Willow/Freezeout Creeks
Watershed Analysis

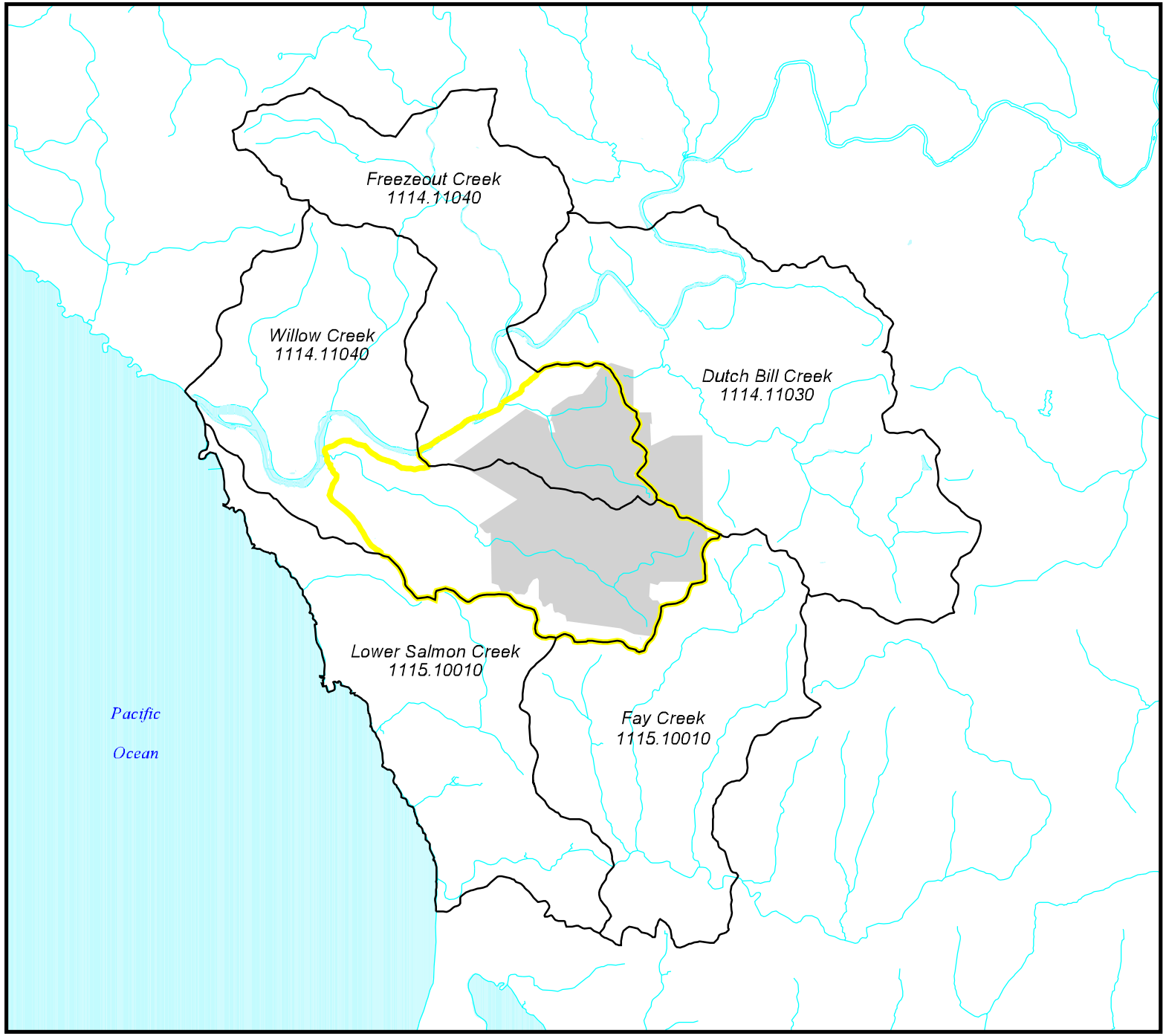
EXECUTIVE SUMMARY

This report presents the results of a watershed analysis performed by Mendocino Redwood Company (MRC) on their ownership primarily in the Willow and Freezeout Creeks watersheds, lands in the Dutch Bill Creek watershed were also evaluated. This watershed analysis was developed to provide a focused approach to evaluating watershed conditions, developing mitigation measures to maintain or improve watershed conditions, and develop significant watershed data to make decisions on how best to manage the aquatic resources within MRC's ownership. This report has also been developed in an attempt to meet the California Board of Forestry's 45 Day Notice for a Watershed Evaluation and Mitigation Addendum (WEMA) or the proposed Interim Watershed Mitigation Addendum (IWMA) also being considered by the Board of Forestry. This study was initiated as a pilot WEMA (or IWMA) for consideration by the Board of Forestry, and it is the intent of MRC to submit this report for that regulatory purpose should the Board of Forestry make a WEMA or IWMA part of the Forest Practice Rules.

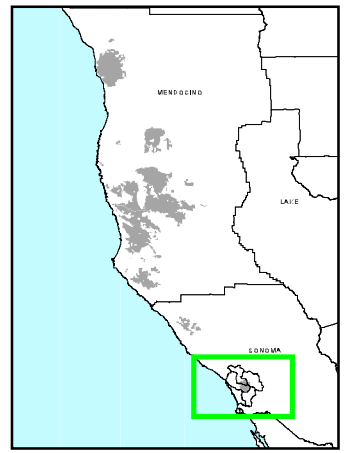
The MRC ownership in the Willow/Freezeout Creeks watersheds is considered the Willow/Freezeout Creeks watershed analysis unit (WAU). Some analysis for the MRC ownership in the Dutch Bill Planning watershed is presented as part of the Willow/Freezeout Creeks watershed analysis. This area in Dutch Bill Creek planning watershed is not intended to be part of the WEMA or IWMA; should this report be used for that purpose. However, that land will be managed with the same land management prescriptions that are determined from this analysis process.

The analysis of the Willow/Freezeout Creeks WAU was conducted following modified guidelines from the Standard Methodology for Conducting Watershed Analysis (Version 4.0, Washington Forest Practices Board). MRC's approach to the Willow/Freezeout Creeks watershed analysis was to perform resource assessments of mass wasting, surface and point source erosion (roads/skid trails), hydrology, fish habitat, riparian condition and stream channel condition. The results of the resource assessments are synthesized and land management prescriptions are developed to address the issues and processes identified in the watershed analysis. Finally, monitoring is suggested to determine the efficacy of the prescriptions to protect sensitive aquatic resources.

Willow Creek / Freezeout Creek Watershed Analysis Unit



Planning Watershed Boundary
Watershed Assessment Unit
Streams
Ocean, Lake, Pond
MRC Ownership



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April 30, 2001

Results

Mass Wasting

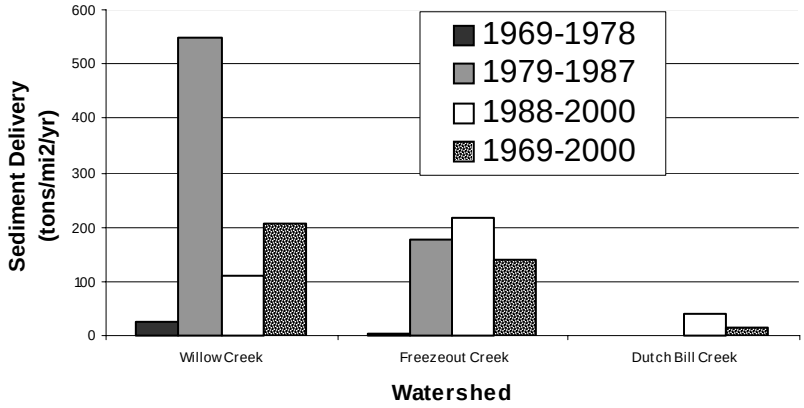
A total of 104 shallow-seated landslides (debris slides, torrents or flows) and 43 deep-seated landslides (rock slides or earth flows) were identified and characterized in the Willow Creek WAU representing the time period 1969-2000. This equated to mass wasting sediment inputs estimated to be at least 160 tons/sq. mi./ yr. over the 1969-2000 time period for the entire Willow Creek WAU. Overall, in the Willow/Freezeout Creeks WAU, sediment delivery from mass wasting was highest in the Willow Creek planning watershed in the 1979-1987 time period (Chart ES-1). This area was particularly high due to legacy harvest practices, compounded by the occurrence of a few very large landslides that significantly increased the sediment delivery amounts that may have been affected by particularly large storms of the 1981-1982 winter.

The forest harvesting technique utilized in the 1950's and 1960's was tractor skidding of logs. This skidding was performed on steep slopes and often in streamside environments and inner gorges, compacting and destabilizing the soil, increasing the frequency of mass wasting.

Approximately 1/3 of the number of shallow-seated landslides are road associated in the Willow Creek WAU, though road related mass wasting only represented 23% of the sediment delivery. The reason that the sediment delivery proportion is so low is due to an abundance of mid-slope road associated failures that do not deliver sediment. Road construction proves to be a significant factor in the cause of shallow-seated mass wasting events. Better road construction practices combined with design upgrades of old roads will lower this amount over time. This mitigation measure will need to be a focus of concern.

The Willow/Freezeout Creeks WAU was partitioned into eight Mass Wasting Map Units (MWMU) representing general areas of similar geomorphology, landslide processes, and sediment delivery potential for shallow-seated landslides. MWMU 3 (the unit representing steep convergent topography) represented the greatest mass wasting sediment delivery for any one unit, providing 54% of the sediment delivered from 1969-2000. Streamside mass wasting (combining MWMUs 1 and 2) yields 21% of the total sediment input.

Chart ES-1. Total Mass Wasting Sediment Input Rate (tons/yr./sq. mi.) from Landslides for MRC Ownership Shown by Watershed and Time Period.



Surface and Point Source Erosion (Roads/Skid Trails)

The overall road surface and point source erosion rate for the Willow/Freezeout Creeks WAU is at least 105 tons/sq. mi./yr. Proportionately Freezeout Creek watershed has the highest level of sediment contributing road areas. The amount of sediment contributing road area needs to be considered for road improvements and erosion reduction throughout the Willow/Freezeout Creeks WAU. By reducing contributing road area the amount of road that contributes sediment during forest management operations is reduced. Road density is currently averaging 7.2 miles of road to every square mile of land MRC owns.

Table ES-1. Road Surface Areas, Contributing Road Surface Areas, Road Lengths and Road Densities for the Willow/Freezeout Creeks WAU.

Planning Watershed	**Road Surface Area (ac)**	**Road Contributing Area (ac)**	**Road Length (miles)**	**Road Density (mi/sq mi)**
Willow Creek	63	9	33.0	7.2
Freezeout Creek	36	7	18.5	7.2
Willow/Freezeout Creeks WAU Total	***99***	***16***	***51.5***	***7.2***

The road network is classified as high, moderate and low surface erosion hazard (Map B-1). The roads with the high hazard are the highest priorities for improvements, monitoring or maintenance. The moderate hazard roads are a medium priority for improvements, monitoring or maintenance. The low hazard roads are not much of a concern for sediment delivery.

High and moderate treatment immediacy controllable erosion and diversion potential sites were identified along the roads in the Willow/Freezeout Creeks WAU and needs to be a focal point of ongoing forest operations. The Willow/Freezeout Creeks WAU currently has 9 high treatment immediacy sites, 23 moderate immediacy sites and 54 sites with a diversion potential. Potentially 26 culverts are too small to pass the 50 year flood and 3 additional culverts likely will not pass the 100 year flood. These sites will be a priority for improvement of the road network in the Willow/Freezeout Creeks WAU. The road number, site number for each individual site is shown on Map B-2 and in Appendix B of this report.

Sediment delivery from skid trails was found to be highest in Willow Creek in the 1950s and 1960s. Freezeout Creek had high sediment delivery in the 1980s, while Dutch Bill Creek had sediment delivery peaks in the 1960s and 1980s. This is mainly due to a high amount construction and use of skid trails during these time periods. Future skid trail sediment delivery rates will be lower than past rates because California Forest Practice Rules and MRC policy mandate better managed tractor yarding activities. Better erosion control measures are used on skid trails such as increased water bar spacing and a practice by MRC of packing the trails with logging debris (slash), when available, after operations to prevent surface erosion. Furthermore, skid trail operation is limited next to watercourses and prohibited directly in watercourses.

Forested and grassland gullies have been observed to be large sediment production areas in Willow Creek. Trihey and Associates (1997) estimate forested gully sediment production over the last 40 years at 160 tons/mi^2/year and grassland gully erosion at 100 tons/mi^2/year.

Hydrology

Throughout the last 40-50 years, in the Russian River watershed, there have been numerous large flood events (Figure C-1). These flood events have the capacity to re-shape river or stream channels and transport large sediment loads. Using the peak flow record from 1940-1998 for the Russian River, the flood of record is 1986 (102,000 cfs) calculated to be a 30 year event for the Russian River (Table C-1). The second highest peak flow of record occurred in 1995 (93900 cfs) and the third highest peak flow was in 1964 (93400 cfs). Although is unlikely that these peak flows directly correlate with storm patterns for Willow and Freezeout Creeks. It is very probable that the magnitude of these storms influenced Willow and Freezeout Creeks. Thus some of the largest storms to influence Willow and Freezeout Creeks likely occurred in 1986 and 1995. The Salmon Creek peak flow data record does not have either the 1986 or 1995 peak flows in its record (Appendix C). However, the time period it does cover shows 1982 as the highest flood of record. The 1982 flood for the Russian River was not that impressive in a relative sense, it registers as about a 7-8 year return interval. Yet, locally on the coast the 1982 storm was very large as shown by the Salmon Creek data.

An analysis of streambed sediment mobility shows several stream segments have high bed mobility. An upper segment of the Willow Creek channel has a low width to depth ratio therefore the bankfull discharge is deeper and more apt to produce a higher predicted D50. However, there is a high amount of stored gravel deposits in the channel and banks of this area and it likely that the high bed mobility is a function of the high sediment supply available to the channel. The two segments along Freezeout Creek both have high predicted median particle size (D50) yet low observed D50 making it rank as having high bed mobility potential. These segments have very high gradients that typically show a tendency toward a larger stream bed size. However, the confounding factor is when a high amount of friction or drag is introduced in the channel, thus slowing water velocities and the ability to transport smaller sediment sizes. This is likely the case in the Freezeout Creek segments. Both channels are stable with large wood debris dams storing sediment, and creating drag on the flow regime thus lowering the segments median particle size. In the case of the Freezeout Creek segments a high bed mobility is expected given the high gradient and frequent wood accumulations.

Riparian Function

The riparian function assessment is divided into two groups: 1) the potential of the riparian stand to recruit large woody debris (LWD) to the stream channel along with the level of concern about current LWD conditions in the stream, and 2) a canopy closure and stream temperature assessment.

Our analysis showed a need for large woody debris in most of the channel segments of the Willow/Freezeout Creeks WAU. Channel segments with LWD levels that are well below targets will need to be a priority for future recruitment and restoration work. Riparian LWD recruitment potential in the Willow Creek/Freezeout WAU is moderate to low (See Map D-1, Riparian module). Past harvesting activities in riparian areas have resulted in small hardwood or mixed conifer/hardwood streamside stands. These streamside stands need to be managed to be become large conifer stands to provide a natural source of LWD over time.

Stream canopy cover and stream temperatures in the Willow Creek/Freezeout Creeks WAU are at favorable levels for salmonids. The three temperature sites in the Willow/Freezeout Creeks WAU show maximum average weekly temperatures (MWAT) that are well below the

maximums for coho salmon (17-18C^{o})(Brett, 1952 and Becker and Genoway, 1979). These MWAT values almost always fall within the preferred temperature range of coho as defined by Brett (1952). The MWAT values observed range from 13.0 to 15.3 during the stream monitoring period of 1994-2000. Instantaneous maximum temperatures recorded at the three temperature sites in the Willow/Freezeout Creeks WAU are higher than the preferred temperature ranges for coho salmon (12-14 C^{o}) and steelhead trout (10-13 C^{o})(Brett, 1952 and Bell, 1986). However, these are maximums and are infrequent or of short duration. The MWAT values for these streams are the best indicators of stream temperature conditions.

Stream Channel Condition

Baseline information on the stream channels of the Willow/Freezeout Creeks WAU was collected and reported (see Table E-1, Stream Channel Condition module). Individual channel segments were categorized into geomorphic units using the baseline stream channel information, topography the channel segments are found in, position in the drainage network, and gradient/confinement classes. Four geomorphic units were established to represent the range of channel conditions and sensitivities to input factors of coarse and fine sediment and LWD (Table ES-2) (see Map E-2, Stream Channel Condition module).

Table ES-2. Stream Geomorphic Units and Sensitivities for the Willow/Freezeout Creeks WAU.

Stream Geomorphic Unit	Approximate Location(s)	Channel Sensitivity		
		Coarse Sediment	Fine Sediment	LWD
I. Depositional Channels Entrenched in Streamside Terraces.	Willow Creek near outlet of MRC lands.	Moderate	High	High
II. Highly Confined Depositional Channels within Steep Canyon Walls.	Majority of Class I watercourses of Willow and Freezeout Creeks	High	High	High
III. Moderate Gradient Transport Segments of Willow and Freezeout Creeks.	Tributary stream channels with slope gradients of 2-8%.	High	Moderate	High
IV. High Gradient Transport Segments of Willow and Freezeout Creeks.	Typically Class III, but some Class II watercourses with slope gradients of 8-20 percent.	Moderate	Low	High

Fish Habitat Assessment

Coho salmon (*Oncorhynchus kisutch*) historically resided in the Willow/Freezeout Creeks WAU. It is uncertain if coho are currently present in this WAU. Coho were not observed in this WAU during fish distribution surveys conducted by LP / MRC between 1994 and 2001.The fish species found during these surveys were steelhead (*Oncorhynchus mykiss*), prickly sculpin (*Cottus asper*), coastrange sculpin (*C. aleuticus*), and stickleback (*Gasterosteus aculeatus*) (MRC 2002). See Section F - Fish Habitat Assessment for distribution.

Fish habitat quality for the 3 main life stages; spawning, rearing, and overwintering habitat were evaluated for salmonids for 2000 (see Table F-3, Fish Habitat Assessment module). For almost all stream segments assessed, habitat conditions are found to be currently poor to fair. Historic information suggests better habitat conditions in the past. The combination of high

sediment inputs in the 1970's and 1980's along with low large woody debris has resulted in lower habitat quality.

Sediment Input Summary

A high amount of sediment inputs are estimated for Willow Creek watershed in the 1950s and 1960s, primarily from skid trail and gully erosion. Mass Wasting is highest in Willow Creek during the 1980s when the largest storms on record created a large amount of debris slide failures. Sediment inputs for mass wasting were only estimated for the past 30 years and road associate erosion for the last decade. However, to provide context for the last 50 years the average rate of erosion for roads and mass wasting was extrapolated for comparison to the gully and skid trail estimates. This extrapolation show gully erosion as the highest contributor (34%) with roads as the lowest (16%)(Table ES-3).

Table ES-3. Proportion of Sediment Inputs by Process for the Willow/Freezeout Creeks WAU, 1950-2000.

Watershed	Road Assoc. Fluvial and Surface Erosion *	Skid Trail Erosion	Gully Erosion (Trihey)	Mass Wasting **
Willow Creek	16%	22%	34%	27%
Freezeout Creek	35%	23%	n/a	42%
Dutch Bill	44%	45%	n/a	10%

* - 1990s estimate used to extrapolate 1950-1990 inputs
** - 1970-2000 estimate use to extrapolate for 1950-1970 inputs

The highest amount of sediment inputs for Freezeout Creek watershed occurred in the 1980s. This is from a high amount of tractor yarding creating skid trail associated erosion and a high amount of mass wasting from large storm events that decade. The proportion of erosion is fairly evenly spread between mass wasting, skid trail and road erosion for Freezeout Creek watershed. However, mass wasting is the largest contributor (42%) in the Freezeout Creek watershed. The land in Dutch Bill Creek primarily has the sediment inputs split between road and skid trail with some mass wasting erosion as well.

Factors Limiting Salmonid Production in the Willow/Freezeout Creeks WAU

The watershed analysis performed in the Willow/Freezeout Creeks WAU identified several factors that likely limit the production of anadromous salmonids in those watersheds. This section summarizes these factors and potential linkages to sources of the limiting factors in the watersheds. The limiting factors considered are migration barriers, water quality, water quantity, sedimentation, temperature, large woody debris, and nutrients.

Table ES-4. Primary factors limiting salmonid production in the Willow/Freezeout Creeks WAU.

Anadromous Salmonid Life Stage	Factor	Reason	Current and Future Source(s)
Spawning	Fish migration barrier, Willow Creek.	High sediment inputs from past forest management activities and straightening of lower reaches of Willow Creek have created coarse sediment aggradation and resulted in adult fish migration barrier.	• Stored sediments in upper channel reaches. • Mass wasting from shallow and deep seated landslides. • Sediment delivery from point source erosion created from roads and skid trails. • Degradation and bank erosion in headwater streams.
Spawning	Fish migration barrier, Freezeout Creek.	Just within the MRC property the Freezeout Creek channel does not facilitate anadromous fish migration.	• Naturally occurring high gradient channel with cascades and waterfalls limits anadromous fish migration.
Rearing	Sedimentation	High sediment inputs from past forest management activities has filled pools and lowered the diversity of rearing habitat	• Stored sediments in upper channel reaches. • Mass wasting from shallow and deep seated landslides. • Sediment delivery from point source erosion created from roads. • Sediment delivery from skid trail erosion. • Degradation and bank erosion in headwater streams.
Rearing, Over-wintering	Large woody debris (LWD)	LWD need is high in the majority of the watercourses in the WAU. This limits pool formation, high flow refuge, habitat cover and sediment routing.	• Conifer trees adjacent to watercourses.
Rearing, Spawning	Water Quality	High erosion rates suggest a possibility of high fine sediment in transport in the watersheds increasing storm water turbidity.	• Surface erosion from roads and skid trails. • Point source erosion from roads and skid trails. • Bank erosion and stored sediments in stream channels.

Watershed Analysis Unit Specific Prescriptions

The following prescriptions were specifically prepared for use in the Willow/Freezeout Creeks Watershed Analysis Units (WAU). These prescriptions are meant to help address issues to aid in the stewardship of aquatic resources of the Mendocino Redwood Company ownership in the Willow/Freezeout Creeks WAU. The prescriptions are meant to be used in addition to the current California Forest Practice Rules and company policies. At the time of the publication of this watershed analysis the forest management policies are governed by interim guidelines prior to the issuance of a Habitat Conservation Plan and Natural Community Conservation Plan (HCP/NCCP). Once the HCP/NCCP is approved then the conservation strategies set forth in these documents will become the company policies. A prescription is only presented if it deviates from these regulations or policies.

Mass Wasting Prescriptions:

Mass Wasting Map Unit 1:

Road placement, construction and management:

- New road construction in MWMU 1 on slopes greater than 50 percent will not occur unless it is the only access available. If new road construction must occur on slopes of 50 percent slope or greater in MWMU 1 it will only be to gain entry in and out of MWMU 1 and construction developed with the approval of a Certified Engineering Geologist.
- Seasonal roads (gets used annually) in MWMU 1 will have the surface of new road construction or re-opened existing roads armored with rock.
- Temporary roads (roads only used periodically, every few years or decades) in MWMU 1 will be storm-proofed (such a suggested in Weaver and Hagans, 1994) prior to the winter period and the surface stabilized with grass seed, mulch or other cover product.
- Any road that is within MWMU 1 will not have winter period heavy truck or log hauling traffic unless armored with a rock surface.

Adjacent to Class I watercourses:

- MWMU 1 will receive no harvest on inner gorge slopes unless approved by a California Licensed Geologist. On other areas (non-inner gorge slopes) within MWMU 1 in addition to the riparian protections set as company policy timber harvest must retain a minimum of 50% overstory canopy dispersed evenly across the slopes.
- The MWMU 1 protections will extend from the edge of the watercourse transition line up to the break in slope of the inner gorge and 25 feet slope distance after the break in slope of the inner gorge or a maximum of 190 feet.
- For those areas that do not have a well defined inner gorge topography in MWMU 1 protections will be 190 feet slope distance in width from the watercourse transition line. Timber harvest must retain 50% overstory canopy.
- The area of protection in MWMU 1 will be an equipment limitation zone (ELZ) except when slopes are less than 40%, or at designated crossings, or on established stable roads or tractor trails.

- The slopes of the inner gorge or the first 50 feet, whichever is longer, will be an equipment exclusion zone (EEZ) except for designated crossings and existing truck roads.
- The area directly adjacent to the break in slope of the inner gorge will retain those trees with a root mass that maintains the stability of that slope break.
- Trees within 10 feet of the bankfull channel will be retained, except for redwood clumps, at least 50% of the clump must be retained with emphasis on leaving the largest trees on the clump.

Adjacent to Class II watercourses:

- MWMU 1 will receive no harvest on inner gorge slopes unless approved by a California Licensed Geologist. On other areas (non-inner gorge slopes) within MWMU 1 in addition to the riparian protections set as company policy timber harvest must retain a minimum of 50% overstory canopy dispersed evenly across the slopes.
- The MWMU 1 protections will extend from the edge of the watercourse transition line up to the break in slope of the inner gorge and 25 feet slope distance after the break in slope of the inner gorge to a maximum distance of 150 feet. For those areas that do not have a well defined inner gorge topography in MWMU 1 protections will be 150 feet slope distance in width from the watercourse transition line.
- MWMU 1 will be an equipment limitation zone (ELZ) except when slopes are less than 40%, at designated crossings, and on established stable roads or tractor trails.
- The slopes of the inner gorge or the first 50 feet, whichever is longer, will be an equipment exclusion zone (EEZ) except for designated crossings and existing truck roads.
- Trees within 10 feet of the bankfull channel will be retained, except for redwood clumps, at least 50% of the clump must be retained with emphasis on leaving the largest trees on the clump.

Mass Wasting Map Unit 2:

Road construction, placement or management:

- Alternatives to road construction or road use, such as cable yarding, helicopter yarding or alternative road placement, will be pursued in MWMU 2.
- New road construction will be avoided in MWMU 2 except when no other feasible route is available. In situations where a new road must go through MWMU 2 new road construction is required to have full bench construction with all construction materials end hauled or a similar treatment and the road operation that meets the lowest risk for erosion will be utilized. If the new road construction occurs in MWMU 2 it must avoid areas where there is a significant likelihood of sediment delivery. The exception is when a qualified certified engineering geologist approves the operations.

Adjacent to Class II watercourses:

- MWMU 2 will receive no harvest on inner gorge slopes unless approved by a California Licensed Geologist. On other areas (non-inner gorge slopes) within MWMU 2 in addition to the riparian protections set as company policy timber harvest must retain a minimum of 50% overstory canopy dispersed evenly across the slopes.

- The MWMU 2 protections will be 100 feet slope distance in width extending from the edge of the watercourse transition line.
- MWMU 2 will be an equipment limitation zone (ELZ) except when slopes are less than 50%, or designated crossings, or on established stable roads.
- The slopes of the inner gorge or the first 50 feet, whichever is longer, will be an equipment exclusion zone (EEZ) except for designated crossings and existing truck roads.
- Trees within 10 feet of the bankfull channel will be retained, except for redwood clumps, at least 50% of the clump must be retained with emphasis on leaving the largest trees on the clump.

Adjacent to Class III watercourses:

- The MWMU 2 protections adjacent to Class III watercourses will extend from the edge of the watercourse transition line on both sides of the watercourse up to a break in slope <70% gradient or 100 feet slope distance, whichever is shortest.
- On slopes adjacent to Class III watercourses in MWMU 2 timber harvest must retain a minimum of 50% overstory canopy dispersed evenly across the slopes.
- MWMU 2 protection area is an equipment limitation zone except when slopes are less than 50%, at designated crossings, and on established stable roads.
- Trees within 10 feet of the bankfull channel will be retained, except for redwood clumps, at least 50% of the clump must be retained with emphasis on leaving the largest trees on the clump.

Mass Wasting Map Unit 3 and 7:

Forester will utilize available resources for identification of unstable areas or areas with predicted slope instability. These include Map A-1 of Mass Wasting Assessment for the Willow/Freezeout Creeks WAU, Division of Mines and Geology landslide maps (if available), or past Timber Harvest Plans.

Forester will walk the ground of this unit prior to prescribing operations. If upon field review the unit is confirmed to meet the definition of MWMU 3 the following guidelines apply:

- No road or landing construction activity will occur in areas identified in the field as having a significant likelihood of sediment delivery to a watercourse from mass wasting unless a site-specific assessment is conducted and operations approved by a California Registered Geologist.
- Harvest operations must retain at least 50% of the overstory canopy unless a site-specific assessment is conducted and operations approved by a California Registered Geologist.

In MWMU 7 Road drainage must be dispersed off of roads in this unit. Concentrated road drainage must be corrected. If new roads are developed in this terrain then concentrated drainage must be avoided.

Mass Wasting Map Unit 6:

No regeneration harvest treatments will be allowed in MWMU 6 unless 50% overstory canopy is retained (averaged across the stand). In those areas of MWMU 6 where an earthflow is active no harvest will occur unless approved by a registered geologist.

Road or tractor trail drainage must be dispersed off of roads/trails in this unit. Concentrated road/trail drainage must be corrected. If new roads/trails are developed in this terrain then concentrated drainage must be avoided.

Aquatic Management Zone Prescriptions:

The company policies for streamside stands are considered appropriate at this time. The exception to this is in MWMU 5, the AMZ will only require a 75 slope distance width.

Trees within 10 feet of the bankfull channel of all watercourses will be retained, except for redwood clumps, at least 50% of the clump must be retained with emphasis on leaving the largest trees on the clump.

If harvest activity is proposed in the APZ along Class I and Large Class II watercourses then effective shade of the watercourse must be managed for. A large Class II watercourse is defined as having greater than 100 acres watershed area. Effective shade is a function of vegetation height, stream width and/or topographic barriers. Effective shade over perennial watercourses will not be reduced below 85 percent canopy, unless as part of an approved riparian restoration project (hardwood conversion to conifer). Cumulatively across the entire the WAU area the shade canopy must average above 85 percent stream shading for Class I and Large Class II watercourses. Those areas with natural grassland openings in the Willow/Freezeout Creek WAU are excluded from the shade averaging.

Road Associated Prescriptions:

High Erosion Hazard Roads:

The long undrained road approaches to watercourse crossings on these roads will be treated with one or a combination of several of these options:

1) Ditch relief culverts can be installed to drain water and sediments concentrated in inside ditches. The ditch relief culverts would be placed such that the majority of long undrained approaches to watercourse crossings of the road would be relieved prior to the watercourse crossing. The discharges of water and sediment from the ditch relief culverts would drain on to the adjacent hillslope where no additional erosion is predicted.
2) Rocked rolling dips or rolling dips can be installed in the road prism. The rolling dips would be placed such that the majority of long undrained approaches to watercourse crossings of the road would be relieved prior to the watercourse crossing. The discharges of water and sediment from the ditch relief culverts would drain on to the adjacent hillslope where no additional erosion is predicted.

3) Long road approaches to watercourse crossings can have the road prism re-shaped such that the road is outsloped toward its outside edge. This out-sloped road would be done so that it allows continuous drainage of the road surface away from the watercourse crossings.

Section of these roads with high controllable erosion areas will be upgraded. The road prism will be out-sloped, perched fill material will be removed and the road prism narrowed where feasible. Unnecessary culverts will be removed and replaced with rocked fords, additional rocked rolling dips will be installed as needed.

Where possible these roads should be a high priority for decommissioning.

Moderate Erosion Hazard Roads:

Maintenance and observation of road conditions on these roads will be conducted by the high road design standards, such as set in the Handbook for Forest and Ranch Roads (Weaver and Hagans, 1994).

Roads that have not been abandoned in the Willow/Freezeout Creeks WAU will be monitored at least once annually during the winter period to look for potential culvert problems, road fill failures, trespassing damages, road drainage problems, or excessive sediment delivery.

High Treatment Immediacy Road Points:

The high treatment immediacy controllable erosion sites will be the highest priority for erosion control, upgrade or modifications to existing design. These sites will be scheduled for repair based on operational considerations of harvest scheduling, proximity and availability of equipment, magnitude of the problem, and accessibility to the site.

Moderate Treatment Immediacy Road Points:

The moderate treatment immediacy controllable erosion sites will be the next highest priority (relative to the high treatment immediacy sites) for erosion control, upgrade or modifications to existing design. The moderate treatment immediacy sites will be addressed when in close proximity to high treatment immediacy sites.

Diversion Potential Road Points:

These diversion potential sites will be a high priority for correction. These sites will be scheduled for repair based on operational considerations of harvest scheduling, proximity and availability of equipment, magnitude of the problem, and accessibility to the site. It is very likely that these sites will be addressed when in close proximity to high treatment immediacy sites.

Under-sized Culverts:

The 23 culverts that will not pass the 50 year flood will be visited in the field and a determination will be made if the culverts are indeed under-sized (identification of under-sized culverts was done by an office-based evaluation that could be inaccurate). If after field review the culverts are found to be under-sized it will be a high priority for replacement to a watercourse crossing structure that will pass the 100-year flood.

The 3 culverts that will not pass the 100 year flood will be visited in the field and a determination will be made if the culverts are indeed under-sized for this sized flood event (identification of under-sized culverts was done by an office-based evaluation that could be inaccurate). If after field review the culverts are found to be under-sized for the 100 year flood it will be a moderate priority for replacement to a watercourse crossing structure that will pass the 100-year flood. Typically the upgrade will occur once the culvert has reached the end of its operational life.

The field review will consist of determining the cross section area of the bankfull channel and comparing it the cross sectional area of the culvert in question. A rule of thumb is that to pass the 100 year flood the culvert opening area needs to be 3 times as large as the bankfull channel cross section area (Cafferata, Spittler, and Wopat, 2000).

WLPZ (aka AMZ roads) sections of road HC:

Road surface and prism treatment and road management:

- Roads used annually in the AMZ will have the surface of new road construction or re-opened existing roads armored with a rock surface.
- Roads used periodically, every few years or decades in AMZ will be storm-proofed (as per Weaver and Hagans, 1994) prior to the winter period and the surface stabilized with grass seed, mulch or other cover product.
- Any road that is within a Class I or II watercourse AMZ will not have winter period heavy truck or log hauling traffic, except emergency situations, unless the road tread is armored with a rock surface.

The road prism and drainage design for AMZ roads will be based on high road design standards such as found in the Handbook for Forest and Ranch Roads (Weaver and Hagans, 1994). If the AMZ road does not currently meet those standards then these roads will be a high priority for upgrades.

Winter period hauling conditions will be monitored carefully. In order to avoid sediment movements and damage to road surface, there will be no log or heavy equipment hauling during periods of rainfall or when roadside ditches are flowing surface runoff, or when road is saturated and cannot support heavy loads, except in emergency situations. At the first sign of measurable rain, trucks will make their final trip out on the road, and trucks not yet on the road will be asked to return home. The road will not be used until rainfall has stopped and the road surface has dried sufficiently so that the surface will not be damaged by use. Only a

Mendocino Redwood Company employee will make or grant the authority to a contractor for this determination.

Gully erosion (Grassland areas and forested areas):

Where road drainage is concentrating water on grassland slopes or in depressions or watercourses in forested areas, the road will be re-shaped to provide for more dispersed water drainage. Where road drainage has previously created gully erosion, the drainage point will be armored to prevent further erosion.

Tractor roads (skid trails) will have erosion control structures placed on them prior to rainy season to disperse water off surfaces and away from potential gully erosion areas. Skid trails, where feasible, will have slash, debris or mulch placed on them to lower surface and gully erosion hazard.

MRC will pursue restoration opportunities to slow or stop gully erosion in Willow Creek.

MRC will develop a grazing plan for the grassland areas of Willow Creek to attempt to regulate the amount of vegetation removal and timing of grazing.

Monitoring

Aquatic resources monitoring will be conducted in the Willow/Freezeout Creeks WAU. The monitoring is a combination of hillslope and in-stream assessments.

Monitoring Plan Goals:

- Test the efficacy of the Willow/Freezeout Creeks WAU prescriptions to address impacts to aquatic resources from timber harvest and related forest management activities.
- To assess long term channel conditions. Are current and future forest management practices inhibiting, neutralizing or promoting stream channel conditions for aquatic habitat?

A monitoring report will be produced each year that monitoring is conducted in the Willow/Freezeout Creeks WAU. The report will cover the monitoring and analysis that has occurred up to that year. If no monitoring is conducted in a given year than no report will be produced. The goal will be to have a report completed by spring of the year following the monitoring.

The monitoring matrix (Table I-1) outlines the hillslope and in-stream monitoring MRC will be conducting in the Willow/Freezeout Creeks WAU. The monitoring will be performed periodically. MRC will be developing a property wide aquatic monitoring strategy. Once that monitoring strategy is complete, the precise timing of the monitoring in the Willow/Freezeout Creeks WAU will be finalized. The information collected in this monitoring effort will be used as part of an adaptive management approach to the Willow/Freezeout Creeks WAU. The monitoring results will be compared to the baseline information generated in the Willow/Freezeout Creeks Watershed Analysis to discover if aquatic habitat or water quality concerns are improving, staying the same or degrading. If aquatic habitat or water quality concerns are not improving then the land management prescriptions will be altered to better protect those impaired resources.

In addition to the aquatic resources monitoring, monitoring of the roads that have not been abandoned in the Willow/Freezeout Creeks WAU will be monitored at least once annually during the winter period.

Table I-1. Monitoring Matrix for Willow/Freezeout Creeks Watershed Analysis Unit.

Monitoring Objectives	**Reasoning, Comments**	**Technique**
1. Determine effectiveness of measures to reduce management created mass wasting.	Management created mass wasting is significant contributor of sediment delivery.	Evaluation of mass wasting following a large storm events or after approximately 20 years.
2. Determine effectiveness of erosion control practices on high and moderate surface erosion hazard roads and landings.	Roads provide sediment delivery in the Willow/Freezeout Creeks WAU.	Randomly selected watercourse crossings, landings and road lengths for erosion evaluation.
3. Determine in-stream large woody debris amounts over time.	Large woody debris is needed for stream channel and aquatic habitat improvement in the Willow/Freezeout Creeks WAU.	Stream LWD inventories and mapping of LWD designation areas in select stream reaches and long term channel monitoring sites.
4. Determine if stream temperatures are staying within properly functioning range for salmonids.	Stream temperature can be a limiting factor for salmonid growth and survival.	Stream temperature probes and modeling conducted in strategic locations.
5. Determine if fine sediment in stream channels is creating effects deleterious to salmonid reproduction.	Many forest practices can produce high fine sediment amounts. Need to ensure fine sediments are not impacting salmonid reproduction.	Permeability measurements on select stream reaches (bulk gravel samples if necessary).
6. Determine long-term channel morphology changes from coarse.	Channel morphology can be altered from sediment increases, possibly affecting aquatic habitat.	Thalweg profiles and cross section surveys on select stream reaches.
7. Determine presence and absence of fish species in Class I watercourses.	Management practices and resource protections can affect distribution of aquatic organisms.	Electro-fishing at select locations to determine species composition and presence.
8. Determine rate or erosion and effectiveness of mitigation measures for gullies.	Gully erosion is a significant sediment delivery process in the WAU.	Transect and permanent cross section monitoring.