	3.3
Tot. Susp. Solids		<1	1		4	4
Tot. Dislv. Solids		230	270		200	160
Dissolved Oxy.		8.9	6.6		7.9	6.5
Chloride		<1	<1		<1	<1
Sulfate		79	66		63	26
Nitrate		0.19	0.16		0.27	0.14
Water Chemistry-EPA Method 200.7						
Antimony		<.02	<.02		<0.02	<0.02
Arsenic		<.001	0.001		<0.001	0.001
Calcium		44	59		49	39
Cadmium		0.00039	0.00033		0.0002	0.00017
Iron		0.04	0.02		0.09	0.2
Mercury		<.01	<.01		<0.0002	<0.0002
Magnesium		12	16		14	8.5
Manganese		0.005	0.004		0.003	0.008
Sodium		3.2	4.1		3.3	2.6
Nickel		<.01	0.03		<0.01	<0.01
Lead		<0.001	0.005		0.002	0.002
Silicon		8.3	9.4		7.1	8.9
Silver		<.01	<.01		<0.01	<0.01
Zinc		0.055	0.066		0.083	0.058

Equinox Resources, Inc.
Van Stone Mine
Water Quality Data

	Van Stone Mine				
	Summary of Water Quality Data				
Name	**1 GW**				
Location	**Northwest Corner Of Containment Dike**				
Field & Water	1994			**1995**	
Quality Data		July	October	**January**	**April**
Temp.(c)					
pH					
Spec. Cond.(1)					
Turbidity(2)		n/a	n/a	n/a	n/a
Tot. Susp. Solids		n/a	n/a	n/a	n/a
Tot. Dislv. Solids		n/a	n/a	n/a	n/a
Dissolved Oxy.		n/a	n/a	n/a	n/a
Chloride		n/a	n/a	n/a	n/a
Sulfate		n/a	n/a	n/a	n/a
Nitrate		n/a	n/a	n/a	n/a
Water Chemistry-EPA Method 200.7					
Antimony		n/a		n/a	n/a
Arsenic		n/a		n/a	n/a
Calcium		n/a		n/a	n/a
Cadmium		n/a		n/a	n/a
Iron		n/a		n/a	n/a
Mercury		n/a		n/a	n/a
Magnesium		n/a		n/a	n/a
Manganese		n/a		n/a	n/a
Sodium		n/a		n/a	n/a
Nickel		n/a		n/a	n/a
Lead		n/a		n/a	n/a
Silicon		n/a		n/a	n/a
Silver		n/a		n/a	n/a
Zinc		n/a		n/a	n/a
Sample to be retaken in September, assuming sufficent volume					
No Water Volume for analysis in October Sample.					
No Water Volume for analysis in January or April 1995 sample.					

Equinox Resources, Inc.
Van Stone Mine
Water Quality Data

Equinox Resources, Inc.
Van Stone Mine
Water Quality Data

		Van Stone Mine			
		Summary of Water Quality Data			
Name	**2 GW**				
Location	**2nd Well at Tailings**				
Field & Water	1994			**1995**	
Quality Data		July	October*	**January**	**April**
Temp.(c)			13.2	4.5	7.1
pH			7.24	7.56	7.49
Spec. Cond.(1)			1086	1071	1305
Turbidity(2)		n/a	920	1200	450
Tot. Susp. Solids		n/a	600	980	640
Tot. Dislv. Solids		n/a	890	520	1100
Tot. Organic Carbon		n/a	<1	12	1.2
Chloride		n/a	2.1	1.4	<1
Sulfate		n/a	340	370	46
Nitrate+Nitrite		n/a	2.3	2.0	2.6
Water Chemistry-EPA Method 200.7					
Antimony		n/a	0.08	0.09	<0.02
Arsenic		n/a	0.029	0.016	0.005
Calcium		n/a	210	200	220
Cadmium		n/a	0.00961	0.00425	0.001
Iron		n/a	110	64	13
Mercury		n/a	<.0002	<0.0002	<0.0002
Magnesium		n/a	78	64	67
Manganese		n/a	3.1	1.5	0.35
Sodium		n/a	23	21	16
Nickel		n/a	0.08	0.06	0.03
Lead		n/a	2.9	0.39	0.087
Silicon		n/a	130	96	30
Silver		n/a	<.01	<0.01	<0.01
Zinc		n/a	0.91	0.45	0.16
Sample to be retaken in September, assuming sufficent volume					
* Water level extremely low, difficulty obtaining sufficent sample.					

ANALYSIS REPORT AM TEST

Equinox Resources
Randy Miller

Date Received: 4/17/96
Date Reported: 5/ 1/96

WATER SAMPLES

AM TEST Identification Number 96-A005503
Client Identification SW1 Creek by School
Sampling Date 4/16/96

PARAMETER	RESULT	Q	D.L.
Conventionals			
Chloride (mg/l)	2.4		1.0
Dissolved Oxygen (mg/l)	11.		1.0
Ammonia Nitrogen (mg/l)	0.016		0.005
Nitrate + Nitrite Nitrogen (mg/l)	0.060		0.01
Total Dissolved Solids (mg/l)	120		1.0
Total Suspended Solids (mg/l)	120		1.0
Sulfate (mg/l)	17.		1.0
Turbidity (NTU)	37.		0.01
Total Recoverable Metals			
Antimony (mg/l)	< 0.02		0.02
Arsenic (mg/l)	0.001		0.001
Calcium (mg/l)	26.		0.10
Cadmium (mg/l)	0.00070		0.00002
Iron (mg/l)	2.1		0.01
Mercury (mg/l)	< 0.0002		0.0002
Magnesium (mg/l)	6.2		0.10
Manganese (mg/l)	0.12		0.002
Sodium (mg/l)	2.6		0.1
Nickel (mg/l)	< 0.01		0.01
Lead (mg/l)	0.024		0.001
Silicon (mg/l)	11.		0.10
Silver (mg/l)	< 0.01		0.01
Zinc (mg/l)	0.19		0.002

ANALYSIS REPORT AM TEST

Equinox Resources
Randy Miller

Date Received: 4/17/96
Date Reported: 5/ 1/96

WATER SAMPLES

AM TEST Identification Number 96-A005502
Client Identification SW2 Creek Below Tailings
Sampling Date 4/16/96

PARAMETER	RESULT	Q	D.L.
Conventionals			
Chloride (mg/l)	1.9		1.0
Dissolved Oxygen (mg/l)	10.		1.0
Ammonia Nitrogen (mg/l)	0.020		0.005
Nitrate + Nitrite Nitrogen (mg/l)	0.049		0.01
Total Dissolved Solids (mg/l)	140		1.0
Total Suspended Solids (mg/l)	26.		1.0
Sulfate (mg/l)	21.		10
Turbidity (NTU)	21.		0.01
Total Recoverable Metals			
Antimony (mg/l)	< 0.02		0.02
Arsenic (mg/l)	0.001		0.001
Calcium (mg/l)	16.		0.10
Cadmium (mg/l)	0.00008		0.00002
Iron (mg/l)	1.4		0.01
Mercury (mg/l)	< 0.0002		0.0002
Magnesium (mg/l)	4.8		0.10
Manganese (mg/l)	0.13		0.002
Sodium (mg/l)	8.1		0.1
Nickel (mg/l)	< 0.01		0.01
Lead (mg/l)	0.001		0.001
Silicon (mg/l)	20.		0.10
Silver (mg/l)	< 0.01		0.01
Zinc (mg/l)	0.028		0.002

ANALYSIS REPORT AM TEST

Equinox Resources
Randy Miller

Date Received: 4/17/96
Date Reported: 5/ 1/96

WATER SAMPLES

AM TEST Identification Number 96-A005501
Client Identification SW3 Creek Above Tailing
Sampling Date 4/16/96

PARAMETER	RESULT	Q	D.L.
Conventionals			
Chloride (mg/l)	1.7		1.0
Dissolved Oxygen (mg/l)	10.		1.0
Ammonia Nitrogen (mg/l)	0.024		0.005
Nitrate + Nitrite Nitrogen (mg/l)	0.050		0.01
Total Dissolved Solids (mg/l)	120		1.0
Total Suspended Solids (mg/l)	26.		1.0
Sulfate (mg/l)	20.		1.0
Turbidity (NTU)	17.		0.01
Total Recoverable Metals			
Antimony (mg/l)	< 0.02		0.02
Arsenic (mg/l)	0.001		0.001
Calcium (mg/l)	14.		0.10
Cadmium (mg/l)	0.00008		0.00002
Iron (mg/l)	1.3		0.01
Mercury (mg/l)	< 0.0002		0.0002
Magnesium (mg/l)	3.6		0.10
Manganese (mg/l)	0.10		0.002
Sodium (mg/l)	8.0		0.1
Nickel (mg/l)	< 0.01		0.01
Lead (mg/l)	< 0.001		0.001
Silicon (mg/l)	20.		0.10
Silver (mg/l)	< 0.01		0.01
Zinc (mg/l)	0.036		0.002

ANALYSIS REPORT AM TEST

Equinox Resources
Randy Miller

Date Received: 4/17/96
Date Reported: 5/ 1/96

WATER SAMPLES

AM TEST Identification Number 96-A005500
Client Identification SW4Creek at Bunrhouse
Sampling Date 4/16/96

PARAMETER	RESULT	Q	D.L.
Conventionals			
Chloride (mg/l)	< 1		1.0
Dissolved Oxygen (mg/l)	8.5		1.0
Ammonia Nitrogen (mg/l)	0.017		0.005
Nitrate + Nitrite Nitrogen (mg/l)	0.056		0.01
Total Dissolved Solids (mg/l)	110		1.0
Total Suspended Solids (mg/l)	90.		1.0
Sulfate (mg/l)	17.		1.0
Turbidity (NTU)	28.		0.01
Total Recoverable Metals			
Antimony (mg/l)	< 0.02		0.02
Arsenic (mg/l)	< 0.001		0.001
Calcium (mg/l)	26.		0.10
Cadmium (mg/l)	0.00050		0.00002
Iron (mg/l)	1.5		0.01
Mercury (mg/l)	< 0.0002		0.0002
Magnesium (mg/l)	5.9		0.10
Manganese (mg/l)	0.085		0.002
Sodium (mg/l)	2.2		0.1
Nickel (mg/l)	< 0.01		0.01
Lead (mg/l)	0.016		0.001
Silicon (mg/l)	9.7		0.10
Silver (mg/l)	< 0.01		0.01
Zinc (mg/l)	0.18		0.002

ANALYSIS REPORT AM TEST

Equinox Resources
Randy Miller

Date Received: 4/17/96
Date Reported: 5/ 1/96

WATER SAMPLES

AM TEST Identification Number 96-A005499
Client Identification SW5 Creek Above Culvert
Sampling Date 4/16/96

PARAMETER	RESULT	Q	D.L.
Conventionals			
Chloride (mg/l)	< 1		1.0
Dissolved Oxygen (mg/l)	9.7		1.0
Ammonia Nitrogen (mg/l)	0.021		0.005
Nitrate + Nitrite Nitrogen (mg/l)	0.024		0.01
Total Dissolved Solids (mg/l)	84.		1.0
Total Suspended Solids (mg/l)	14.		1.0
Sulfate (mg/l)	5.4		1.0
Turbidity (NTU)	6.9		0.01
Total Recoverable Metals			
Antimony (mg/l)	< 0.02		0.02
Arsenic (mg/l)	< 0.001		0.001
Calcium (mg/l)	22.		0.10
Cadmium (mg/l)	0.00046		0.00002
Iron (mg/l)	0.27		0.01
Mercury (mg/l)	< 0.0002		0.0002
Magnesium (mg/l)	3.4		0.10
Manganese (mg/l)	0.016		0.002
Sodium (mg/l)	1.6		0.1
Nickel (mg/l)	< 0.01		0.01
Lead (mg/l)	0.001		0.001
Silicon (mg/l)	6.6		0.10
Silver (mg/l)	< 0.01		0.01
Zinc (mg/l)	0.022		0.002

ANALYSIS REPORT AM TEST

Equinox Resources
Randy Miller

Date Received: 4/17/96
Date Reported: 5/ 1/96

WATER SAMPLES

AM TEST Identification Number 96-A005498
Client Identification SW6 Creek at Culvert
Sampling Date 4/16/96

PARAMETER	RESULT	Q	D.L.
Conventionals			
Chloride (mg/l)	< 1		1.0
Dissolved Oxygen (mg/l)	9.3		1.0
Ammonia Nitrogen (mg/l)	0.029		0.005
Nitrate + Nitrite Nitrogen (mg/l)	0.074		0.01
Total Dissolved Solids (mg/l)	120		1.0
Total Suspended Solids (mg/l)	190		1.0
Sulfate (mg/l)	26.		10
Turbidity (NTU)	50.		0.01
Total Recoverable Metals			
Antimony (mg/l)	< 0.02		0.02
Arsenic (mg/l)	0.001		0.001
Calcium (mg/l)	30.		0.10
Cadmium (mg/l)	0.0010		0.00002
Iron (mg/l)	2.7		0.01
Mercury (mg/l)	< 0.0002		0.0002
Magnesium (mg/l)	8.6		0.10
Manganese (mg/l)	0.16		0.002
Sodium (mg/l)	2.8		0.1
Nickel (mg/l)	< 0.01		0.01
Lead (mg/l)	0.033		0.001
Silicon (mg/l)	12.		0.10
Silver (mg/l)	< 0.01		0.01
Zinc (mg/l)	0.31		0.002

ANALYSIS REPORT

AMTEST

AmTest Inc.
Professional Analytical Services
14603 N.E. 87th
Redmond, WA
98052
Fax: 206 883 3495
Tel: 206 885 1664

Equinox Resources
P.O. Box 32
Colville, WA 99114
Attention: Randy Miller

Date Received: 4/17/96
Date Reported: 5/ 1/96

Project Name: Van Stone Mine
Project #: 235

WATER SAMPLES

AM TEST Identification Number	96-A005497
Client Identification	SW8 Creek at Houses
Sampling Date	4/16/96

PARAMETER	RESULT	Q	D.L.
Conventionals			
Chloride (mg/l)	< 1		1.0
Dissolved Oxygen (mg/l)	11.		1.0
Ammonia Nitrogen (mg/l)	0.030		0.005
Nitrate + Nitrite Nitrogen (mg/l)	0.23		0.01
Total Dissolved Solids (mg/l)	70.		1.0
Total Suspended Solids (mg/l)	180		1.0
Sulfate (mg/l)	8.8		1.0
Turbidity (NTU)	46.		0.01
Total Recoverable Metals			
Antimony (mg/l)	< 0.02		0.02
Arsenic (mg/l)	0.001		0.001
Calcium (mg/l)	9.6		0.10
Cadmium (mg/l)	0.00020		0.00002
Iron (mg/l)	2.5		0.01
Mercury (mg/l)	< 0.0002		0.0002
Magnesium (mg/l)	3.0		0.10
Manganese (mg/l)	0.13		0.002
Sodium (mg/l)	2.8		0.1
Nickel (mg/l)	< 0.01		0.01
Lead (mg/l)	0.007		0.001
Silicon (mg/l)	14.		0.10
Silver (mg/l)	< 0.01		0.01
Zinc (mg/l)	0.092		0.002

ANALYSIS REPORT

AM TEST

Equinox Resources
P.O. Box 32
Colville, WA 99114
Attention: Randy Miller

Date Received: 4/17/96
Date Reported: 5/ 1/96

Project Name: Van Stone Mine
Project #: 235

WATER SAMPLES

AM TEST Identification Number	96-A005504
Client Identification	WW2 Water Well II
Sampling Date	4/16/96

PARAMETER	RESULT	Q	D.L.
Conventionals			
Total Organic Carbon (mg/l)	2.5		1.0
Chloride (mg/l)	1.8		1.0
Ammonia Nitrogen (mg/l)	0.030		0.005
Nitrate + Nitrite Nitrogen (mg/l)	3.5		0.01
Total Dissolved Solids (mg/l)	1100		1.0
Total Suspended Solids (mg/l)	430		1.0
Sulfate (mg/l)	690		10
Turbidity (NTU)	160		0.01
Total Metals			
Antimony (mg/l)	< 0.02		0.02
Arsenic (mg/l)	0.004		0.001
Calcium (mg/l)	220		0.10
Cadmium (mg/l)	0.0013		0.00002
Iron (mg/l)	9.1		0.01
Mercury (mg/l)	< 0.0002		0.0002
Magnesium (mg/l)	77.		0.10
Manganese (mg/l)	0.21		0.002
Sodium (mg/l)	15.		0.1
Nickel (mg/l)	0.01		0.01
Lead (mg/l)	0.067		0.001
Silicon (mg/l)	35.		0.10
Silver (mg/l)	< 0.01		0.01
Zinc (mg/l)	0.20		0.002

APPENDIX H
WATER SUPPLY/PUBLIC WORKS

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The Water Supply/Public Works module assessment for the Onion Creek Watershed Administrative Unit was conducted in accordance with version 3.0 of the Washington Forest Practice Board *Standard Methodology for Conducting Watershed Analysis*, November, 1995.

Certified Analyst: Chris Fairbanks
Cascades Environmental Services Inc.
1111 N. Forest St.
Bellingham, WA 98225
(360) 671-1150

_____ _____

Chris Fairbanks Date

APPENDIX H. WATER SUPPLY/PUBLIC WORKS

1.0 INTRODUCTION

The purpose of this report is to identify water supply systems and public structures in the Onion Creek watershed and to determine if these structures are located in an areas sensitive to:

- Mass wasting events;
- Inputs from fine and coarse sediment;
- Increases of water temperature;
- Changes in peak or base flows, and;
- Changes to nutrient inputs.

Vulnerability of the water supply systems and public works which are located in sensitive areas is evaluated for potential changes of inputs as a result of forest management practices. Vulnerability is high where there is a potential for deliverability of a hazardous input. For example, a bridge in a flood hazard area has a high vulnerability to peak flows.

For the purpose of this report, public works are defined as physical structures used by the public that were constructed and are maintained with public funds. These structures include roads, bridges, schools, parks, fish hatcheries, and public buildings. Water supplies include structures and systems that convey water for domestic, agricultural and aquacultural uses. Water associations are considered water supply systems however, water diversion for a single private user is not considered as a public water supply.

1.1 Summary

Publicly funded facilities and structures in the Onion Creek Watershed Administrative Unit (WAU) consist of the Onion-Clugston Creek Road network including accompanying culverts, the Onion Creek School, and the City of Northport. Water supply for residences in the Onion Creek watershed is provided by private wells. Public wells provide water to the Onion Creek School and the City of Northport. No diversions are present in Onion Creek for public water supply or for irrigation associations. A decommissioned water supply diversion structure is present in stream segment 3 which provided water to a nearby dolomite mine which operated during World War II.

The road system includes several secondary roads branching from the Onion-Clugston Creek Road. Many of the secondary roads provide access to private residences. Steven's County maintains several of these roads to the point where public ownership ends. Generally, the roads are outside of the 100-year flood hazard area and have low vulnerability calls. Short sections of the Onion-Clugston Creek Road and the secondary road, Widow Hawk Road, are located in the 100-year flood hazard area and have moderate vulnerability to peak flows and high vulnerability

to coarse sediment. In stream segment 4, Onion Creek flows through a culvert under the Onion-Clugston Creek Road within the 100-year flood hazard area. This culvert has a moderate vulnerability to peak flows and a high vulnerability to coarse sediment. In stream segment 2, Onion Creek flows through a culvert under Washington State Highway 25. This culvert is not in flood hazard area and has a low vulnerability to peak flows and a high vulnerability to coarse sediment. Highway 25 runs through the Onion Creek WAU but does not enter the 100-year flood hazard area and has a low vulnerability to peak flows and coarse sediment.

Deliverability of peak flows and coarse sediment is low to the Onion-Clugston Road, Widow Hawk Road, State Highway 25 and associated culverts. Because standard forest practices are adequate to protect these structures, casual mechanism reports where not written.

The Onion Creek Elementary School and associated water well are not located in the 100-year flood hazard area and therefore, have a low vulnerability to peak flows and coarse sediment.

The City of Northport, though technically within the Onion Creek WAU, would not likely be affected by inputs from forest practices in the Onion Creek watershed. The city is located on a terrace above the Columbia River. A few small streams drain the side slopes above the city but, no streams flow through the city.

Washington Water Power Company and US West Communications Inc. maintain transmission networks within the Onion Creek WAU. Because the transmission networks are privately maintained they are not considered Public Works in this watershed analysis.

2.0 METHODS

Methods used in this module follow Version 3.0 of the Watershed Analysis Manual (WDNR, 1995). Information was obtained through: 1) interviews with individuals familiar with the watershed; 2) interpretation of 1992 black and white aerial photographs (1:14,000 - 1:16,400), 1:24,000 USGS topographic maps, road maps, and land ownership maps; 3) interpretation of the Federal Emergency Management Agency (FEMA) flood insurance rate maps (FIRM); 4) field inspection of public works and; 5) discussions with other watershed analysis team members.

Default vulnerability ratings for water supply structures and public works specified in Version 3.0 were assigned when appropriate.

3.0 RESULTS

3.1 Water Supply

Public water supply for the City of Northport and the Onion Creek School is provided by wells. The City of Northport operates three wells within the city limits. A portion of this system may be within the Columbia River flood hazard area (J. Schwab, Water Superintendent pers. comm). Domestic water for residences within the Onion Creek watershed, outside of the City of Northport service area, is provided by private wells. Irrigation for agricultural or residential purposes is provided by private surface or groundwater withdrawal. No water associations for irrigation or domestic use operate in the Onion Creek WAU.

3.2 Public Works

Public works within the watershed include the following:

Onion Creek School
Steven's County Road system
City of Northport

For the purpose of this module, flood hazard area refers to areas likely to be inundated by 100-year flood events as defined on the 1990 FEMA FIRM Map for Stevens County. Elevations of the flood hazard areas are not provided on these maps.

3.2.1 Onion Creek School

Onion Creek School is a small elementary school with about 70 students in grades 1 through 5 and is located at the junction of Lotze Creek Road with Onion Creek Road. Drinking water for the school is provided from a well on the school property. The school property is not in the 100-year flood hazard area and has a low vulnerability to peak flows and coarse sediment.

3.2.2 Road System

An extensive network of roads exists in the Onion Creek WAU. Stevens County maintains portions of this network. Clugston-Onion Creek Road is the main road through the watershed and is a two lane road paved with asphalt and gravel. County roads branching from Clugston-Onion Creek Road are constructed of gravel and native soil. Private roads used for residences or forest practices extend from the county roads and are also constructed of gravel and native soil. State Highway 25 parallels the Columbia River and crosses Onion Creek in stream segment 2. Onion Creek passes through a concrete box culvert (approx 6 ft by 6 ft) under State Highway 25. This culvert is not within the 100-year flood hazard area indicated on the FEMA FIRM map. Onion Creek passes through a corrugated metal culvert under Clugston-Onion Creek Road in

stream segment 4. This culvert is within the 100-year flood hazard area (Map H-1). A short section of the Clugston-Onion Creek Road lays within the 100-year flood hazard area near stream segment 7 (Map H-1). A portion of Widow Hawks Road lays in this flood hazard area near stream segment 801 (Map H-1).

Table G-1 lists these public works with standard assessment vulnerability calls. Culverts are not specifically addressed in the Public Works Module so the standard assessment vulnerability calls for bridges over streams were used.

3.3 Washington Water Power Transmission Lines

A network of overhead power transmission lines is present throughout the watershed. The power transmission grid is owned and operated by Washington Water Power, a private electrical power provider. Though the transmission lines provides a resource to the residences in the Onion Creek WAU, the system is privately maintained and not a public resource.

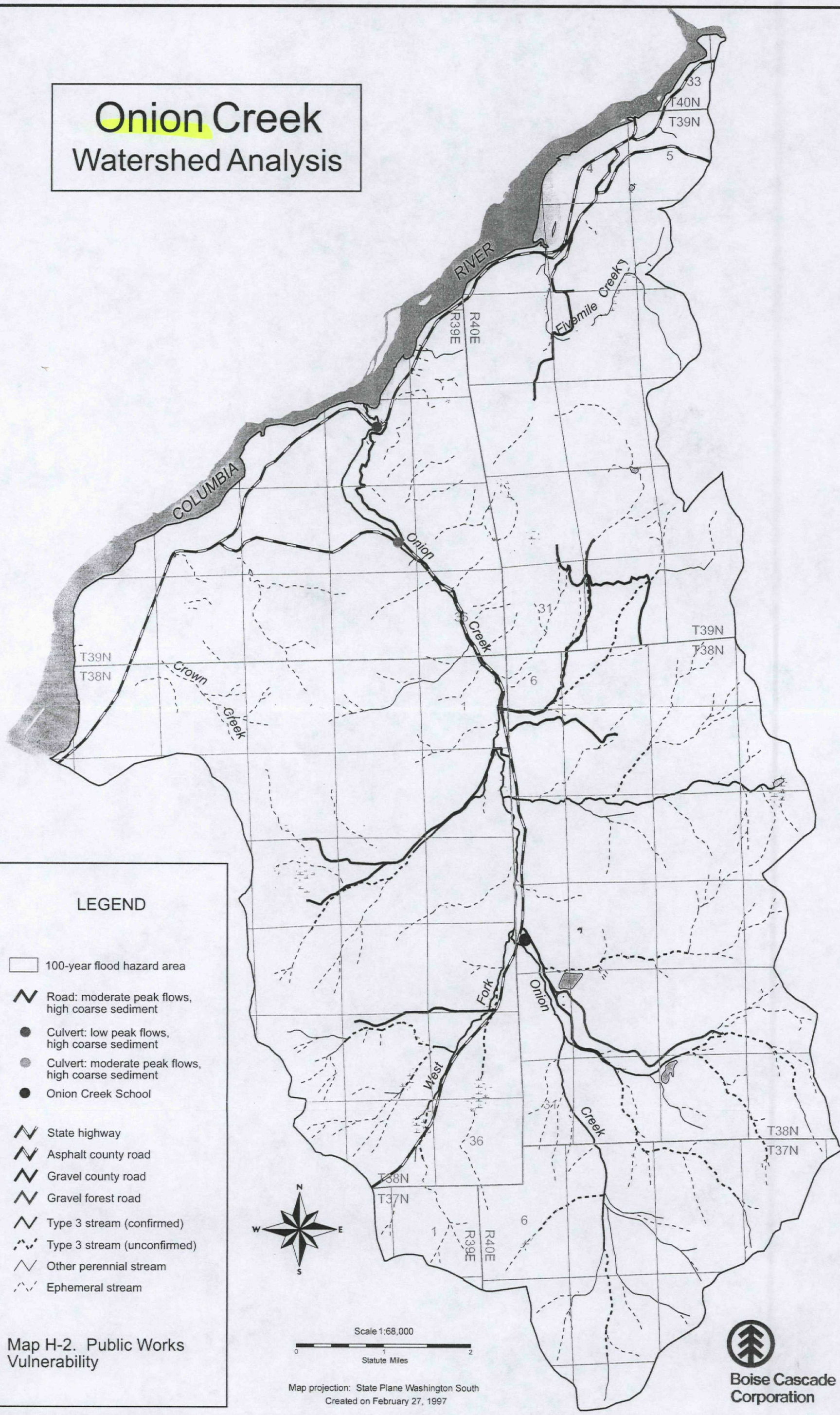
3.4 US West Communications Telephone Cables

A network of buried telephone cables is present throughout the watershed. This network is owned and operated by US West Communications, a private telephone company. This system provides a resource to the residences in the Onion Creek WAU however, the system is privately operated and is not a public resource.

3.5 City of Northport

The City of Northport is located in the Onion Creek WAU and is 4 miles northeast from the mouth of Onion Creek on State Highway 25. The Columbia River has a much larger impact on the public works of the City of Northport. Forest practices in the Onion Creek WAU would have little impact on the Columbia River and the City of Northport. For this reason the vulnerability of Northport public works is not discussed in this report.

Onion Creek
Watershed Analysis



Map H-2. Public Works Vulnerability

Form H-1: Water Supply Assessment Interview

Person Interviewed: Joe Schwab

Representing: Water Superintendent
City of Northport

Address: City of Northport
Telephone #: (509) 732-4450

Date Interviewed: October 18, 1996

Specific experience in watershed being analyzed? Yes

If yes, detail: Water Superintendent for the City of Northport

Are water supply diversions present? The City of Northport water is supplied from three wells that are located within the city limits and is not reliant on Onion Creek for any water supply needs.

Where are the diversions located? Not applicable

What is diverted water used for? Not applicable

Is diversion sensitive to fine sediment inputs? Not applicable

Is diversion sensitive to coarse sediment inputs? Not applicable

Is diversion sensitive to temperature increases? Not applicable

Is diversion sensitive to changes in flow?

Is diversion sensitive to nutrient inputs?

Are any fish hatcheries located in the watershed?

Are there any diversions of water from this watershed in areas downstream of the WAU?

4.0 REFERENCES

WDNR. 1995. Standard methodology for conducting watershed analysis. Washington Forest Practice Board. Department of Natural Resources. Olympia, WA.

Table H-1. Vulnerability Calls for Public Works

Public Works	Input	Vulnerability Call
Onion Creek Road in stream segment 7	Peak Flows Coarse Sediment	Moderate High
Widow Hawks Road in stream segment 7	Peak Flows Coarse Sediment	Moderate High
Culvert in stream segment 2	Peak Flows Coarse Sediment	Low High
Culvert in stream segment 4 within 100-year flood hazard area	Peak Flows Coarse Sediment	Moderate High