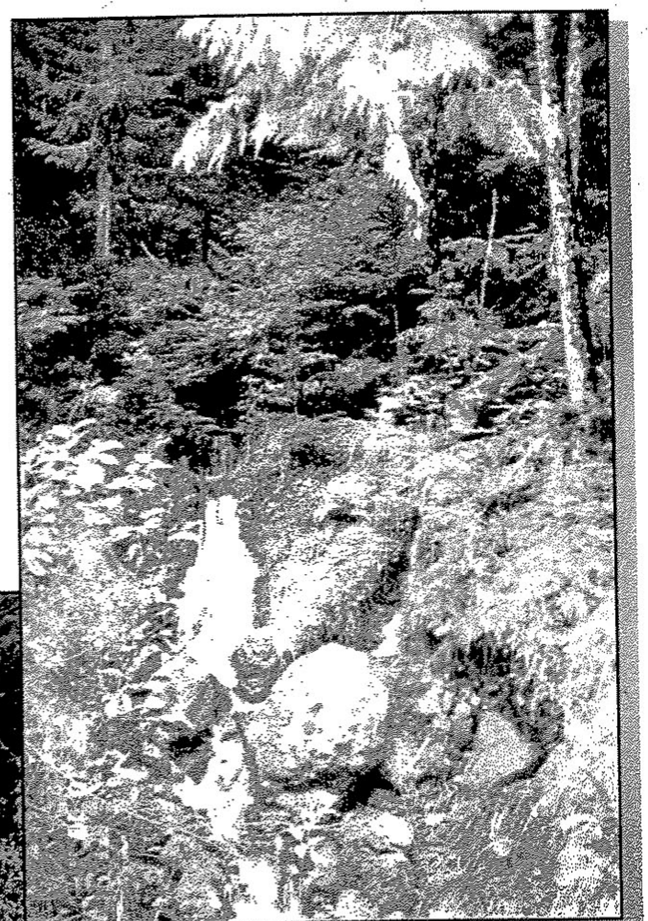
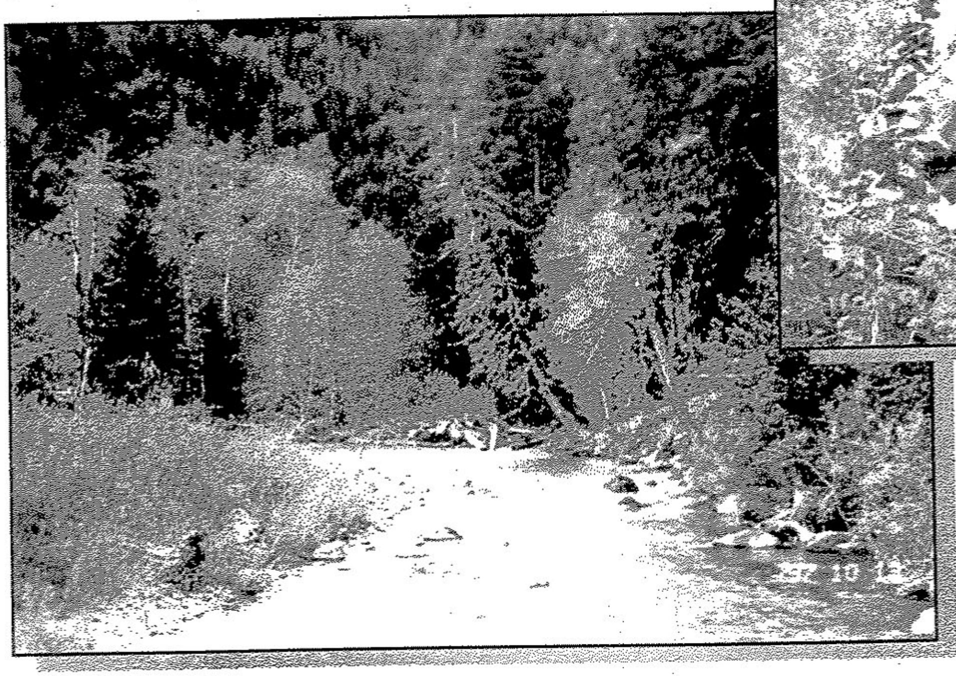
Gifford Pinchot National Forest

Tilton Watershed Analysis





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Tilton Watershed Analysis

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1. INTRODUCTION

The purpose of this analysis is to develop a scientifically based understanding of the processes and interactions occurring in the Tilton watershed and how past management activities have influenced near- and long-term resource conditions. This analysis focuses on issues and values within the watershed, given the constraints imposed by the land management allocations and the Record of Decision (USFS and BLM 1994).

Specific goals and objectives of the analysis are to:

- Determine management opportunities in timber stands that will lead to reaching the goals and objectives described in the Record of Decision (ROD) Standards and Guidelines for late successional reserves.
- Provide restoration guidance that leads to attainment of the Aquatic Conservation Strategy (ACS), as specified in the ROD.
- Define riparian reserves and appropriate management activities in those reserves.

1.1 ANALYSIS PROCESS

Documentation and analysis procedure follow the guidelines in the Federal Guide to Watershed Analysis. Issues and key questions, developed by the Forest Service with EA Engineering, guide the content of this analysis. Key questions are designed to focus the assessment on the important questions, so that efforts are concentrated on the processes and conditions directly related to desired conditions and beneficial uses.

The Tilton watershed was stratified by subbasins; 6th field watersheds define the subbasins (Figure 1). Information used in the analysis consisted of Forest Service GIS maps and associated databases, aerial photography, field sampling, and interviews with the Forest Service and local science agencies. Private landowners were contacted regarding their watershed analysis as well as harvest management direction. Considering the mixed ownership, amount and quality of data at the subwatershed level is highly variable.

An interdisciplinary team consisting of a hydrologist, geologist, fisheries biologist, wildlife biologist, and silviculturalist conducted this analysis. Forest Service personnel and the public provided key information and insights to the history and conditions in the Tilton Watershed (Appendix A).

2. WATERSHED OVERVIEW

2.1 CULTURAL FEATURES

(Detailed account of past human uses in (Appendix B)

The Tilton watershed analysis encompasses 54,837 acres. This analysis focuses on federal lands located northwest of the town of Morton. This represents approximately one-quarter of the drainage. Lands administered by Murray Pacific, Weyerhaeuser, and the Forest Service create a mosaic of ownership in the Tilton watershed. Table 1 displays the subwatersheds and their respective ownership allocations. Distribution of private and National Forest land is presented in Figure 2.

Table 1: Subwatershed Acres by Ownership

Subwatershed	Stream	Private*	NF	Total	%Federal
21A	Little Creek	1,794	2,448	4,242	58
21B	Upper Side Wall Drainage	510		510	0
21C	Bear Canyon	9,652	1,616	11,267	14
21D	Wallanding	441	1,777	2,218	80
21E	West Fork Tilton	3,957	849	4,807	18
21F	Coon Creek	1,907	154	2,061	7
21G	Connelly Creek	3,151	645	3,796	17
21I	Upper Side Wall Drainage	3,799	669	4,469	15
21J	Lower Side Wall Drainage	1,514		1,514	0
21K	Lower NF Tilton	1,404	1,067	2,471	43
21L	Tumble Creek	252	2,513	2,765	91
21N	Winnie Creek	1,276	956	2,233	43
21P	Jesse Creek	1,226	760	1,986	38
21Q	Otter Creek	862	693	1,555	45
21R	Mid. NF Tilton	1,570	1,832	3,402	54
21S	Snow Creek	1,240	122	1,362	9
21T	Trout Creek	3,033	1,145	4,179	27
Totals		37,590	17,246	54,837	

* Includes State Land

Past management activities on National Forest lands consist primarily of timber harvests and road building. Private land has been managed under regeneration harvest practices since the 1920s. Timber harvests on National Forest land began in the 1950s. Approximately 7,361 acres, or 43 percent, of all National Forest lands within the watershed have stand origins within the last 40 years. It is likely that most of this acreage originated from regeneration harvest. On private lands, it is estimated that greater then 50 percent of stands have origins within the last 40 years.

Timber harvesting has led to a fairly extensive road system in the Tilton watershed. Access through the watershed provided by state, federal, county, and private roads. Table 2 displays the miles of road within each subwatershed for both private and public lands.

Table 2: Miles of Road

Subwatershed	Total WA Acres	Miles of Road	Miles of Road per Sq Mile
21A	4,242	18	2.7
21B	510	2	2.8
21C	11,267	60	3.4
21D	2,218	20	5.8
21E	4,807	27	3.6
21F	2,061	16	4.9
21G	3,796	18	3.1
21I	4,469	25	3.6
21J	1,514	6	2.5
21K	2,471	18	4.6
21L	2,765	26	5.9
21N	2,233	18	5.3
21P	1,986	14	4.5
21Q	1,555	11	4.5
21R	3,402	17	3.2
21S	1,362	9	4.3
21T	4,179	26	3.9
Totals	**54,837**	**331**	**3.9**

Of significant importance to the vegetation structure in the Tilton assessment area is a catastrophic fire that is believed to have covered much of the North Fork Tilton River drainage as well as the area south of the Connelly Creek drainage. Various sources place the time of this fire from the mid-1800s (LSR assessment 1997; general consensus among several local individuals) to as far back as 1775 (Clevinger 1951). This analysis will assume the fire year to be 1825.

Following the fire, the land base was most likely heavily weighted toward the grass/pole stage. Stocking levels and uniform tree size seen today in most of the National Forest stands indicate that this was a stand replacement fire. Very little older forest (older than the post-fire stands) exists today in this fire area, suggesting that the fire was intense and very thorough in its coverage. One notable exception is the old- growth forest seen in the headwaters of Little Creek (Section 24, T.14N R.3E). This area appears to have been spared by the fire, revealing potential forest conditions elsewhere in the watershed given the absence of disturbances.

2.2 PHYSICAL FEATURES

All tributaries in the analysis area flow into the Tilton River which flows into the Cowlitz River system. Tilton River flows into the Cowlitz in the backwater of the Mayfield Dam, located at River Mile 52. Downstream two miles is the Salmon Hatchery Barrier Dam; the Barrier Dam is a fish Barrier.

The North Fork of the Tilton River watershed analysis area, including the West Fork of the Tilton River and its tributaries, Bear Creek, and Connelly Creek, consists predominantly of the Eocene Northcraft Formation. The Northcraft is described by Schasse (1987) as predominantly volcanics interbedded with continental sedimentary rocks of the Puget Group. Two volcanic centers have been located in T14N, R3E, which are the likely sources for the Northcraft andesite/basalt flows. Field investigations have found the Northcraft to be highly variable in its erosivity. Where the bedrock is highly fractured (and/or more thinly bedded) it erodes quickly to silt/clay. This presents an easily liquifiable soil, and lends itself to earthflows and slumps. In other sections, where the massive andesite is devoid of fracturing and resistant to erosion, it presents a steep bedrock surface and acts as a plane of initiation for debris flows. The Puget Group is the predominant bedrock east of the divide between the North Fork and West Fork of the Tilton River. It consists of continental sedimentary rocks, sandstone, siltstone, and shale, with coal locally. Massive to thinly bedded sandstones and siltstones were found in the analysis area where observations were made. It would likely represent a fine sediment source due to its easily erodible nature.

In the lower valley of the North Fork of the Tilton, a tongue of the Hayden Creek Drift extends up the valley for approximately two miles from the confluence with the Tilton River. The Hayden Creek drift is a Pre-Fraser till deposit that shows evidence of being reworked by the Cowlitz River (Schasse 1987). This represents an important source of sediment for the lower portion of the North Fork drainage.

The Tilton watershed analysis area lies within a tectonically active region, with Mt. Rainier to the northeast and Mt. St. Helens to the south. Only a low threat exists to this basin from either of these sources, and the threat would likely be from ashfall, depending on wind direction. No quaternary volcanics were observed or mapped in the basin.

2.3 MANAGEMENT ALLOCATIONS

The Northwest Forest Plan (1994) designated a network of Late Successional Reserves (LSR) with the objective to protect and enhance conditions of late successional and old-growth forest ecosystems. National Forest lands within the Tilton watershed are included in the Mineral LSR. The Record of Decision (ROD) provides the framework for management of terrestrial and aquatic ecosystems. The ACS addresses specific goals and objectives pertaining to aquatic habitat conditions. The ACS goals and objectives limit management to those activities which protect and/or enhance the aquatic environment. Figure 2 displays the LSR land management allocations.

3. ANALYSIS OF THE ISSUES

In order to develop land management recommendations for the Tilton watershed, an interdisciplinary team identified and examined natural resource issues. The following list of issues and key questions focused this analysis on those issues deemed most pertinent to the Tilton watershed.

Issues are organized sequentially, such that information contained in the preceding issue is used in the analysis of the following issue. Issues start with vegetation and upslope concerns (terrestrial) and progress to aquatic zone.

3.1 ISSUE 1 – TERRESTRIAL ECOSYSTEM

For this analysis, the terrestrial ecosystem is described as a function of vegetation and wildlife species. Emphasis is placed on current forest structure and how the current structure defines wildlife habitat. The following key questions were examined for this analysis.

- **Key Question 1** – How have past land management activities altered forest structure, composition, and pattern?
- **Key Question 2** – How have the changes in forest structure and riparian zones affected the suitable habitat for species of interest?

In order to adequately address these two questions several other questions needed to be answered. The additional questions are not highlighted in the text, but rather, the questions represent the discussion content of the terrestrial ecosystem.

- What is the current pattern and distribution of forest stands in the watershed?
- How has habitat connectivity been affected by forest management practices?
- How are private lands in the watershed managed?
- What is the status and habitat capability for threatened, endangered, and sensitive species in the watershed?
- What are likely trends in populations of TES species identified in the watershed based on management for late successional conditions?
- What is the current and projected future condition of big game biological winter range in the watershed?
- What special or unique habitats occur in the watershed?

3.2 ISSUE 2–AQUATIC CONSERVATION STRATEGY

The Aquatic Conservation Strategy (ACS) provides nine guidelines for management. The ACS guidelines are intended to ensure the maintenance and restoration of the riparian and aquatic ecosystems. In order to best determine management practices appropriate to meet the ACS objectives in the Tilton watershed, the following key questions are addressed. These questions are designed to investigate historical processes, mechanisms of change, current conditions, and resource trends.

- **Key Question 1** – Have roads and vegetation manipulation altered the flow regime?
- **Key Question 2** – What are the dominant erosional processes in the Tilton watershed?
- **Key Question 3** – What are the riparian zone functions?
- **Key Question 4** – What are the channel processes and conditions?
- **Key Question 5** – What are the historic and current distribution of fish species?

As with the terrestrial assessment, to adequately address the aquatic ecosystem several other questions needed to be answered. The following questions are examined in the text but are not highlighted:

- Have management activities caused or contributed to mass wasting or surface erosion?
- What is the distribution of vegetation structure in the riparian zones?
- Are there cumulative impacts preventing the attainment of the ACS objectives?
- What watershed and road restoration opportunities exist in the Tilton watershed?

4. ISSUE – TERRESTRIAL ECOSYSTEM

4.1 VEGETATION

4.1.1 Data Sources and Data Gaps Identified

Information for describing forest vegetation on the Gifford Pinchot National Forest is the GIS database and accompanying Oracle database. The output from these sources was verified by field inspection and interpretation of 1989 and 1993 aerial photography. Harvest updates to these databases were confirmed with maps of units harvested since the database was created. Existing data on snags and down wood is not presented due to limited survey data and variability of field observations.

The aerial photo coverage for the Tilton watershed is mostly from 1989. Some 1993 coverage is available for the eastern end of the watershed only. The use of 1989 photos created some inaccuracies in describing the current condition. However, the accuracy of the GIS database is adequate for this large-scale analysis; but it is likely that some individual stand data is not accurate, because stands were lumped into structural stage classification.

Forest vegetation on private lands in the Tilton watershed is described from aerial photo interpretation and personal communication with resource managers for Murray Pacific and Weyerhaeuser.

4.1.2 Assumptions

Most of the focus of this watershed analysis is on lands within the administrative boundaries of the Gifford Pinchot National Forest. Of these lands, more attention is given to National Forest lands than to private lands.

It is assumed that vegetative conditions on Weyerhaeuser lands were generally the same as that of the intermingled National Forest lands up until the time of Weyerhaeuser's harvest activity over the last three decades.

4.1.3 Reference (Historic) and Current Conditions

Succession is the natural process by which a plant community's species composition and tree size change over time in response to a disturbance, of either human or natural origin. The condition of a stand and a forest depends on its position in the forest succession timeline.

Structural stages are a set of classifications for describing forest stand conditions on the basis of individual tree sizes and canopy diversity. This classification system describes the successional conditions of a stand or forest.

Four broad structural stages were defined for this watershed: grass/pole, small tree, large tree and nonforest. These stages are defined as follows:

1. **Grass/pole Forest**—one-storied stands whose trees range in size from seedlings to poles less than 9.0" diameter at breast height (dbh).
2. **Small Tree Forest**—one- or two-storied forest stands of 9.0" dbh up to 18.0" dbh (for the Pacific Silver Fir Zone occupying the highest elevations of the watershed) or 20.9" dbh (for the Western Hemlock Zone covering the majority of the watershed).
3. **Large Tree Forest**—single- or multi-storied stands greater than 18.0" dbh, or equal to or greater than 21.0" dbh (depending on forest zone).
4. **Nonforest**—rock, water, avalanche chutes, administrative sites with little or no vegetation, meadows, grasslands, forblands, and shrublands.

Plant Zone distributions were not considered critical to this analysis. (Plant Zones are defined as areas where a particular tree species is expected to dominate in stable, mature stands approximating climax conditions.) For informational purposes, the breakdown in Plant Zones for the Mineral LSR is 78 percent western hemlock and 22 percent Pacific silver fir. The breakdown for the Tilton watershed would be approximately the same.

4.1.4 Historic Vegetation – General Description

For this analysis, reference conditions are defined as those conditions existing in 1880. The year 1880 is used because it is recent enough that forest conditions from that period can be described (at least qualitatively), yet are prior to significant influence by Euro-American settlers. This "snapshot in time" is important for describing how management activities have altered forest conditions.

The year 1880 is important because it explains much of the current condition of the watershed. In that year, much of the Tilton watershed was in the early- to mid- successional stage of recovery from a very large wildfire. The land base was likely heavily-weighted toward the grass/pole stage. Various sources place the time of this fire anywhere from the mid-1800s (LSR assessment 1997; general consensus among several local individuals) to as far back as 1775 (Clevinger 1951). This analysis will assume the fire year to be 1825.

This wildfire is believed to have covered much of the North Fork Tilton River drainage as well as the area south of the Connelly Creek drainage. The thorough stocking levels and uniform tree sizes seen today in most of these National Forest stands indicate that this was a stand replacement fire. Very little older forest (older than the post-fire stands) exists today in this fire area, suggesting that the fire was intense and very thorough in its coverage. One notable exception is the old growth forest seen in the headwaters of Little Creek (section 24, T.14N. R.3E.). This area appears to have been mostly spared by the fire, revealing potential forest conditions elsewhere in the watershed given the absence of disturbance.

In Connelly Creek and to the north, historic disturbances include scattered windthrow and wildfire. The same fire that covered the North Fork Tilton drainage likely spotted into the basin, but not with the same stand replacement intensity. So, in 1880, this area was likely a mosaic of stand ages and structures—some grass/pole stands (from North Fork Tilton River fire) to large tree stands (withstood above fire, likely originating at same time as section 24 mentioned above).

Fire suppression throughout this century has halted wildfire as a significant natural disturbance on the Tilton landscape. Timber harvesting has replaced wildfire as the primary disturbance shaping forest conditions. Private land has been harvested since the 1920s. Harvests on National Forest land began in the 1950s.

Approximately 7,361 acres, or 43 percent, of all current National Forest lands within the watershed have stand origins within the last 40 years. It is likely that most of this acreage originated from regeneration harvest. It is important to note that some of these young stands were harvested when they were privately held. Land trades over the years have placed them in National Forest ownership.

Very little commercial thinning has been done on National Forest lands in the watershed. In 1979, 92 acres were thinned in Section 36, T.14N, R.4E; this stand is in the Trout Creek/Eagle Creek drainage (21 T). This stand is currently in the 81–120-year-old class and large tree stage.

4.1.5 Current Vegetation – Amount, Distribution and Location

National Forest Lands

The amounts of current (1997) grass/pole, small tree, large tree, and nonforest structural stages on National Forest lands in this watershed are shown in Table 3. Figure 3 displays the distribution of forest structure classes in the Tilton watershed; Figure 4 displays the age class distribution of forest age.

No quantitative analysis was performed on non-National Forest lands within the watershed. These lands, primarily in private ownership, will be described qualitatively later in this analysis.

Grass/Pole—The grass/pole forest occupies the largest acreage of National Forest land in the watershed—7,343 acres, or 43 percent. This stage is primarily the result of regeneration harvest over the past 20 years.

The largest block of this stage is located in the Wallanding (21D) and Tumble Creek (21L) drainages, comprising 48 percent of the grass/pole total. In fact, these drainages comprise the majority of the largest contiguous block of National Forest land in this analysis area. Much of this area is blocked acreage of regeneration harvest by Murray Pacific, likely in the late 1970s and early 1980s. This land was traded to the National Forest in the mid-1980s.

Table 3: Number of Acres in Each Vegetation Structural Stage Currently Found on National Forest Lands in the Tilton Watershed

Subwatershed	Grass/Pole (acres)	Small Tree (acres)	Large Tree (acres)	Non-Forest (acres)
A	61	1,319	1,064	5
B*	--	--	--	--
C	357	436	814	9
D	1,272	300	192	13
E	749	8	78	15
F	110	12	31	0
G	144	205	297	0
I	95	217	353	4
J*	--	--	--	--
K	361	133	572	0
L	2,275	51	171	14
N	163	362	414	17
P	302	247	209	1
Q	203	177	309	<1
R	495	507	794	37
S	80	42	0	0
T	676	370	89	10
Total Acres (% of Watershed)	7,343 (43%)	4,386 (25%)	5,387 (31%)	126 (1%)

* Subwatersheds B and J do not contain National Forest land.

Other grass/pole forests resulted from fragmented regeneration harvest in the late 1980s and early 1990s, spread out among several tributaries to North Fork Tilton River. Large blocks of regeneration harvest 21–40 years ago in the headwaters of West Fork Tilton River (21E), Eagle Creek, and Trout Creek (21T) gave rise to most of the rest of the grass/pole acreage in the watershed.

Small Tree—At 4,386 acres, the small tree forest occupies the smallest area of National Forest land in the watershed—25 percent. These stands originated from the 1825 stand replacement fire.

Much of this structural stage is located in the Little Creek (21A) and Rockies Creek (21R) drainages; 42 percent of this stage is located here. Small tree forest tends to be located on upslope sites where productivity is lower than riparian sites. In general, the small tree forest has high tree stocking levels. As a result, this forest tends to have closed canopy conditions.

Large Tree—The large tree stage accounts for 5,387 acres, or 31 percent, of National Forest lands— the second largest stage in the watershed. As with the small tree stage, these stands originated from the 1825 fire. Unlike the small tree forest, these stands tend to occupy north aspects and the higher site (more productive) ground where tree growth is more rapid, accelerating both individual tree growth and structural diversity. However, the upslope occurrences of the large tree forest still tend to be fairly uniform in structure. In many cases, structural diversity appears to be similar between small tree and large tree forests.

A total of 50 percent of this stage is located in the Little Creek (21A), Bear Canyon (21C), and Rockies Creek (21R) drainages. In the Little Creek drainage, this stage is often intermingled with small tree forest, with large tree forest occupying the lower slopes of most major drainages. This stratification is the result of differences in soil productivity and climate.

As mentioned earlier, a significant block of highly diverse large tree forest—likely spared in the 1825 fire— exists in Section 24 of T.14N R.3W. This section and the rest of the National Forest land in the Little Creek (21A) drainage show the least impact from human disturbance of any drainage in the watershed. Little more than two percent of this drainage has ever been harvested. The harvested areas are concentrated in two stands on the western edge of the drainage.

Non-Federal Lands

Weyerhaeuser owns the bulk of the private lands in the western two-thirds of the watershed (west from the eastern boundary of the North Fork Tilton River drainage). Almost all of these lands are in the grass/pole stage. There appears to have been two distinct periods of recent harvesting on these lands: the late 1970s (when an estimated <25% of the recent harvest occurred) and the late 1980s (estimated >75% of the recent harvest). Almost all of the available timber has had regeneration harvest. Small areas of low volume/low value forest were left in the Bremer Mountain area (21C) and near the Little Rockies (21R). Commercial thinning opportunities, starting in about 10 years, will likely be the next period of significant activity.

Weyerhaeuser lands are being successfully reforested (primarily with Douglas-fir) and managed for timber production on a 50-year rotation. Crown closure is occurring quickly on these lands. Passage from the grass/pole to the small tree structural stage should happen at about age 30–35 years. Species and structural diversity is minimal, as timber production is the primary focus on these lands. Weyerhaeuser lands within the Tilton watershed are currently for sale (Jeanie Hunt, Weyerhaeuser, 11 November 1997). Weyerhaeuser forest management practices in the Tilton watershed are currently not guided by an HCP.

Murray Pacific owns most of the land in the eastern one-third of the watershed, with rare National Forest in-holdings. There is a wide array of age classes in this ownership, from young grass/pole plantations to small tree "mid-rotation" stands to some large tree old-growth stands. Much of this land was clear-cut in the 1950s and 60s by St. Regis, the previous landowner. The large acreage of "mid-rotation" stands originated from this activity. Murray's old-growth stands, particularly those in the Connelly Creek (21G) drainage, were clear-cut or selectively cut in the 1920s and 30s. This activity followed the construction of a logging railroad system (Murray Pacific 1993).

Murray Pacific manages their land for timber production on a 60-year rotation (50 years on low elevations, up to 75 years on high elevations). Their management practices are guided by their Habitat Conservation Plan (HCP). This plan calls for at least 10 percent of the landscape to be left in no-harvest reserves. Riparian buffers will make up the majority of these reserves. Wildlife leave tree patches (with a minimum spacing of 800 feet designed for owl dispersal) and buffers around special habitat sites, e.g., wetlands and sensitive wildlife habitat, will comprise the rest.

4.1.6 Current Landscape Patterns – Patch Size, Shape, Spatial Arrangement and Connectivity

Landscape patterns across the watershed are split geographically into two distinct types: the extremely fragmented landscape of National Forest and Weyerhaeuser land in the western two-thirds of the watershed, and the moderately fragmented landscape of the predominantly Murray Pacific land in the east. These two types will be discussed separately.

From the eastern boundary of the North Fork Tilton River drainage to the west, nearly the entire landscape is broken into alternating sections of National Forest and Weyerhaeuser ownership. Almost all the Weyerhaeuser lands are in the grass/pole structural stage. This land has been harvested (regeneration harvest) over the last 20 years, primarily in the last 10 years. The fragmented landscape pattern is the result of harvest and the checkerboard ownership patterns. Thus, the older forest patches which occur only on National Forest lands have a maximum size of one section, or approximately 640 acres. Assuming an absence of natural disturbance, maximum late successional patch size will reach 640 acres in the future. However, some windthrow of large trees on National Forest land is expected as rotational harvest on neighboring private land continues. This windthrow may decrease the effective size of late successional patches.

The eastern one-third of the watershed (dominated by Murray Pacific ownership) is a broad mix of age classes. This mix is a result of a disturbance regime much different than the western two-thirds of the watershed. The 1825 fire largely missed this area. Instead, the natural disturbances shaping this area were small fires and blowdown events.

Murray Pacific started out as the Murray family's West Fork Timber Company (for West Fork Tilton River) in 1912. This company conducted both selective and regeneration harvests. The Connelly Creek (21G) drainage, in particular, was selectively cut. Much of the residual forest from that cutting stands today as large tree, old-growth type forest.

St. Regis Timber Company owned some of the land in this portion of the watershed until 1978, when Murray Pacific bought these lands. This portion of the watershed was harvested (regeneration) in the 1950s and 1960s. The resulting reproduction in this area is uniformly stocked and likely on the low end of the small tree structural stage. These stands are 30+ years old.

The grass/pole structural stage on these National Forest lands is a result of planned and actual land exchanges, and road access constraints. Section 28 T.14N. R.4E. was harvested in anticipation of a land exchange, which fell through (at least for this section). Section 25 of the same township was previously owned (and presumably harvested) by Murray Pacific, then traded into National Forest ownership. Much of the balance of this current National Forest ownership was harvested via timber sales to St. Regis because St. Regis had sole road access rights.

The National Forest lands here are predominantly in the grass/pole structural stage. However, in the Connelly Creek (21G) drainage and south, the forest is heavy to small tree and large tree.

Patch size and overall area of older forest will decrease in the short term, as Murray Pacific harvests its old- growth timber. Over time, almost all of the large tree forest in the eastern one-third of the watershed will be on National Forest lands. However, connectivity may be a more prevalent part of the landscape than on the western two-thirds. This is because of the riparian buffers and wildlife leave tree clumps Murray Pacific has committed to in its HCP. The contiguous ownership pattern contributes to overall connectivity as well.

4.2 WILDLIFE

The Tilton watershed area provides habitats for a variety of wildlife species, including some federally listed as threatened or endangered, and some designated as sensitive by the Regional Forester. Four wildlife issues were identified as important to the Tilton watershed for this analysis: (1) species associated with late successional forest conditions, particularly threatened and endangered species, (2) deer and elk biological winter range, (3) special or unique habitats, and (4) connectivity of habitat, especially riparian corridors.

4.2.1 Data Sources and Data Gaps Identified

During the data collection phase of the Tilton River watershed analysis, information on wildlife resources was gathered from wildlife specialists at the Randle Ranger District office. Of particular interest was information on threatened, endangered, and sensitive (TES) species known to occur or that may potentially occur in the analysis area, as well as management of late successional reserves and species associated with them. During the data collection phase, it was determined that several TES species were known to occur in the analysis area, including the northern spotted owl and marbled murrelet. In addition, information on vegetative structural stages and types, big game winter range, and spotted owl habitat was obtained from the Forest Service GIS database.

Two cursory field visits of the watershed were conducted to assess overall watershed conditions. Specific surveys to gather information on habitat conditions and species present in the watershed were not conducted. As a result, the following data was not available or collected for this analysis:

- Density, size distribution, and tonnage information on down logs and snags

- Current and historic information about occurrence, distribution, and density of wildlife species on private land

- Current information regarding location and status of threatened, endangered, and sensitive species on federal lands, including northern spotted owl and marbled murrelet.

4.2.2 Assumptions

Due to a lack of recent data on wildlife species and habitat conditions in the Tilton watershed, several assumptions were made for the analysis:

- Due to a lack of species sighting records, a species is assumed to be present in the watershed if its habitat occurs in sufficient patch size. For very large home range species, such as grizzly bear and wolverine, presence may depend on the existence of suitable habitats in adjoining watersheds.

- The most recent surveys to detect spotted owl in the Tilton watershed were conducted from 1990–1992. It is assumed that these pairs are still located in the watershed area.

- Management activities on private land will have continuing effects on the connectivity of wildlife habitat in the Tilton watershed.

4.2.3 Historic and Current Conditions

Current habitat conditions within the Tilton watershed have been influenced by natural ecological phenomena, such as forest fires, volcanic eruptions, and flooding. Following these events the forest revegetated through natural succession. As settlers moved into the area, timber management activities became the primary disturbance that shaped the landscape. Vegetative conditions on a large portion of National Forest land has been shaped by timber harvest. On private lands in the Tilton watershed, forest stands are managed at a 50- to 75-year rotation.

4.2.4 General Wildlife and Habitats

Habitat conditions are inherently related to wildlife abundance in both the number of species and the number of individuals. Vegetation structure, in particular, is often the primary determinant of habitat preference, whether used for breeding, foraging, or cover. Forest management activities in the Tilton watershed have played a key part in shaping the vegetation structure directly influencing the wildlife species currently found there. The majority of forest vegetation in the Tilton watershed is composed of Douglas-fir and Pacific silver fir associations. Section 4.1.3 provides descriptions of the four vegetative structural stages used in this analysis to describe habitat conditions in the Tilton watershed. The following discussion briefly describes what species may be found in the grass/pole, small tree, and large tree habitat types.

A large portion of the watershed is composed of the grass/pole habitat type. This early seral stage habitat is primarily the result of recent harvest activities. Grass/pole habitat is used by a variety of wildlife species, including black-tailed deer, rabbits, hummingbirds, sparrows, bluebirds, and voles.

Small tree habitat is interspersed throughout the watershed and often occurs adjacent to large tree riparian corridors or between grass/pole and large tree habitat. The majority of small tree stands in the Tilton watershed are characterized by nearly closed crown canopy. As a result, there are few resources available to wildlife because there is little ground vegetation. Some species that may use small tree habitat include small mammals, such as ground squirrels, chipmunks, and woodrats, or highly mobile large mammals that utilize open-canopy small tree habitat for foraging and use closed-canopy small tree habitat for resting or escape cover.

Large tree forest is found on approximately 31 percent of National Forest lands in the Tilton watershed. This habitat occurs in small disconnected patches or along stream courses. The large tree stands found in the watershed are the result of regrowth after an extensive stand replacing fire in the early 1800s. As a result, the majority of large tree habitat may consist of trees that approach the diameters of old-growth trees, but the very large snags, high volumes of down woody material, and high structural diversity (important components of old-growth stands) are largely absent. Consequently, use of the large tree habitat by species most dependent on snags, down wood, and high structural diversity (such as terrestrial amphibians, cavity nesting species, and forest carnivores) may be limited.

4.2.5 Threatened, Endangered, and Sensitive (TES) Wildlife Species

A total of 14 TES wildlife species have been identified as occurring or potentially occurring in the Tilton watershed based on sightings or available habitat. The analysis area also contains designated critical habitat for the northern spotted owl (*Strix occidentalis caurina*) and marbled murrelet (*Brachyramphus marmoratus*), both listed as threatened species under the Endangered Species Act. Table 4 lists all TES wildlife species, including federal Candidate species, that are known or suspected to occur within the Tilton watershed. This section provides a brief discussion on range, life history, and occurrence of the TES wildlife species listed in Table 4. Trends are described only for those species associated with late-successional habitat that are known to occur in the watershed.

Larch Mountain salamander—Once thought to be restricted to the immediate vicinity of the Columbia River Gorge of Oregon and Washington, populations of the Larch Mountain salamander have recently been found near Mt. St. Helens just south of Mt. Rainier (Leonard et al. 1993). The Larch Mountain salamander has fairly restricted habitat requirements including steep talus slopes where the talus has a moist microclimate associated with a covering of mosses. This species is more common in areas where undisturbed dense overstories of coniferous or deciduous trees help maintain the microclimate making them closely associated with old-growth forests. Land use activities that impact microclimate conditions in suitable talus slopes or create fragmented forest habitat are likely to have a negative effect on this species. A talus slope covering approximately 14 acres is found in subwatershed L. This west facing slope is fairly exposed and has little surrounding vegetation due to intensive harvest. Given these conditions, it may provide little habitat for Larch Mountain salamander at this time. As the surrounding forest develops into large tree habitat the preferred microclimate may evolve along the perimeter of the talus slope. Two populations of Larch Mountain salamander were documented east of Tilton by Murray-Pacific in 1996. Surveys by the Randle and Packwood Forest Service Ranger Districts have documented five populations, but none have been found in the Tilton watershed.

TABLE 4 THREATENED, ENDANGERED, SENSITIVE, AND CANDIDATE WILDLIFE SPECIES KNOWN TO OCCUR OR WITH POTENTIAL TO OCCUR IN THE TILTON WATERSHED

Species Name		Legal Status		
Common	**Scientific**	**Federal**	**State**	**Forest Service**
Amphibians and Reptiles				
Larch Mountain salamander	*Plethodon larselli*	SOC		S
Spotted frog	*Rana pretiosa*	C	C	PS
Tailed frog	*Ascaphus truei*	SOC		
Cascade frog	*Rana cascadae*	SOC		
Northwestern pond turtle	*Clemmys marmorata marmorata*		E	S
Birds				
Common loon	*Gavia immer*		C	S
Marbled murrelet	*Brachyramphus marmoratus*	T	T	
American peregrine falcon	*Falco peregrinus anatum*	E	E	S
Northern spotted owl	*Strix occidentalis caurina*	T	E	S
Bald eagle	*Haliaeetus leucocephalus*	T	T	S
Northern goshawk	*Accipiter gentilis*	SOC	C	PS
Olive-sided flycatcher	*Contopus borealis*	SOC		
Mammals				
Townsend's big-eared bat	*Plecotus townsendii*	SOC	C	S
Long-legged myotis	*Myotis volans*	SOC		
Long-eared myotis	*Myotis evotis*	SOC		
Fringed myotis	*Myotis thysanodes*	SOC		
Gray wolf	*Canis lupus*	E	E	S
Grizzly bear	*Ursus arctos*	T	E	S
Pacific fisher	*Martes pennanti pacifica*	SOC		
California wolverine	*Gulo gulo luteus*	SOC		S
North American lynx	*Lynx canadensis*	C	T	S

Legal Status:

E = Listed as Endangered by State and/or Federal Agencies.
T = Listed as Threatened by State and/or Federal Agencies.
C = Candidate species for listing as threatened or endangered by State and/or Federal Agencies.
SOC = Designated as a Federal Species of Concern by the U.S. Fish and Wildlife Service.
S = Listed as a Sensitive Species by the U.S. Forest Service.
PS = Proposed as a Sensitive species by the U.S. Forest Service.

Spotted frog—Spotted frogs are found from southeast Alaska south to northeast California and east to western Montana and northwestern Wyoming. In the western portion of their range, including the western Cascades, populations of spotted frogs have declined possibly due to introduction of non-native bullfrogs (*Rana catesbeiana*), DDT poisoning, and alteration of habitat (Nussbaum et al. 1983, and Stebbins 1985). The spotted frog is highly aquatic requiring perennial water areas such as springs, marshy ponds, lakes, or slow moving streams with associated shoreline vegetation of sedges, rushes, and grasses. This species is found in a wide range of habitats including forests dominated by Douglas fir and ponderosa pine as well as semi-arid to arid sites dominated by sagebrush (Stebbins 1985). Land use activities that disturb shoreline areas are likely to negatively effect this species. The majority of streams in the Tilton watershed are fast flowing and have little streamside vegetation. These streams provide little opportunity for spotted frog. A small lake and two wetland areas have been identified in subwatersheds E and N and may provide suitable conditions for this frog. Occurrence of spotted frog in the Tilton watershed is unknown.

Northwestern pond turtle—The western pond turtle is found from southwestern British Columbia south to the Sacramento Valley, California from sea level to 6,000 feet. Sightings in Washington are concentrated around the eastern edge of Puget Sound and a small portion of the Columbia River (Nussbaum et al. 1983). The northwestern pond turtle inhabits a wide range of fresh or brackish water habitats. Although adults are habitat generalists, hatchlings and juveniles require very specialized habitat for survival through their first few years. Prime habitat includes low flow regions of rivers, sloughs or backwater areas, marshes, and moderately deep ponds. Deep, still water with abundant emergent woody debris, overhanging vegetation and rock outcrops is optimal for basking and thermoregulation. These turtles are also associated with surrounding forest habitat for hibernation and egg-laying. This species is sensitive to stream siltation resulting from tree removal and road building. In addition, ground altering disturbance from logging near streams can disturb or destroy hibernating and egg-laying sites. A small lake located in subwatershed E may provide suitable habitat for northwestern pond turtle; however, occurrence of the species is unknown.

Common loon—The common loon is known to breed at only a few locations in western Washington. From September to May the common loon frequents estuarine and suitable marine habitats along the Pacific coast. This species requires deep freshwater lakes with an abundance of fish for breeding. Nests are built on the ground within four feet of water and are usually concealed by vegetation or rocks. The species is susceptible to human disturbance during nesting. The closest occurrence of common loon is from Riffe Lake approximately 3.5 miles south of the Tilton watershed. This sighting was of migrating loons; no nesting activity has been confirmed. The small lake located in subwatershed E does not meet the size or prey requirements of common loon.

Marbled murrelet—The marbled murrelet is found on nearshore waters from the Bering Sea, Alaska, south to central California. Distribution of marbled murrelets at the southern end of their range, including Washington, Oregon, and California, becomes more disjunct presumably as the result of logging activity that has removed nesting habitat. These birds feed on small fish within 2 miles of the coast and nest in stands of old-growth coniferous forests up to 50 miles inland. Forest stands must include trees with wide branches or other natural platforms suitable for the support and protection of the egg. Timber harvest and road building directly affect murrelet nesting and roosting habitat by removal of old-growth trees required for nesting, and by opening the canopy and fragmenting the forest, potentially increasing nest predation by corvids (crows and jays).

National Forest lands within the Tilton watershed are included in the Mineral LSR which is designated as critical habitat for the marbled murrelet. The Mineral LSR is the only location on the Gifford Pinchot National Forest where marbled murrelets are known to nest. Behavior indicating nesting has been documented in the Tilton watershed as recently as 1992. No further surveys have been conducted on National Forest lands in the Tilton watershed, although surveys conducted on adjacent private lands have documented sightings of murrelet, with no nesting behavior, as recently as 1994. Large tree habitat in the Tilton watershed may provide limited nesting opportunities for marbled murrelet. U.S. Fish and Wildlife Service personnel have documented murrelets on sites as small as 3 acres; however, there is no information regarding nesting status or nesting success in these areas.

Trends: Over time, as forest conditions in the Mineral LSR and Tilton watershed mature, structural characteristics that provide suitable nesting habitat would gradually develop in areas that are not currently classified as nesting habitat. The largest consolidated block of late successional habitat will develop in subwatersheds, D, and L. In the future, this area will mature into approximately 4,289 acres of late successional habitat. In the western portion of the watershed harvesting on private land will continue to fragment the forest habitat creating blocks of late successional stands adjacent to stands in a 60-year harvest rotation. This area will provide limited habitat for murrelet.

American peregrine falcon—Surveys conducted in Washington in 1990 found nesting peregrine falcons along the outer coast, in the San Juan Islands, and along the Columbia River Gorge (Allen 1991). Washington primarily provides migratory and wintering habitat for peregrine particularly in estuaries where falcons prey on large concentrations of waterfowl and shorebirds. Peregrine falcons typically breed near wetlands, lakes, rivers, or other water sources that provide an abundance of waterfowl prey. Nests are found on high cliffs with nesting on human-made structures increasing in recent years. A peregrine sighting was documented in 1989 immediately north of the Tilton watershed. Rock cliffs are found in a limited area in the northern portion of the Tilton watershed. No nesting has been documented, but the area may be used as a foraging base by migrating falcons.

Northern spotted owl—The northern spotted owl breeds from southwestern British Columbia south through western Washington and western Oregon to Marin County, California. This subspecies uses dense, old-growth forest that exhibits a high degree of structural complexity with noted preference for mixed conifer and Douglas-fir habitats. Snag or tree cavities are used for nesting, but abandoned nests of other species may be used as well, especially if adequate snags are not available. The northern spotted owl is strictly nocturnal foraging for small rodents, arthropods, and birds by swooping down from perches. Juvenile spotted owls prefer mature and old-growth forests for roosting and dispersal with risk of predation high in open and fragmented landscapes. The northern spotted owl is extremely sensitive to habitat destruction, due to its low tolerance for high temperature and its reliance on late successional forest. Timber harvest and road building can directly affect spotted owl nesting, roosting, and foraging habitat through removal of large trees and opening of the canopy layer.

National Forest lands within the Tilton watershed are included in the Mineral LSR which is designated as critical habitat for the northern spotted owl. The most recent surveys to locate spotted owl in the Tilton watershed were conducted in 1990–1992. Results from those surveys revealed nine pairs of owls in the Mineral Block with six of those pairs occurring on National Forest lands in the Tilton watershed. Based on National Forest GIS information, 5,870 acres of suitable habitat for spotted owl have been identified in the Tilton watershed. Forty-eight percent of the suitable habitat occurs in subwatersheds A, C, and R.

Approximately 92 percent of suitable spotted owl habitat is large tree Douglas-fir and western hemlock forest with, the remainder in small tree habitat. Although large tree stand condition is characterized by trees with an average dbh of 21 inches and nearly closed crown cover, very large snags and large amounts of down woody material is lacking. As a result, the large tree forest may provide adequate roosting and dispersal habitat, but may not fulfill optimal conditions for nesting and foraging. Currently, the majority of large tree forest across the watershed is fragmented, with the largest blocks between 300 and 400 acres. These patches are found in subwatersheds A, C, and N. In addition, a significant portion of large tree stands are located in riparian areas, most likely the result of riparian buffer zones. These areas may provide good movement corridors for owls through the watershed and to adjacent lands.

Approximately 4,385 acres of forest in the Tilton watershed meet the criteria for northern spotted owl dispersal habitat: trees 11-inches dbh with 40 percent canopy closure. This habitat is formed by small tree structural stage forest, all of which is composed of Douglas-fir. However, GIS map coverage indicates only 483 acres of the small tree structural stage forest is currently designated as spotted owl habitat. This spotted owl dispersal habitat is largely fragmented throughout the Tilton watershed, but does provide connections between areas of large tree forest.

Trends: As forested stands in the Tilton watershed mature, structural conditions that define spotted owl habitat will develop, increasing the number of acres of suitable habitat. The largest consolidated block of forest occurs in the center of Tilton watershed, in subwatersheds D and L. Although this area is currently in the grass/pole structural stage, it will mature to provide approximately 4,289 acres of late successional habitat; the largest consolidated block in the Tilton watershed. Application of vegetation management in this area will promote the development of late successional conditions preferred by the spotted owl.

Privately owned lands in the Tilton watershed are expected to have a rotation schedule of approximately 60 years. Quality nesting, roosting, and foraging habitat is not expected to develop on these lands, although some opportunities for roosting and foraging may develop during the final rotation age depending on post-harvest practices and stand treatments. It is likely that these stands may provide some potential for dispersal habitat for 25–30 years or until subject to regeneration harvest. The presence of large tree riparian corridors will be extremely important for spotted owls in order to facilitate movement through the younger habitat patches.

Bald eagle—Bald eagles are highly territorial and exhibit strong site tenacity, with paired birds returning to the same area year after year. If possible, birds will stay in the territory throughout the year, only leaving if food becomes scarce or weather conditions are severe. A good territory for eagles has a suitable nest tree, lots of perches both within and along the perimeter of the territory, and good foraging areas (Stokes and Stokes 1989). In Washington, potential habitats are riparian areas along rivers, streams, lakes, sloughs, and reservoirs; coastal estuaries and beaches; and old-growth forest stands within one mile of water. An abandoned bald eagle nest was identified on the Tilton watershed in 1990. No surveys have been conducted to determine whether the nest has been occupied in recent years. Bald eagles have been documented on the watershed, but no information on nesting is available.

Wintering bald eagles concentrate in areas where food is available, such as lakes and rivers that have an abundance of fish and waterfowl. They may also use upland areas where carrion and small mammals provide adequate forage. Wintering eagles commonly roost in large groups either in single trees or large forest stands within proximity to a winter food source. Although single eagles have been documented on the watershed, there are no known communal roosts.

Northern goshawk—Goshawks prefer large areas of mature forests, including mixed conifer and pine habitats, interspersed with meadows or other riparian areas. Essential components of goshawk habitat include adequate foraging and post-fledging habitat consisting of contiguous patches of mature conifer stands with dense canopy cover, snags, and down logs interspersed with meadow openings and deciduous riparian corridors. Breeding goshawks use large tracts of mature and old-growth forest where they can maneuver in and below the canopy to forage, and where trees are large enough to provide a foundation for nest construction (Reynolds et al. 1992). Snags and dead-topped trees are used as prey plucking posts and are often located in close proximity to the nest site. Outside the breeding season, the birds remain solitary and roam widely over an area of 20–40 square miles (Stokes and Stokes 1989).

Similar to the spotted owl, suitable goshawk habitat in the Tilton watershed is found in large tree forest stands. Stand openings and structural diversity are essential for goshawks because of the necessity to maneuver through the stand in pursuit of prey. In addition, snags, downed logs, and developed understory will enhance the density of goshawk prey. Dense, large tree stands that have not developed adequate openings and understory as the result of past harvest practices will provide little opportunity for foraging. No surveys have been conducted to determine presence of goshawk on National Forest land in the Tilton watershed. Goshawks have been documented on adjacent private land, but breeding status is unknown.

Trends: As forested land in the Tilton watershed develops and is managed to reach late successional conditions, the amount of potential goshawk habitat will increase as large tree stands generate critical habitat components. In the western portion of the Tilton watershed, short-term rotation harvest on private land will continue to create a fragmented landscape. This will disrupt large contiguous blocks of late successional forest decreasing the amount of nesting area but possibly providing forest edges where prey are abundant and accessible. However, it must be noted that evidence suggests that goshawks prefer mature forests for foraging (Reynolds et al. 1992).

Townsend's big-eared bat—The Townsend's big-eared bat occurs from southern California north to Vancouver Island. Its range is restricted to the western half of California, Oregon, Washington, and British Columbia. Across its range, the Townsend's big-eared bat can be found in all habitats, with the exception of subalpine and alpine areas. It is a cavern-dwelling species with local distributions restricted by the availability of caves, man-made structures, tunnels, and mines that can be used for roosting, hibernation, and maternity colonies. Townsend's bats are extremely sensitive to human activity and will abandon sites even after one visit. A single Townsend's bat was documented in the Tilton watershed on private land. Due to a lack of caves, tunnels, and mines in the watershed, man-made bridges may provide the best roosting habitat opportunities for Townsend's bat.

Gray wolf—Historically, gray wolves were breeding residents in Washington. Currently, the species is becoming re-established in Washington with an increase in the number of sightings on nearby Packwood Ranger District since 1991. Individuals, and on some occasions, multiple animals have been sighted; however, it is uncertain whether these animals are pure wolves or hybrids. The gray wolf uses a wide range of forested and open habitats given there is little human activity and there is an ungulate prey base. Due to the amount of human disturbance in the Tilton watershed, it is unlikely that wolves use the area on a continuing basis.

Grizzly bear—Grizzlies have never been common in Washington state. The grizzly bear ranges over large areas and typically uses many vegetation types to fulfill its life requisites. Of particular importance to bears are wet meadows, swamps, bogs, streams, and conifer and subalpine forests. Grizzly bears can be found in nearly every forest type, but areas with little human disturbance may be preferred. There have been no confirmed sightings of grizzly bear on the Gifford Pinchot National Forest, although suitable habitat is available. The nearest confirmed sighting is from just west of Mt. Rainier in the summer of 1993. The Tilton watershed currently does not exhibit large tracts of undisturbed area that are necessary to support grizzly bears. In addition, the watershed is largely isolated from large undisturbed tracts of forest that may be used by these bears.

California wolverine—The California wolverine is a wide-ranging species which uses a variety of habitats that provide year round food supplies in large, undisturbed wilderness areas. Wolverines use caves, logs, rock outcrops, and burrows for cover, generally in dense forest stands. Wolverines forage by scavenging ungulates or preying on small mammals. The closest sightings of wolverine are from the Tatoosh Wilderness approximately 30 miles to the east of the analysis area. Because of its isolation from undisturbed wilderness areas and level of human disturbance, it is unlikely that the Tilton watershed has suitable habitat for this species.

North American lynx—The lynx ranges from Canada into northeast and north-central Washington into northern Idaho. In Washington, the lynx is primarily found above 3,280 feet in remote areas, and is associated with extensive tracts of dense forest that are interspersed with rock outcrops, bogs, and thickets. They are almost entirely dependent on the availability of snowshoe hare, their primary prey, and may be found in a mosaic of forest types from early successional to mature conifer and deciduous forests, as long as snowshoe hares are present. Den sites of the lynx tend to be located in old-growth forest stands with an abundance of down woody debris. Ridges and riparian areas are often used by lynx as travel corridors. There are no recorded sightings of lynx in the Tilton watershed nor is there any information on abundance of snowshoe hare. It is unlikely that lynx would occur in the Tilton watershed based on the level of human disturbance and isolation of the watershed from large tracts of wilderness.

Record of Decision (ROD) Protection Buffer Species

The ROD afforded extra protection for a selected group of wildlife species that were considered rare or locally endemic. The great gray owl, Van Dyke's salamander (*Plethodon vandykei*), and Larch Mountain salamander are protection buffer species identified for the Tilton watershed.. There is little suitable habitat for great gray owl located in the watershed. The habitat is associated with a small wetland located in subwatershed N. No surveys have been conducted to determine presence of great gray owl in the watershed.

Guidelines for Van Dyke's and Larch Mountain salamander habitat require three survey visits, under appropriate weather conditions, to determine presence or absence. The discovery of either species requires the establishment of buffer zones to protect the species and associated habitat at that location. As discussed above, no Larch Mountain salamanders have been documented on FS land in the Tilton watershed. Van Dyke's salamander have been documented on both FS and private land in the Tilton watershed. Occurrences have been recorded in tributaries to Connelly Creek, and North Fork and West Fork Tilton river.

ROD Survey and Manage Species

The ROD identified survey and manage amphibian and mollusk species for which standards and guidelines would provide benefits. For these species, known sites would be managed, surveys prior to ground-disturbing activities would be conducted, extensive surveys to identify high priority sites for management would be conducted, and general regional surveys would be conducted to determine necessary levels of protection. Little is currently known on the presence of amphibian and mollusk species within the watershed. Although limited information is available regarding occurrences of salamanders in the watershed, no data exists for mollusks.

Survey and manage amphibian species that may occur in the watershed include Van Dyke's salamander, Larch Mountain salamander, and spotted frog. Since 1997, surveys for Larch Mountain and Van Dyke's salamanders have been required for ground disturbing projects.

Potential survey and manage mollusk species that may occur in the watershed include:

Columbia dusky snail	*Lyogyrus* n. sp. 1
Puget Oregonian snail	*Cryptomastix devia*
Evening field slug	*Deroceras hesperium*
Warty jumping slug	*Hemphillia glandulosa*
Malone jumping slug	*Hemphillia malonei*
Panther jumping slug	*Hemphillia pantherina*
Blue-gray taildropper slug	*Prophysaon coeruleum*
Papillose taildropper slug	*Prophysaon dubium*

All proposed ground disturbing projects with a Decision Notice signed after 30 September 1998 will require surveys to determine the presence of the eight mollusk species listed above.

Deer and Elk Biological Winter Range

Generally, biological winter range (BWR) is defined as lands below 2,200–2,400 feet in elevation. The Gifford Pinchot Forest Land and Resource Management Plan (LRMP) calls for 44 percent of the biological winter range in optimal cover, preferably well distributed across the watershed in 60-acre blocks. Optimal cover is defined as forested stands with an average dbh greater than 21 inches, with four canopy layers and an overstory generally exceeding 70 percent canopy closure. Thermal cover stands are defined as forested stands averaging 9–20 inches dbh and greater than 60–70 percent canopy closure. Hiding cover is usually reached when forested stands are tall enough, approximately 4.5 feet tall, to screen animals. Open forage includes both natural openings (i.e., meadows, shrublands) and regeneration harvest openings up until about age 20.

Currently, 3,171 acres of the Tilton watershed is designated as BWR with 2,629 acres (83 percent) on National Forest land. The majority of BWR is found in subwatersheds A, C, K, and R. All three vegetative structural stages are represented and provide adequate foraging and cover areas for deer and elk. Table 5 provides a breakdown of BWR acres and percent on National Forest lands by cover conditions. Optimal cover is found in large tree habitat comprising 50 percent of the BWR. In addition, a portion of the small tree habitat may meet thermal and hiding cover requirements. This exceeds the amount called for in the LRMP; however, large tree stands may be lacking in structural diversity due to past disturbance. As a result, the canopy provides excellent cover and snow interception, but adequate forage is often not available because of a lack of understory vegetation.

TABLE 5 NATIONAL FOREST BIOLOGICAL WINTER RANGE ACRES AND PERCENT BY COVER CONDITION FOR THE TILTON WATERSHED.*

	Optimal Cover	Thermal and Hiding Cover	Open Forage	Total
Acres	1,332	701	596	2,629
Percentage	51%	26%	23%	100%

* The calculations in this table are based on information from the GIS vegetation database and have not been field verified. Actual acreages in the field may differ.

Open forage areas comprise 23 percent of the BWR and are well interspersed throughout, providing foraging areas adjacent to cover areas. The remaining 26 percent of BWR consists of small tree stands. As mentioned above, this stand structure may fulfill cover requirements, and if canopy cover is relatively open, it may be used for foraging. Although National Forest lands will be managed to reach late successional conditions resulting in a decrease of foraging areas, harvest practices on adjacent private lands will routinely provide openings to maintain a mosaic of structural stages. Large tree riparian zones will provide big game with movement corridors in order to move to and through forest stands.

Open road density on deer and elk winter range in the Tilton watershed is well above the 1.7 miles/square-mile limit specified in the LRMP. Road density in subwatersheds that have relatively large amounts of BWR range from 2.72 miles/square mile (subwatershed A) to 5.81 miles/square mile (subwatershed D). High road densities contribute to poaching of big game and an increased risk of animal/vehicular collisions.

4.2.6 Habitat Connectivity

Connectivity can be defined as a measure of the extent to which the landscape pattern of the late successional/old-growth ecosystem provides for biological and ecological flows that sustain late successional/old-growth animal and plant species (FEMAT 1995). Connectivity is species specific and is a function of mobility, population size and distribution, and degree of dependence on a specific habitat type. Late successional/old-growth stands are mosaics of microhabitats which differ according to vegetative structure, aspect, elevation, and other key factors. Each microhabitat may provide key resources to particular wildlife species during different stages of their lives or under particular conditions. Sufficient stand size is a key element to maintaining microclimates associated with old-growth stands, and ensuring long-term survival of old-growth habitats and associated wildlife species (Samson et al. 1991). If habitat patches are not large enough to support self-sustaining populations, connectivity can provide links or corridors between habitat patches to compensate for the deficiency.

Wildlife corridors or landscaped linkages are currently the most widely advocated method for countering the effects of habitat fragmentation (Noss and Harris 1986). Less mobile species, and species that do not readily disperse across altered habitats, may depend on the presence of undisturbed corridors between habitat patches (Harris 1984). Corridors function to link habitat patches create a larger total area of available habitat. They facilitate the dispersal of species between habitat patches when the patches are too small to independently support viable populations (Samson et al. 1991). Based on stand age and structure, there are relatively few continuous wildlife corridors in the Tilton watershed. Riparian corridors along Little and Jesse creeks, and ridgetop corridors in the northwestern portion of the watershed are segmented by private land and, as a result, do not provide highly functional dispersal or movement corridors for wildlife.

Habitat fragmentation is the process of reducing size and connectivity of stands that compose a forest (FEMAT 1995). Fragmentation may be human caused (e.g., road building, harvest activities) or be the result of natural events (e.g., fires). Timber harvesting and road construction result in the formation of edge habitat. Edge effects in forested areas may include changes in microclimate, increases in shade-intolerant vegetation, the introduction of weedy exotic plant species and tree pathogens, and increases in windthrow of trees. Edges were formerly considered to be generally beneficial to wildlife, largely because of an emphasis on game species. Populations of forest interior birds and mammals are currently of greater conservation concern because edge habitat already makes up a large proportion of wildlife habitat in many regions.

The current fragmented conditions in the Tilton watershed may result in isolation of individuals or small groups of less mobile species and disrupt the microhabitat conditions required by some species. There is little opportunity for recruitment of native species, particularly less mobile terrestrial species from the surrounding area because of habitat fragmentation and isolation of the Mineral Block from surrounding forest lands. Presence of edge species, such as Corvids (crows and jays), and non-native wildlife is ubiquitous throughout the watershed as the result of fragmentation and increased human access and activity. These conditions may interfere with the ability of the watershed to provide for self-sustaining populations.

Trends: Over time, as late successional forest develops on National Forest lands, private lands will continue to be managed on a 60-year harvest rotation. As a result, a patchwork of late successional stands and younger regeneration stands will be created. In order to maintain connectivity of the late successional blocks, corridors of large tree habitat are necessary. Although many of the riparian areas on National Forest lands exhibit large tree corridors, including North Fork Tilton River and Little and Jesse creeks, the interspersion of private lands disrupts the corridors resulting in fragmentation and a lack of connectivity. However, if the integrity of riparian and ridgetop corridors is maintained on private land, wildlife species such as spotted owl that prefer late successional habitat will be able to move through disturbed or unsuitable habitat to reach desired habitat.

The Mineral LSR is relatively isolated from other LSRs or other large tracts of undisturbed areas such as wilderness. The management of the Mineral LSR, including the Tilton watershed, for late successional conditions will result in an isolated and largely fragmented block of habitat. On a landscape scale, the watershed will provide some habitat for less mobile species currently found there, and on a regional scale will also provide more mobile species, such as spotted owl, with a link between the Peninsula range and interior LSRs within the Gifford-Pinchot and Mt. Baker-Snoqualmie National Forests.

4.2.7 Roads

The open road density in the Tilton watershed is the highest on the Forest. This may be attributed to the interspersion of private lands throughout the watershed and the dissected terrain. Table 2 lists the number of miles of road/square mile found in each subwatershed. These figures represent an average for National Forest and private lands.

To a large degree, high road densities often result in a greater incidence of poaching. In addition, roads fragment forest stands reducing habitat capability for species associated with interior late successional forest. In the Tilton watershed, habitat capability for nearly all TES wildlife species is reduced as the result of high road densities.

4.2.8 Special or Unique Habitat Areas

Special and unique habitats include rock outcrops, cliffs, talus slopes, wet meadows, alpine and sub-alpine habitat, shrublands, wetlands, lakes, and ponds. Few areas in the Tilton watershed have been identified as special or unique habitat. The Rockies, a botanical special interest area that has unusual flora endemic to the area, has been proposed as a Research Natural Area. This area occurs in the northern portion of the watershed in subwatershed D.

One lake is located in the eastern portion of the Tilton analysis area. The lake, found in subwatershed E, is approximately 7 acres in size and is partially surrounded by a brush field and large tree forest. An area identified as wetland is found in the western portion of the watershed in subwatershed N. The wetland covers approximately 7 acres and has a small perennial stream meandering through it. Both these wetland areas may provide habitat for highly aquatic amphibians, such as spotted and Cascades frogs, and may provide foraging areas for deer and elk.

One sizeable talus slope is found on National Forest land in subwatershed L. The slope covers about 14 acres and is largely surrounded by grass/pole habitat as the result of past harvest activities. This relatively large talus slope may provide suitable habitat for Larch Mountain salamander, if management activities have not significantly disturbed microhabitat conditions. Over time, as the forest around the talus slope develops into late successional habitat, the microhabitat conditions required by the Larch Mountain salamander may be created and/or restored.

There are few rock cliffs in the Tilton watershed. These areas are found in the extreme northern portion of subwatersheds D and R. These cliffs may provide suitable nesting ledges for peregrine falcon, although none have been documented at this time.

5. ISSUE 2 – AQUATIC CONSERVATION STRATEGY

5.1 ANALYSIS PROCEDURE

It is the intent of this analysis to establish linkages between current aquatic conditions to hillslope and riparian conditions. Establishing this link allows for the identification of the initial disturbance, how the disturbance is routed to the channel environment, and the resulting effects to the aquatic ecosystem. Pieced together, this will describe the watershed function. To this end, three key resource conditions and processes were investigated: (1) hillslope runoff and erosion, (2) riparian zone function, and (3) channel processes.

Each resource is discussed individually and includes a historical conditions perspective, current conditions, and trends in conditions. Hillslope (erosion and hydrology) and riparian condition results are then combined, or synthesized, with channel processes to determine channel conditions.

Beneficial uses focus on the fishery resource within the Tilton watershed. Following the investigations on hydrology, erosion, riparian zones, channel conditions, and beneficial uses, ACS ratings are assigned to sixth field watersheds (chapter 6).

5.2 DATA SOURCES

The following analyses were based on data from the Forest Service GIS and Oracle databases, Murray Pacific lands watershed analysis, and from field data collection.

5.3 ASSUMPTION

Aquatic environments are strongly influenced by hillslope and riparian conditions and functions. To attain ACS objectives, hillslope and riparian conditions and functions need to be intact. Assumptions and judgments regarding specific resources are noted in the assessment text.

5.4 KEY QUESTION 1 – HAVE ROAD BUILDING AND VEGETATION MANIPULATION ALTERED THE FLOW REGIME?

5.4.1 Method

This method deviates from the protocol used by the Gifford Pinchot National Forest, which utilizes the WAR and ARP procedure. Through discussions with the Forest's soil scientist it was determined that the Forest's procedure is not appropriate for the following reasons:

1. Greater than 50 percent of the watershed is in private ownership with no vegetation description.

2. ARP values are used in timber sale planning by comparing existing values to threshold values set at approximately 70 percent. Considering the level of harvest on both FS and private lands as well as the level of road building, it was determined prior to this assessment that the thresholds have been exceeded.

3. For planning purposes, the WAR and ARP values are used to determine potential increases in runoff due to timber harvesting. Timber management guidelines in the LSR are very restrictive and would not result in alterations to runoff.

In developing a conceptual model and forming assumptions for factors leading to changes in flow regime, findings from the Pacific Northwest, Intermountain Forest and Range Experimental Stations, and The Rocky Mountain Forest and Range Experimental Station (e.g., Harr et al. 1979; J.D Cheng 1980; Troendle and Leaf 1981; Leaf 1975; Troendle and King 1985; Jones et al. 1996; Wemple et al. 1996) were used, as well as Dennis Harr's Summaries at Oregon State University (Harr 1975; Harr et al. 1975) and several papers included in the International Symposium on Forest Hydrology (Dortignac 1965; Pereira 1965). A summary of the key findings is described below:

- There is a net increase in peak water equivalent in harvested/burned watersheds.
- Snow melt rates were highest in open plots.
- Storms produced higher peak discharges and increased volume following 25–30 percent of drainage in clear-cut condition.
- Duration of annual floods increased.
- Loss of transpiration accounted for 2/3 of the change in flow with 1/3 from loss of interception.
- Road network increased drainage density altering flow routing efficiency.
- Elevated peak flows decreased rapidly after year 6, but remained altered for 20-30 years.

Using this background data, a hydrologic module was developed.

The net effect of decrease in transpiration, increase in peak water equivalent, and design of the road system was assumed to be most influential in altering quick flow and peak discharge. The fundamental concepts underlying these assumptions are: loss of transpiration allows quicker recharge of soil, reduction in canopy closure will reduce interception, and the presence of roads add to the drainage network. "Net effect" was chosen because all three factors are simultaneously involved. Consequently, determining the relative contribution of any one variable is not significant.

These assumptions focused the cumulative effects analysis on road densities and recovery rates of harvested units. "Recovered" in this analysis is considered to be "hydrologically recovered." Harvest units are hydrologically recovered when re-establishment of leaf area is sufficient to return transpiration rates to pre-harvest levels and canopy closure is sufficient to prevent excessive snow loading. The Connelly Creek watershed analysis uses a 25 year recovery period, as recommended by the Washington Department of Natural Resources (1991); this recovery period is applied to the Tilton watershed geographic area. Temporally, the maximum difference in streamflow response generally occurs the first five years proceeding disturbance and decreases logarithmically with time.

Equivalent Clearcut Method (ECA)

To standardize the data and facilitate comparisons among watersheds, hydrologic recovery is expressed in terms of Equivalent Clearcut Acres (ECA). ECA is determined from vegetation stand age. A percent recovery coefficient is assigned to the 0-10 age class, the 11-20 age class, and the 21-40 age class. The coefficients, or recovery factors, are 20 percent, 50 percent, and 100 percent, respectively. At the sixth field watershed level, acres in each age class are multiplied by the coefficient to determine the unrecovered acres. Adding the unrecovered acres in each age class yields total unrecovered acres for the watershed. This total represents the ECA for the watershed.

In assigning coefficients, the mid-point in each year class was assumed to represent the mean vegetation age of the subbasin; these are 5, 15, and 30 years. Research data indicates that hydrologic recovery occurs at an exponential rate. This exponential trend drove the 20, 50, and 100 percent recovery value assignment. At age 5, grasses and brush along with small planted conifers cover the soil surface and begin to establish root mass in the soil profile. At 15 years old, ground surfaces are fully vegetated with an established root system. Additionally, planted conifers begin to provide an over story canopy. At year 30 an over story canopy of small trees is established with an under story of brush.

Limitations

In assigning the same recovery values to each sixth field watershed, the ECA results are, therefore, relative. The higher the ECA, the higher the potential for changes to the flow regime. Due to unknown vegetative maturity on private lands, it is not known how these relative values relate to absolute changes in the flow regime. Additionally, there is inherent error in assigning the same coefficient to the same forest stand regardless of site conditions.

The analysis is designed to compare vegetative recovery between watersheds and not to give an absolute number; the results are intended to highlight hydrologic sensitive areas. With this in mind, the results from the analysis are not sensitive to the assigned recovery coefficients.

5.4.2 Current Condition

Table 6 lists the sixth field watersheds and their respective road densities. The table is ranked based on road densities; watersheds with the highest road density are listed first to watersheds with the lowest road density. Acres of road surface are calculated using an average road width of 20 feet and includes all ownership; calculated this represents 2.4 acres per mile. All road acres are considered unrecovered.

Table 7 displays age class and the associated acreage at the sixth field watershed level. These data were multiplied by the recovery factor to determine vegetative recovery, or ECA, for each watershed. For aquatic conservation strategy objective ratings (chapter 6), aerial photographs are used to fill in data gaps on private land.

Results, in Table 8 column 7, are sorted from the highest ECA percentage, or least recovered, to the lowest ECA percentage. Column 7 indicates the hydrologic recovery on federal lands. Column 8 indicates the significance of federal land conditions on the entire basin. As mentioned in the methods section, these values are relative. The watersheds appearing near the top of the table have a higher potential for alterations to the flow regime than those appearing near the bottom of the list. Research suggests that flow alteration begins when the basin is in 20-30 percent ECA condition.

Table 6: Road Densities

Sub-watershed	Stream Name	Total WA Acres	Miles of Road	Acres of Road Surface	Miles of Road Per Sq. Mi.
21L	Tumble Creek	2,765	26	63	5.9*
21D	Wallanding Creek	2,218	20	48	5.8
21N	Winnie Creek	2,233	18	44	5.3
21F	Coon Creek	2,061	16	39	4.9
21K	Lower N.F. Tilton	2,471	18	44	4.6
21P	Jesse Creek	1,986	14	34	4.5
21Q	Otter Creek	1,555	11	27	4.5
21S	Snow Creek	1,362	9	22	4.3
21T	Tout Creek	4,179	26	63	3.9
21E	West Fork Tilton	4,807	27	65	3.6
21I	Upper Side wall Tributary to Tilton River	4,469	25	61	3.6
21C	Bear Canyon	11,267	60	145	3.4
21R	Middle N.F. Tilton	3,402	17	41	3.2
21G	Connelly Creek	3,796	18	44	3.1
21B	Side wall Tributary	510	2	5	2.8
21A	Little Creek	4,242	18	44	2.7
21J	Lower Side Wall Tributary to Tilton River	1,514	6	15	2.5
Total		**54,837**	**331**		**3.9**

* (Circa 1993) Following road obliteration efforts, road density decreased to 3.3 mi/mi^2

Table 7: Age Class and Acreage of Vegetative Units in the Tilton Watershed

Subwatershed	USFS Lands (years)							
	≤ 10 years	11–20	21–40	41–80	81–120	> 120	No Data	Total
21A	58	3	–	–	181	2202	5	2448
21B	–	–	–	–	–	–	–	0
21C	136	221	–	–	–	1250	9	1616
21D	99	183	991	–	150	342	13	1777
21E	88	308	353	–	–	86	15	849
21F	–	16	–	95	31	12	–	154
21G	16	20	–	257	43	309	–	645
21I	95	–	–	–	–	569	5	669
21J	–	–	–	–	–	–	–	0
21K	238	123	–	2	–	704	–	1067
21L	226	1510	535	–	0	226	16	2513
21N	163	–	–	–	70	706	17	956
21P	148	154	–	–	168	289	2	760
21Q	149	53	–	–	–	490	0	693
21R	443	52	–	–	81	1221	37	1832
21S	–	30	50	42	–	–	–	122
21T	–	0	902	142	89	3	10	1145
Total	**1859**	**2672**	**2830**	**538**	**813**	**8407**	**127**	**17246**

Table 8: Equivalent Clearcut Acreage Per Sixth Field Watershed (Federal Land Only)

Subwatershed	Age <10 yrs	Age 11-20 yrs	Age 21-40 yrs	Equivalent Clearcut Acres (ECA)	Federal Ownership Acres	% ECA Federal Land	% ECA Watershed
21B	0	0	0				
21J	0	0	0				
21L	226	1510	535	963	2513	37	36
21E	88	308	353	224	849	26	6
21P	148	154	0	195	760	26	12
21K	238	123	0	252	1067	24	12
21Q	149	53	0	146	693	21	11
21R	443	52	0	380	1832	21	12
21N	163	0	0	131	956	14	8
21C	136	221	0	219	1616	14	3
21S		30	50	15	122	12	3
21I	95	0	0	76	669	11	3
21D	99	183	991	170	1777	10	10
21F	0	16	0	8	154	5	2
21G	16	20	0	23	645	4	2
21A	58	3	0	48	2448	2	2
21T		0	902	0	1145	0	2

Findings

To assess potential alterations to the flow regime, the road surface variable is added to the equivalent clearcut variable. Together, they represent the cumulative impact to surface runoff. Total disturbance acres is the addition of road surface acres and ECA acres. Results are sorted from the watersheds with highest disturbance to watersheds with the lowest level of disturbance (Table 9).

Relatively, the highest level of disturbance in federal lands is shown in the top five entries in Table 9. These indicate the top 25th percentile. Of the top 5 subwatersheds, 21L (Tumble Creek) and 21E (West Fork Tilton) have the highest level of disturbance per watershed area— 39 and 28 percent respectively. These two sixth field watersheds represent the highest potential that surface flow processes have been altered on federal lands.

Note: Road and vegetation data includes FS lands only. Consequently, percent ECA (column 8) refers to federal land and not watershed area.

5.4.3 Trends

Private land will continue to be harvested at a 60 year rotation. Depending on the distribution and magnitude of harvest within a subwatershed, surface flows may, or may not, be influenced. On federal lands the trend is improving. Roads have been, and will continue to be, removed from the system; this will reduce road surface acres within the basin.

In the two subwatersheds of concern, Tumble and West Fork Tilton Creeks, harvest activity predominately occurred 11-20 years ago. Harvest units in these areas have recovered approximately 50 percent. Assuming no additional harvests, the recovery trend will continue for another 5-10 years, at which point they will be fully recovered. Additionally, all National Forest lands are in analysis area is in the Mineral LSR. Harvest guidelines contained in the LSR are very restrictive and following those guidelines should not result in alterations to the flow regime.

5.5 KEY QUESTION 2 – WHAT ARE THE DOMINANT GEOMORPHIC PROCESSES IN THE WATERSHED?

5.5.1 Method

Mass wasting and road erosion is the focus of this assessment. The management activities of harvest and road building are investigated to determine their influence on hillslope erosion processes. Current road and mass wasting erosion information derived from Forest Service

Table 9: Combination of Roads and Equivalent Clearcut Acres

Sub-Watershed	Stream Name	FS Ownership (Ac.)	Veg. ECA (Ac.)	Miles of Road	Road Surface Area (Ac.)	Total (rds.& veg.) ECA (Ac.)	% ECA FS Lands
21L	Tumble Creek	2513	936	23.11	37	992	39
21E	West Fork Tilton	849	224	5.96	14	238	28
21P	Jesse Creek	760	195	1.87	5	200	26
21K	Lower N.F. Tilton	1067	252	3.93	10	262	25
21Q	Otter Creek	693	146	1.84	4	150	22
21R	Middle N.F Tilton	1832	380	4.85	12	392	21
21N	Winnie Creek	956	131	6.27	15	146	15
21S	Snow Creek	122	15	1.16	3	18	15
21C	Bear Canyon	1616	219	5.94	14	233	14
21I	Upper side Wall Tributary to Tilton	669	76	2.73	7	83	12
21D	Wallanding Creek	1777	170	15.92	39	209	12
21F	Coon Creek	154	8	1.52	4	12	8
21G	Connelly Creek	645	23	0.92	2	25	4
21A	Little Creek	2448	48	4.16	10	58	2
21T	Trout Creek	1145	0	8.84	21	21	2
21B	Side Wall Tributary		0	0	0	0	
21J	Lower Side Wall Tributary to Tilton River		0	0	0	0	

supplied GIS maps and field investigation. Locations and causal mechanisms of erosion are noted.

In order to determine the reference condition, it was necessary to describe how the landscape has responded to management activities. Reference conditions are then described as the landscape minus these mechanisms.

5.5.2 Current Condition

Mass Wasting—There are two inherent watershed characteristics which greatly influence erosion and mass wasting— soil depth and topography (details in the geology summary). Shallow soils atop bedrock characterize the sources in the Tilton. A shallow soil layer limits the volume of sediment produced during mass wasting events. Topography in the Tilton watershed is characterized as steep and dissected. The greater the slope, the greater the shear force on the soil mantle from gravitational forces.

Based on the high drainage density, topography, and geology, it is inferred that shallow debris flows are the dominant erosional process. Resource areas identified as sensitive to debris flows are located primarily on concave slopes. Concave slopes tend to be collection areas for both sediment and water. Sediment and organic material accretes in these concave features through colluvial processes. When precipitation intensity is sufficient, the sediment can become saturated and resemble a fluid composed of water and sediment. The additional weight of the water increases shear force while the solution decreases the friction, or shear resistance, between the top-soil and the underlying bedrock. Slides initiate as the shear force of water/sediment body increases beyond the shear resistance. This process can be the mechanism forming first order streams. Although these are typically shallow in depth, debris flows can extend from the headwater area to the valley bottom.

Clear-cutting in steep headwater areas increased surface runoff (discussed in hydrology) and decreased soil cohesion by reducing root strength. The geomorphic response to harvesting and road building was shallow landslides and debris flows in headwater drainage areas and below road prisms. Table 10 lists the number of identified mass wasting features in the sixth field watersheds. Figure 5 displays the distribution of landslides.

Table 10: Identified Mass Wasting Features

Subwatershed	Stream Name	Number
21A	Little Creek	10
21B	Side wall trib.	11
21C	Bear Canyon	13
21D	Wallanding	2
21E	West Fork Tilton	no data
21F	Coon Creek	no data
21G	Connelly Creek	32*
21I	Upper Side Wall Tributary to Tilton	no data
21J	Lower Side Wall Tributary to Tilton	no data
21K	Lower N. Fork Tilton	no data
21L	Tumble Creek	83**
21N	Winnie Creek	11
21P	Jesse Creek	7
21Q	Otter Creek	11
21R	Middle N. Fork Tilton	13
21S	Snow Creek	no data
21T	Trout Creek	no data

* Included in the Connelly Creek Watershed Analysis
** Included in the Tumble Creek restoration project

Based on field observation, the majority of first- and second-order channels in clear-cut areas have scoured down to bedrock and currently support a low diversity of vegetation. In contrast, first-order channels in a forested condition maintain a soil profile supporting a variety of botanical species. Even following the flood of 1996, there is very little evidence that significant scouring events occurred in heavily vegetated areas.

The Connelly Creek watershed analysis (Murray Pacific Corps 1993) investigated mass wasting and concluded that 90 percent of mass wasting events were associated with shallow rapid landslides and debris flows. Similarly, the Forest Service GIS database and field sampling indicate that nearly all debris flows initiated in steep headwall areas; or road segments acting to concentrate surface flows similar to concave slopes.

Roads—There are currently over 300 miles of road in the Tilton assessment area. Table 6 lists miles of road in each subwatershed. Road mileage information in the southern most portion of the watershed (lower 15 percent) was not available. Otherwise, the road lengths include both National Forest and private land.

The "Tumble Creek Basin Watershed Restoration Project" assessment serves as an example of how roads alter hillslope processes leading to erosion. In the Tumble Creek basin, sidecast road construction on steep slopes has left a legacy of roadfill failures—3.4 failures per mile of road in that basin. Sidecast road construction has been observed as the most susceptible to failure (Krieter 1997, pers. comm.). Capturing surface and sub-surface flow as well as culvert blockage has been identified as the causal mechanism for road failures. Lack of road maintenance on Level 2 and Level 3 roads was also noted as a primary cause of debris slides.

In the Tumble Creek restoration effort, 22 miles of road obliteration occurred including roadfill pullback, culvert removal, water barring, roadbed ripping, and stabilization of exposed soils with fertilizer and seed. This reduced road densities from 5.8 to 3.3 miles/square mile. From field observations, it appears that the road decommissioning project was generally a success. Drainage crossings are stable, and the instance of roadfill failures is greatly reduced. Revegetation of the road beds is beginning with widespread grasses; the conifers planted are generally still stunted, less than 2 feet in height; compaction of the road bed is presumed to be the causal mechanism.

Several road associated mass wasting events have been identified in the Tilton assessment area. Appendix C is a compilation of roads directly, and indirectly, contributing to debris flows/landslides. The Connelly Creek watershed assessment noted that 90 percent of hillslope failures were related to harvest and road construction.

5.5.3 Reference Condition

While it is difficult to determine the historic frequency of mass wasting in the Tilton, it can be inferred from research and field observations that past land use practices have both directly, and indirectly, been the mechanism for several current mass wasting events. Montgomery and Buffington (1993), determined that colluvial hollows either respond to disturbances by accelerated accretion or by a higher frequency of excavation. Montgomery and Dietrich (1994), state "Root strength of both coniferous and understory vegetation provides significant apparent cohesion to the soil."

Therefore, based on the susceptibility to failure from perturbations, field observations, and the Connelly Creek assessment, it is determined that mass failure frequency has significantly increased due to past harvest and road construction practices.

5.5.4 Future Trends

Frequency of mass wasting events is expected to decrease but maintain a level above historic. As timber harvest entries decrease, so will the frequency of mass wasting. Additionally, as the National Forest and private landowners reduce road densities, occurrences of road related failures is expected to decrease. Lastly, first and second order channels in past clearcuts have previously failed, and in the short term, are not expected to fail again.

Existing roads have the potential to fail. Based on past experience, these will continue to trigger mass wasting events.

5.6 KEY QUESTION 3 – WHAT ARE THE CONDITIONS AND FUNCTIONS OF THE RIPARIAN ZONES?

5.6.1 Methods

According to the ROD, riparian zones consisting of 340 feet (two potential tree heights) on either side of fish-bearing streams and 170 feet on nonfish-bearing streams were analyzed. Based on GIS information, approximately 12,500 acres have been allocated as streamside riparian buffers. GIS, aerial photo interpretation, and field observations were used to characterize the condition.

5.6.2 Reference Condition

River valley morphology for nearly all channel segments in the Tilton watershed is classified as confined. Confinement limits floodplain development. Consequently, riparian species (willows, sedges etc.) that depend on fine fluvial sediment deposits to establish are few and are limited to the stream margins. Based on the confined nature of the valley bottoms and field observation of uncut riparian areas, it is surmised that large conifers historically dominated the vegetative structure along the channel system. With this spatial distribution, the potential wood recruitment into the system was very high.

5.6.3 Current Condition

The physical functions of the riparian areas are: (1) stabilize stream banks via root mass, (2) provide a canopy to reduce solar radiation input, and (3) supply large woody debris to the channel system.

In a sediment transport dominated system, stream banks are generally composed of large rock and bedrock; finer materials are transported downstream (details in key question 4). This is the structure for most reaches in the Tilton watershed. As such, stream banks are inherently stable and resistant to tractive forces (water velocities). Root mass from vegetation provides a secondary source of stabilization. Restated, channel banks without mature vegetation are not highly susceptible to accelerated bank erosion.

The lower reach of the North Fork Tilton is the exception. In the lower reach, segments of the stream channel flow through the Hayden Creek Drift. Channel banks in these sections are composed of easily erodible glacial till. However, the till is deep (15–25 ft.) and the stream is undercutting the toe far below rooting depth.

Stream temperatures are influenced by a number of variables including climate, flows, and solar radiation. In assessing the role of riparian canopy cover on temperature regulations, findings contained in the "Water quality and water temperature monitoring for surface waters in the Mineral Tree Farm" (Beak 1995) are correlated to the Tilton watershed. The temperature sites in Table 11 apply to the Tilton watershed based on proximity and elevation.

Table 11: Percent of Time Water Temperature Exceeded State Standards

Station	Number of Hours Exceeding State Standards of 16 °Celsius					
	Confined (hours)	**% Exceeded**	**Unconfined (hours)**	**% Exceeded**	**Station Elev. (ft)**	**Total Hours Recorded**
Con-5	134	9	NA	0	1,480	1,440
Con-8	0	0	NA	0	2,560	1,440
Con-2	51	4	NA	0	1,045	1,296
Con-2	50	3	NA	0	1,045	1,968
Con-5	17.5	1	NA	0	1,480	1,968
WF-1	NA	0	498	26	1,065	1,920
WF-6	NA	0	166	9	1,205	1,920
KI-2	45	3	NA	0	1,350	1,440
KI-8	430	30	NA	0	1,500	1,440
KI-11	0	0	NA	0	1,810	1,440
KI-6	NA	0	858	45	870	1,920
Kos-4	NA	0	202	11	1,000	1,920
Kos-6	8	1	NA	0	2,660	1,440
Kos-2	NA	0	342	24	790	1,440
Kos-7	0	0	NA	0	1,430	1,440
Kos-9	0	0	NA	0	3,000	1,440
Total	**735.5**		**2,066**		–	–
Mn Elev. (ft)	1,760		822		–	–
% exceeded	4		23		–	–

Temperature monitoring occurred from 15 July to 15 September (1994 & 1995), when streams are most susceptible to increased water temperatures. Temperature sites are stratified based on confinement (as confinement was assumed to provide a geologic canopy) reducing solar radiation input. Station elevations are also noted. Temperatures were recorded at 30-minute intervals. The percent exceeded row in Table 11 represents the percent of time water temperatures exceeded state standards of 16°Celsius (C).

In summary, confined channel segments exceeded state water quality standards 4 percent of the time. Unconfined channels segments exceeded standards 23 percent of the time. None of the peak stream temperatures reported from 1992 to 1994 approached lethal levels for salmonids (Beak 1995). From this data, it can also be inferred that elevation is a factor in susceptibility to increases in temperature.

Similar to the stream channels on Murray Pacific lands, National Forest drainages are highly confined. In these areas, it appears that in the absence of a vegetative canopy cover, hillslopes provide a shade cover adequate in protecting against long periods of elevated stream temperatures. This is especially true for the Tilton watershed which is predominately oriented north to south, where the majority of drainages are oriented perpendicular to the movement of the sun.

Unconfined channel segments regardless of riparian canopy cover are more likely to experience elevated stream temperatures. This can be partly attributed to the wide valley bottom. Even under mature forested conditions, water surfaces are still exposed to solar radiation input.

Combining the limited exposure to warm water with the thermal refugia, such as cold water tributaries, deep pools, and seeps, it is not likely that water temperatures limit lotic environments. In addition, frequent rainfall and high water velocities reduce susceptibility to water temperature increases.

While the function of bank stabilization and canopy closure is important to the system, large wood debris (LWD) is critical in protecting/stabilizing the aquatic environment.

Large wood debris is very influential in channel conditions. Specifically, wood provides a large roughness element. As a large roughness element, wood converges and diverges flow velocities. This is a critical process in the formation of pools and retaining spawning gravels. Historically, large fir trees lined the channel banks. With this spatial distribution, the potential wood recruitment into the system was very high.

Currently, large wood recruitment potential is high in 42 percent of federal lands. Large wood recruitment potential is based on the presence of large tree structure. Table 12 presents vegetative structure of the riparian areas by sixth field watersheds. This percentage is considered lower on private lands (private lands comprise more than 50 percent of the streamside riparian zones). Figure 6 & 7 display the spatial distribution of vegetative structure and age class respectively.

As a result of past road building and harvest in the riparian zones, wood recruitment potential has decreased. Wood debris falling into the creek is generally small, < 12". The size class provides temporary roughness at lower flows, but the transitory nature of small wood does not create holding pools or velocity refugia during high flows. Effects to the channel environment are discussed in Key Question 4 (What are the channel processes and conditions?).

Table 12: Number of Acres in Each Vegetation Structural Stage for Riparian Areas by Subwatershed (Federal land only)

Subwatershed	Non Forest	Grass /Pole	Small Tree	Large Tree	% Large Tree	Total
21A	2.6	25.1	328.5	528.3	59.7	884.5
21B	--	--	--	--	--	--
21C	6.6	171.5	165.6	395.0	53.5	738.7
21D	1.6	216.9	78.3	93.9	24.0	390.7
21E	11.3	163.0	3.9	26.8	13.1	205.0
21F	--	39.2	--	7.6	16.3	46.8
21G	--	69.5	87.6	146.9	48.3	304.1
21I	2.7	37.2	33.1	142.4	66.1	215.5
21J	--	--	--	--	??	--
21K	--	149.3	29.8	262.4	59.4	441.5
21L	5.3	708.3	9.6	46.6	6.1	769.8
21N	13.3	57.0	60.2	168.3	56.3	298.7
21P	1.7	108.6	52.1	116.9	41.9	279.3
21Q	--	85.7	62.3	187.3	55.9	335.2
21R	6.7	210.3	115.3	373.6	52.9	705.9
21S	--	2.7	16.8	--	0.0	19.5
21T	--	120.4	134.4	0.4	0.2	255.2
Total	**51.9**	**2164.6**	**1177.5**	**2496.4**	**42.4**	**5890.4**

5.6.4 Future Trends

Riparian management opportunities for harvest in riparian zones have become increasingly more restrictive. Restrictions apply to both private and federal lands. Therefore, as harvest decreases in the riparian zones, the condition trend will improve. The rate of improvement will follow the growth curves of the tree species. Consequently, several decades will be required before wood recruitment potential approaches historic levels.

5.7 KEY QUESTION 4 – WHAT ARE THE CHANNEL PROCESSES AND CONDITIONS?

5.7.1 Method

In determining changes to channel morphology from past land activity, stream channels were stratified based on two criteria. The first stratified the channels based on riparian zone condition— harvest and no harvest buffers. The second stratified the channels based on sediment transport capacities. The classification is based on "Channel Classification, Prediction of Channel Response, and Assessment of Channel Condition"(Montgomery and Buffington 1993). Each channel type is discussed individually. Methods vary slightly between reaches and will be discussed individually.

Figure 8 displays the distribution of source, transport, and response reaches in the watershed. In summary,

- **Source Reach**—These are high gradient, sediment storage reaches likely to experience debris flows. Slope range is >30 percent.
- **Transport Reach**—These have high sediment transport capacities and channel geometry alterations from increased sediment load is not likely, as sediment is quickly transported downstream. Slope range is from 3 to 30 percent.
- **Response Reach**—These are low gradient, typically unconfined, reaches. Response reaches are considered most susceptible to changes in sediment and/or flow changes due to the low transport capacity. Sediment delivered to the channel system from source reaches and mobilized through the transport reach deposits in the response reach. Slope range is < 3 percent.

In assessing channel conditions and establishing relationships between channel types and riparian zone conditions, several stream channels were investigated and are noted below.

5.7.1.1 Source Reaches

Channels designated as source are first and second order channels. They are also colluvial hollows. Source reach channels are considered vulnerable to scouring events such as debris flows and shallow landslides. Source reaches are examined in the upslope erosion section.

According to the Rosgen classification method, source reaches can be generalized as A1 and A2 channel types.

5.7.1.2 Transport Reaches

At the watershed scale, as evident from Figure 3, sediment transport processes dominate over deposition. Lack of fluvial features, such as mid channel and lateral bars, indicates stream velocities are competent in transporting sediments entering the channel, supporting the transport dominated conclusion.

According to the Rosgen classification method, transport reaches can be generalized as B2 and B3 channel types.

Reference Condition—Research indicates the natural frequency of pool spacing is estimated to be 1–5 channel widths, increasing in frequency with increasing gradient. Montgomery and Buffington (1993) note typical pool spacing for a step-pool system is 1–4 channel widths. Chin (1989), found pool spacing frequencies of 2.2–1.7 channel widths, with pool frequency increasing in steeper gradients.

Transport reaches in the Tilton watershed can be further classified as a step-pool system; slopes range from 3 percent to 20 percent. With very low sinuosity and floodplain development, the majority of energy dissipation is turbulence generated by channel obstructions, such as LWD and large substrate. Step-pool sequences occur because the size of the bed materials, including vegetation debris, is large relative to the size of the channel (Chin 1989).

Current Condition—To establish current condition, several channel segments were investigated. Channel segments were stratified by condition of riparian zones— with a riparian buffer and without a riparian buffer. This stratification was chosen to establish the interaction between the riparian and channel environment. Field sampling was conducted in Fisher, Wallanding, Tumble, Otter, Winnie, and Jesse Creeks.

Field sampling indicated that wood loading into the channel environment was considerably higher in reaches with "no harvest" riparian zones. Correspondingly, the number of pools were 15 times greater in streams with LWD than in streams lacking LWD. In steeper gradients, buried logs created a series of steps by acting as hydraulic controls. In the moderate gradient channels, LWD redirects flow velocities creating either a scour, when flows converge, or a deposition, when flows diverge.

With these processes active, the moderate gradient transport channels are more accurately defined as a forced pool-riffle system. Forced pool systems rely on convergence and divergence of flows to scour pools and form bars (Montgomery et al. 1995).

Presence of LWD increased channel complexity. Channels with instream complexity have a combination of gravel deposition for spawning, pool formation for holding habitat, velocity breaks for high flow refugia, and instream structure for cover. Channels reaches lacking LWD were simplified with few pools and little instream cover.

It is expected that with reductions in instream roughness components there is a corresponding increase in mean flow velocities. A common channel response to increased flow velocities is bank scour and channel widening. However, neither bank scour nor channel widening were observed. This can be attributed to natural bank stability. Bank substrates are composed of small boulders to cobbles and are resistant to scouring.

In reaches with or without LWD, aggradation of sediment delivered from the upslope environment was not evident. Although erosion has increased from mass wasting and roads, little evidence indicates that the sediment is adversely affecting channel conditions. Gradients are steep (3 to 30 percent) and provide sufficient energy to transport the sediment downstream.

Based on the correlation between riparian vegetation and wood recruitment, and the relationship of wood recruitment to channel condition, it is assumed the distribution of reaches with simplified channel form follows the distribution of harvested riparian areas. Currently, 42 percent of the riparian areas support mature vegetation on National Forest lands (see riparian function assessment and Figure 7). On private lands, the percentage of mature riparian vegetation is considered lower.

5.7.1.3 Response Reaches

Methods—Response reaches in the Tilton are very limited. These reaches were identified on maps and visited in the field. It was assumed that if the sediment regime has increased in the watershed, evidence could be found in the response reaches.

Current Condition—Upon field inspection, the channel resembled processes consistent with a plane-bed morphology. Plane-bed morphology is characterized as "plane-bed channels lack free form bars, have subdued cross-section topography, and consist primarily of riffles" (Montgomery et al. 1995).

According to the Rosgen classification method, response reaches can be generalized as C3 channel types.

No wood was observed in these channel reaches. Width to depth ratios exceeded 25. Pool-riffle percent was observed at 80 percent riffles, and 20 percent pools. Pocket pools provide the majority of pool habitat.

Mean diameter of surface substrate is estimated to be in the small to large cobble class. A mixture of cobbles, gravel, and sand composed the subsurface substrate. This indicates that bedload sediments during a bankfull flow event includes a range of sediment particles. On the receding limb of the hydrograph, the larger particles "fall out" and the finer surface material is transported out of the watershed.

In summary, channel complexity has been simplified. Consequently, deep pool habitat and spawning gravel presence is low. Due to the general absence of deep pools, instream structure and overhanging vegetation, instream cover is also rated low.

Reference Condition—In an attempt at presenting reference conditions for the response reaches, physically based conclusions are necessary. Comparison to undisturbed channels was not possible due to the fact that all channel segments have been subjected to past disturbances. The physically based analysis focuses on processes active in forming a plane-bed morphology. Montgomery et al. (1993), describes processes as "plane-bed channels respond to increased flows by bed coarsening, creating turbulence; an increase in sediment can cause significant aggradation; removal of large woody debris can change a pool-riffle morphology to a plane-bed morphology."

Considering that upslope erosion and peak flows have increased, and the presence of wood has decreased (each discussed in previous key questions) any or all responses are feasible. However, field observations do not indicate aggradation. Therefore, it is assumed that the net effect of increased flows and reduction in LWD modified the pool riffle processes to processes consistent with a plane-bed morphology. Consequently, reference conditions supported greater complexity. Complexity in terms of substrate particle size distribution and scour-fill sequences.

5.8 KEY QUESTION 5 – WHAT IS THE HISTORIC AND CURRENT FISH DISTRIBUTION IN THE WATERSHED?

5.8.1 Reference Condition

Prior to the construction (mid-1960's) of the Mayfield Dam and the Salmon Hatchery Barrier, both resident and anadromous fish species were present in the Cowlitz River Basin, including the Tilton Watershed. Coho salmon, spring and fall chinook salmon, sea-run cutthroat, and winter steelhead were reported to be abundant in the Cowlitz Basin (GAIA Northwest, INC., 1993). Summer steelhead were present in the Cowlitz but numbers were few. GAIA Northwest also noted that cutthroat trout were widely distributed throughout the basin and represent the dominate native resident fish species.

Stream surveys (Bryant, 1949) conducted in the Tilton Watershed identified anadromous species in the following subbasins:

- Mainstem Tilton- Fall chinook, coho salmon, winter steelhead, and sea-run cutthroat.
- North Fork Tilton- Coho salmon and winter steelhead.
- Otter Creek- Few fingerlings of coho salmon near mouth.
- Winnie Creek- Few fingerlings of coho salmon and resident trout near the mouth.
- Connelly Creek- Coho salmon and winter steelhead
- East Fork of the Tilton River- Coho salmon and trout.

Fisher, Wallanding, and Jesse Creeks were also surveyed but fish were not observed.

Based on the distribution of fish species throughout the Cowlitz River Basin and observations from the 1949 survey, it is assumed that fish species present in the Cowlitz were also historically present in the Tilton Watershed. However, coho salmon and winter steelhead appeared to utilize both the Cowlitz and the Tilton rivers more than the other anadromous species.

Distribution of the anadromous species through the Tilton Watershed is assumed to be limited by habitat suitability and migration barriers. Barriers were identified in: (Bryant, 1949)

- Bear Canyon- Inaccessible due to cascades.
- Fisher Creek- Small and accessible for only short distances.
- Wallanding Creek- 3/4 mile from confluence with the N. Fork, 12 foot cascades preventing migration up Wallanding and Tumble Creeks.
- Otter Creek- Habitat poor above 100 yards due to high gradients.
- Rockies Creek- Blocked by 10 foot falls located 100 yards above the mouth.
- Jesse Creek- Impassible 20 foot falls located 300 yards above mouth.
- Winnie Creek- At 1200 yards above mouth, 18 foot falls prevents passage.
- East Fork Tilton- Impassible falls at river mile 6.
-

5.8.2 Current Condition

Two major hydroelectric facilities were completed in 1962 (Mayfield Dam) and 1968 (Mossyrock Dam); they are located at river mile 50 and 65, respectively. These dams flooded miles of rearing and spawning habitat and prohibited migration of both anadromous and resident fish species (GAIA Northwest Inc. 1993). An impassable dam, the Salmon Hatchery Barrier Dam, is located at river mile 50.

Anadromous species

In response to the migration barrier, salmon and steelhead have been trucked above Mayfield Dam to repopulate the Upper Cowlitz, Cispus and Tilton Rivers. From the early 70's to the mid 80's, spring/fall chinook, coho salmon, and steelhead were hauled around the barrier and planted in the Tilton River. On average, approximately 4800 adult and jack salmon were released in the Tilton annually. Steelhead were hauled and planted at an average annual rate of 3400 adults. Concurrently, chinook and coho salmon fry were planted at an average annual rate of 580,000 in the Tilton.

Trucking fish around the barrier and releasing them in the Tilton River continues. Adult and fry fall chinook, adult and fry coho, and adult and fry steelhead are hauled around the barrier and released. Sea-run cutthroats have recently been hauled around the barriers. Sea-run cutthroat returned for the first time in 1997 (John Squires, Per. Com. 11/97).

While it is known that salmon and steelhead were released into the Tilton River, the distribution of these fish into the analysis area is not known. The nearest release location is a few miles upstream of the North Fork confluence with the Tilton. Fish released at this location, as well as other locations, have access to the North Fork and other tributaries in the analysis area but the utilization is uncertain.

Resident species

Resident salmonids consist of rainbow and cutthroat trout. Conversations with local residents and the reviewing of Murray Pacific's Watershed Analysis, resident fish are distributed throughout the watershed where suitable habitat exists. Based on field observation and topographic maps, nearly all mainstems in sixth field watersheds have suitable habitat for salmonids. However, this is a generalization. Field surveys are required to determine accurate fish distribution.

6.0 AQUATIC CONSERVATION STRATEGY EVALUATIONS

6.1 METHOD

Each sixth field watershed is evaluated in terms of meeting the nine ACS objectives. Ratings are founded on the information contained in the hydrology, hillslope erosion, riparian function, and channel condition assessments. Interpretations of the objectives and rating criteria follow the WSU evaluation method contained in the Upper Cowlitz Watershed Analysis (Gifford Pinchot N.F 1997, pps. 5-1 to 5-7). Due to local site conditions found in the Tilton Watershed the method described in the Cowlitz WA was modified; deviations from the method are in Italic type.

ACS objectives pertain to the entire watershed regardless of ownership. On average, the Forest Service manages 32 percent of the land within the Tilton Watershed assessment area (Table 1). Where possible, the use of aerial photography and random field sampling developed the qualitative assessment on private land to integrate with the Forest Service data. In subwatersheds with less than 20 percent federal ownership, extrapolating from known data and forming assumptions on conditions are provided on a case by case situation.

Rating Definitions and Confidence

The following scale is used to rate each objective, as listed in the Upper Cowlitz Watershed Analysis.

Good (G): Criteria elements are essentially the same as historic/reference conditions. The sixth field watershed meets the management objectives with only minor exceptions.

Fair (F): Criteria elements have changed somewhat from historic/reference conditions. The sixth field watershed is at the threshold for meeting the management objectives.

Poor (P): Criteria elements have definitely changed from historic/reference conditions. The sixth field watershed does not meet the management objective.

Data Gap (D) Insufficient information to assign rating.

NA: Not applicable
NA is assigned to ACS objective #7 in cases where the absence of a floodplain feature prevents a justifiable rating.

A confidence rating is assigned to each evaluation criteria. Confidence ratings are primarily based on data availability, but also express complexity of evaluation.

High (H)	High confidence that the assigned rating is accurate.
Moderate (M)	Moderate confidence that the assigned rating is accurate.
Low (L)	Low confidence that the assigned rating is accurate.
MP	Data contained in the Murray Pacific Watershed Assessments.

<u>Aquatic Conservation Strategy Objectives</u>

The following objectives are presented as they appear in the ROD:

1. "Maintain and restore the distribution, diversity, and complexity of watershed and landscape-scale features to ensure protection of the aquatic systems to which species, populations and communities are uniquely adapted."

   The following ratings were used:

   Good: Watershed conditions display a natural and relatively undisturbed drainage system.
   Fair: Watershed conditions display moderate human disturbance, with some road caused interference of drainage patterns.
   Poor: Road density (>2.0 mi/mi^2), with numerous road systems affecting drainage patterns.

2. "Maintain and restore spatial and temporal connectivity within and between watersheds. Lateral, longitudinal, and drainage network connections include floodplains, wetlands, upslope areas, headwater tributaries, and intact refugia. These network connections must provide chemically and physically unobstructed routes to areas critical for fulfilling life history requirements of aquatic and riparian-dependent species."

   The following ratings were used:

   Good: No roads, no blockages, no culvert obstructions, and no dams.
   Fair: Roading along the floodplain. Some wetlands/floodplains are disconnected.
   Poor: Subsurface flow, impassable culverts.

3. "Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations."

The following ratings were used:

Due to the disparity of channel processes and responses to disturbances between source and response reaches, two rating systems are employed— one for source reaches and one for response reaches.

For transport reaches:

NOTE: The rating system focuses on large wood, as large wood was observed as the key component determining channel conditions. Conversely, bank scour and channel widening were not used to rate channel conditions due to the inherent stability of the streambed and channel banks; channel bed and banks are composed of large substrate and, therefore, are resistant to change from management disturbances. (Please see channel processes -transport reaches assessment).

Good: Large roughness elements (LWD) are present and provide sufficient structure to create a step-pool system. Average pool spacing is two to four channel widths. Instream processes of scour and deposition are maintaining a balance between pool formation and gravel deposition. Instream cover and complexity are relatively unchanged from reference conditions.

Fair: Segments of riparian vegetation harvested, reducing large wood debris recruitment, leading to reduced instream wood. Channel morphology indicates a reduction in pool forming processes; pool spacing averages 5-10 channel widths. Instream complexity and cover are reduced from reference conditions.

Poor: A majority (>60%) of the riparian zone along the channel has been harvested, leading to a system-wide reduction in instream LWD. Channel morphology is dominated by shallow riffles with very little instream complexity and cover.

For response channels and lakes:
Response reaches were field visited to determine condition

Good: Shorelines of lakes and ponds, streambank, channel conditions, channel migration, observed LWD concentrations, stream bottom configuration, upper bank and inner gorge conditions resemble natural (historic) conditions.

Fair: Shorelines of lakes and ponds display moderate increases in erosion due to management influences. Moderate alterations in streambank and channel conditions, channel migration, stream bottom configuration, upper bank and inner gorge areas when compared to historic conditions.

Poor: Shorelines of lakes and ponds display numerous signs of increased erosion due to management influences. Significant alterations in streambank and channel conditions, channel migration, stream bottom configuration, upper bank and inner gorge areas when compared to historic conditions.

4. "Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities."

   The following ratings were used:

   Good: Stream temperatures 12°C - 14°C
   Fair: Stream temperatures 14.1°C - 15.9°C
   Poor: Stream temperatures 16°C+

5. "Maintain and restore the sediment regime under which aquatic ecosystems evolved. Element of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport."

   The following ratings were used:

   Good: The timing, volume, and rate of sediment delivery to streams is similar to historic conditions.

   Fair: The timing, volume, and rate of sediment delivery to streams has been moderately altered due to management activities.

   Poor: The timing, volume, and rate of sediment delivery to streams has been significantly altered throughout the basin area due to management activities.

6. "Maintain and restore in-stream flow sufficient to create and sustain riparian, aquatic, and wetland habitats and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected."

Due to vegetative data gaps, ARP and WAR values were not calculated. Rather, the criteria rating for potential changes to the flow regime is based on current federal land vegetative condition and ocular estimations of vegetative condition on private lands. Road acreage for both federal and private lands are incorporated. (Refer to hydrology assessment and table 9 for method and calculated Equivalent Clearcut Acres)

The following ratings were used:

Good: Less than 20% of the watershed is in Equivalent Clearcut Condition (ECA).
Fair: Between 20% and 30% of the watershed is in ECA condition.
Poor: Greater than 30% of the watershed is in ECA condition.

7. "Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands."

The following ratings were used:

Good: Natural and undisturbed floodplain and wetland conditions.
Fair: Moderate disturbance to wetlands, water tables, and channel conditions as a result of management activities.
Poor: Moderate to high disturbance of wetlands, water tables, and channel conditions as a result of management activities.

8. "Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and supply amounts and distributions of coarse woody debris sufficient to sustain physical complexity and stability."

9. "Maintain and restore habitat to support well-distributed populations of native plant, invertebrate, and vertebrate riparian-dependent species."

Subwatershed	21A	Little Creek	58% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	H	Road density is 2.7 mi/mi^2; ~40% of drainage Clearcut resulting in scouring of numerous intermittent channels
2) Connectivity between watersheds	G	H	Less than 1% of riparian zone roaded. Zero stream crossings.
3) Integrity of aquatic systems	F	M	**Transport channel**: LWD potential on Federal land is good with 60% of rip. Zone in large tree structure. 20% of stream length on private harvested. No scouring observed.
4) Water quality for healthy ecosystems	G	L	No data but based on Murray Pacific (MP) data, riparian canopy and confinement, water temperatures are assumed healthy.
5) Appropriate sediment regime	F	M	Road mileage is 2.7. 10 slides observed in basin. High transport capacities remove sediment from channels.
6) In stream flow	F	M	Equivalent Clearcut Acres (ECA) 2% on federal land. ~ 30% basin clearcut on Private land. Entire watershed in Transient Snow Zone (TSZ).
7) Floodplain Function	NA	NA	Entire drainage highly confined- no floodplain
8) Structural diversity of plant communities riparian reserves	F	H	60% of Federal lands in large tree. Sections in private land in grass pole structural stage.
9) Habitat to support well distributed populations of riparian species	F	H	Connectivity is dissected through private land but high on federal land.

Subwatershed	21B	Side Wall Tributary to Tilton	0% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**

*500 acre watershed flowing east into the Tilton. No data available in this drainage. Contains no federal land.

Subwatershed	21C	Bear Canyon	14% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	L	Road information is lacking in lower watershed. Based on past harvest levels, review of aerial photography, and extrapolating from known sites, several intermittent streams have scoured.
2) Connectivity between watersheds	G	M	Less than 2 percent of the riparian zone is roaded, although road information is lacking. HWY 508 is the only road crossing on the mainstem.
3) Integrity of aquatic systems	F	L	Overstory of trees along mainstem have been removed- it is assumed that the drainage lacks LWD. Channel appears to have widened following harvest and is now recovering
4) Water quality for healthy ecosystems	G	M	Entire drainage has a dense canopy of hardwoods. Also inner gorge provides geologic canopy.
5) Appropriate sediment regime	P	H	Nearly 70% of basin has been clearcut. Thirteen small slides have been located. There are over 60 miles of Rds.
6) In stream flow	P	L	Nearly 70% of the Basin has been clearcut on private lands. On federal lands, 14% of the watershed is in ECA condition. Temporally, there has been an altered flow regime. It is not certain at this point the level of alteration as many units on private land show full recovery.
7) Floodplain Function	NA		The channel is highly confined and floodplain are generally absent.
8) Structural diversity of plant communities riparian reserves	P	M	Aerial photography shows hardwood domination along the mainstem. This follows harvesting of the riparian zone. But the historic distribution of conifers along the channel is unknown.
9) Habitat to support well distributed populations of riparian species	P	L	Connectivity of hardwoods is good. Historic distribution of hardwoods/conifers not known. Few large trees along channels.

Subwatershed	21D	Wallanding Creek	80% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	H	Road density is 5.8 mi-rds/mi^2
2) Connectivity between watersheds	F	H	1% of the riparian zone is roaded. Two stream crossings Rds. 7307 and 024 cross the drainage reducing connectivity but not eliminating it.
3) Integrity of aquatic systems	P	H	**Transport reach:** Poor rating due to lack of LWD and LWD potential in several reaches. Correspondingly, there is a lack of pool formation. Channel integrity is rated good in lower reach where rip. zones contributing LWD which is creating scour pools.
4) Water quality for healthy ecosystems	P	M	No data is available but channel is moderately confined (geology provides little canopy) and riparian buffers are lacking. There is a high potential for water temperatures above historic. Water temps probably decrease through the lower reach due to closed canopy.
5) Appropriate sediment regime	P	H	There are 5.8 mi-rds/mi^2. Approximately 60% of the watershed has been clearcut. Both are increasing surface erosion.
6) In stream flow	F	M	High road densities (5.8 mi/mi^2) and past clearcuts created a very high potential for altered flow regime. However, most harvest units are in the 21-40 year age class and considered hydrologically recovered. ECA is 12%. Majority of the watershed is in the TSZ.
7) Floodplain Function	P	M	Rd. 7307 crosses Wallanding Creek in a low gradient marsh environment. Road surface is capturing ground water and routing down road. Floodplain and riparian areas both upstream and downstream of the crossing fully inundated, indicating nominal effect due to road crossing. Entire upper basin harvested in low gradient-unconfined reach, high potential that the floodplain and wetlands have increased inundation periods.
8) Structural diversity of plant communities riparian reserves	P	H	24% of the riparian zone maintains large tree structure. Low gradient reach in upper basin harvested, removing overstory vegetation structure.

Subwatershed	21D	Wallanding Creek	80% NF
9) Habitat to support well distributed populations of riparian species	P	M	Only 24% of the riparian zone is in large tree. Entire upper reach harvested reducing connectivity and distribution of large tree structure.

West Fork Tilton Subwatershed 21E			18% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	H	Road density is 3.6 mi/mi^2. There are 16 road crossings. High harvest levels create high potential for debris flows in first order channels.
2) Connectivity between watersheds	D		
3) Integrity of aquatic systems	D		
4) Water quality for healthy ecosystems	G	H	Water quality conditions are rated good. Stream temps. Exceeded 16°C briefly in July. **MP**
5) Appropriate sediment regime	D		
6) In stream flow	P	L	10% of federal lands in ECA conditions. Past harvest on private land likely led to altered flow regime, but present vegetative recovery is not known. Majority of watershed in TSZ.
7) Floodplain Function	G	L	Riparian shade rated high for a discrete channel reach, otherwise unknown. **MP**
8) Structural diversity of plant communities riparian reserves	D		
9) Habitat to support well distributed populations of riparian species	D		

Subwatershed	21F	Coon Creek	16% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	G	Road density is 4.9 mi/mi^2.
2) Connectivity between watersheds	G	M	Only one rd. (7002) crosses Coon Creek near the headwaters.
3) Integrity of aquatic systems	F	L	**Transport reach:** Based on past harvest to riparian zones on private lands, lack of LWD likely.
4) Water quality for healthy ecosystems	G	M	Channels have full canopy of hardwoods. Channel is confined providing geologic canopy.
5) Appropriate sediment regime	F	M	Entire upper basin harvested. Several slides noted on aerial photographs. Many have healed. Rd. density is 4.9 mi/mi^2
6) In stream flow	F	M	8% of federal land in ECA conditions. Past harvesting on private land had high potential to increase peak flows. However, most units have hydrologically recovered.
7) Floodplain Function	NA		Drainage is highly confined- no floodplain
8) Structural diversity of plant communities riparian reserves	P	M	Nearly entire channel length, rip. zone dominated by hardwoods. Historic conditions are not known.
9) Habitat to support well distributed populations of riparian species	P	M	Hardwood species currently dominate riparian species following harvest of conifers.

(For 21G all data from Murray Pacific Watershed Analysis 1993)

Subwatershed	**21G**	**Connelly Creek**	**17% NF**
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	H	Several debris slides in first order channels.
2) Connectivity between watersheds	P	H	Nearly two-thirds of culverts obstructed.
3) Integrity of aquatic systems	F	H	**Transport reach**: Reduction in LWD has reduced pool frequency.
4) Water quality for healthy ecosystems	F	M	Maximum stream temps. are not adversely affecting trout but state standards are exceeded.
5) Appropriate sediment regime	P	H	~ 30 mass wasting features identified.
6) In stream flow	F	H	On average peak flows increased approximately 10%; municipal water supply for the town of Morton.
7) Floodplain Function	D		
8) Structural diversity of plant communities riparian reserves	P	H	>50% of riparian stands have a low LWD potential for private and federal.
9) Habitat to support well distributed populations of riparian species	P	H	>50% of riparian stands have converted from conifer to hardwood species

Subwatershed	21I	Upper Side Wall Tributary	15% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	H	Road density is 3.6 mi/mi^2.
2) Connectivity between watersheds	F	M	All face drainages into the Tilton Mainstem are crossed by primary road systems. Development in Morton reduces connectivity to the Tilton.
3) Integrity of aquatic systems	NA		Channels system is 1st and 2nd order intermittent channels
4) Water quality for healthy ecosystems	D		
5) Appropriate sediment regime	P	M	Outside Federal land entire basin has been harvested, roads and housing development likely increased sedimentations
6) In stream flow	P	L	12% of Federal land in ECA condition. Outside Federal land entire basin has been harvested ~ 80%.
7) Floodplain Function	NA		Floodplain acres are in the mainstem Tilton. To analyze requires separate assessment.
8) Structural diversity of plant communities riparian reserves	F	M	harvesting in upper drainage reduced large tree. 66% of National Forest lands maintains large tree structure. In lower portions development cleared riparian veg.
9) Habitat to support well distributed populations of riparian species	P	M	Clearing of riparian vegetation in both the upper and lower drainages reduced vegetation complexity.

Subwatershed	21J	Lower Side Wall Tributary	0% NF
Management Objectives	**Rating**	**Confidence**	**Rationale**

*Subwatershed 21 J is entirely in private ownership with ~80% of drainage outside NF boundaries - **No data available**

Subwatershed	21K	Lower N.F. Tilton	43% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	H	Road density is 4.6 mi/mi^2.
2) Connectivity between watersheds	P	H	Main roads along either side of the NF cross every tributary flowing into the N F near the floodplain. Several road crossings in upper watershed.
3) Integrity of aquatic systems	F	M	**Response reach:** Mainstem lacking structure and complexity. Riffle dominated with little deep pool habitat. Field observations indicate bank scouring and associated channel widening.
4) Water quality for healthy ecosystems	F	L	No data but due to unconfined nature of channel, temperatures are likely to exceed 16°C. Riparian zones have been harvested adding to the potential to increased temps.
5) Appropriate sediment regime	P	H	Ten landslides have been identified. Four are directly contributing sediment into Tilton. Three slides identified in Fisher Creek. Road density (4.6 mi/mi^2) increasing sediment into creek.
6) In stream flow	F	M	Small fully harvested side wall drainages have high potential for alterations in flow. Difficult to say for mainstem as it is a function of all subwatersheds upstream.
7) Floodplain Function	G	M	One road crossing along mainstem. Tributaries are confined and lack floodplain development.
8) Structural diversity of plant communities riparian reserves	P	H	Nearly entire riparian zone harvested along NF Tilton. Simplified Vegetation structure. Very Little LWD potential.
9) Habitat to support well distributed populations of riparian species	P	H	Harvesting has reduced vegetation diversity in private ownership along mainstem. Roads run the entire riparian corridor.

Subwatershed	21L	Tumble Creek	91% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	H	Road density is 3.3 mi/mi^2. > 80% of basin clearcut. Both have contributed to debris flows in 1st and 2nd order channels.
2) Connectivity between watersheds	F	M	No road crossings along mainstem. Several road-channel crossings washed out improving connectivity.
3) Integrity of aquatic systems	P	H	**Transport reach:** Stream channel clearing and harvest in riparian zones greatly reduced in-channel LWD.
4) Water quality for healthy ecosystems	G	H	A single year sampling indicated that 5 days exceeded 16°C. Tumble Creek restoration assessment rated stream temperatures as "good"
5) Appropriate sediment regime	P	H	More than 80 mass wasting features have been identified.
6) In stream flow	P	M	~ 36% of the basin is in ECA condition. Nearly the entire drainage is in the TSZ. Reduced road density and recovery of past harvest reducing management effects to peak flow.
7) Floodplain Function	G	M	Due to confined channel little floodplain exists. There are no stream crossings along mainstem.
8) Structural diversity of plant communities riparian reserves	P	H	100% of riparian zone harvested
9) Habitat to support well distributed populations of riparian species	P	H	6% of riparian zones in large tree structure.

Subwatershed	21N	Winnie Creek	43% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	H	Road density is 5.3 mi/mi^2. First and second order channels scoured in clearcut areas.
2) Connectivity between watersheds	F	M	Three road crossings along mainstem. ~1% of riparian zone roaded.
3) Integrity of aquatic systems	P	H	**Transport reach:** Riparian zones along 80% of the channel harvested, LWD correspondingly has been reduced. From Aerial photos channel has scoured and widened.
4) Water quality for healthy ecosystems	F	M	Riparian canopy has opened increasing solar radiation input, but channel is confined which provides geologic canopy.
5) Appropriate sediment regime	P	H	High road density (5.3 mi/mi^2) has increased sedimentation. Ten road related slides identified in Winnie.
6) In stream flow	P	M	14% of federal lands in ECA condition. ~ 30% of private lands clearcut in late 1980's. Road density is 5.3 mi/mi^2.
7) Floodplain Function	P	H	Limited floodplain due to confined geomorphology. But channel has scoured and widened reducing floodplain function.
8) Structural diversity of plant communities riparian reserves	P	H	56% of federal lands in large tree structure. Approximately 80% of riparian zone harvested along mainstem. Lower reach of Winnie maintains high LWD potential
9) Habitat to support well distributed populations of riparian species	P	H	Large tree structure greatly reduced reducing connectivity and mature habitat.

Subwatershed	21P	Jesse Creek	38% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	H	Road density is 4.5 mi/mi^2. Entire upper watershed harvested resulting in debris flows in 1st and 2nd order channels
2) Connectivity between watersheds	F	M	Mainstem free of road crossings. Upper watershed roads cross tributaries.
3) Integrity of aquatic systems	P	H	Large earth flow observed on private land in section 5. Flow scoured entire channel length.
4) Water quality for healthy ecosystems	F	L	No data exists but based on confinement and temperature findings elsewhere in the assessment area, elevated stream temperatures are not expected
5) Appropriate sediment regime	P	H	Seven slides and a large earth flow identified in basin. High road density.
6) In stream flow	P	M	26% of federal land in ECA condition. ~ 30% of private land clearcut.
7) Floodplain Function	P	H	There is limited floodplain development due to confined geomorphology. However, stream margins have scoured.
8) Structural diversity of plant communities riparian reserves	P	H	42% of federal lands in large tree structure. ~30% of riparian zones along mainstem clearcut on private land.
9) Habitat to support well distributed populations of riparian species	P	H	Past harvesting has reduced large tree structure decreasing connectivity and complexity.

Subwatershed	21Q	Otter Creek	45% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	H	Road density is 4.5 mi/mi^2. Headwater area harvested resulting in debris flows in 1st and 2nd order channels
2) Connectivity between watersheds	G	M	There is one road crossing along the mainstem
3) Integrity of aquatic systems	F	H	**Transport reach:** On private lands no LWD observed. Morphology dominated by low gradient riffles. FS land maintains high LWD potential and is assumed to have good LWD loading into channel for pool formation. 50% FS land along creek.
4) Water quality for healthy ecosystems	G	L	No data exists but based on confinement and temperature findings elsewhere in the assessment area, elevated stream temperatures are not expected
5) Appropriate sediment regime	P	H	11 slides in basin were identified, 6 are contributing sediment directly into creek. High road density of 4.5 mi/mi^2.
6) In stream flow	P	M	21% of federal lands in ECA condition. Entire headwaters harvested. ~ 30% of private lands clearcut. High road density.
7) Floodplain Function	F	M	Near mouth road crossing North Fork alters flood flow in Otter.
8) Structural diversity of plant communities riparian reserves	P	H	42% of federal lands in large tree structure. On private lands ~40% of channel harvested.
9) Habitat to support well distributed populations of riparian species	P	H	Harvesting decreased connectivity and reduced complexity.

Subwatershed	21R	Middle N. Fork Tilton	54% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	M	Road density is 3.2 mi/mi². ~40% basin clearcut. Intermittent channels on west slope have scoured to bedrock.
2) Connectivity between watersheds	F	H	1% of riparian zone roaded. Road 73 crossing is constricting floodplain.
3) Integrity of aquatic systems	P	H	**Response reach:** Riparian zone harvested along ~40% of channel. LWD potential is low. No wood observed in channel. Field observations indicate bank scouring and associated channel widening.
4) Water quality for healthy ecosystems	F	L	No temperature data available but ~40% of channel length lacks canopy cover and channel is moderately confined exposing stream surface to solar radiation. Elevated temps. are probable.
5) Appropriate sediment regime	P	H	Road Density is 3.2 mi/mi². Eight debris flows were observed in 1st order channels. Roads and clearcuts in Rockies Creek contributing sediment.
6) In stream flow	P	H	12% of federal land in ECA condition. ~40% of subwatershed in clearcut condition on private land. Entire basin in the TSZ.
7) Floodplain Function	F	M	1% of floodplain roaded. Interruption of floodplain inundation below Rd. 73.
8) Structural diversity of plant communities riparian reserves	P	H	53% of riparian buffer on federal land maintains large tree structure. ~ 60% of channel length has small (50 ft.) buffer on private land.
9) Habitat to support well distributed populations of riparian species	F	M	~ 60% of channel length with very little riparian development.

Subwatershed	21S	Snow Creek	9% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	M	Road density is 4.3 mi/mi^2.
2) Connectivity between watersheds	F	M	There are two road crossings in Snow Creek
3) Integrity of aquatic systems	P	M	**Transport reach:** Nearly 100 percent of the riparian zone along the mainstem has been harvested. Based on correlation between LWD potential and pool formation it is assumed that instream LWD to form pools is lacking.
4) Water quality for healthy ecosystems	G	M	Hardwoods provide full channel canopy. Riparian shade is rated high and only one day in 1994 exceeded 16°C. **MP**
5) Appropriate sediment regime	D		
6) In stream flow	D		
7) Floodplain Function	D		
8) Structural diversity of plant communities riparian reserves	P	M	Due to harvest riparian corridors dominated by hardwoods. Very little large tree structure.
9) Habitat to support well distributed populations of riparian species	P	M	Large tree connectivity and diversity reduced throughout channel system due to harvest.

Subwatershed	21T	Trout Creek	27% NF
Management Objectives	**Rating**	**Confidence**	**Rationale for Rating**
1) Existence of aquatic features at landscape scale	P	H	Road density is 3.9 mi/mi^2.
2) Connectivity between watersheds	G	M	There is 1 road crossing the mainstem. 1% of Riparian areas in roaded condition.
3) Integrity of aquatic systems	F	M	**Transport reach:** Data on channel conditions lacking, but based on the correlation between riparian large tree structure and aquatic condition; conditions are assumed fair.
4) Water quality for healthy ecosystems	G	M	Hardwoods provide full channel canopy. Riparian shade is rated high and only one day in 1994 exceeded 16°C. **MP**
5) Appropriate sediment regime	F	L	No data but review of 1993 aerial photos indicates very little slope instability. There are few roads along creeks in Trout and Eagle that have potential to directly deliver sediment.
6) In stream flow	G	M	Two percent of federal lands is in ECA condition. Small patch cuts observed on private lands.
7) Floodplain Function	NA		Floodplains are very limited in this basin due to confinement.
8) Structural diversity of plant communities riparian reserves	F	M	Riparian harvest in lower reach and in Eagle creek reduced large tree structure and connectivity.
9) Habitat to support well distributed populations of riparian species	F	M	High percentage of large tree structure along Trout Creek. Connectivity is interrupted in a few locations in lower reach.

7. RECOMMENDATIONS TO MANAGEMENT

7.1 INTRODUCTION

This section identifies management opportunities, restoration recommendations, and information needs to improve future forest and aquatic conditions in the Tilton watershed. The primary focus of the Team was the desired future conditions for terrestrial and aquatic ecosystems and management options that may be used to reach these conditions. Because the Tilton watershed is entirely within the Mineral LSR, the guidelines for desired conditions for the terrestrial ecosystem were guided by the ROD Standards and Guidelines (1994) and the Gifford Pinchot National Forest Draft Forestwide Late-Successional Reserve Assessment (1997). Goals for the aquatic ecosystem were driven by the Aquatic Conservation Strategy.

Recommendations, in some cases, are not consistent with the ROD's standards and guidelines. This watershed analysis, consistent with the LSR Assessment (1997), recognized the need for silvicultural treatments in stands older than 80 years. Although these stands exceed the maximum age for stand manipulation activities stated in the ROD, the team felt that some treatment would improve stand structure and resulting wildlife habitat. These recommendations are important because wildlife generally respond to ecological characteristics, not stand age (Hayes et. al. 1997).

Management recommendations are based on resources needs, and therefore, organized by resource.

7.2 TERRESTRIAL ECOSYSTEM

The objective of the Late-Successional Reserve is to protect and enhance large blocks of late-successional and old-growth forest ecosystems which provide habitat for species associated with these forest systems (LSR Assessment 1997). The objective of the following recommendations are to accelerate the growth and development of early through mid-seral stands into late successional stands. The following opportunities were identified during the analysis; however, they do not represent the only opportunities. Through project level planning the agencies and owners may find additional project areas and prescritions.

7.2.1 Treatment Guidelines

General forest is defined as grass/pole, small tree, and large tree stands in the Tilton watershed that do not have a special management designation (i.e., BWR or riparian reserve). Silviculture treatments are designed to encourage the initiation of structural diversity, maximize individual tree development, and encourage some understory vegetation development.

Thinning densely stocked young stands can accelerate the development of late successional structure (Hayes, et. al. 1997). A stand can be pre-commercially thinned as early as age 10, after individual trees have started expressing dominance. Commercial thinning of older stands, starting roughly at age 40, can also hasten large tree development. There is a tradeoff in the benefits of stocking control at a young age versus an older age. Younger stands respond more quickly to thinning than older stands because of rapid individual tree growth rates. Thinning young stands also encourages large crowns. On the other hand, a thinned older stand can reach old growth characteristics sooner than a younger stand.

Pre-commercial and Commercial Thinning—The following treatment guidelines are based on recommendations in the LSR Assessment (1997) and apply to small tree and grass/pole stands. Thinning should be designed to leave:

- 10 percent or more of the resultant stand in unthinned patches
- 3 to 10 percent of the resultant stand in openings roughly 1/4 to ½ acre in size
- 3 to 10 percent of the resultant stand in heavily thinned patches, of less than 50 trees per acre
- the remaining 65 to 70 percent of the area should be thinned to a spacing considered appropriate for future management objectives

Typical pre-commercial thinning spacings would range from 110 to 360 trees per acre. For commercial thinning, leaving post-thinning tree stocking with a relative density of 35 will maximize growth on residual trees while allowing for future suppression mortality. Such mortality will yield future snags and down wood.

Thinnings should also be designed to maintain or increase existing species diversity. For example, minor species, such as western redcedar, in a stand should be left uncut. Existing microsites of low stocking, hardwood patches and natural openings should be maintained.

Structural Enhancement—Snags may be created by various methods: the most desirable methods include introducing heart rot organisms and blasting tops off of live trees with explosives. Girdling is less desirable because girdled trees tend to shear off where girdled.

Down logs can be created by falling or blasting live trees. As snags are likely limiting in most stands, they are not a viable option for felling. Blasting of live trees is most desirable as it creates a ragged edge for more rapid decomposition.

Canopy gaps should average about 30 feet wide with a maximum width of 60 feet. A maximum of 15 percent of each stand should be in these canopy gaps.

Understory plantings of shade-tolerant trees will accelerate multiple canopy layers. Such plantings should take advantage of increased light levels where snags or down wood have been created.

7.2.2 Treatment Opportunities

Management opportunities for stand treatment in the Tilton watershed are constrained by the checkerboard ownership pattern and existing structural stages. Recommended treatments to expedite late successional habitat are listed by priority— Older small tree stands, younger small tree stands and grass pole stands. Constraints on their implementation are discussed.

Older Small Tree— Older small tree stands are those stands in the small tree structural stage that originated from the 1825 stand replacement fire. Two stand ages are identified in the older small tree category: 120+ and 81-120 year old stands. These stands are small in diameter, relatively even-aged, and lack vertical diversity, primarily because of high stocking levels. It is recognized that the ROD Standards and Guidelines restrict activities in stands older than 80 years. However, the Team believes this group of stands is the best opportunity for near term attainment of late successional habitat.

To increase the quality and quantity of existing late successional habitat blocks, priorities would be to commercially thin small tree stands adjacent to existing blocks of large tree forests with old growth characteristics. Commercially thinning these small tree stands, within and adjacent to, large tree stands is intended to develop late successional corridors and increase interior old growth blocks. Identified opportunities in the 81-120 age class are: (Refer to Figures 9&10)

- Section 36 of Wallanding Creek (21D&R)
- Section 26 of Little Creek (21A)
- Section 4 of Jesse Creek (21P)

These lands have the least amount of old forest fragmentation in the watershed. Further, the landscape in Little Creek benefits from corridors of large tree forest in the major drainages, including most of the headwaters.

Identified commercial thinning opportunities in the 120+ age class exhibiting small tree structure are:

- Section 22 of Little Creek (21A)
- Section 36 of Rockies Creek (21R)
- Section 10 of Otter Creek (21Q)

Note: Treatments in section 26 of Little Creek and 36 of Rockies would develop a Corridor into future late successional habitat in Wallanding Basin.

Younger Small Tree— Younger small tree stands are those stands in the small tree structural stage with origins 41-80 years ago. As with the older small tree stands, the best opportunity to increase current late successional habitat blocks is thinning units adjacent to large tree blocks. Identified thinning opportunity to increase existing large tree blocks is Section 16 of Connelly Creek within subwatershed 21G.

This section of National Forest land could serve as a corridor from Murray Pacific land (to the east) into the future late successional block in the Wallanding and Tumble Creek subwatersheds. Additional opportunities are:

- Section 4 of Snow Creek (21S)
- Section 26 of Trout Creek (21T)

Large Tree—Nearly all large tree stands in the Tilton watershed are designated as spotted owl habitat. These large tree stands are greater than 80 years old and are the result of regrowth after the 1825 stand replacement fire. Tree size in these stands is approaching late-successional conditions, so thinning is not warranted. However, structural diversity is lacking. In order to improve current and future conditions in these stands, the Team recommends that canopy openings be created to increase canopy layering. This treatment will encourage growth of understory plants that will provide cover for ground nesting birds and some species of small mammals, as well as foraging opportunities for ungulates.

Due to a lack of survey data, it is uncertain whether large tree stands meet the LSR Assessment (1997) recommendations for snags and down wood. If surveys find snags and down wood lacking in large tree stands, the Team recommends treatments to improve these characteristics. However, the cutting of green trees to create down wood or canopy openings, and girdling or topping green trees, to create snags should only be implemented if the stands have sufficient live trees to meet required levels of large overstory trees described in the LSR Assessment (1997).

Grass/Pole —The third priority is to pre-commercially thin the large blocks of young, densely vegetated grass/pole stands that will develop into future large tree / late successional forest habitat. ORGANON growth models show diameter growth of trees in heavily thinned stands to be almost double that of trees in unthinned stands (Hayes, et. al. 1997).

The large block of grass/pole forest in the Wallanding and Tumble Creek drainages presents the best opportunity for treatment. The Team recommends concentrating these treatment efforts in the oldest stands–11 to 20 years old. These stands should be targeted first because they are reaching the upper diameter limits suitable for pre-commercial thinning.

7.2.3 Biological Winter Range (BWR)

Recommendations for stand treatment in those areas identified as BWR follow thinning guidelines in the LSR Assessment (1997) for the general forest with a few modifications. BWR areas identified on figure 11. Since current forest conditions in the Tilton BWR meet the optimal cover requirements, stand management for BWR is catered to the foraging requirements of deer and elk keeping in mind the future decreasing trend in available foraging areas. Management recommendations for BWR are listed below. Those BWR criteria in bold are deviations from the general forest treatment and are designed to create foraging areas for deer and elk.

- **10 percent in openings of 1 to 3 acres**
- 3 to 10 percent in heavily thinned condition (less than 50 trees/acre)
- **65 to 75 percent thinned to 110 trees/acre**
- 10 to 15 percent left untreated

The reason for increasing the size of openings is to create a sustained open canopy for forage production. Similarly, thinning to the low range of the existing standards and guidelines of 110-360 trees per acre would increase foraging opportunities for big game. Implementing the recommendations listed above will maintain optimal cover.

Management thinning activities in the next ten years (year 0-10) to enhance forage production should focus in the 11-20 year old age class. Management activities in year 11-20 should focus in stands currently 0-10 years old, as current 0-10 year old stands will progress into the 11-20 year old stands. Thinning in stands of age 0-10 would result in minor increases in foraging opportunities. Beyond year 20, quantity and quality of forage habitat needs to be re-evaluated before further treatments are recommended.

7.2.4 Roads

The Gifford Pinchot Access and Travel Management Plan (ATMP) identifies roads in the Tilton watershed proposed for closure or decommissioning. Throughout the forest, road closures will help reduce fragmentation and increase connectivity of terrestrial habitat. The area of highest priority for road decommissioning for wildlife resources is in the BWR. To optimize road decommissioning benefits, rip the road surface and seed with palatable native forage; additional foraging areas will be created for big game.

7.3 RIPARIAN ECOSYSTEM

Recommendations for riparian zone width are shown in Figure 6 - structural stages within riparian buffers. The team recommends following the guidelines listed in the ROD, unless modified by site specific planning:

- Two site potential trees (340 ft. Slope distance) for class I and II streams, and for natural lakes and ponds.
- One site potential trees (170 ft. Slope distance) for class III and IV streams.

For drainage features not meeting the definition of seasonally-flowing or intermittent streams defined in the ROD, the team recommends applying a 25 foot buffer zone on either side. Although riparian vegetation is lacking in these areas, maintaining unimpeded water flow during high runoff periods is important for hydrologic function. Specifically, protection buffers could be considered geomorphic reserves, as these areas have a high potential to initiate debris flows. Locations of ephemeral drainages are not mapped and will need to be identified during project planning.

7.3.1 Opportunities in Riparian Reserves

The biggest concern within the riparian zone is the lack of large tree structure. The lack of large tree structure is not, and is not expected to in the near term, provide adequate large wood recruitment into the channel environment. Lack of large tree structure has also reduced habitat connectivity and species diversity. The ROD describes acceptable management opportunities within riparian reserves, stating "Apply silvicultural practices for Riparian Reserves to control stocking, reestablish and manage stands, and acquire desired vegetation characteristics needed to attain Aquatic Conservation Strategy objectives."

From a sixth field watershed perspective, riparian reserves lack large tree development and, correspondingly, in-channel large woody debris is reduced. These conditions prevent the attainment of ACS objectives # 3, 8, and 9— Physical integrity of the channel environment; structural diversity of plant communities; and habitat to support well-distributed population of species.

To improve riparian functions, thinning in grass/pole or small tree structural stands (see figure 6) is recommended. The intent is to expedite the development of large tree structure through silvicultural treatments.

In developing management guidelines within riparian reserves, the following site characteristics should be considered during project level planning.

- Sensitivity of hillslope to erosion and mass wasting. Identify hillslope angle of repose, soil erosivity and productivity characteristics; and local drainage characteristics, i.e. convex or concave slope orientation.
- Potential fluvial erosion. Identify the location of the management activity relative to the high flow stage ~ 5-25 yr return interval.
- Instream beneficial uses and their sensitivity to disturbance. Identify the location and timing of beneficial uses.
- Habitat for riparian dependent species. Identify habitat characteristics at project site and along the entire riparian corridor.

Limitations

Effectiveness of thinning prescriptions in riparian zones to attain ACS objectives is limited by private ownership. Streamside conditions on private land have a significant influence on channel conditions. Consequently, federal actions in riparian reserves within watersheds containing greater than 60% private ownership are not likely to achieve desired future aquatic conditions. In these subwatersheds, efforts by private landowners are required to obtain desired future conditions. Otherwise, channel segments will alternate between good and poor conditions.

Considering the ownership limitations, the best opportunity to improve riparian functions and aquatic conditions at a basin level is in the Wallanding and Tumble watersheds.

Wallanding: Gradient is moderate in the upper reaches of Wallanding. At this location, potential sedimentation from hillslopes is reduced compared to the higher gradient reaches downstream. The upper reach of Wallanding has a unique geomorphology for the Tilton Assessment area; it is unconfined. Unconfinement allows for wetland development within the floodplain. This presents an opportunity to create large tree structure adjacent to upland wetland habitat that is otherwise absent at the 5th field watershed level.

Tumble: In channel LWD and associated pool habitat is absent from the system. Furthermore, riparian reserves lack large tree structure for the entire channel length. However, the reach below the confluence with Wallanding is inner gorge geomorphology. Thinning in the lower reach is not recommended for stability concerns in the steep inner gorge.

7.4 AQUATIC ECOSYSTEM

This section describes management recommendations intended to improve aquatic conditions. Recommendations focus on surface runoff, erosion, and instream structure.

To improve hydrologic function, focus road decommissioning/obliteration in hydrological sensitive areas. Identified hydrologic sensitive areas are the first five sixth field watersheds listed in table 9. Combining past harvest activity with road mileage, these locations have the highest probability of an altered flow regime. Target road densities to the range of 2-3 miles of road per square mile of watershed. High priority locations are roads or sections of roads that increase the drainage network. Locations are typically long sections of road without culvert relief that drain into existing channels; or in areas where a series of roads cross the same drainage.

Reducing road densities will also reduce erosion. With a reduction in road miles, frequency of road fill failures and stream crossing failures is expected to decrease. In addition to the general road recommendation, several roads have been identified as the mechanism for mass wasting features. Appendix C lists the roads identified. These are considered significant non-point sedimentation sources. Two criteria were used to develop the road list —if the road caused two or more mass wasting events, or if roads failed during the 1996 storm event. Landslides originating from the 1996 storms were field visited and stabilization measures designed. These slides are denoted in Appendix C with a slide ID number. Site assessments and recommendations are included in attachment A.

Instream structure is lacking in all observed channels. Sections of channel within federal ownership with large tree riparian vegetation structure are the exceptions (see Figure 6). Considering the mixed ownership, the best opportunity to improve aquatic habitat condition exists in the Wallanding and Tumble Creeks basin.

Both the Wallanding and Tumble Creeks lack instream structure. Additionally, large wood debris recruitment potential is rated low. As a result, instream structure and associated habitat complexity will be lacking for long periods of time. Therefore, to improve aquatic habitat, in-channel placement of large native materials is recommended. Native materials include large substrate and wood debris. General guidelines for implementation include:

- Substrate greater than 36" should be used—a size sufficient to remain stable during high flows
- Alignment of substrate should follow a vortex rock weir (a V-shaped orientation pointing upstream).

- Center rock needs to be keyed into channel bottom with the top elevation just below baseflow elevation.
- Each subsequent upstream rock needs to be at a slightly higher elevation with the most upstream rocks at or slightly above bankfull elevation. This will act to focus flow velocities toward the channel bed at all flows allowing for continual scour.
- Large wood debris should be greater than 24" in diameter; length should be greater than twice bankfull width.
- Unless a specific objective is identified, anchored placement of wood debris in not recommended.

The lower reach of the North Fork Tilton River is another good opportunity for instream structure enhancement. Habitat enhancement is recommended to encourage anadromous species use in the mainstem of the NF Tilton River. Although information on current anadromous fish use is lacking, quality pool and spawning habitat appears lacking. Velocity refugia during high flows is also lacking. Project implementation will require coordination with private landowners and the State Dept. of Fish and Wildlife.

Design considerations

Bedload volumes are expected to be high due to past hillslope failures, road building and harvesting. In designing instream structures, elevated bedloads need to be considered. Specifically, upstream of log or boulder vortex weirs aggradation is likely, as backwater effects allow for sediment deposition. This can have benefits such as retainment of spawning gravel. On the other hand, aggradation can cause flows to circumvent the structure leading to bank erosion. High bedloads can also prevent the objective of the weir (pool creation) by sediment deposition.

Due to the fact that Wallanding and Tumble creeks are confined to moderately confined with well armored banks, aggradation and backwater effects leading to bank erosion is unlikely. Pool filling is more problematic. Therefore, it is important to maintain a hydraulic elevation head (difference between water surface elevation up and downstream of the structure) sufficient to excavate the bedload sediments from the pool. If implemented, the structure will act as a grade control; the structure will need to be designed to handle not only the forces of flowing water but also the weight of captured sediments.

7.5 INFORMATION NEEDS

Botanical species of concern and recreation were not addressed during the coarse of this analysis. These two resources should be evaluated and detailed during project level planning.

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Appendix A
List of People Consulted

List of people consulted:

EA Engineering Core Team

Mike Mathews	Team Leader/Hydrologist
Alicia Pool	Wildlife
Jay Walters	Silviculture
Michael Maudlin	Geology
Jodene Issacs	GIS coordinator

Forest Service Agency Specialists

Shawn Jones	COR/Geologist
Maggie McHugh	Planning coordinator
Paul Miller	Wildlife
Gary Wright	Silviculture
John Wade	Soil Scientist
John Hawkins	GIS coordinator
Mark Krieter	Hydrologist

Other Agencies

Washington Department of Natural Resources
United States Fish and Wildlife Service

Public/Private

John Squires
Weherhaeuser Corp.
Murray Pacific Corp.

Appendix B
Past Human Uses

Past Human Uses

Tilton River Watershed[1]

Data Sources

Information on past human use of the analysis area was obtained primarily from reference material on file with the Heritage Program, Gifford Pinchot National Forest Headquarters. The general description of prehistoric human use is based upon interpretation of archaeological data from sites in the entire upper Cowlitz River watershed. The characterization of regional trends incorporates temporal and spatial models of prehistoric land use in the Cascades proposed by Greg Burtchard (1990). Supplemental data on Taidnapam bands in the Tilton River watershed were provided by anthropologist Randy Bouchard and are based on his recent study of Melville Jacobs' unpublished field notes at the University of Washington, Seattle. Significant gaps exist in the records available for the historic period, particularly with regard to the history of timber harvest within the National Forest boundary.

Historic Conditions - Prehistoric Land Use Patterns

Early Prehistoric Period: ca. 7,000 to 3,500 years ago

Archaeological evidence from sites in the upper Cowlitz watershed suggests that initial human use of the area began around 7,000 years ago. No prehistoric occupations from this time period have been confirmed within the Tilton River watershed. Use is probable, however, given the proximity of other presumably early sites along the Cowlitz River. Early Period people likely employed foraging subsistence strategies that required frequent shifts in residence and a broad-based economy. During this initial period of human occupation, hunting and gathering would have involved daily forays from camp to obtain food on an "encounter basis". Little use was made of storage technology. As resources close to camps were exhausted, camp locations were moved. Some subsistence activities were probably planned around locally abundant resources. Archaeological data from the upper Cowlitz area have provided little information regarding social or political organization, beliefs, cultural affiliation, or the structure of the settlement system.

Faunal remains from sites dating to this period indicate that deer and anadromous fish were probably the most important sources of food for early peoples. Elk, mountain sheep, snowshoe hare, mountain beaver, and grouse were also hunted or caught during this time period. Archaeobotanical remains from two sites suggest that elderberries and hazelnuts were gathered locally, and huckleberries were also collected by Early Period people. Samples from Layser Cave suggest higher frequencies of xeric flora, such as oak, existed during this period, a trend also apparent in the results of pollen studies conducted in the Tilton River watershed (Barnosky 1981).

Early period people engaged in trade with groups from outside the area. Exotic materials found within the area include clamshell and *Olivella* beads, indicating a trade network with coastal groups. Obsidian toolstone from Oregon sources suggests a southern network of exchange that may have involved contact with lower Cowlitz River, Columbia River, or Portland Basin groups. The distribution of toolstone materials in upper Cowlitz area archaeological sites indicates that some prehistoric bands may have ranged as far east as the crest of the Cascade Range during annual subsistence forays.

Abandonment: ca. 3,500 to 1,500 years ago

Human use within much of the Upper Cowlitz basin appears to have ended abruptly with the onset of Mount St. Helens' Smith Creek Eruptive Phase 3,900 to 3,500 years ago. Lewarch and Benson (1991) suggest that the intensity of volcanism,

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[1] Draft report submitted to EA Engineering, Science, and Technology for Tilton River Watershed Analysis. Prepared by Richard McClure, Gifford Pinchot National Forest, Vancouver, WA - 12/12/97.

including the largest tephra eruptions in the history of the volcano, may have been the initial cause of human abandonment. Environmental degradation resulting from Smith Creek phase eruptions may have included tree defoliation, burial of herb and shrub layer flora by a meter thick deposit of pumice, and intensive sediment loading in streams and rivers (McClure 1992). Effects to the subsistence resources of the native human population were undoubtedly devastating. The sequence of radiocarbon dates shows a hiatus in occupation throughout much of the upper Cowlitz basin that lasted until circa AD 450

In reevaluating potential casual mechanisms which may underlie the hiatus, Kenneth Reid (1993) suggests that we consider the cooling effects of neoglaciation, documented between 3,700 and 2,000 BP (1950 BC to 50 BC). A temporal correlation between glaciation records and volcanism was noted by Loren Davis, in his recent assessment of volcanism and culture change in southern Washington (Davis 1995). Davis acknowledges that direct effects of the Mount St. Helens eruptions were more extensive proximal to the volcano, but hypothesizes that more lasting and widespread *indirect* effects may have resulted from atmospheric loading of sulfuric aerosols during eruptive events.

Tephra studies by Mullineaux (1981) and others demonstrate that the area from Cowlitz Falls to Randle was within the zone of thickest tephra deposition, directly downwind from the eruption. Archaeological sites in the Mineral Block lack the deposits of the Smith Creek (set Y) pumice so common in soil profiles near Randle. One of the prehistoric sites within the Tilton River analysis area produced a radiocarbon date of 2,240 years BP, suggesting that areas peripheral to the heavy tephra fall were probably recolonized by people somewhat earlier than those immediately downwind.

Late Prehistoric Period: ca. 1,500 to 150 years ago

By 300 BC, people were utilizing upland ridges along the watershed divide between the Tilton River and Nisqually River drainages. It is assumed that these people utilized a subsistence strategy quite different than their predecessors. A regional shift toward increased sedentism occurred between 5,000 and 2,500 years ago (Burtchard 1990). Groups that reoccupied the area about 1,500 years ago are thought to have used a strategy incorporating logistically-organized collection, processing, and storage of key resources. These developments may have given rise to the development of semi-permanent winter villages not unlike those used by native groups in the historic period.

Well-preserved faunal remains from several sites within the Upper Cowlitz watershed indicate some of the animal species present in the general area ca. AD 750 to AD 1690. Archaeobotanical studies suggest that plant communities along the Cowlitz River valley bottom during this period were reasonably similar to the modern native vegetation, as Douglas-fir, western red cedar, red alder, cottonwood, salal, Oregon grape, oceanspray, and elderberry are represented in samples of charcoal, seeds and tissue.

Throughout the Northwest, prehistoric populations peaked during this time period. Burtchard (1997) suggests that the density of human populations was reaching environmental carrying capacity. Possible responses were greater emphasis on the collection of more "marginal" resources - those requiring greater energy expenditure for return. Late Period people appear to have exploited a greater variety of environments than had the earlier culture.

The Taidnapam

During the 19th century the Tilton River study area lay within the territory of the Taidnapam, or Upper Cowlitz Indians. These people spoke Northern Sahaptin, a language shared with several groups living east of the Cascade Range. Settlements were scattered along the Cowlitz River and larger tributaries between Mossyrock and Packwood. The total population of Taidnapam circa 1840 was estimated at 350 (Ray 1974) but may have been as high as 1000 before epidemic diseases swept through the area at the onset of the historic period (Ellis et al. 1991).

Individual settlements were the basis of band organization. Village/band populations varied in size from 20 to 75 people. Settlements were comprised of one or more large cedar wood gable-roof houses occupied by multiple family groups. At least two settlements existed in the Tilton River watershed, including the villages of *Lala'lx* and *Wa-sa,* each the nucleus of a local band (Kennedy et al. 1997:174). The band of Taidnapam living at the mouth of the Tilton were known as the *lalalxla'ma*, or "*lala'lx* people" (Jacobs 1934:239), from their name for the Tilton River. The Morton Taidnapam families called themselves *wasala´ma*, and took their band name from *wasa´*, the name for

Davis Lake. Using the average estimated populations of settlements prior to the effects of disease, the inferred protohistoric resident population of the Tilton River watershed may have been between 50 and 75 individuals (Ellis et al. 1991), although there are no specific data from *Lala'lx* and *Wa-sa* to confirm such an estimate.

There were three principal trails providing access to the Tilton River area. From the vicinity of Morton, a trail led north over the divide near Summit Creek to the Nisqually River. Another trail extended from the Davis Lake valley, east of Morton, through Fern Gap and south to the Cowlitz River near the mouth of Rainey Creek. A third trail went from the Tilton River south, through Highland Valley over a divide to the Cowlitz River at Harmony.

Deer were the most frequently hunted game, and, along with salmonids, a significant component of the diet. Curtis (1913) reports that they were taken at all seasons. A place for game near the Tilton River was known as *Pu-co-ca-tum* (Kiona 1953), but its exact location is unknown, Elk, bear, and mountain goats were also hunted, the latter in late summer, when family groups were camped in the mountains for berry picking. The bow and arrow was the principal hunting weapon for larger game. The use of dogs in fall/winter elk hunting is indicated by Curtis (1913). Deer, elk, and mountain goat meat was dried in the sun on wooden racks, sometimes over smoky fires, as a means of preservation (Yoke 1934). Smaller game obtained by the Taidnapam include mountain beaver, marmot, and grouse (Kiona 1964; Smith 1964). Grouse were probably obtained during the late summer when they congregate in huckleberry patches.

In a Taidnapam myth recorded from Louis Castama (Jacobs 1934:242), Coyote decrees that the Tilton River shall always contain "Graylings, salmon trout, silverside, Chinook salmon, steelhead". In the same myth, Coyote teaches the people how to catch salmon by making a basket trap for them in the Tilton River. Various data suggest that the "grayling" described by native consultants may actually be mountain whitefish. Besides traps, the Taidnapam used several other methods to obtain fish. According to Jim Yoke (1934) and Lewy Costima (1934), dip nets, spears, traps, and line hooks were also used. Dip nets made of soft maple and willow were used specifically for salmon. Spears consisting of a pole and detachable point, sometimes double-tined, were also used for salmon and steelhead. Hooks on long ropes were used for trout. Traps were placed in shallow streambeds and apparently included "dams", in Costima's terminology, used in conjunction with the basket traps. In addition to immediate cooking, some fish were dried on racks and stored for future use.

A variety of plant foods were gathered by the Taidnapam from several ecological communities. Most frequently mentioned in the ethnographic and ethnohistoric literature are huckleberries. Three species, *Vaccinium deliciosum*, *V. membranaceum*, and *V. ovalifolium*, which occur most abundantly between 915 m and 1,520 m in elevation, were preferred (Smith 1964). Huckleberry gathering was usually done by the women and children based at mountain camps during the late summer. Berries were pressed into cakes or dried to a raisin-like form on mats laid atop wooden racks or directly on the ground. Fires were purposefully set to promote productivity of huckleberries in mountain locations (Kiona 1964, 1965). Specific references to Indian berry picking in the mountains at the headwaters of the Tilton River are lacking. However, Taidnapam elder Mary Kiona mentioned that "the Indians that lived in Morton area would head up for those hills, that ran down the Nisqually and the Cowlitz River, and the high ranges, that was the huckleberry patches... " (1953:61).

Salal berries, wild strawberries, red elderberries, thimbleberries, salmonberries, blackberries, and the berries of Oregon grape were also eaten (Gunther 1945). Camas was the most important root food. There is some indication that Taidnapam people living in the Morton area may have traveled to root-digging grounds along the middle reaches of the Cowlitz River for camas. The bulbs of this plant were baked in earth ovens. Bulbs of several lilies were also collected and prepared in this manner. Greens of wild celery (water parsley), wood sorrel, and rhizomes of several ferns were collected and eaten in the spring.

The extent to which Taidnapam residents of *Lala'lx* and *Wa-sa* utilized the lands presently within the National Forest boundary is not known. The only ethnohistoric references to use of a specific landform in the area are the oral traditions of local Indian people describing the intentional burning of timber in the Little Rockies area (Clevinger 1951). In the 1858 account of a man named LaQuash who had witnessed the conflagration, a fire was reportedly set "on the side of Rooster Rock Mountain, just north of the hamlet of Cinebar" to promote rainfall during a period of extended drought. A second account of the fire was obtained from an Indian man at Bremer in 1890. The forest fire ultimately burned an estimated 1,250,000 acres. Using timber stand ages, Clevinger (1951) estimated that the large fire occurred ca. AD 1776-1801.

Direct interaction with non-native people began in the period ca. 1833-1840 as local Indian people took their furs to the Hudson's Bay Company trading post at Cowlitz Farm, near present-day Toledo. By 1882, however, few Indians remained in the area, which had been almost totally depopulated by smallpox, according to Tompkins (1933). The smallpox epidemic occurred in 1853, but the effects of endemic malaria in the 1830s and the appearance of measles at Cowlitz Farm in 1848 may also have contributed to a 85% population loss by 1860 (Boyd 1990). Government treaty negotiations in 1855 proposed removal of the Taidnapam, grouped with the Cowlitz, to a new reservation on the coast of Washington. Tribal leaders objected to the proposal and treaty negotiations came to a halt. Despite this, the United States government formally and unilaterally extinguished Indian title to all lands in the upper Cowlitz River basin in 1864. In this same year, the Land Grant Act deeded thousands of acres of land in the Tilton River watershed to the Northern Pacific Railroad.

The upper Tilton River watershed remained isolated. When the first non-native settlers arrived in 1884 and 1885, they found two Indian families living in the Bremer area (T.13N., R.3E., Sec. 27). These included the households of Louis Satanas and Jack Castama. The Satanas and Castama families of Bremer were listed as Cowlitz Indians in Robinette's 1919 Schedule of Unenrolled Indians. In 1927 anthropologist Melville Jacobs visited the farm of Lewy Costima (Louis Castama) at Bremer to dictate traditional myths and texts in the Sahaptin language.

Historic Conditions - Historic Period Land Use Patterns

A significant shift in human land use occurred between 1880 and 1890. It was during this decade that the cultural composition of the area changed from an essentially Sahaptin-speaking indigenous population to one of English - speaking immigrants. Into the 1880s, the subsistence economy of the small local native population continued to focus on traditional hunting and gathering. Increasingly, they sought employment as laborers and hired hands for the settlers who had began to establish land claims in the area in 1884 and 1885. These new settlers brought with them the traditions of agricultural subsistence, property ownership, and the desire to become part of a regional market economy.

Under provisions of the 1862 Homestead Act, many of the initial settlers filed claims on Federal lands in the area. Others purchased land from the Northern Pacific Railroad Company. To finance railroad construction, Northern Pacific offered millions of acres of land for sale in the Washington Territory and Idaho. The company established a land department with an agent in Portland who managed the sale of lands to new settlers (Winsberg 1972:44). Prices in 1883 were from five to ten dollars an acre, and the land generally sold in 40 or 80 acre parcels. By 1896 there were twenty familes living in the upper Tilton River watershed. By 1910 a large percentage of the population included people from the southern Appalachians, but also included emigrants from the Great Lakes, Ozark uplands, Great Plains, and Europe (1972:6-7).

The local economy was initially oriented toward subsistence agriculture. To prepare the land for cultivation or livestock "slash and burn methods were usually employed. Oats, wheat, barley, and potatoes, carrots, onions, cabbage and other vegetables were raised for personal use. Horses, dairy and beef cattle, hogs, sheep, chickens and turkeys were raised on the family farms, and sometimes driven over trails and primitive roads to markets in Chehalis, Spanaway, or Tacoma (Winsberg 1972:16). Turkeys were taken to Elbe and shipped by rail to Tacoma markets. For subsistence, settlers also took advantage of locally abundant resources, such as salmon, which could be found "running up every tiny stream." Some trapped fur-bearing mammals, gathered cascara bark, or cut shingle bolts as a source of supplemental cash income.

By 1889, a commercial center with store and post office had been established in the valley bottom between Davis Lake and the Tilton River at the crossroads of four trails, eventually becoming the city of Morton. Access to the area was by trail until about 1890. By 1891 the "Bear Canyon Trail" had been widened into a wagon road from Chehalis, the route corresponding to the present-day State Highway 508. With the arrival of a railroad terminus of the Tacoma Eastern Railroad in 1910, the community grew rapidly, and by 1912 included a sawmill, bank, theatre, and newspaper office. The town was incorporated as the city of Morton in 1913. Despite a devastating fire in 1924 that destroyed much of the business district, the population of Morton grew from 300 in 1910 to 1140 by 1950 (Winsberg

1972:47).

National Forest Administration

Federal lands in the analysis area were initially managed under the General Land Office, and were added to the Pacific Forest Reserve in 1906. Known as the Ashford, or Mineral Addition, these lands were subsequently administered as a separate Ranger District of the Rainier National Forest, becoming a part of the larger Mineral Ranger District in 1919. When the Rainier National Forest was dissolved in 1933, the Mineral District became part of the Snoqualmie National Forest. Since 1969, the Mineral Block has been administered by the Gifford Pinchot National Forest. District headquarters were at Morton for several years but by 1922 had moved to Mineral.

Mineral District personnel were also involved in trail maintenance and construction to improve access for general forest administration and fire suppression. Between 1906 and 1942 over 60 miles of trail had been built within the Tilton River watershed (Table 1). Several routes, such as the Newaukum Lake Trail and West Fork Trail, were initially used as pack trails by prospectors to access mining claims. During the 1950s and 1960s many of these trails were replaced by roads built for timber harvest access.

Table 1. Trails maintained by the Forest Service ca. 1906-1970

Trail Name	FS Number	est. Length	Use Life
West Fork Trail	280 (906)	7.5 miles	ca. 1912-1970
West Fork - A Trail	280A (906)	3.0 miles	ca. 1942-1970
Jesse Creek Trail	291	6.0 miles	ca. 1935-1949
Rooster Creek Trail	297	8.5 miles	ca. 1931-1949
North Fork Tilton Trail	298	3.5 miles	ca. 1922-1975
Connelly Ridge Trail	299 (910)	5.0 miles	ca. 1910-1970
Connelly Creek Trail	none	5.0 miles	ca. 1912-1949
Newaukum Lake Trail	(904)	4.5 miles	ca. 1906-1958
Newaukum Rock Trail	(905)	2.5 miles	ca. 1942-1976
Alder Creek Trail (Way)	none	7.5 miles	ca. 1935-1949
Bremer Mtn. Trail	none	7.5 miles	ca. 1935-1949
trail, ridge E. of Heller Creek	none	1.5 miles	ca. 1912-1938
trail, ridge N. of Snow Creek	none	2.0 miles	ca. 1931-1958

Fire patrols and lookout stations were established by the Forest Service for fire detection. The Rockies Lookout, built in 1922, was the first fire lookout in the entire Mineral District. The West Fork Tilton Lookout was built in 1934 and the Newaukum "Emergency" Lookout sometime later. Both were administered by the State Department of Natural Resources. Telephone lines were installed along trails to these lookouts as part of a Forest Service communication network. Forty-two fires, most caused by lightning strikes, were reported within the analysis area between 1920 and 1947. The largest was a lightning-caused fire over 1,500 acres in size that occurred south of Soos Creek in 1945.

Besides fire protection duties, Forest Service personnel began adminstration of commercial timber sales on National Forest lands in the area during the late 1920s. This role came to dominate the management activities of the district over subsequent decades, and most significantly after World War II. Responding to economic and political pressure, the Forest Service left behind the era of "custodial" resource management to enter a period of intensive commodity production (Hirt 1994).

Mining

Local residents began prospecting for coal about 1902. A mineral exploration and survey party reportedly connected with the Northern Pacific Railroad Company spent the summer of 1903 examining the upper Tilton River watershed (Winsberg 1972:27). Deposits of anthracite coal were identified in several drainages within the present National Forest boundary. Historic records (Chesmore and Chatters 1980:18-19; Welch and Daugherty 1987:15) indicate at least twenty-five coal mining claims were established in this area, all between the years 1902 and 1909. Most of the claims were associated with anthracite deposits along the West Fork Tilton River and its tributaries of Trout Creek, Soos Creek, Snow Creek, and Coon Creek. A few claims were also established within the Tumble Creek and Bear Creek drainages. GLO surveyors in 1909 described the extent to which some of the mines in the vicinity of Bear Creek were developed, noting that, "Several tunnels have been dug, one 1800 ft. and two some 600 ft. and expensive machinery hauled in at great expense. The occupants claim to have expended $45,000 in machinery and work." (Welch and Daugherty 1987:15)

Cinnabar ore, the source of distlled mercury, is associated with deposits of coal in the western portion of the study area, north and northeast of the communty of Cinebar. A series of fourteen mineral claims filed between 1926 and 1929 in the vicinity of Cinnabar Creek and Jesse Creek (Layser 1987), within the National Forest boundary, may be associated with cinnabar exploration. Commercial extraction of cinnabar and local production of mercury had begun in 1917, but was focused on mines located a few miles east of Morton (Winsberg 1972:27). Over a million dollars of mercury was shipped from two Morton companies between 1917 and 1930. Operations ceased in 1940 with a drop in mercury prices due to importation.

Logging

With the construction of the Tacoma Eastern Railroad line to Morton in 1910, commercial extraction of local timber resources became feasible. By the following year, L.T. Murray had established the West Fork Logging Company and began construction of a lumber railroad to link with the Tacoma Eastern line north of Morton (Liddle 1995:22). A 52 ton Climax locomotive was purchased for the operation. Within five years, Murray's company was hauling 250,000 board feet of logs from land holdings in the Tilton watershed and had 200 loggers working out of two camps on the South Fork and West Fork of the Tilton. Murray expanded company timberlands in the 1920s through the purchase of 30,000 acres from the Northern Pacific Railroad Company. Continued growth of the West Fork Logging Company led to the creation of the Murray Pacific Corporation, which today manages the 54,000 acre Mineral Tree Farm incorporating lands in the Tilton watershed.

Railroad logging within the National Forest boundary was associated with Murray's initial West Fork Tilton operations. Forest Service records indicate that other companies were also awarded timber sales along the West Fork rail line. During the 1920s, both the Elbe Lumber and Shingle Company and the Silver Falls Logging Company harvested timber on the West Fork (Hagon 1927). By the 1930s, the railroad ended about four miles up the drainage, on lower Trout Creek. Records for the 1940s indicate that the Lindberg and Hobi Company logged 590 acres of National Forest timber on the West Fork between 1943 and 1945. Murray's West Fork Logging Company alone logged 1,990 acres of National Forest timber in 1944. After World War II the West Fork rail line was converted to a truck road.

Several sawmills were established in the Tilton River area for the purpose of rough lumber and railroad tie production and export (Winsberg 1972:28). One of the largest mills in the area was that of the Taylor Logging and Lumber Company, built at Lindberg, a tiny community north of Morton in 1918. Between 1915 and 1950 Morton was known as the "tie capital of the world" for its specialized production of railroad ties. The national post-war economic boom resulted in an increased demand for more timber from National Forest lands to supply Puget Sound area mills and local operators.

Heritage Resources in the Analysis Area

Evidence of past human use in the study area exists in the form of prehistoric and historic archaeological sites and features, standing historic structures, trails, and historic landscapes. Heritage resources are documented through the process of cultural resource inventory by field surveys for specific land management activities. Since 1975, thirty survey projects covering approximately 11,476 acres have been completed on Tilton watershed lands within the National Forest boundary. The surveys included field examination of proposed timber sales and land exchanges with private timber management companies. A total of 10 cultural resource sites have been identified within the analysis area as a result of these surveys. This frequency suggests one of the lowest densities of historic and prehistoric sites for any watershed administered by the Gifford Pinchot National Forest.

The identified sites include two prehistoric archaeological sites located on mountain ridges. One of these sites, designated 45LE277, is the only cultural resource property within the watershed that has been determined eligible to the National Register of Historic Places. The remaining sites represent use of the area by non-native people in the early 20th century. They include the deteriorated remains of five cabins, two mine shafts, and the burned remains of three fire lookout stations. Archaeologists have also documented the locations of several abandoned trails in the area. Another prehistoric site has been reported by Chesmore and Chatters (1980:27) on the North Fork Tilton River, but not verified. Additional, as yet undocumented sites may exist throughout the analysis area.

Implications for Ecosystem Management and Restoration

Information pertaining to past human use of the watershed was examined from the perspective of ecosystem management. A stated goal for management of National Forest lands in is the maintenance of a "properly functioning, self-sustaining ecosystem." The principal questions addressed by this analysis relate to the retention of native plant and animal species within the watershed including adequate distributions of suitable habitat and populations.

Comparing the reference (historic) and current conditions, the most obvious change in species composition and distribution is that of human populations. As the ethnohistoric data suggest, the properly functioning, self-sustaining ecosystem of 200 years ago probably included a human population of 50 to 75 people. Current numbers are over ten times that figure. The subsistence economy of 200 years ago limited human populations to sustainable levels *within the watershed ecosystem.* As the ethnic composition of the area changed in the late 19th century, the structure of the economy shifted toward greater reliance on a regional market economy. As different resources were exploited by non-native residents, the entire relationship to the local ecosystem changed radically, both in terms of land use patterns and the quantities of resources extracted from the environment. The underlying question, which cannot be fully explored within the scope of this analysis, remains, "Can a properly functioning, self-sustaining ecosystem exist without humans occupying a niche as hunter-gatherers at historic population levels?".

Historic shifts in local land use practices and the resource demands of an increasing *regional* population resulted in impacts to the occurrence and distribution of other plants and animals native to the analysis area. Among the most obvious changes have involved populations of several aquatic species that were economically important to local Native people. Coho salmon (*Onchorhynchus kisutch*), Chinook salmon (*Onchorhynchus tschawytscha*), steelhead (*Oncorhynchus mykiss*), and "grayling", probably mountain whitefish (*Prosopium williamsoni*), were historically present in the Tilton River, according to Jim Yoke (1934) and Lewy Costima (1934), Taidnapam men interviewed in 1927 by anthropologist Melville Jacobs. Identification of coho (silver) salmon is based on Sahaptin fish taxonomy which uses the noun *sinux* for this species, instead of *tkʷinat* for Chinook, *shushaynsh* for steelhead, or the generic *núsux* for all salmonids. Mountain whitefish are still resident within the Tilton system, but construction of Mayfield Dam on the Cowlitz River has eliminated native runs of all three anadromous species. Hatchery coho and steelhead have been reintroduced, but numbers and distribution do not approximate historic conditions. This situation suggests a departure from the historic conditions of a naturally functioning ecosystem.

Archaeological and historic data pertaining to past human uses have their greatest applications to ecosystems management when they can provide specific information on the presence or absence, relative frequencies, and distribution of floral and faunal species, including those that may have been economically important to Native inhabitants. The lack of specific ethnographic and ethnohistoric information about traditional land use, and the absence of archaeobotanical and zooarchaeological data from prehistoric sites provides little opportunity for comparison between current and historic conditions within the analysis area, aside from the presence/absence of certain fish species.

In terms of identifying potential for restoration efforts, the historic data suggest several areas where further study may be necessary. The presence of anthracite coal and cinnabar ore deposits within the analysis area attracted prospectors early in the 20th century. The extent to which various claims on National Forest land were developed is not well-known. Historic references suggest that most mineral extraction occurred on private lands outside the National Forest boundary or outside the watershed. However, field assessment may be warranted to determine needs for shaft closures, rehabilitation of tailing piles, and restoration of access roads. Similarly, impacts of railroad logging in the West Fork Tilton drainage are not known. Field assessment of parcels in Forest Service ownership may be necessary to evaluate potential effects to slope stability, or the need for rehabilitation of former railroad grade beds.

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Appendix C
Road Related Failures

Road number &Segment	Slide ID*	Subwatershed	Location	Mangement Allocation
7100156_01		Winnie	SW 1/4 sec. 27	Private
7100124		Winnie	SW 1/4 sec. 33	Private
7300000_06		Little Creek	SE 1/4 sec. 26	Federal
7100600_01		Jesse	NE 1/4 sec. 5	Private
7100025_02		Bear	NE 1/4 sec. 8	Federal
5011015_01		Bear	NW 1/4 sec. 17	Private
7100049_01		Bear	NW 1/4 sec. 8	Federal
7304018_01		Otter	SW 1/4 sec. 11	Private
7300068_01		Rockies	NE 1/4 sec. 11	Private
7307022_01		Wallanding	SE 1/4 sec. 1	Private
7106000_03		Lower N.F Tilton	SW 1/4 sec. 13	Private
7302022_01		Lower N.F Tilton	SW 1/4 sec. 18	Federal
7000283	0522	Eagle Creek	SW 1/4 sec. 28	Federal
7300000	05594	N.F. Tilton Rvr	NE 1/4 sec. 14	Federal
7307304	05595	Wallanding	SW 1/4 sec. 12	Federal
7007007	05603	Tumble	SW 1/4 sec. 6	Federal
7307024	05605	Tumble	NE 1/4 sec. 7	Federal
7302047	05609 05606 05607	Tumble	SW 1/4 sec. 7 (Three slides)	Federal
7007058	05610 05611 05613 05614	Tumble	SW 1/4 sec. 5 (four slides)	Federal
7106095	05619	N.F Tilton Rvr.	NE 1/4 sec. 14 (Three slides)	Federal

* Slide ID number from the Gifford Pinchot GIS database unique identifier

ATTACHMENT A

Tilton Watershed Mass Wasting assessments

EROSION CONTROL DESIGN

Project I.D. Number 05605 Watershed Name N. FORK OF TILTON RIVER (TUMBLE CREEK)
Prepared by M MAULDIN Date 10-15-97 Weather CLEAR
Estimated Size 2 ac Estimated Location ~1/4 mi N of ... FR 7307.0?? GPS
Actual Location ~20 DOWN SLOPE FROM ROAD. PhotoPoint#'s 2 Elevation 2400'
~~Ecoclass~~ Major Vegetation FIR / ALDER Slope 70% Aspect SOUTH

Nature of Problem (give estimate of size)

Erosion: Sheet___ Rill___ Gully(s) ✓

Streambank___ Channel___ Stream order___

Stability: Slump ✓ Landflow___ Debris Slide___

General Cause: Natural ✓ Management Related___

Condition Trend: Improving ✓ Healed___ Worsening___

Treatment Units: (describe dimensions and treatment)

Area # 1

PLANT AREA #1 WITH A 6'x6' ARRAY OF ALDERS AS SOIL DEPTH ALLOWS ~50 trees needed ~30% OF FACE IS WEATHERED BEDROCK, ALSO THE STEEP EMBANKMENTS CAN BE PLANTED WHERE SOIL STATE ALLOWS. SLIDE IS BEGINNING TO REVEGETATE NATURALLY.

Area # 2

Area # 3

Area # 4

Area # 5

Area # 6

Area # 7

Area # 8

Area # 9

Area # 10

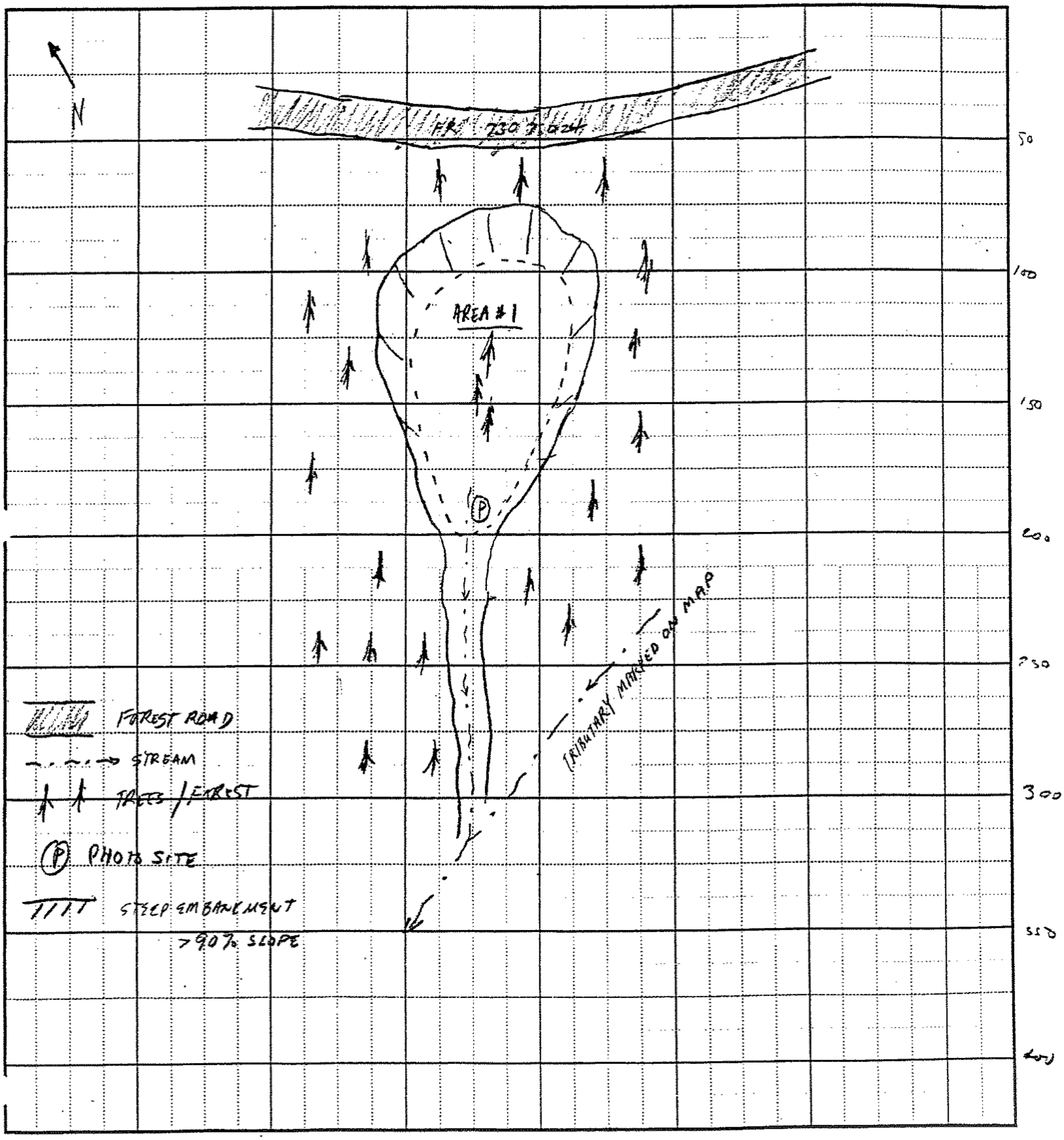
Area # 11

Area # 12

Special Notes

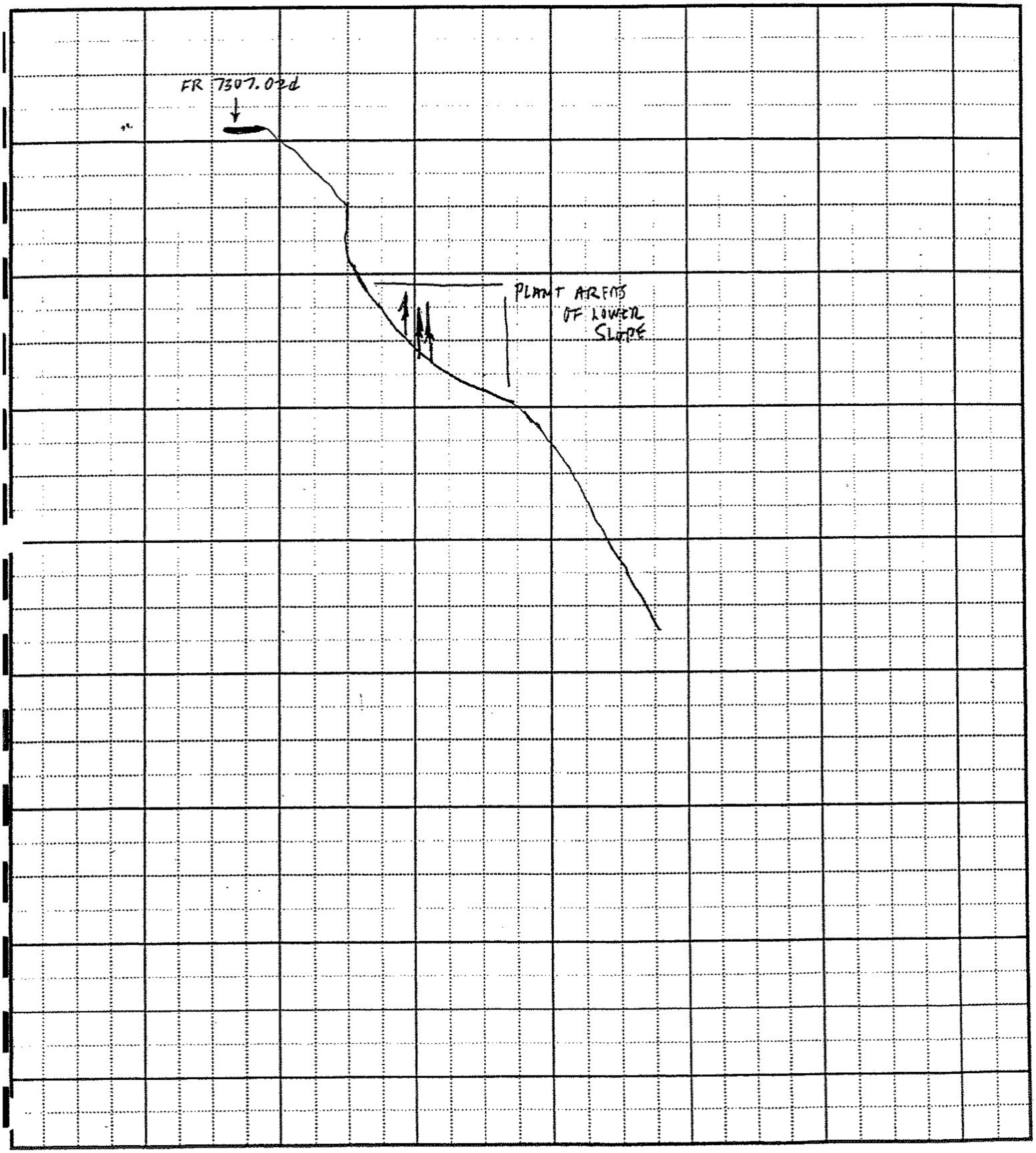
THIS SLIDE IS A DEEP SEATED ROTATIONAL SLUMP - IT WILL BE DIFFICULT TO STABILIZE MORE THAN THE SURFACE OF THIS SLIDE. SLIDE CONTINUES DOWN TRIBUTARY AND ENTERS TUMBLING CREEK BELOW. RIPARIAN AREA OF TRIBUTARY IS RESTABILIZED.

Site 05605 M. MAUDLIN **Date** 10-15-97



Site 05605 M. MAUDLIN **Date** 10-15-97

PROFILE OF SLIDE



EROSION CONTROL DESIGN

Project I.D. Number 05606 Watershed Name N. FORK OF TILTON (TUMBLE CREEK)
Prepared by M. MAURIN Date 10-20-97 Weather CLEAR
Estimated Size 150-200' Estimated Location .5 mi E of FR 7302/7302.047 junction GPS
Actual Location ON FR 7302.047 PhotoPoint#'s 11 Elevation 2300'
~~Ecoclass~~ Major Vegetation FIR / ALDER Slope 60-70% Aspect WEST

Nature of Problem (give estimate of size)

Erosion: Sheet ___ Rill ___ Gully(s) ✓

Streambank ___ Channel ___ Stream order ___

Stability: Slump ___ Landflow ___ Debris Slide ✓

General Cause: Natural ___ Management Related ✓ BLOCKED CULVERT

Condition Trend: Improving ___ Healed ___ Worsening ✓

Treatment Units: (describe dimensions and treatment)

~~Area # 1~~ :

THE SLIDES WERE INITIATED BY A BLOCKED CULVERT ~500' EAST OF SLIDES. FR 7302.047 HAS ROUTED THE STREAM FLOW ALONG ITS SURFACE TO THE SLIDES, WHICH REPRESENT WHERE THE FLOW TOPPED THE ROAD AND CUT INTO THE FILL.

~~Area # 2~~ :

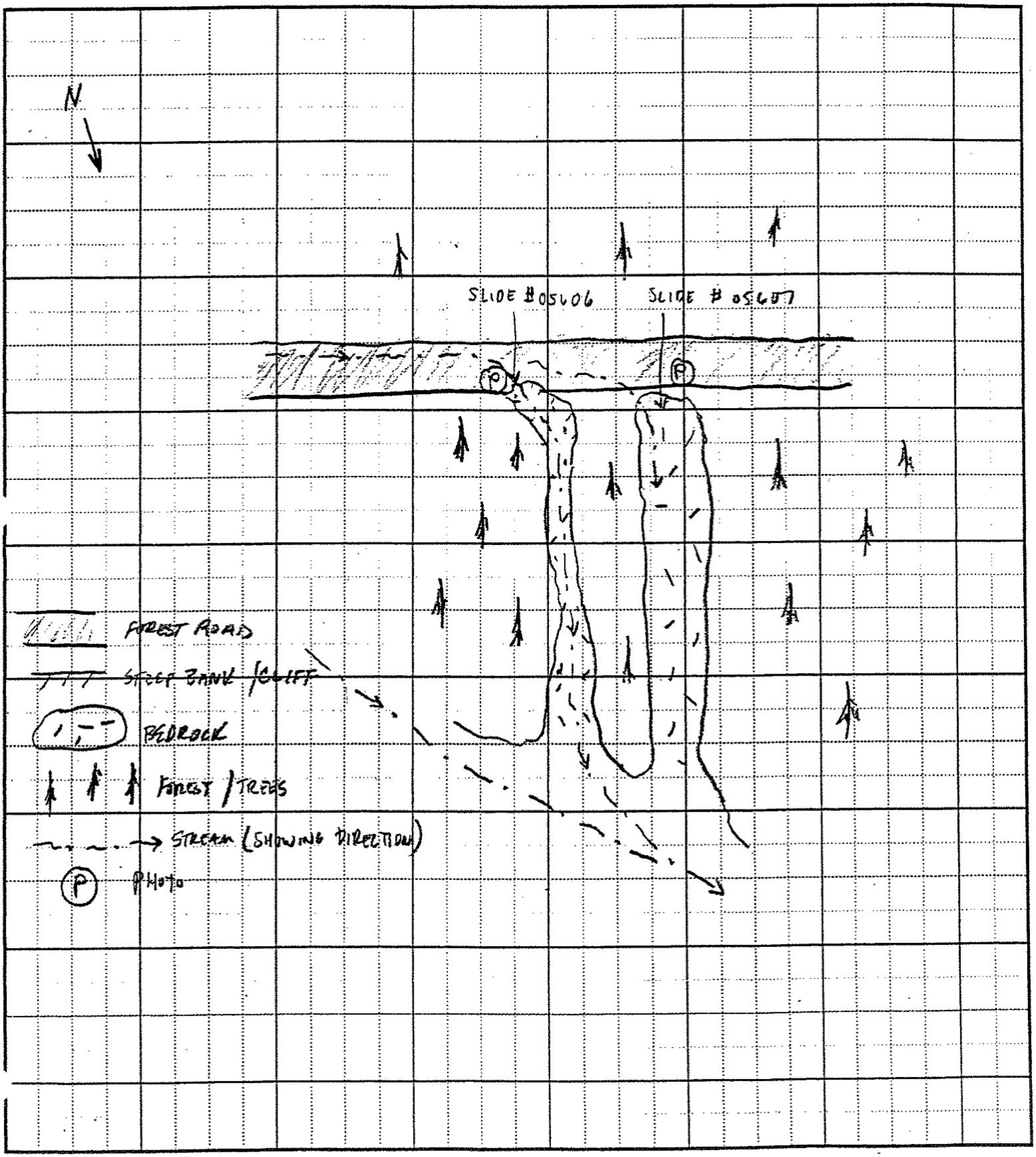
THE MOST IMPORTANT STEP IS TO REMOVE THE PLUGGED CULVERT AND ENSURE PROPER FUNCTIONING OF THE STREAM CROSSING. WHEN THIS IS ACHIEVED THEN THE ROAD CAN BE REBUILT.

~~Area # 3~~:

WHEN ROAD IS REBUILT ANY EXPOSED FILL SHOULD BE BLANKETED AND PLANTED WITH ALDER IN A 6'x6' ARRAY. ~ 50 trees needed for this failure.

Area # 4

Site 05606 + M. MAULDIN **Date** 10.20.97
05607 OVERVIEW



EROSION CONTROL DESIGN

Project I.D. Number 05607 Watershed Name N. FORK OF TILTON (TUMBLE CREEK
Prepared by M. MAURER Date 10-20-97 Weather CLEAR
Estimated Size 150-200' Estimated Location .5 mi E of FR 7302/7302.047 GPS —
Actual Location ON FR 7302.047 PhotoPoint#'s 12 Elevation 1200'
~~Ecoclass~~ Major Vegetation FIR / ALDER Slope 60-70% Aspect WEST

Nature of Problem (give estimate of size)

Erosion: Sheet___ Rill___ Gully(s) ✓

Streambank___ Channel___ Stream order___

Stability: Slump___ Landflow___ Debris Slide ✓

General Cause: Natural___ Management Related ✓ BLOCKED CULVERT

Condition Trend: Improving___ Healed___ Worsening ✓

Treatment Units: (describe dimensions and treatment)

~~Area # 1~~

THIS SLIDE IS ALSO RELATED TO THE SAME CULVERT BLOCKAGE THAT CAUSED SLIDE # 05606. THIS SLIDE HAS REMOVED ALL MATERIAL DOWN TO BEDROCK. NO RESTORATION POSSIBLE - BEYOND CLEARING OR REPLACING THE CULVERT.

Area # 2

Area # 3

Area # 4

EROSION CONTROL DESIGN

Project I.D. Number 05609 Watershed Name N. FORK TILTON RIVER (TUMBLE CREEK)
Prepared by M. MAULDIN Date 10.16.97 Weather CLEAR
Estimated Size 1 ac Estimated Location 1/4 mi N OF TRIB ON FR 7302.047 GPS —
Actual Location ON FR 7302.047 PhotoPoint#'s 2, 3, 4 Elevation 2400'
~~Ecoclass~~ Major Vegetation ALDER / FIR Slope 70% Aspect NORTH

Nature of Problem (give estimate of size)

Erosion: Sheet ____ Rill ____ Gully(s) ✓ 2' DEEP ALONG ROAD - 6' INTO ROAD FILL

Streambank ____ Channel ____ Stream order ____

Stability: Slump ____ Landflow ____ Debris Slide ✓

General Cause: Natural ____ Management Related ✓ PLUGGED CULVERT, ROAD FILL FAILURE

Condition Trend: Improving ____ Healed ____ Worsening ✓

Treatment Units: (describe dimensions and treatment)

~~Area # 1~~ : ROAD DRAINAGE:

ROAD IS ROUTING WATER FROM TRIBUTARY OF TUMBLE CREEK FOR ~1/4 mi AND DELIVERING IT DOWN THE HILLSIDE IN A NUMBER OF PLACES - DEPENDING ON FLOWS OF TRIBUTARY. THIS IS CAUSING RAPID HEADCUTTING OF ROAD FILL IN THESE PLACES. THERE ARE NO FUNCTIONING CULVERTS OR ROAD DIPS BETWEEN SLIDES AND TRIBUTARY.

~~Area # 2~~ : CONT.

THE HIGHEST PRIORITY IS REPAIRING THE CULVERTS AT THE STREAM CROSSINGS/OR REPLACING THEM WITH PERMANENT DRIVEABLE DIPS. SECONDLY, THE INSIDE DITCH HAS BEEN ERODED TO A DEPTH OF 2' IN PLACES - AND IS UNDERCUTTING THE INSIDE OF THE ROAD. PLACING COBBLES IN THE DEEPEST SECTIONS WILL SLOW VELOCITIES AND ENCOURAGE SOME DEPOSITION - THE IDEA

~~Area # 3~~ : CONT.

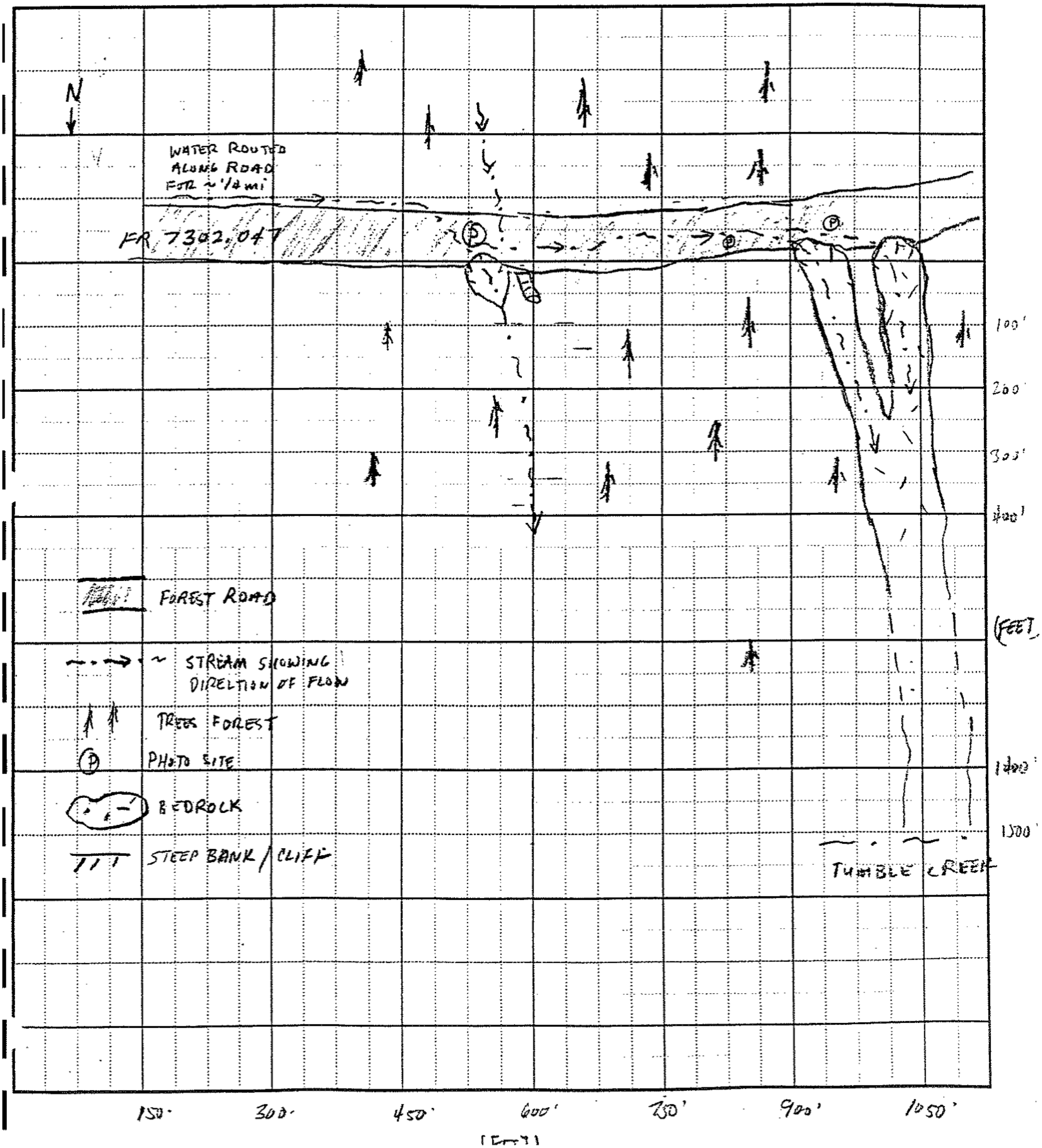
IS NOT TO COMPLETELY FILL THE DITCHES, BUT PARTIALLY FILL THEM AND PUT IN DRIVABLE DIPS TO ALLOW MORE OPPORTUNITIES FOR RUNOFF RELIEF. THIRDLY, IF FR 7302.047 IS TO BE KEPT OPEN THEN NEW FILL WILL BE REQUIRED WHERE HEADCUTTING HAS REMOVED IT. NEW FILL SHOULD BE STABILIZED BY PLANTING ALDER IN A 6'x6' ARRAY AND HYDROSEEDED IF FILL ALLOWS.

Area # 4 : SLIDES

THE SLIDES HAVE REMOVED ~2-5' OF UNCONSOLIDATED COLLUVIUM FROM THE STEEP BEDROCK SURFACE OF THE HILLSLOPE. THE GULLIES ARE ON BEDROCK AND CONTINUE DOWN TO TUMBLE CREEK - AFFORDING NO RESTORATION OPPORTUNITIES. IN ANOTHER PLACE THE ROAD RUNOFF IS RUNNING ACROSS THE ROAD AND DOWN AN EXISTING GULLY. I RECOMMEND A NEW CULVERT AT THIS SPOT - LARGER THAN THE EXISTING ONE - TO HANDLE ROAD RUNOFF AS WELL AS THE EXISTING DRAINAGE. ROAD FILL IS BEING HEADCUT INTO AT THIS POINT AS WELL. NO OPPORTUNITIES FOR RESTORATION. NEW ROAD FILL REQUIRED.

Site 05609 M MAUDLIN Date 10-16-97

OVERVIEW OF SITE



EROSION CONTROL DESIGN

Project I.D. Number 05610 Watershed Name N. FORK of TILTON RIVER (TUMBLE CREEK)
Prepared by M. MAUDLIN Date 10-21-97 Weather CLOUDY
Estimated Size <.1ac Estimated Location ~½ mi W of 7007/7007.058 junction GPS —
Actual Location on FR 7007.058 PhotoPoint#'s — Elevation 2800'
~~Species~~ Major Vegetation FIR/ALDER Slope ~70% Aspect SOUTH

Nature of Problem (give estimate of size)

Erosion: Sheet___ Rill___ Gully(s)___

Streambank___ Channel___ Stream order___

Stability: Slump___ Landflow___ Debris Slide___

General Cause: Natural___ Management Related ✓ FILL FAILURE

Condition Trend: Improving ✓ Healed___ Worsening___

Treatment Units: (describe dimensions and treatment)

Area # 1

THIS SLIDE OCCURED ON SPARSELY VEGETATED, STEEP BEDROCK SLOPES. SINCE FR 7007.058 IS SCHEDULED TO BE REMOVED THEN THIS SITE WILL BE TAKEN CARE OF DURING DECOMISSIONING. FILL SHOULD BE OUTSLOPED TO ~25% THEN SEEDED AND PLANTED WITH ALDER IN ADDITION TO THE EVERGREENS TRADITIONALLY PLANTED.

Area # 2

Area # 3

Area # 4

EROSION CONTROL DESIGN

Project I.D. Number 05611 Watershed Name N. FORK TILTON RIVER (TUMBLE CREEK)
Prepared by M. MAUDLIN Date 10·21·97 Weather CLOUDY
Estimated Size 1ac Estimated Location ~½ mi W of 7007/7007.05B JUNCTION GPS —
Actual Location ON FR 7007.05B PhotoPoint#'s — Elevation 2800'
~~Ecoclass~~ Major Vegetation FIR/ALDER Slope ~70% Aspect South

Nature of Problem (give estimate of size)

Erosion: Sheet____ Rill____ Gully(s)____

Streambank____ Channel____ Stream order____

Stability: Slump____ Landflow____ Debris Slide____

General Cause: Natural____ Management Related ✓ FILL FAILURE

Condition Trend: Improving ✓ Healed____ Worsening____

Treatment Units: (describe dimensions and treatment)

Area # 1

THIS SLIDE OCCURED ON SPARSELY VEGETATED, STEEP BEDROCK SLOPES. SINCE FR 7007.05B IS SCHEDULED TO BE REMOVED, THIS SITE WILL BE TAKEN CARE OF DURING THE DECOM PROCESS. FILL SHOULD BE OUTSLOPED TO ~25% THEN SEEDED AND PLANTED WITH ALDERS IN ADDITION TO THE FIRS THAT ARE TRADITIONALLY PLANTED.

Area # 2

Area # 3

Area # 4

EROSION CONTROL DESIGN

Project I.D. Number 05613 Watershed Name N. FORK OF TILTON RIVER (TUMBLE CREEK)
Prepared by M. MAUDLIN Date 10·17·97 Weather CLEAR
Estimated Size <.5 AC Estimated Location ~ 1/10 MI UPSTREAM OF TRIB FROM SOUTH GPS ——
Actual Location —— PhotoPoint#'s —— Elevation 2500'
~~Ecoclass~~ Major Vegetation FIR / ALDER Slope 70-80% Aspect NORTHWEST

Nature of Problem (give estimate of size)

Erosion: Sheet ✓ Rill ___ Gully(s) ___

Streambank ___ Channel ___ Stream order ___

Stability: Slump ___ Landflow ___ Debris Slide ✓

General Cause: Natural ✓ Management Related ___

Condition Trend: Improving ✓ Healed ___ Worsening ___

Treatment Units: (describe dimensions and treatment)

Area # 1

THIS SITE WAS UNDERCUT BY TUMBLE CREEK; IT IS STEEP AND IN SHALLOW SOILS CUT DOWN TO BEDROCK. THE HILLSIDE IS SPARSELY VEGETATED. THERE IS LITTLE OPPORTUNITY FOR RESTORATION.

Area # 2

Area # 3

Area # 4

EROSION CONTROL DESIGN

Project I.D. Number 05614 Watershed Name N. FORK OF TILTON RIVER
Prepared by M. MAUDLIN Date 10-21-97 Weather CLOUDY
Estimated Size 1 ac Estimated Location ~1/8 MI W OF FR 7007.058/7007.051 JUNCTION GPS —
Actual Location ON FR 7007.058 PhotoPoint#'s — Elevation 2800'
~~Ecoclass~~ Major Vegetation FIR / ALDER / Slope ~70% Aspect SOUTH

Nature of Problem (give estimate of size)

Erosion: Sheet___ Rill___ Gully(s)___

Streambank___ Channel___ Stream order___

Stability: Slump___ Landflow___ Debris Slide___

General Cause: Natural___ Management Related ✓ FILL FAILURE

Condition Trend: Improving ✓ Healed___ Worsening___

Treatment Units: (describe dimensions and treatment)

Area # 1

THIS SLIDE OCCURED ON SPARSELY VEGETATED, STEEP BEDROCK SLOPES. SINCE FR 7007.058 IS SCHEDULED TO BE REMOVED THEN THIS SITE WILL BE TAKEN CARE OF DURING DECOMISSIONING. FILL SHOULD BE OUTSLOPED TO ~25% AND SEEDED AND PLANTED WITH ALDERS IN ADDITION TO THE FIRS TRADITIONALLY PLANTED.

Area # 2

Area # 3

Area # 4

EROSION CONTROL DESIGN

Project I.D. Number 05619 Watershed Name NORTH FORK OF TILTON RIVER
Prepared by M MACOLIN Date 10·15·97 Weather CLEAR
Estimated Size <.1 ac Estimated Location ON FR 7106.095 GPS
Actual Location ~1200' FROM START OF FR 7106.095 PhotoPoint#'s 1 Elevation 1800'
~~Ecoclass~~ Major Vegetation FIR / HEMLOCK / ALDER Slope ~70-80% Aspect NORTH

Nature of Problem (give estimate of size)

Erosion: Sheet ✓ Rill ___ Gully(s) ___

Streambank ___ Channel ___ Stream order ___

Stability: Slump ___ Landflow ___ Debris Slide ✓

General Cause: Natural ___ Management Related ✓

Condition Trend: Improving ✓ Healed ___ Worsening ___

Treatment Units: (describe dimensions and treatment)

Area # 1 : ROAD FILL

A ROAD FILL COLLAPSE ON STEEP BEDROCK OCCURED HERE. IF THE ROAD IS TO REMAIN OPEN THEN THE COLLAPSE WILL HAVE TO BE FILLED AND BLANKETED TO COVER ANY EXPOSED MATERIAL THAT MAY ERODE. IF THIS ROAD IS TO BE DECOMISSIONED IN THE NEAR FUTURE THEN THE REMAINING FILL SHOULD BE PULLED BACK TO REDUCE SEDIMENTATION. ANY EXPOSED MATERIAL COULD BE HYDROSEEDED.

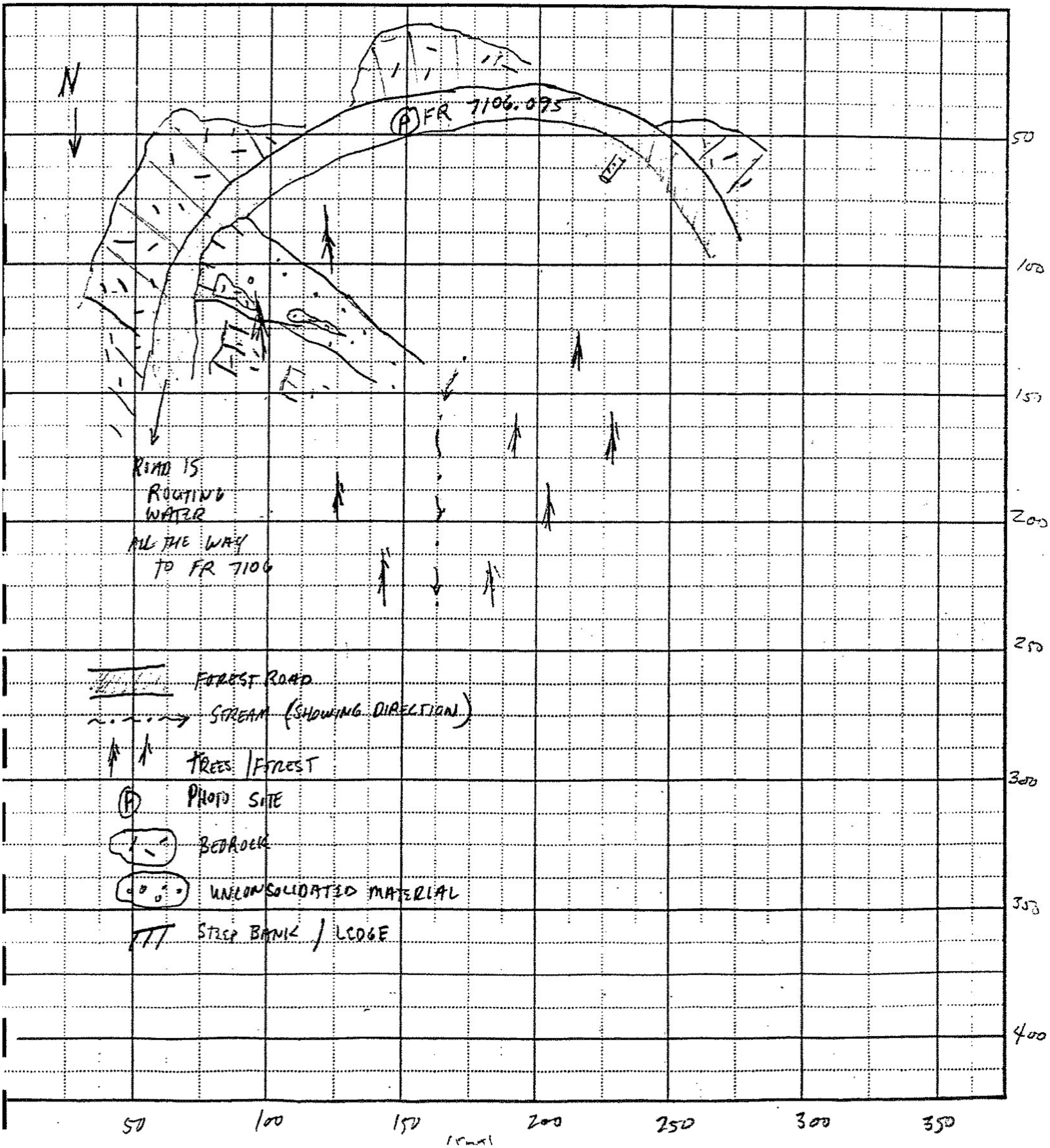
Area # 2

Area # 3

Area # 4

ite 05619 Date 10.15.97

M. MAUDLIN.



EROSION CONTROL DESIGN

Project I.D. Number 0522 Watershed Name N. FORK OF TILTON RIVER (EAGLE CREEK)
Prepared by M. MAUDLIN Date 10.17.97 Weather CLEAR
Estimated Size < .5 ac Estimated Location .1 mi PAST ROAD TO THE SOUTH ON FR 70.283 GPS —
Actual Location ON FR 70.283 PhotoPoint#'s 9 Elevation 3600'
~~Ecoclass~~ Major Vegetation FIR / ALDER Slope 60% Aspect EAST

Nature of Problem (give estimate of size)

Erosion: Sheet ✓ Rill ____ Gully(s) ____

Streambank ____ Channel ____ Stream order ____

Stability: Slump ____ Landflow ____ Debris Slide ✓

General Cause: Natural ____ Management Related ✓ ROAD FILL FAILURE

Condition Trend: Improving ✓ Healed ____ Worsening ____

Treatment Units: (describe dimensions and treatment)

Area # 1

SLIDE FACE FROM FR 70.283 TO BREAK IN SLOPE AT TOE. IF FR 70.283 IS TO REMAIN OPEN THEN THIS AREA WILL NEED TO BE COVERED WITH EROSION CONTROL BLANKET AND STAKED WITH ALDERS IN A 6'×6' ARRAY - (60 trees). IF FR 70.283 IS TO DECOMISSIONED THEN THE ROAD FILL SHOULD BE PULLED BACK TO 25% AT THIS SITE AND PLANTED.

Area # 2

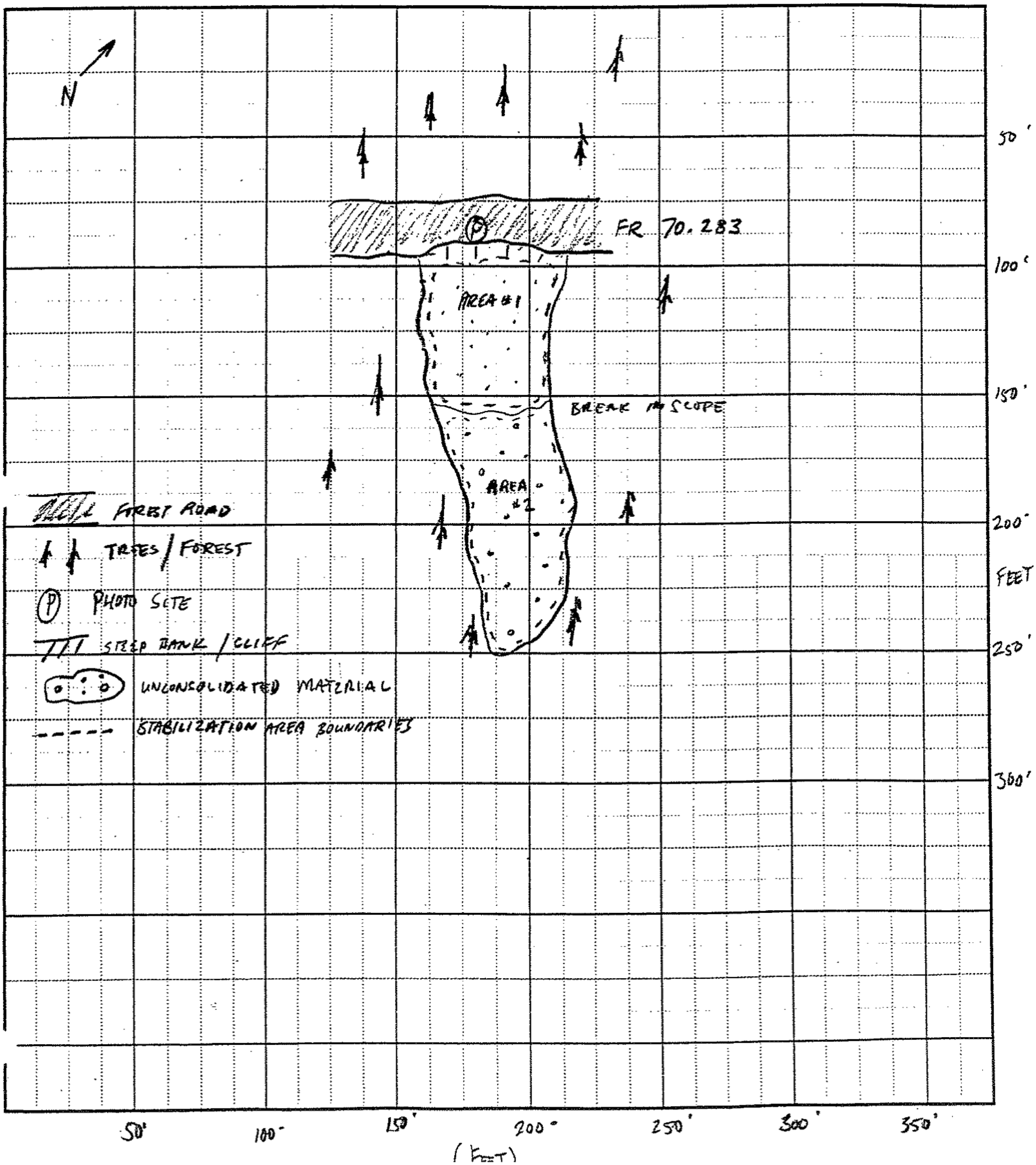
THE DEPOSITION AT THE SLIDE TOE. THIS AREA SHOULD BE PLANTED WITH A 6'×6' ARRAY OF ALDERS TO ENSURE STABILIZATION OF THE TOE. (80 trees). ALTHOUGH THIS SLIDE DOES NOT ENTER THE CREEK A POTENTIAL FOR SEDIMENT DELIVERY TO EAGLE CREEK EXISTS. TOE IS BEGINNING TO REVEGETATE WITH SHRUBS AND GRASSES - NEEDS LONGER TERM STABILIZATION.

Area # 3

Area # 4

Site 0522 Date 10-17

M. MAUDLIN



13F 2

EROSION CONTROL DESIGN

Project I.D. Number 05594 Watershed Name W FORK OF TILTON RIVER
Prepared by M MAUDLIN Date 10-15-97 Weather CLEAR
Estimated Size <.1 ac Estimated Location ~.1 mi N of FR 73/7304 junc. GPS
Actual Location ON FR 73 PhotoPoint#'s — Elevation 1200'
~~Ecoclass~~ Major Vegetation ALDER / FIR Slope 90% Aspect EAST

Nature of Problem (give estimate of size)

Erosion: Sheet___ Rill___ Gully(s)___

Streambank___ Channel___ Stream order___

Stability: Slump___ Landflow___ Debris Slide ✓

General Cause: Natural___ Management Related ✓ ROAD FILL FAILURE

Condition Trend: Improving___ Healed ✓ Worsening___

Treatment Units: (describe dimensions and treatment)

Area # 1

SITE IS A VEGETATED OLD ROAD FILL FAILURE. THE SITE IS VERY STEEP AND LOOSE. POTENTIAL EXISTS FOR UNDERCUTTING BY N. FORK OF TILTON RIVER - CAUSING A NEW SLIDE HERE.

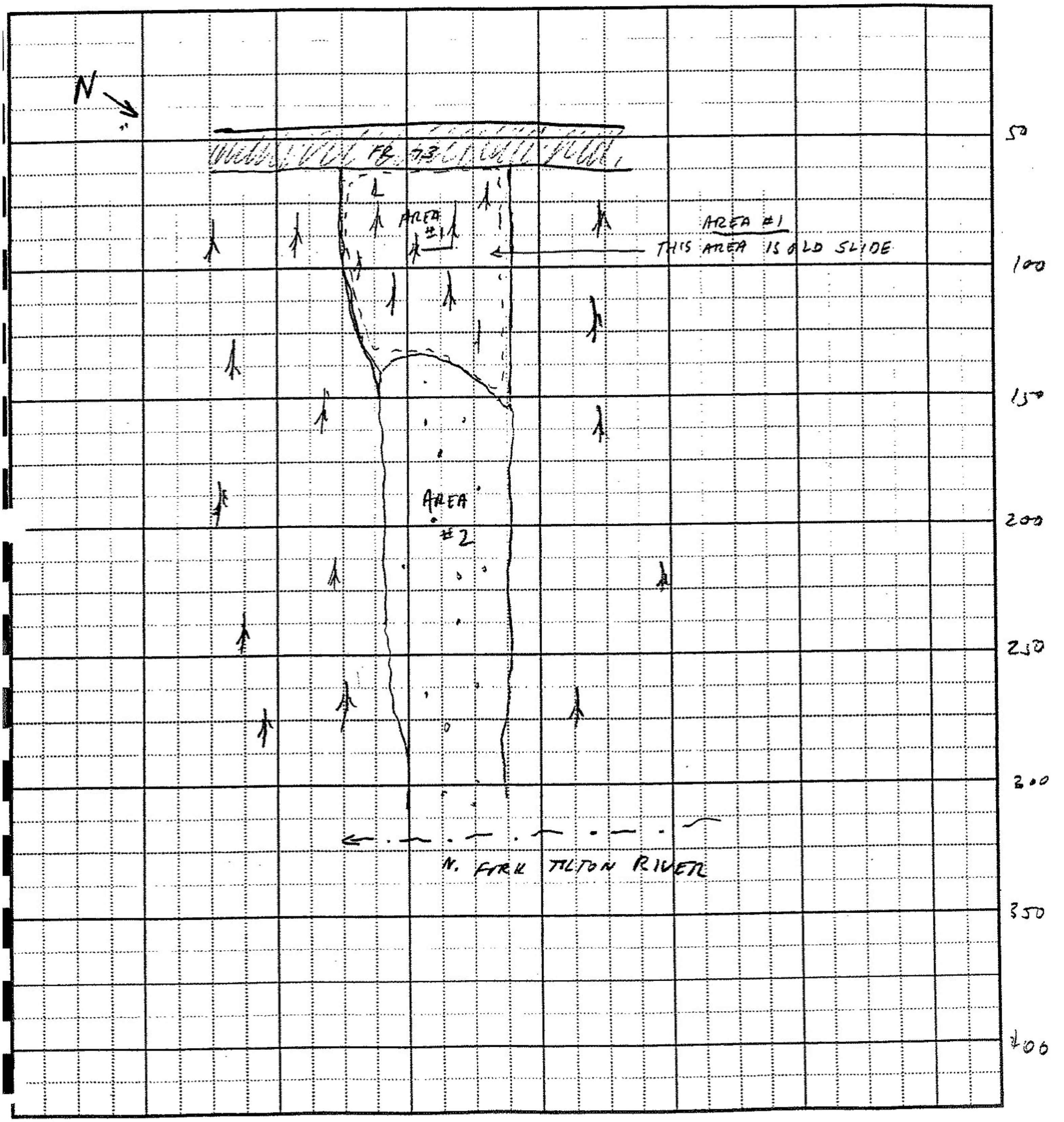
Area # 2

THE BOTTOM PORTION OF THE OLD SLIDE HAS SLID AGAIN. IT IS ~90% SLOPE, AND ENTERS THE NORTH FORK OF THE TILTON RIVER DIRECTLY. I HAVE NO RECOMMENDATIONS FOR STABILIZING THIS SLOPE.

Area # 3

Area # 4

Site 05594 M. MAULDIN Date 10.15.97



1 of 2

EROSION CONTROL DESIGN

Project I.D. Number 05595 Watershed Name N. Fork Tilton (Wallanding Creek)
Prepared by M. Maudlin Date 11.20.97 Weather Clear
Estimated Size 0.5 ac Estimated Location .4 mi E of 7307/7307.068 Junction GPS ——
Actual Location On FR 7307 PhotoPoint#'s 10 Elevation ~2000'
~~Ecoclass~~ Major Vegetation Fir / Maples / Alder Slope 70% Aspect Southeast

Nature of Problem (give estimate of size)

Erosion: Sheet ✓ 5000 ft² Rill ______ Gully(s) ______

Streambank ______ Channel ______ Stream order ______

Stability: Slump ______ Landflow ______ Debris Slide ✓

General Cause: Natural ______ Management Related ✓ Undercut by Road

Condition Trend: Improving ✓ Healed ______ Worsening ______

Treatment Units: (describe dimensions and treatment)

Area # 1

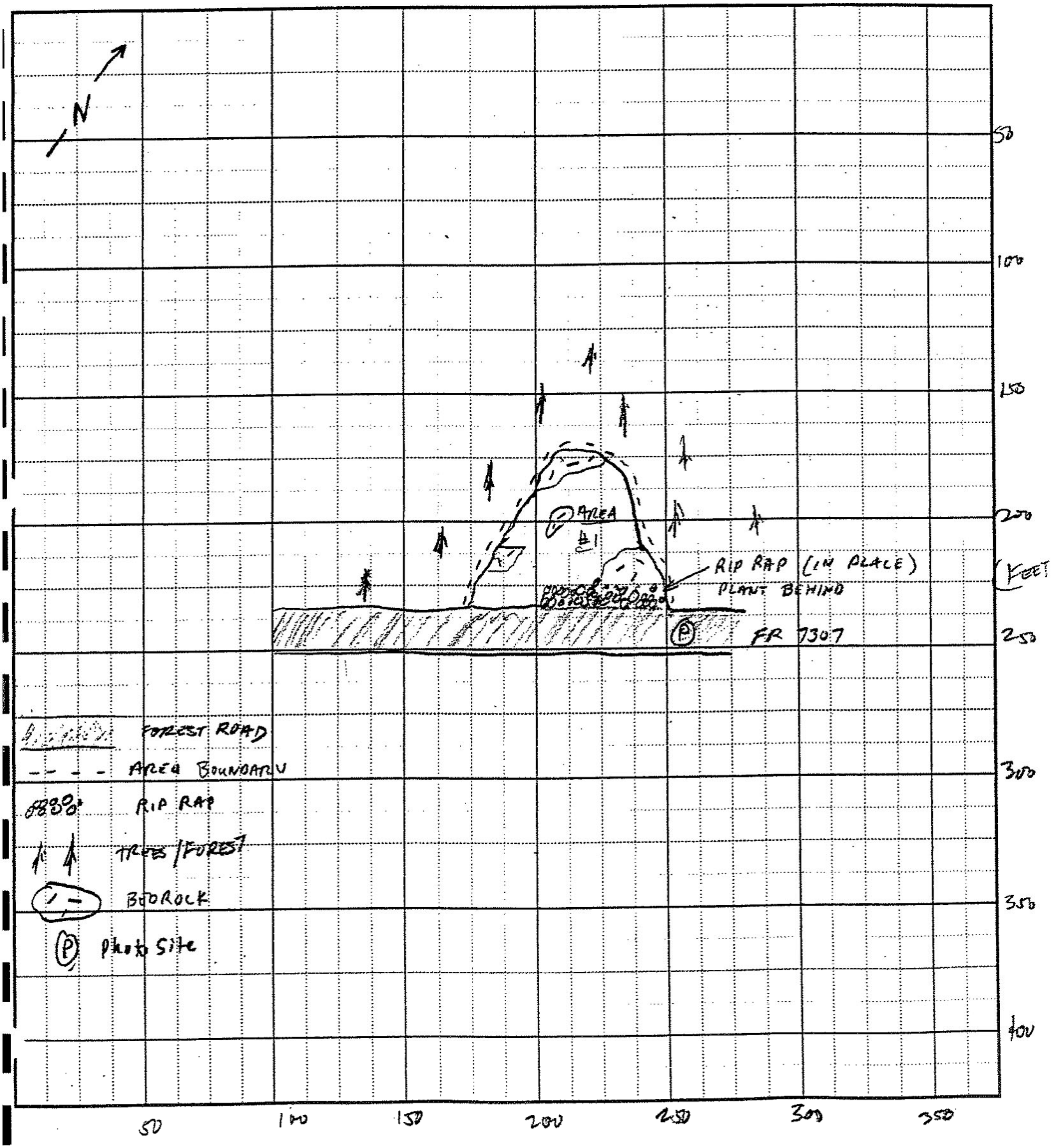
Hydroseed the face of the slide and plant alders on sediment behind the rip rap which is already in place. This will act as a sediment trap while stabilizing the material behind the rip rap. 30 trees

Area # 2

Area # 3

Area # 4

Site 05595 M. MAHDLIN Date 10.20.97



EROSION CONTROL DESIGN

Project I.D. Number 05603 Watershed Name N. FORK TILTON RIVER
Prepared by M. MAUDLIN Date 11-16-97 Weather CLEAR
Estimated Size ~1ac Estimated Location ~MP 1 ON FR 7007 GPS —
Actual Location ON FR 7007 PhotoPoint#'s 5, 6, 7 Elevation 3400'
~~Ecoclass~~ Major Vegetation FIR / ALDER Slope 40-60% Aspect NORTHWEST

Nature of Problem (give estimate of size)

Erosion: Sheet ____ Rill ____ Gully(s) ✓

Streambank ____ Channel ____ Stream order ____

Stability: Slump ✓ Landflow ____ Debris Slide ____

General Cause: Natural ✓ Management Related ✓ ROAD FILL FAILURE CONTRIBUTION

Condition Trend: Improving ____ Healed ____ Worsening ✓

Treatment Units: (describe dimensions and treatment)

Area # 1

THE HUMMOCKY AREA OF THE SLUMP IS MOSTLY EXPOSED SOILS. THIS AREA SHOULD BE HYDROSEEDED TO REDUCE SURFICIAL EROSION. SECONDLY A 8'x8' ARRAY OF ALDERS SHOULD BE PLANTED FOR LONG TERM STABILIZATION. 150 trees needed. CARE SHOULD BE TAKEN WHEN REMOVING THE MATERIAL FROM THE ROAD NOT TO OVERSTEEPEN THE UNSTABLE MATERIAL OF THE SLUMP.

Area # 2

DOWNSLOPE OF THE ROAD SHOULD BE PLANTED TO STABILIZE THE MATERIAL. 6'x6' ARRAY OF ALDERS, 80 trees needed.

Area # 3

THE STREAM CHANNEL IS STABILIZING AND REVEGETATION HAS BEGUN - DUE TO INCREASED SEDIMENT LOAD OF THE TRIBUTARY IT REPRESENTS A SOURCE FOR TUMBLE CREEK UNTIL REVEGETATION IS COMPLETE.

Area # 4

Site 05603 Date 10·16·97

M. MAULDIN