Humboldt Redwood™

January 23, 2013

Mr. Matthias St. John
California Regional Water Quality Control Board
North Coast Region
5550 Skylane Blvd, Suite A
Santa Rosa, CA 95403

Subject: Enrollment of portions of THP 1-12-084 HUM in the Freshwater Creek WWDR, "Tier II"

Dear Mr St. John:

HRC is requesting Tier II enrollment under Watershed-Wide Waste Discharge Requirement (WWDR) Order No. R1-2006-0041 for portions of THP 1-12-084 HUM. The enrollment is comprised of 273.2 acres of group selection/selection and 15.3 acres of right of way, (144.3 clear-cut equivalent acres). Total acres currently enrolled or proposed for enrollment under Order No. R1-2006-0041 Tier II is shown in the Attached Pre-Harvest Planning Report. The Erosion Control Plan (ECP), Form 200 and an annual waste discharge enrollment fee have already been submitted for this THP.

Landslide risks associated with this plan were evaluated in compliance with the Freshwater Creek and Elk River WWDR Permit Acreage Enrollment and Compliance Monitoring Program Quality Assurance Project Plan (Version 2.0, September 1, 2006) approved by the Executive Officer of the North Coast Regional Water Quality Control Board, as part of THP preparation. The Licensed Geologist performed this analysis in the Geology report included in the plan. This approach uses commonly accepted standards for geologic practices in forest management (Sidle et al. 1985, Soeters and Van Western 1996, and Sidle and Ochiai 2006) to assess factors known to contribute to landslides, such as steepness of slope, slope convergence, hydrology, geologic features, and visibly unstable areas. Overlapping and complementary scientific techniques combining state-of-the-art digital elevation model (DEM) slope stability models, field investigation, and terrain analysis were used in this assessment.

The Next Beck THP is located in the southwestern portion of the Freshwater Creek Watershed on slopes above and along Freshwater and South Fork Freshwater Creeks. The plan area spans the Freshwater Fault Zone and consequently is underlain by a variety of sediments associated with the Coastal and Central Belts of the Franciscan Complex. The Franciscan Complex is a regional bedrock unit that is composed of three broad, northwest-trending belts: the Eastern, Central, and Coastal belts. These belts become progressively older; more deformed and develop a higher grade of metamorphism to the east. In the plan area, Central and Coastal belts

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sediments are separated by a splays of the Freshwater fault zone, which passes through the central portion of the plan area.

The services of a California State licensed professional geologist were retained during the layout of this THP. A California Geologic Survey Note 45 compliant report was published by the project geologist that documents their consultation on this project. Included in this report is a Tier II level review. Based on the level of review provided in the geologic report, it is HRC's opinion that the proposed units of Next Beck meet the requirements for Tier II enrollment.

The THP proposes an uneven-age silviculture retaining 75 sqft of basal area, except for those areas restricted by geologist review, where 120 sqft of basal area will be retained . Sub-merchantable trees and those with specific wildlife value characteristics (e.g., cavities, large limbs, broken tops, snags, etc.) will be retained within the harvest area to the extent feasible. Cable and ground based yarding is approved for the unit. Post-harvest no site preparation will occur.

Greater detail regarding this landslide hazard assessment is provided in the attached *THP Unit Review for Tier 2 Enrollment.* The licensed geologist involved with the Tier 2 landslide risk evaluation has concluded the proposed harvest operation, if implemented as planned and approved, will result in a negligible increase in potential for post-harvest landsliding; and thereby meets the applicable Zero Delivery of landslide related sediment performance standards of NCRWQCB Orders R1-2006-0041 and R1-2008-0071.

Please do not hesitate to contact me should you have any questions or comments regarding this application for enrollment into WWDR (Order No. R1-2006-0041).

Respectfully,

Jon Woessner,
Area Manager RPF #2571
Humboldt Redwood Company, LLC

Attachments:
Professional Certification of Design
THP Unit Review for Tier II enrollment
Pre-harvest Planning Report
Maps

Table 1 Proposed 2013 Harvest in Freshwater Creek

THP Name	THP Number	Unit Number	Silviculture CC	ROW	shr	SEL	CC Equivalent	Hazard Low	High*
Upper Little Fresh	12-064	1				20	10.0	19.94	0.2
Upper Little Fresh	12-064	2				45.3	22 7	44.9	1.5
Upper Little Fresh	12-064	3				29.3	14 7	19 7	36 9
Upper Little Fresh	12-064	4				29.8	14 9	20.2	36 9
Upper Little Fresh	12-064	5		1 2		28.4	14 8	9.2	78 3
Upper Little Fresh	12-064	6&8		0.6		36.1	18 4	33 8	11 1
Upper Little Fresh	12-064	7				11	5 5	11	0 0
Next Beck's thing	12-084	T1		0.4		46.7	23 6	45	8.1
Next Beck's thing	12-084	T2		15 3		273.2	144.3	270.1	70.7
Another Whiskey	11-007	1				19.2	9 6	16 2	11 5
Another Whiskey	11-007	6 tier 2				45.1	22 6	42 8	8 8
Another Whiskey	11-007	6 tier 1				12.2	6.1	11.7	1.9
Another Whiskey	11-007	7				61 6	30 8	50 1	44 2
							337 7		

*The acres represented here have been converted to High Hazard Acres by multiplying by 3 8404

TBD - Planning is either in the approval or preperation stage. Acreages are not finalized yet They will be finalized prior to enrollment

Highlight Indicates a THP and Specific Unit to be enrolled prior to establishing an enforceable Zero Discharge Monitoring Plan (Tier I). Weighted Acreage Totals are listed below to demonstrate compliance with the Staff Landslide Model limit of 144 Harvest Acres in Freshwater Creek. Other THP Units will be enrolled after approval of the aforementioned Monitoring Plan

No Highlight Indicates a THP and Specific Unit to be enrolled after establishment of an enforcable Zero Discharge Monitoring Plan (Tier II)

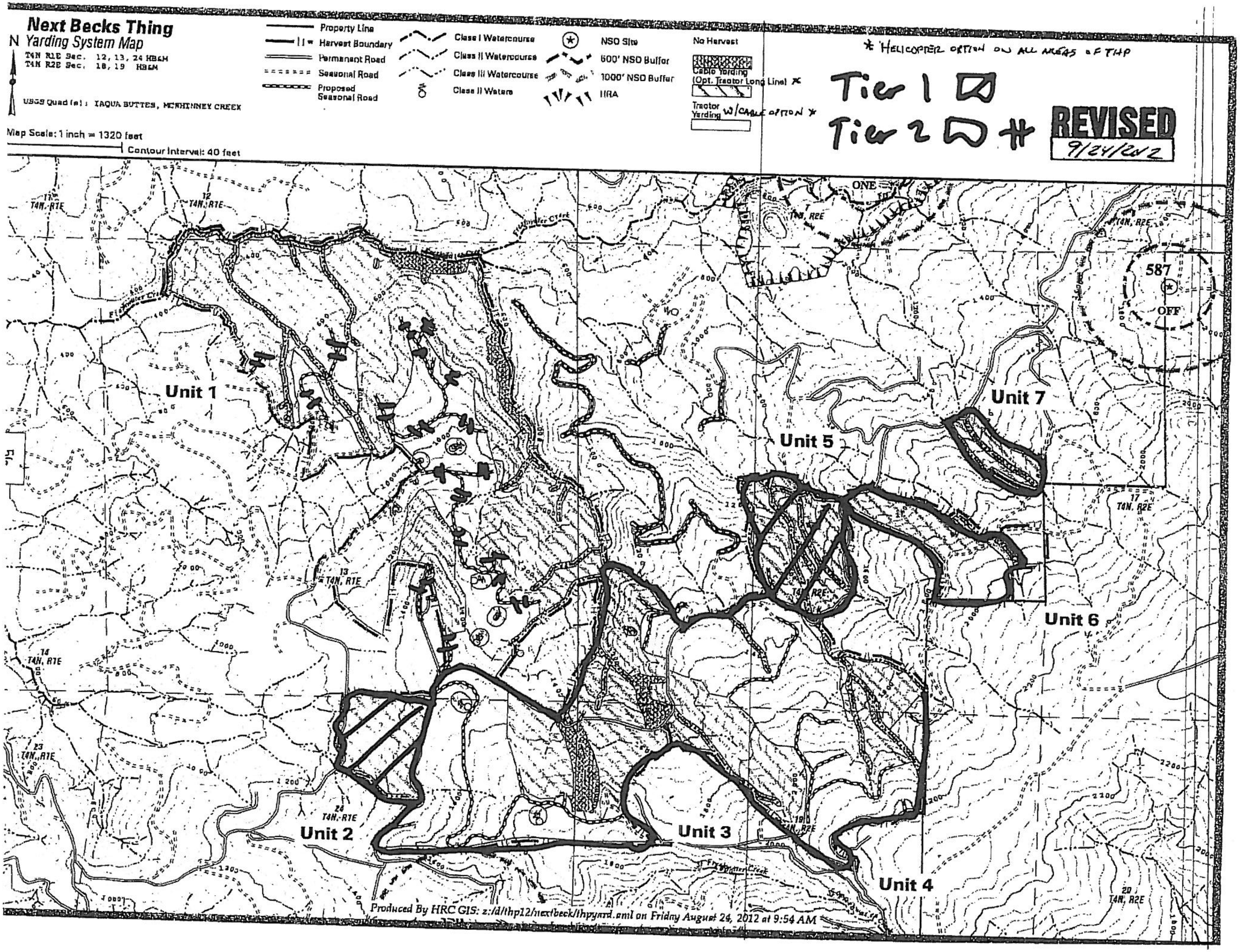
Total Clear Cut Equivilant Acres enrolled or submitted for enrollment	337.7

Table 2 Summary of THPs to enrolled prior to establishment of Zero Discharge Monitoring Plan for Freshwater Creek

THP Number	Unit Number	Harvest Acres	Hazard Low	High*
Upper Little Fresh	1	20	19 94	0 2
Upper Little Fresh	2	45 3	44 9	1 5
Next Beck's thing	T1	47 1	45	8 1
another Whiskey	6 T1	12 2	11 7	1 8
	Totals	124 6	133.2	

Table 3. Summary of THPs by Yarding System and Site Preparation for Freshwater Creek

THP Name	THP Number	Unit Number	Yarding System Ground Based	Yarder	Helicopter	Site Preparation Mechanical	Broadcast
Upper Little Fresh	12-064	1	2	18		0	0
Upper Little Fresh	12-064	2	0	34.1			
Upper Little Fresh	12-064	3	2 7	26 6			
Upper Little Fresh	12-064	4	2 9	26 9			
Upper Little Fresh	12-064	5	1 2	9 2			
Upper Little Fresh	12-064	6&8	11 6	25.1			
Upper Little Fresh	12-064	7	11	0			
Next Becks thing	12-084	5	0	18.2			
Next Beck's thing	12-084	T2	111 9	117 4			
Another Whiskey	11-007	1	11 8	14 9			
Another Whiskey	11-007	6 tier 2	2 9	44 2			
Another Whiskey	11-007	6 Tier 1	10.2	2			
Another Whiskey	11-007	7	1 3	54 9			


Next Becks Thing
N Yarding System Map
T4N R1E Sec. 12, 13, 24 HB&M
T4N R2E Sec. 18, 19 HB&M
USGS Quad(s): IAQUA BUTTES, MCWHINNEY CREEK
Map Scale: 1 inch = 1320 feet
Contour Interval: 40 feet
Property Line
Harvest Boundary
Permanent Road
Seasonal Road
Proposed Seasonal Road
Class I Watercourse
Class II Watercourse
Class III Watercourse
Class II Waters
NSO Site
600' NSO Buffer
1000' NSO Buffer
IIRA
No Harvest
Cable Yarding (Opt. Tractor Long Line) *
Tractor Yarding w/CABLE OPTION *
* HELICOPTER OPTION ON ALL AREAS OF THP
Tier 1
Tier 2
REVISED
9/24/2012
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
Unit 6
Unit 7
587
OFF
ONE
T4N, R1E
T4N, R2E
Produced By HRC GIS: z:/d/thp12/nextbeck/thpyard.aml on Friday August 24, 2012 at 9:54 AM

Professional Certification of Design

I, Shane Beach, P.G. 7396, 1/2/2013,
Name, license #, Date

REGISTERED GEOLOGIST
SHANE M. BEACH
No. 7396
STATE OF CALIFORNIA

Signature

Place licensed seal here

hereby certify, in accordance with North Coast Regional Water Quality Control Board (NCRWQCB) Order Nos. R1-2006-0039 and R1-2006-0041, that the attached application and the description of THP modifications, and the materials submitted along with:

THP No. 1-12-084 HUM (Next Becks Thing)

a. are in accordance with accepted practices, and recognized professional standards;
b. comply with the requirements of the Monitoring and Reporting Program No. R1-2008-0071, approved by the Executive Officer of the North Coast Regional Water Quality Control Board; and
c. provided that the THP is properly implemented, operated, and maintained, are adequate for the THP to meet the applicable Zero Net Delivery performance standards of NCRWQCB Orders R1-2006-0039, R1-2006-0041, and R1-2006-0103, insofar as such performance can reasonably be predicted by accepted engineering geologic practices.

The opinions presented in the subject THP have been developed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable engineering geologists practicing in this or similar localities. No other warranty, expressed or implied, is made as to the professional advice included in this report.

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8/16/2012

GEOLOGIC EVALUATION OF THE NEXT BECKS THING TIMBER HARVEST PLAN, HUMBOLDT COUNTY, CALIFORNIA

Prepared for: Mr. Jay Fazio, RPF

INTRODUCTION

Humboldt Redwood Company (HRC) Geology Department presents this report in response to the Forester's request for an evaluation of selected areas within the Next Becks Thing Timber Harvest Plan (THP). The THP roughly encompasses approximately 639 acres within the southeastern portion of Freshwater Creek watershed. The proposed silviculture is Group Selection with Single Tree selection within RMZ's and identified unstable areas. The yarding methods will include cable and ground based. Refer to maps provided with the plan by the Forester for a complete delineation of proposed silviculture and yarding methods for the plan.

The Next Becks Thing THP is within the CalWater Upper Freshwater Creek watershed. The unit extends from prominent low elevation Class I watercourses to ridge tops (Figure 1). Pertinent location information is presented below in Table 1.

Table 1: Location Information	
Legal Description	Sections 12, 13 and 24; T4N, R1E; HB&M. Sections 18 and 19, T4N, R2E; HB&M.
USGS Quadrangle	McWhinney Creek and Iaqua Buttes7.5-minute quadrangle.
Cal Watershed	Upper Freshwater Creek (11110.000101)

Freshwater Creek is listed as sediment impaired under Section 303(d) of the Clean Water Act. There are no known domestic or agricultural water supplies within 1000 feet of the THP area.

We were asked by the Forester to address unstable areas as defined in California Forest Practice Rules and HRC Habitat Conservation Plan (HCP) prescriptions for the Freshwater Creek watershed, dated August 15, 2002 (PALCO, 2002). Conditions requiring the input of a California licensed geologist based on the "Hillslope Management Checklist" and Special Riparian and Hillslope Prescriptions (PALCO, 2002) were identified by the Forester, published geological information, conditions found during geologic evaluations for neighboring THPs, and aerial photograph review. Special Riparian and Hillslope Prescription areas consist of inner gorges, headwall swales, and other areas identified as having a "very high hazard" based on slope stability and sediment delivery issues. The "Hillslope Management Checklist" is based on the guidelines developed co-operatively between the California Geological Survey (CGS, formerly CDMG) and CALFIRE (formerly California Division of Forestry and Fire Protection (CDF)), contained in CLFA (1999), to be used by a Forester for determining the need for need for input from a California licensed geologist during THP preparation.

The appropriate scope of our THP evaluation was determined based on the location of the THP units, published geological information, conditions found during geologic evaluations for neighboring THPs, conditions observed by the RPF, and aerial phogographic review. We also considered potential impacts of specific operations within the proposed plan insofar as they may affect any recommendations we provide.

The purpose of our investigation was to evaluate the proposed harvest with respect to sediment delivery to watercourses as a result of landsliding resulting from THP activities. The recommendations provided by us were incorporated into the THP prior to submittal and are part of the plan. Our study was conducted in accordance with generally accepted engineering geological standards and practices, with the objective of providing a geological evaluation in accordance with the guidelines set forth by the Department of Conservation, California Geological Survey in Note 45 (CGS, 1999; formerly California Division of Mines and Geology). It is our opinion that our evaluation of slope stability conditions using previously-developed geological information, aerial photographs, and on-the-ground observations, consistent with established engineering geological practices, is sufficient to characterize slope stability conditions within the THP units, evaluate the potential impacts of THP activities on slope stability and sediment delivery, and guide mitigations. We worked in close support and co-ordination with the RPF to implement recommended mitigations for actual and potentially unstable areas. To the best of our knowledge, this plan conforms to Forest Practice Rules and the hillslope management mass-wasting strategy that applies to HRC's ownership under prescriptions developed based on the ERSC watershed analysis.

Scope of Investigation

For the purposes of this investigation we performed:

- Review of pertinent geologic maps.
- Review of pertinent adjacent geologic reports.
- Review of aerial photography for the entire plan area.
- Geologic reconnaissance of the THP area and evaluation of slope stability.
- Recommendations for mitigations provided to the RPF.
- Delineations of zones requiring mitigations.
- Analysis of observations and data.
- Report preparation.
-

POTENTIAL IMPACTS OF THP ACTIVITIES ON SLOPE STABILITY

This section provides a somewhat detailed account of the most recent literature pertaining to the interactions between forested hillslopes, timber harvesting, and mass wasting. The discussion should educate the reader as to how we have defined our scope and presented the information in the format presented. The discussion is intended to provide insite regarding our assessement of risks associated with the proposed harvest activities.

Timber harvest related impacts on slope stability fall into two general categories: 1) impacts of tree removal and 2) impacts of ground disturbance (yarding scars and road building). Impacts of tree removal consist of loss of root strength, loss of evapotranspiration, and loss of canopy effects. Impacts of ground disturbance consist of surface and groundwater diversion, changes in slope mass balance (cutting and filling) and potential instability of fill due to poor compaction (excess porosity) or incorporated organic debris.

Keppeler et al. (1994) documented increased groundwater levels after clearcut logging and cable yarding in coastal northern California and offered a range of possible causes including decreased evapotranspiration and decreased canopy interception due to tree removal, and decreased soil infiltration capacity due to yarding-related compaction. Montgomery et al. (2000) monitored rates of shallow landsliding after clearcut logging in coastal southern Oregon. Montgomery et al. (2000) concluded that, while landslide rates increased dramatically, the increased landsliding occurred mainly in areas that were already slide-prone, as demonstrated by previous landslide occurrence and as derived from a model of landslide occurrence based on soil strength parameters, slope steepness, and slope hydrology. Montgomery et al. (2000) modeled variation in soil cohesion as a function of root strength to explain increased landslide occurrence in clearcut harvested areas and noted piezometric variations in response to rainfall microbursts. Their analysis was weighted towards root strength as a primary influence, however, piezometric variation in response to microbursts was also considered a possible influence. Keim and Skaugset (2003) documented the attenuation of peak rainfall intensity under forest canopy and concluded based on modeling that such attenuation may be significant to pore pressures at shallow soil depths. Keim and Skaugset (2003) presented the caveat that their model of soil infiltration was simplified to not include possibly significant attenuation of peak pore pressures by on-ground organic debris. Iverson and Major (1987) documented the dynamics of pore pressure waves and groundwater levels in soil resulting from storm and seasonal rainfall, and concluded that pore pressure waves from storms attenuate rapidly in the upper soil. The piezometric variation noted by Montgomery et al. (2000) appears to be analogous to the pore pressure waves noted by Iverson and Major (1987). Cafferata and Spittler (1998) found a preponderance of management-related landslides in the Caspar Creek Watershed between 1967 and 1997 to be caused by earthworks (roads, landings, and skid trails). In particular, earthworks constructed prior to the implementation of the Forest Practices Act were found to be significant sources of landsliding decades after their original construction, in contrast with those constructed according to Forest Practice Rules. Bawcom (2003) studied the effects of clearcut harvesting conducted during the 1980s and 1990s on landsliding in the Jackson Demonstration State Forest. Among the 32 shallow landslides associated with clearcut units, all but four were associated with roads, landings, and skid trails. None of the dormant deep-seated landslides associated with clearcut units showed evidence of re-activation. Bawcom (2003) concluded that there was little evidence to suggest that vegetation removal associated with clearcut harvesting of Coastal Redwoods was a significant contributor to slope instability. The findings of Bawcom (2003) and Cafferata and Spittler (1998) indicate that the effects of ground disturbance and roads are the most significant impacts to slope stability.

Root reinforcement is a significant factor allowing soils to remain stable on steep slopes (CGS, 2004; Krogstad, 1995; Schmidt et al., 2001; Ziemer, 1981). According to Krogstad et al. (1999) and Schmidt et al. (2001) the effect of root reinforcement on soil stability is limited by the depth to which roots penetrate the soil, and increased effective cohesion of the soil due to lateral root reinforcement may outweigh vertical anchoring as a factor increasing soil stability. CGS (2004) provides a literature-based discussion of effective soil cohesion as a function of vital root biomass and indicates that root reinforcement may increase effective soil cohesion by as much as a factor of two. Root strength loss could increase the potential for movement of shallow landslides.

Krogstad (1995) uses pipe-model theory and physiological considerations to model root biomass as being proportional to sapwood basal area and foliage density. The analysis by Krogstad (1995) provides a basis for estimating the potential loss of root strength after harvest as proportional to the decrease in foliage. Krogstad (1995) also describes the distribution of vital root biomass as a function of proximity to the tree bole and the age of the tree. Root biomass is generally concentrated near the tree bole, however, it is relatively more distributed for younger trees, particularly in stands not experiencing crown competition.

Krogstad (1995) and Roering et al. (2003) have some important implications for root reinforcement relative to tree age, species, and stand structure, with potential for guidance of silvicultural practices for maintaining slope stability. The root reinforcement contributed by larger trees relative to smaller trees is less than proportional to relative tree size, since a relatively large portion of the basal area of large trees is composed of heartwood, which does not support vital root mass. The root reinforcement associated with larger trees is more concentrated near the tree bole, especially when the greater spacing between larger trees is considered. All other factors equal, the greatest potential for slope failure within a stand occurs where the root reinforcement is the lowest (Roering et al., 2003). Occurrence of landslides in forested areas in the Oregon Coast Range is empirically associated with areas beyond the radii of dominant overstory conifers, particularly in areas vegetated with hardwoods and herbaceous vegetation (Roering et al., 2003). These considerations suggest that critical root reinforcement may be contributed by understory conifers in the gaps between the overstory trees in a mixed-age stand. Canopy closure may be used as a proxy for estimating root reinforcement with some qualification. Crown competition decreases the distribution of root reinforcement. Canopy closure is only one metric for the robustness of tree crowns, which is more directly proportional to root reinforcement than canopy closure. The theoretically optimal stand from a root reinforcement standpoint would consist of vigorously growing long-crowned conifers evenly spaced on the slope and not experiencing crown competition.

The amount of root strength loss after harvest is proportional to the mortality and decay of root systems after harvest. Root mortality varies according to harvested species, harvest practices, and site preparation after harvest (Schmidt et al., 2001; Ziemer, 1981). Decay of Douglas-fir root systems results in a maximum loss of strength within about 10 years after harvest, however, variations of decay rates between climates and species result in uncertainty regarding the timing of the strength loss (Schmidt et al., 2001; Ziemer, 1981). Decay rates are slow for Coastal Redwoods and the mortality of their root systems is significantly less than 100% after harvest, so a significant portion of the root strength is retained. CGS (2004) discusses relative die-off rates of old growth and second growth redwood root systems after harvest. Root mass vitality is typically maintained after harvest of second growth redwoods due to rapid stump sprouting. Root mass vitality is depressed after harvest of old growth redwoods because of decreased probability of stump sprouting and less canopy biomass to support the root mass. One implication of the argument presented by CGS (2004) is that the potential root mass die-off of old growth redwoods is proportional to the vitality of the existing crown, consistent with the findings of Krogstad (1995).

The greatest short-term loss of root strength is associated with clearcut harvest, however, recovery of root reinforcement is variable after harvest depending on site treatment and reforestation (Schmidt et al., 2001; Ziemer, 1981). Understory root systems may ameliorate the loss of root strength between harvest and mature reforestation (Schmidt et al., 2001). According to Ziemer (1981), 50% root reinforcement recovery occurs typically between 15 and 25 years after harvest. Ziemer (1981) also cites possible 100% recovery after about 25 years after harvest, however, Schmidt et al. (2001)

estimates that hardwood invasion after harvest may delay full recovery by 100 years or more. Silvicultural systems that result in reduced crown competition, such as overstory selection and thinning, stimulate the growth of understory trees, with potential for a net gain in root reinforcement if the vigorous growth of understory roots exceeds the decay rate of the harvested roots (Ziemer, 1981). The replacement of the more concentrated root systems of larger trees with the more distributed root systems of the released understory also would result in more distributed root reinforcement according to the model of Krogstad (1995). Depending on the pre-harvest stand conditions, a similar long-term result is possible with vigorous reforestation after clearcut or rehabilitation harvest, although the time interval to achieve it would obviously be longer.

The significance of canopy interception and evapotranspiration to storm hydrology and slope stability remains controversial. Evapotranspiration is generally accepted as a significant component of annual water budgets for forested lands (cf. Keppeler et al., 1994; Jones, 2000; Ziemer, 1981). Under arid summer conditions in the Sierra Nevada, evapotranspiration depletes as much as 30 cm of soil moisture from forested areas relative to non-forested areas (Ziemer, 1981). The findings of Jones (2000) and Ziemer (1981) indicate that evapotranspiration can be expected to have a signature on dry-season water table levels and decrease the antecedent groundwater levels to storms following a seasonal dry period. During high rainfall periods and winter conditions, evapotranspiration potential is lower and the water budget becomes dominated by large storms. Jones (2000) compiled a series of paired watershed studies and found that the greatest difference between storm runoff peaks from logged and unlogged watersheds occurs with small storms under dry antecedent conditions. Smaller differences occur as the storm season progresses, raising the antecedent moisture level, and with larger storms. While the review in Jones (2000) does not directly address harvest impacts on slope stability, it is significant for evaluating the hydrologic effects of timber harvesting relative to seasonal groundwater and winter storm conditions. Keppeler et al. (1994) addresses harvest impacts on groundwater levels in a paired catchment study, with results that are in broad outline consistent with the results reported in Jones (2000). Keppeler et al. (1994, Figure 4) indicates increases in piezometric levels after clearcut harvest on the order of 0.3 - 0.5 M relative to equivalent pre-harvest conditions during the study period, with the largest increases associated with low groundwater periods. Significantly, the study period was abnormally dry with infrequent storms, favoring the development of inter-storm soil moisture deficits in the forested control swale (Keppeler et al., 1994). This suggests less relative increase in groundwater under post-harvest conditions during normal or wet (i.e. landslide-triggering) winter conditions than the amounts derived from the study period. Keppeler et al. (1994) referred to the decreasing difference between pre- and post-logging piezometric levels relative to storm size as indicating that "post-logging responses would not be dramatically increased for larger storms during fully saturated conditions." The results in Keppeler et al. (1994) suggest that active deep-seated landslides could have their activity levels increased due to hydrologic changes after logging, but also suggest a lower probability of a dormant deep-seated landslide reaching a threshold of instability as a result of logging.

While it is theoretically possible for a very large storm to occur during the period when the difference in soil moisture between forested and un-forested areas may be critical to slope stability, landslide-triggering storms generally occur during the period when the antecedent influences of other large storms dominate the water budget. In the opinion of Ziemer (1981), "the critical period during which forested slopes are drier than cut slopes may be insignificantly short."

Average canopy evaporation rates during *small* (<1.2") winter storms in a coastal climate in New Zealand, similar to that of Humboldt County, have been estimated in a range from 0.26"– 0.33" per day (Pearce, 1980 and oral communications, cited by the "UC Team", 1999). A 3"/24 hour rainfall event is considered potentially significant to slope stability and triggers landslide monitoring under the HRC Habitat Conservation Plan. The evaporation rates cited by the UC Team (1999) indicate a *maximum* evaporative loss of approximately 11% of the rainfall in a 3"/24 hour event. Since evaporation is controlled by relative humidity, the evaporation rate would be higher for rainfall during warmer periods when relative humidity is lower, and lower for large winter storms when relative humidity is highest.

Keim and Skaugset (2003) presented citations indicating that canopy evaporation rates after 5-10 mm of precipitation drop to insignificance relative to rainfall rates experienced during landslide-triggering storms. Reid (1998) presented data from *small* (0.13"-1.3") winter storms in the Freshwater Creek watershed showing a 17% to 36% difference in rainfall reaching the ground between open areas and areas under forest canopy. The time intervals of the storms were not specified, so it is not possible to evaluate the consistency of the data presented in Reid (1998) with the evaporation rates cited by the UC team (1999) or Keim and Skaugset (2003). According to an abstract by Reid and Lewis (2004), evaporative losses in a 100 year old Douglas-fir/redwood forest canopy are approximately 22% of the total annual rainfall, asymptotically approaching 21% for storms with rainfall totals greater than 70 mm (2.8"). The assumption of the Reid and Lewis (2004) study is that the difference between the rainfall detected on collectors beneath forest canopy and in an adjacent clearing (six total) is due entirely to evaporation and stemflow losses. That assumption is not valid. The differences between the locations where rainwater falls into and out of the canopy are significant, particularly under windy conditions. Under an alternative hypothesis, not considered by Reid and Lewis (2004) but discussed in the presentation of that paper, the results indicate substantial re-direction of rainfall by the canopy, rather than large evaporative loss, during large storms. Additionally, the evaporation rates postulated under the Reid and Lewis (2004) model are at a minimum twice the evaporation rates cited by the UC Team (1999).

Reid and Lewis (2004) hypothesize that large evaporation rates from mature conifer forest canopy occur because of the large surface area of foliage. That hypothesis incorrectly assumes that the surface area of foliage is the surface area available for evaporation of water. Redwood and Douglas-fir fronds are very efficient devices for gathering surface water into large, spheroidal drops. That is an evolutionary water-conserving feature that allows conifers to extend their photosynthetic period under drought conditions, utilizing condensation and fog. The evaporative surface of water stored in spheroidal drops is much lower than the evaporative surface that would occur if water were evenly distributed over the fronds, as the Reid and Lewis (2004) model assumes. It is also unclear how the rainfall re-direction issue was addressed in the studies that provided the canopy evaporation data cited by the UC Team (1999). Taking those results at face value, it is theoretically possible for a storm to occur where a canopy evaporation rate of less than 0.3"/day makes a critical difference to slope stability. There is, however a greater probability of storms occurring that exceed a 0.3"/day critical evaporation window, and an even greater probability if the critical evaporation rate is smaller.

To summarize, canopy interception during large storms may be mainly significant as a microburst buffer that would attenuate pore pressure waves in near-surface soils, analogous to infiltration through on-ground organic debris. The loss of microburst buffering is an impact limited to the area where the canopy has been removed. Loss of on-ground organic debris, through either yarding-related ground disturbance or site preparation, may be of equal or greater significance relative to canopy loss as an impact on microburst buffering.

Given the dynamic and evolving nature of the literature surrounding tree removal and shallow landsliding, HRC Geology incorporates this background information into an analysis of potential harvest impacts based on past and current slope stability conditions and the effects of past disturbances on slope stability conditions, as revealed by thorough observation of historical and field evidence. Potential slope stability conditions are considered in the context of the past and current slope stability conditions, potential impacts from root strength loss, evapotranspiration changes, canopy interception, ground disturbance, and drainage disturbance. Our operating assumptions are the following, based on empirical observation and literature review in accordance with standards and practices for engineering geology:

- Slide-prone terrain can be identified by evaluating where landsliding has occurred in the past and identifying the conditions that led to landsliding. Younger landslides are more likely than older landslides to be near a threshold of instability that could be impacted by management practices. The activity classification system of Keaton and DeGraff (1996) provides a tool for evaluating the potential sensitivity of landslides to management-related disturbances.
- Transient loss of root strength can be expected, however, much root strength will be retained after logging of Coastal Redwood because of the ability of cut redwood to re-sprout stumps and maintain vital root systems after harvest. Alternative silvicultural prescriptions can mitigate this hazard.
- Evapotranspiration and canopy interception may influence the potential for shallow landsliding by influencing the antecedent conditions for large storms early in the storm season. Their effect diminishes as the storm season progresses.
- Canopy interception may help attenuate pore pressure waves from precipitation microbursts in the upper soil layers. It is probably a relatively insignificant factor in the overall water budget of large storms.
- Ground disturbance from road building and yarding are relatively important impacts of timber harvest due to potential for drainage disruption, unstable fills and soil compaction. Impacts are specific to road locations road construction practices, yarding techniques, and site geological conditions. Ground disturbance impacts must be evaluated relative to the road construction and yarding systems proposed and those used in the past.

Studies of deep-seated landslides show that activity of these features is controlled by a complex of structural, rheologic, hydrologic, and climatic factors. Initiation of activity or re-activation of sliding may be caused by large triggering events such as earthquakes, secular changes in climatic or hydrologic regime, or disturbance of the mass balance (head loading and toe cutting) of the slope. Mass balance disturbance may be due to natural or anthropogenic factors. The most significant anthropogenic mass balance and hydrologic disturbances are associated with roads and landings. Harvesting on active deep-seated landslides may increase their activity rate or extend their active seasonal period. From a land management standpoint, the most serious issues pertain to recognition of features that are likely to have their activity level affected by timber harvesting.

Given all of the above factors, recognition of deep landslide features potentially impacted by timber harvesting would be best facilitated by using the activity classification system contained in Keaton and DeGraff (1996). The Keaton and DeGraff (1996) system contains variations for slides in humid and arid climates. The activity classification of morphological features in humid climates is based on Wieczorek (1984). This approach has the merit of evaluating landslide sensitivity based on objectively observable morphological features that indicate age of activity. Morphological activity and sensitivity indicators would provide a means of estimating the severity of disturbance necessary to affect the activity of a deep-seated landslide.

GEOLOGIC AND GEOMORPHIC SETTING OF THE THP

Geologic Setting

The Next Becks Thing THP is located within the Northern Coast Ranges Province of California. The province is characterized by north-northwest oriented ranges that reflect the dominant regional structural trend. In the northern part of the province, the structural trend is dominated by northwest-striking, northeast-dipping thrust faults and northwest trending fold axes that accommodate northeast directed shortening. Shortening is in response to convergence of the North American and Gorda Plates across the Cascadia subduction zone. In the southern part of the province, the local structural grain is dominated by north-northwest trending strike-slip faults associated with the San Andreas transform margin between the North American and Pacific Plates. Between the northern and southern portions of the province, the northwest trending structure is overprinted with west-northwesterly trending folds and thrust faults. The superimposed west-northwest trending structures are generally accepted to be a result of the northward migration of the Mendocino Triple Junction (Kelsey and Carver, 1988; Aalto et al., 1995). The Mendocino Triple Junction (MTJ) marks the location where the Cascadia subduction zone to the north transitions to a transform margin to the south.

Because of the seismotectonic setting of Humboldt County, there are numerous sources of potentially large earthquakes. Six distinct sources of damaging earthquakes are described in Humboldt County. In general, the six seismic sources are a manifestation of the interaction between three opposing tectonic plates (North American, Gorda, Pacific). The six sources are a breakdown of source earthquakes from different inter-plate and intra-plate fault systems. Large earthquakes have occurred and will occur in the vicinity of the THP (January 9 and February 4, 2010). Slope stability may be reduced by strong ground accelerations. Site response during strong ground motion will depend on a complex interaction between site-specific conditions of earth materials, topography, lithology, hydrology, earthquake wave travel path and distance to source.

Falls (1999) (Figure 2a) geologic mapping shows the Franciscan mélange in fault contact with the Wildcat Group near the western extent of the proposed THP. The Yager terrane is mapped within the lower elevations of deeply incised drainages west of the plan area. Progressing east, Falls (1999) maps thrust faults repeating sections of the mélange, interrupted by the Central Belt of the Franciscan Complex. McLaughlin et al. (2000) maps the Freshwater Fault, and associated splays, in close proximity to the Coastal Belt Thrust Fault at similar map locations identified by Falls (1999).

Falls (1999) describes the Cretaceous / Jurassic Franciscan Complex mélange is a highly sheared shale matrix that includes numerous erratic blocks of greenstone, greywacke, conglomerates, mudstone, and schists to name a few. The Central Belt of the Franciscan Complex is described as well consolidated sandstone, siltstone, and shale with minor amounts of conglomerate that are moderately to highly deformed and highly sheared locally. The Yager terrane is described as early tertiary interbedded well consolidated silty shales, sandstones, and conglomerates.

Numerous authors map the Freshwater fault as an east-dipping, thrust or reverse fault (McLaughlin et al., 2000; Jennings, 1994; Knudsen, 1993; Clarke, 1992, Ogle, 1953). Acoustical reflection surveys by the US Geological Survey support this interpretation (Clarke, 1992). Past THPs have provided structural interpretations associated with the faulting. Fault mapping by SHN (2000) and SGD (2001) have delineated contacts roughly consistent with published mapping.

Geomorphic Setting

As previously noted, the THP overprints a significant thrust fault zone. A significant increase in elevation occurs from west to east. This is expressed as a series of steps to the east. The areas underlain by the Wildcat Group sediments, west of the THP, include slopes that are typically smooth with deeply incised prominent watercourses. The drainage patterns, ridge-top elevations, and subsequent channel incision suggest a somewhat uniform underlying strata resulting in uniform slope weathering and channel development. The areas underlain by the mélange exhibit regional, random hummocky surfaces and the occasional hard rock outcrop. Slope inclinations range from nearly flat to nearly vertical in response to the faulting, failing, or irregular weathering that is common to heterogeneous rock matrixes. The eastern portion of the THP, underlain by the Central Belt of the Franciscan complex, exhibits the greatest relief, moderate to well incised watercourses, and typically more steeply inclined slopes. Due to shearing, slope breaks are often sharply defined. Observations of the underlying soils typically show variable mixing of the prominent lithologies. It is common in the eastern portions of the unit to observed, greenstone, chert, hard indurated sandstone within an apparent Wildcat group silty sand matrix.

Falls, 1999, maps numerous deep seated translational / rotational landslides and earthflows across the Freshwater fault zone. Previous THP geology reports consider these landslides to be dormant mature in age, or last active when faulting was occurring. Shearing across the fault coupled with uplift resulted in over-steepened and further weakened rock material that failed.

Additional surface morphology has been observed due to ground based dragging of the felled old growth logs to railroads. This has imparted surface alterations that resemble closely spaced hummocks, cross slope furrows, and extensive redistribution of soils where atop swales that were utilized as prominent yarding corridors.

Pedogenic and Engineering Soils

Review of the USDA pedogenic soils map shows variability of soils underlying the unit. The unit is underlain by Atwell, Hugo, Josephine, and Boomer series soils.

Atwell soils are mapped in the upper and lower elevations of the THP area. Atwell soils are described as very deep and derived from sheared sedimentary rocks (US Soil Conservation Service (USSCS), National Cooperative Soil Survey 1957). Characteristics reported by the USSCS (1957) consider the soil as a moderately well drained silt-loam with moderate permeability to a depth of 80 inches (ML-CL to GM-GC).

Hugo soils are described as well drained soils that form in weathered materials from sandstone, shales and conglomerates typically occurring on strongly dissected mountains with narrow ridge tops (U.S. Soil Conservation Service, 1958-1965). Hugo soils typically are comprised of gravelly sandy clay loams that measure to a depth of 60 inches. The textures vary from silty sands to silty gravels (SM to GM) and offer rapid permeability rates parleying to well drained characteristics.

The Josephine soils are described to consist of deep, well drained soils that formed in colluvium and residuum weathered from altered sedimentary and extrusive igneous rocks. Josephine soils are on broad ridge-tops, toe-slopes, foot-slopes, and side-slopes of mountains.

Boomer soil series consists of deep and very deep, well drained soils that formed in material weathered from metavolcanic rock. These soils usually form on upland slopes ranging from 2-75 % inclination. The soil textures are described as fine-loam to gravely-loam with horizons A-Bt containing gravely sandy clays. Deeper horizons contain silty clays and clay loam. The typical section is comprised of a sandy silty clay (SM to SC w/ gravels) that varies in depth with parent material. that are well drained with moderately slow permeability.

During our reconnaissance, we also evaluated soils in natural exposures and road cuts in general accordance with the Unified Soil Classification visual-manual method (ASTM D2488-90). We observed fine silty to sandy soils (SM-ML) and slightly coarser grained materials (SM –GM). Observed soils were from approximately 3 feet to greater than 6 feet in depth, and thickest on gently inclined slopes. Soils appear generally coarser in steeper upslope areas with increasing fines on gentler slopes.

Observed bedrock consisted of highly indurated meta-sandstone grading to schist facies in lower slope positions with zones of dense fracturing (BABo). Bedrock exposed in upslope positions of the THP area include well consolidated fine grained sandstone exhibiting a blocky fracture pattern. The highly indurated, well consolidated bedrock indicates low potential to liquefy when saturated in a disturbed state. It appears intersecting fracture planes and structural features within the bedrock will pose the most significant implications for earthwork and slope stability.

LAND USE HISTORY/AERIAL PHOTOGRAPHIC REVIEW

An aerial photographic review was conducted spanning from 1948 through 2010. This was done to establish a relative background rate of landsliding and locations and compare it to the rate viewed following timber harvesting. Unfortunately, the slopes were harvested prior to the first photo record. SGD, 2003, note in their aerial photograph review that clearcut harvesting had occurred prior to 1940. Landslides identified within the photographic review are discussed in further detail in the site characterization portion of the report if they are located within the THP area.

The 1948 aerial photographs show the entire area of the harvest plan recently clearcut (within 10 years). Access to the plan area utilized a railroad grade constructed within and adjacent Freshwater Creek. Rail inclines connected the lower rail grade to an upper, mid-slope rail grade consistent with a segment of Road 15 (U Road in HRC alphanumeric labeling system). Additional rail grades were utilized to access timberlands outside the plan area. We noted numerous cut slope and fill slope failures adjacent the upper and lower train grades within the plan area. Additional mass wasting appears throughout the very steeply inclined slopes that flank the prominent Class I and Class II watercourse channels. Identified by a mottled distribution of high albedo, the mass wasting appears to be limited to shallow localized debris slides or sloughing.

The 1954 aerial photographs depict a young stand of timber that is increasing in canopy closure. The previously observed mass wasting appears, for the most part, to be re-vegetating. Addition new mass wasting features were not observed.

By 1965, the train grade coincident with road 15 had been fully converted to a truck road and connected to Kneeland Road to the north and Elk River to the south. The canopy had increased to nearly 100 percent closure. The mass wasting observed in the previous photographs was almost completely covered by canopy.

Through 1994, we did not detect any mass wasting within the plan area. Road construction and partial harvested occur in the southwestern portion of the THP.

By 1997, a significant road system was constructed west of the plan area. Cable yarded partial harvesting was conducted adjacent the new road system. No harvesting occurred within the proposed THP. We observed small, isolated areas of recent streamside landslides adjacent Class I and Class II watercourses within the proposed THP.

The 2000 photographs demonstrate a somewhat resilience to mass wasting following the significant road construction and partial harvest west of the unit. We found no new landslides to report. Previously harvested slopes in the southwestern portion of the plan are largely re-vegetated. The remainder of the unit remains as maturing 2nd growth redwood and fir.

By 2003, small ground-based and cable yarded clearcuts had occurred adjacent eastern portions of the plan. New road construction occurred outside the western, mid-slopes portions of the proposed plan area. The majority of the proposed plan area remains as un-harvested 2nd growth. The areas previously harvest in the early 1990s remains without evidence of mass wasting.

By 2007, road construction and timber harvesting continued adjacent the proposed plan area. We did not observe the development of new landslides within the proposed plan area.

The 2010 photographs show little change within the proposed THP. Cable yarded selection harvests occurred to the west and east of the proposed units. No landslides were observed.

In summary, from aerial photographs and 10+ years following the initial harvest, the slopes underlying the proposed unit appear to accommodate timber harvesting with little mass wasting response. It is common for field level review of the slopes to increase the number of landslides located within the unit. Landslides did occur, however the density remained very low and distribution was limited to the steep streamside slopes and newly constructed roads and old train grades (likely fills). No evidence was observed suggesting reactivation of the multitude of mapped deep seated landslides or earthflows.

The HCP provides Riparian Management Zones (RMZ) that typically exclude the more steeply inclined stream side slopes. The HCP also provides road construction guidelines that direct more appropriate construction methods based on slope inclination, road inclination, erodibitly of the founding soils, and anticipated runoff volumes.

Recent timber harvesting in the vicinity of the current THP was conducted under N90 THP (1-00-428HUM), Incline THP (1-01-201HUM), East Incline THP (1-03-198HUM), Mid Incline THP (1-05-123HUM), and Becks THP (1-10-012HUM).

SITE CHARACTERIZATION
(Figures 3a through 3e)

Due to the large number of acres included within the unit, nearly every slope morphology and watercourse classification is found. Four clearcut harvest units are encompassed by the proposed THP. The harvests were all conducted under the HCP, two under interim prescriptions and two under the Freshwater Watershed Analysis prescriptions. At the most, the harvests document a minimal mass wasting response to modern clearcutting (applying the HCP and FPR rules) and limited activities where within unstable areas.

Group Selection harvest is proposed for the unit. Areas within the Class I and Class II RMZ and unstable areas are proposed for Single Tree Selection. Both cable and tractor yarding is proposed for the unit. Review of the Yarding methods map included in the THP will show that this equates to the cable yarding of steeply inclined slopes and ground based yarding of the gently inclined slopes. A significant amount of new road construction is proposed. New road construction locations were selected to access necessary yarding positions while minimizing construction through watercourse crossings, steep slopes, and potentially unstable slopes. Road construction for the Becks THP consisted of a similar amount of new road construction in similar underlying geologic material. We have not observed a significant amount of mass wasting resulting from the recently constructed roads in the Becks THP.

The stand composition varies between Redwood and Douglas Fir with minor inclusions of Grand Fir and hardwoods. The Forester informed us the stand averages 65 percent Redwood, 30 percent Doug Fir, and the remaining 5 percent is comprised of Grand Fir and hardwoods. The average basal area measures between 100 and 200 square feet where thinning and selection harvesting occurred in the late 1980s and early 1990s. Un-entered 2nd growth comprises the majority of the THP. Basal area estimates average 300 square feet per acre. The Forester has informed us that the basal area retention will typically range between 120 and 150 sq. ft where 2nd growth harvesting has not occurred. The intended mark will space the retained timber for future growth.

Of the hazard areas identified in the THP, the most populous appear to be over steepened streamside slopes. Thrust faults have been documented within the plan area by several authors (McLaughlin et al., 2000; Jennings, 1994; Knudsen, 1993; Clarke, 1992, Ogle, 1953). It appears that faulting along the Freshwater Fault and the Coastal Belt Thrust has contributed to over steepened streamside slopes within the plan area. This interpretation is based on asymmetrical topography of streamside slopes adjacent some of the prominent watercourses in the plan area. That is to say, over steepened slopes are present on one side of a watercourse while slopes opposite the same watercourse are moderate or gently inclined. These faults show evidence of displacement during the early Quaternary (700,000-1.6 million years ago) and will not impact proposed harvest operations. However, slope morphology resulting from Quaternary faulting presents conditions relevant to the proposed harvest plan.

For the most part, the steep streamside slopes display raveling of shallow gravelly soils (GM) and shallow debris sliding that exposes well consolidated meta-sandstone in head scarps and lateral margins. We observed increased spacing of smaller old growth stumps and increased fir species where steep streamside slopes are present. This appears typical of slopes with higher levels of disturbance. The watercourse channels typically expose competent bedrock and seldom exhibit significant accumulations of colluvium. Therefore, as a blanket prescription, the Forester has proposed no group openings on steep streamside slopes or any landslides with a high potential for sediment delivery to a watercourse. In several locations the Forester extended the outer band of the Riparian Mitigation Zone (RMZ) upslope to encompass steep or potentially unstable slopes. The areas within the outer band of the RMZ will remain single tree selection with a canopy retention standard of 60% on Class II watercourses and 50% on Class I watercourses.

Mass Wasting

A total of 42 mass wasting features were identified in the field, and are shown on Figures 3a through

3e. Many of the features display similar characteristics and few have significant potential to be affected by the proposed selection harvest. The most common types of mass wasting within the plan area are debris slides and debris slide slopes. Earth flows, translational/rotational landslides, headwall swales, and inner gorge slopes occur less frequently. The following descriptions provide information used to assess mass wasting potential and potential harvest related impacts. Indicators utilized to gage relative slope stability in the field include old growth stumps, vegetation, slope morphology (scarps, deposits, hummocky ground, swept timber), and stand composition and approximate stand age. Slopes with undisturbed old growth stumps, straight growing mature second growth conifer, and lacking morphology related to mass wasting indicate a relatively high degree of slope stability. On slopes with disturbed old growth stumps, and second growth conifer that is swept, tilted, or younger than surrounding stands we often observed morphology related to landsliding.

Several of the mapped landslides are within and adjacent watercourses and require increased retention as part of the HCP Prescriptions Based on Watershed Analysis (Palco, 2002). Landslides proposed for harvest within the THP, that are dormant historic or younger, with significant potential to deliver to a watercourse have been divided into groups of similar characteristics and described below. All features described below are dormant historic or younger. Mapped landslides not described below are dormant young or older, do not support merchantable timber or, are not proposed for harvest.

Debris Slides and Debris Slide Slopes

The majority of the landslides (27 of the 42 mapped landslides) within the Next Becks Thing THP are active suspended or historically active debris slides and debris slide slopes. In general, debris slides are less than 200 feet long, 50-100 feet wide, and 3-5 feet deep. Larger debris slides have occurred within the plan area. Debris slides and debris slide slopes often initiate at a break-in-slope near ridge tops and adjacent watercourses. The steepest slopes and slopes with fresh landslide morphology support significantly lower volumes of merchantable timber. Many of the mapped landslides are within Class I and Class II RMZ buffers and will maintain 50 percent or 60 percent canopy closure post harvest respectively.

Debris slides and debris slide slopes targeted for increased retention and no group openings are dormant historic or younger, have delivered, or have high potential to deliver to a watercourse and extend outside the RMZ. The mapped landslides and landforms that fall into this category include **9**, **13**, **14**, **15a**, **18**, **19**, **21**, **24**, and **27**.

Debris slide slope **9** (Figure 3a) is inclined between 75 and 90 percent on west, north, and east facing slopes. The north facing slope leads towards an inner gorge slope (**10**) upslope of a Class I watercourse. A train grade crosses the down slope extent of debris slide slope and likely contributed to instability at the site. A large debris slide (**9a**) initiated upslope of the train grade and evacuated a portion of the grade. The train grade is intact adjacent **9a** with minor cut slope failures that deposit on the existing grade. Timber on landform **9** is dominated by fir trees that are widely spaced slightly swept and tilted. Robust vegetation is present on the majority of the slope beneath the over story canopy. Debris slide **9a** and inner gorge **10** have been flagged with no cut and are not proposed for harvest. No group openings and 120 square feet of basal area per acre is proposed for the north facing slope on landform **9**. The west and east facing slopes of landform **9** do not lead directly towards a watercourse.

Landform **13** (Figure 3a) is a debris slide slope containing dormant historic debris slides internally. This landform leads directly to Class I/Class II tributary to Freshwater Creek and has likely delivered sediment to the watercourse. Dense brush is present beneath the canopy and we did not observe recent landslide activity indicated by exposed soil. The stand is dominated by fir trees and we observed widely spaced old growth stumps that appear smaller than average indicating a higher degree of disturbance on this slope. We recommend the Forester expands the harvest exclusion zone for the RMZ to the outer band of the RMZ and retains 120 square feet of basal area retention per acre with no group openings.

Landform **14** (Figure 3b) is a debris slide slope located at the confluence of two Class II watercourses. Slope inclinations range from 75 to 90 percent and are densely vegetated. The majority of the landform is within the Class II RMZ and will retain 60% canopy post harvest. Steep raveling slopes extend approximately 80 feet upslope of the RMZ. The Forester informed us no group openings will occur on the landform and 120 square feet of basal area per acre retention will remain post harvest. We concur with the Foresters proposal.

Landslide **15a** (Figure 3b) is a dormant historic debris slide that is void of merchantable timber. The landslide is located within a broader swale containing muted landslide morphology suggesting dormant old to dormant mature landsliding. The Forester proposes no group openings and retention of 120 square feet of basal area per acre post harvest. We concur with the Foresters proposal.

Landslide **18** (Figure 3c) is a dormant historic debris slide that initiated at the outboard edge of Road 15. The upslope half of the landslide is void of merchantable timber. The down slope portion of the landslide contains limited amounts of conifer that is backfilled with colluvium. No harvesting is proposed on landslide **18**. We concur with the Foresters proposal to exclude this landslide from harvest.

Landform **19** (Figure 3c) is an area of steeply inclined streamside slopes. We observed raveling of gravely soils and exposures of highly fractured, well consolidated meta-sandstone. This slope does not support a robust stand of mature second growth timber. The RMZ flagging has been expanded upslope to encompass this landform. The Forester informed us no trees would be marked for harvest at this location.

Landslide **21** (Figure 3c) is a dormant historic debris slide that delivered to a Class II watercourse. The source area and body of the landslide are vegetated with brush and saplings. Mature second growth conifer is present in the deposit zone within the RMZ. Green tree retention ("L" trees) has been marked upslope of the head scarp. The Forester proposes no group openings and retention of 120 square feet of basal are per acre post harvest.

Landforms **24** (Figure 3b) are steep streamside slopes characterized as debris slide slopes. Small, shallow dormant historic debris slides are present internally. These slopes are dominated by fir trees and contain dense underbrush. The Forester proposes to retain 120 square feet of basal area per acre with no group openings.

Landslide **27** (Figure 3b) is a dormant historic debris slide that initiated at a break in slope leading towards a Class II watercourse. The head scarp extends approximately 130 feet upslope of the Class II RMZ. The trees on the landslide are a similar size as the surrounding stand indicating this debris slide may have became active in response to the initial clear cut harvest. The Forester proposes to retain 120 square feet of basal area per acre post harvest with no group openings.

Earthflows

Three active suspended to dormant historic earthflows were identified within the plan area. These landslides are likely pore pressure induced and move seasonally or on longer time intervals in response to peak flow conditions. Typically these slides have a subtle lobate expression with narrow heads and broad toes. At the heads of these slow-moving features are moderately weathered scarps that range between 4 and 6 feet in height. Typically, the head scarps, which are commonly arcuate-shaped, grade into moderate-sized (less than 6 feet) semi-linear lateral scarps. The surface expressions of scarps vary based on the timing and magnitude of ground movement. In recently active, faster moving areas, we observed fresh un-vegetated scarps; in less mobile regions scarps have weathered expressions, but retain a near-vertical orientation.

The bodies of these earthflows are characterized by low to moderate gradient (20-50 percent) slopes with irregular and hummocky surface expressions. The slow moving flows are generally characterized by numerous scarps showing incremental offsets that subtly deform standing timber with the old growth stumps showing the most deformation. These landslide types have demonstrated an increased sensitivity to even age silviculture and road construction. Therefore, no road construction is proposed in the vicinity of an active suspended to dormant historic earthflow and basal area retention has been increased on the three active suspended to dormant historic earthflows identified within this plan.

Landslide **7** (Figure 3a) is a very small, recently active earthflow that initiated within the fill prism of the train grade adjacent Freshwater Creek. The landslide is 70 feet long, 30 feet wide, and 2 feet deep. No sediment delivery was observed as the landslide parallels a Class II watercourse. The landslide is within the Class II RMZ so no group openings will occur. No merchantable timber is present on the body and green tree retention ("L" trees) has been marked adjacent the perimeter of the landslide. The proposed harvest activities are not likely to significantly alter existing stability conditions at this location.

Landslide **12** (Figure 3a) is an active suspended to dormant historic earthflow located in the northeastern portion of the proposed THP. We observed swept second growth timber and rotated old growth stumps on the body of the landslide. One old growth stump is split with approximately 15 feet of lateral offset between the two halves. The head scarp and lateral margins are not clearly defined by prominent scarps. The extent of the landslide was determined by the transition to un-deformed old growth stumps and straight growing second growth timber. A sharp break in slope is present in the lower body of the landslide where slope inclinations increase and lead towards a swale containing a Class III watercourse. It appears reduced lateral support caused by the break in slope is a driving mechanism for the upslope slide mass. The Forester proposes no group openings and 120 square feet of basal area retention per acre.

Landslide **20a** (Figure 3c) is an active suspended to dormant historic earthflow located down slope of Road 15. We observed hummocky slope morphology, swept second growth timber, and numerous rotated old growth stumps. A class II watercourse is present within the slide body. Watercourse morphology is erratic and poorly developed. Subdued earthflow morphology is present upslope of **20a** and shown on the Mass Wasting Location Map (Figure 3c) as landslide **20**. The right lateral margin of **20a** is non-distinct and likely located within a Class II watercourse channel. The left lateral margin is well defined, approximately 4-6 feet tall, and near vertical. The RMZ for the Class II watercourse encompasses the landslide. The Forester informed us no trees are marked for harvest within landslide **20a**.

Translational/Rotational

Translational/rotational landslides within the plan area are typically dormant young or older. These landslides are typically identified by topography expressing step-riser morphology within swales and steep slopes in the source area ("riser"). The "steps" are characterized by low to moderate gradient (25-50 percent) lens shaped benches with uneven surfaces supporting un-deformed second growth conifer. Typical landslide characteristics are generally muted and old growth stumps appear undisturbed.

We identified 1 landslide (**11**) classified as translational/rotational that is dormant historic. We did not identify any translational/rotational landslides that are active or suspended. Landslides that are dormant young or older have a low potential for reactivation and likely will not deliver sediment to a watercourse.

Landslide **11** (Figure 3a) is a dormant historic translational/rotational landslide located in the northeastern portion of the THP. The head scarp is weathered and vegetated with ferns and mature second growth redwoods. The head scarp is 4-6 feet tall and in close proximity to the train grade. A low gradient "step" slope extends approximately 40 feet down slope from the head scarp. The landslide delivers to a Class I watercourse and is encompassed within the RMZ for the Class I watercourse. Within the Class I RMZ 50% canopy must be retained. The Forester informed us this will equate to approximately 150 square feet of basal area retention per acre. We worked with the Forester to mark trees for harvest on this slide that will have the least impact to slope stability. In general we avoided marking individually growing trees and targeted trees growing on the upslope side of stump clumps. Ideally this will retain some of the benefits from canopy effects and limit the loss of root strength.

Inner Gorges and Headwall Swales

Inner gorges, as defined by the HCP, are located within and adjacent the proposed harvest plan. Geomorphic inner gorges were mapped along watercourses at various locations within the THP. Geomorphic inner gorges are typically less than 100 feet wide and generally do not support robust timber stands. Inner gorges identified here have very steep slopes leading to highly confined watercourse channels, typically Class I and Class II watercourses. Mass wasting associated with inner gorges is largely dormant historic or older. We attribute dormant inner gorge processes to highly competent bedrock more resistant to erosion and down cutting than other lithologies in the region. All inner gorges are within RMZ and will not be subjected to harvesting. The proposed harvest is unlikely to exacerbate erosion from inner gorges due to RMZ buffers and selection silviculture.

We observed one headwall swale, as defined by the HCP, present within the proposed harvest plan. This landform has been cataloged as **16** and appears on Figures 3b, 3c and 3d. This landform has been encompassed in NO CUT flagging and will not be harvested on.

Landform **23** (Figure 3c) has been identified as inner gorge slopes by the Forester. We concur with the Foresters interpretations. The Forester expanded the RMZ harvest exclusion zone to encompass landform **23**, therefore, no harvest operations will occur at this location.

Landform **32** (Figure 3e) meets the HCP definition of an inner gorge slope. The break in slope defining the feature does not extend outside the WLPZ flag line. Landslides within the feature are generally dormant historic with a few areas that appear active suspended close to the watercourse and within the harvest exclusion zone. A commercial thin harvest plan was conducted on this slope in the mid 1990s leaving the existing canopy reduced which dramatically limits harvesting within the WLPZ for this harvest plan. We observed approximately 5 trees marked for harvest upslope of the break in slope defining the inner gorge. We did not observe evidence of instability on the main line haul road (Road 15) that crosses this feature. Based on our observations, it does not appear the proposed harvest will have a significant impact on slope stability at this location.

Dormant Young and Older Landsldies

Numerous additional dormant young to dormant old deep seated landslides are mapped throughout the figures. We do not provide discussion regarding the failures in an attempt to simplify this report. The landslides have been evaluated in previous THPs and found to be largely unaffected by prior clearcut timber harvest activities. In some cases, there stability has been assessed to accommodate significant road systems. This plan proposes a regional selective harvest with the option of groups (up to 2.5 acre block where the complete overstory will be removed). The larger 20 and 40 acre clearcut units encompassed by this harvest plan suggests that the small clearings will present a minor to insignificant increase in the potential for mass wasting if the HCP and FPR protocols have been followed. In our experience, it is highly uncommon for harvest related impacts triggered reactivation of dormant landslides.

RECOMMENDATIONS

The recommendations for mitigation of landslide hazards and risks relative to THP activities have been incorporated into the unit layout by the Forester as described in the site characterizations for individual landslides. The harvest exclusion areas are marked on the ground with NO CUT flagging. Otherwise, default prescriptions and exclusions marked by the Forester are adequate protection for watercourses from mass wasting and sedimentation.

Road Construction Recommendations

Road Point 350 on the X65.50827676 Road correlates with a dormant historic debris slide upslope of a proposed Class II watercourse crossing. The proposed road crosses the down slope extent of the landslide which deposited in the watercourse. The Forester proposes to install a permanent culvert at this location. We recommend excavating the deposit from the watercourse to the extent feasible, minimize cut slope heights and rock armoring the excavation into the deposit with rip-rap. A rolling dip will be installed to drain surface water away from the crossing.

Road Segment 3150-3280 on the U97 Road identifies a segment of full bench construction on steep raveling slopes. The nearest watercourse is approximately 350 feet down slope from the bottom of the steep raveling slopes and approximately 500 feet from the proposed road location. Gently to moderately inclined slopes are present between the proposed road location and the nearest watercourse. Based on the proximity to the nearest watercourse, gently to moderately inclined slopes, and absence of a fill prism, it appears unlikely this site poses significant potential to deliver to a watercourse.

Road Point 1975 on the U97 Road identifies a dormant historic translational/rotational landslide that delivered to a Class II watercourse. This landslide was previously mapped by John Coyle and

Associates (2003). The proposed road alignment crosses upslope of the head scarp of the landslide. We recommend no side cast at this location. No fills are to be placed on the landslide identified by Road Point 1975.

JUSTIFICATION

Harvest impact concerns within the THP consist of the potential for ground disturbance and loss of root strength after harvest to trigger shallow landsliding and sediment delivery to watercourses. The risk of sediment delivery to watercourses is evaluated relative to the proposed operations. High hazard areas with risk of sediment delivery to watercourses are protected by the retention requirements initiated by steep slopes leading to watercourses, and expansion of RMZ boundaries for specific high hazard areas. The retention of timber is the best way to mitigate potential impacts from loss of root strength.

CONCLUSIONS

The Next Becks Thing THP is located in proximity to areas with a high natural degree of instability and sediment production. The natural instability arises from fractured / sheared and weathered bedrock, rapid tectonically driven fluvial downcutting, and a climate characterized by large winter storms. Early timber harvest practices included yarding large logs downhill towards watercourse, and construction of yarding corridors and railroad grades on unstable slopes. Yarding corridors and railroad grades associated with the initial harvest entry concentrated surface water and moved soils, causing drainage disruption on potentially unstable slopes.

The THP contains areas that exhibited an unstable response to past timber harvest practices and large storms. The proposed harvest will leave significant retention and involve limited ground disturbance in sensitive areas and will not have an impact comparable to the initial harvest activities. The areas with the highest risk of sediment delivery to watercourses and areas where the required retention is not feasible are avoided.

Potential impacts of harvest with cable and ground-based yarding include loss of canopy, partial loss of root cohesion, and slope drainage disturbance related to tractor yarding. While these impacts are acknowledged, we are of the opinion that the silviculture, yarding methods, and layout of the plan as proposed by the RPF are geologically compatible with the observed slope stability conditions and will mitigate potential impacts of harvest on sediment delivery to watercourses.

Impacts from sediment delivery are not anticipated to exceed offsetting sediment mitigation required under the terms of the HRC Habitat Conservation Plan.

We have used our best professional judgment to assess the present and future slope stability risks and assist the Forester in proposing a harvest plan that does not increase the risk to the resources present in the Freshwater Creek watershed.

LICENSED SIGNATURE

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ATTACHED FIGURES

Figure 1: Location Map
Figure 2a: Geologic and Geomorphic Features Related to Landsliding (Falls, 1999)
Figure 2b: Key to Geologic and Geomorphic Features Related to Landsliding
Figure 3a: Mass Wasting Location Map, northern
Figure 3b: Mass Wasting Location Map, central
Figure 3c: Mass Wasting Location Map, southwestern
Figure 3d: Mass Wasting Location Map, south central
Figure 3e: Mass Wasting Location Map, south eastern
Figure 4: Harvest Restirctions Map
Figure 4a: Harvest Restictions Map, Expanded View
Figure 5: Road Point Location Map

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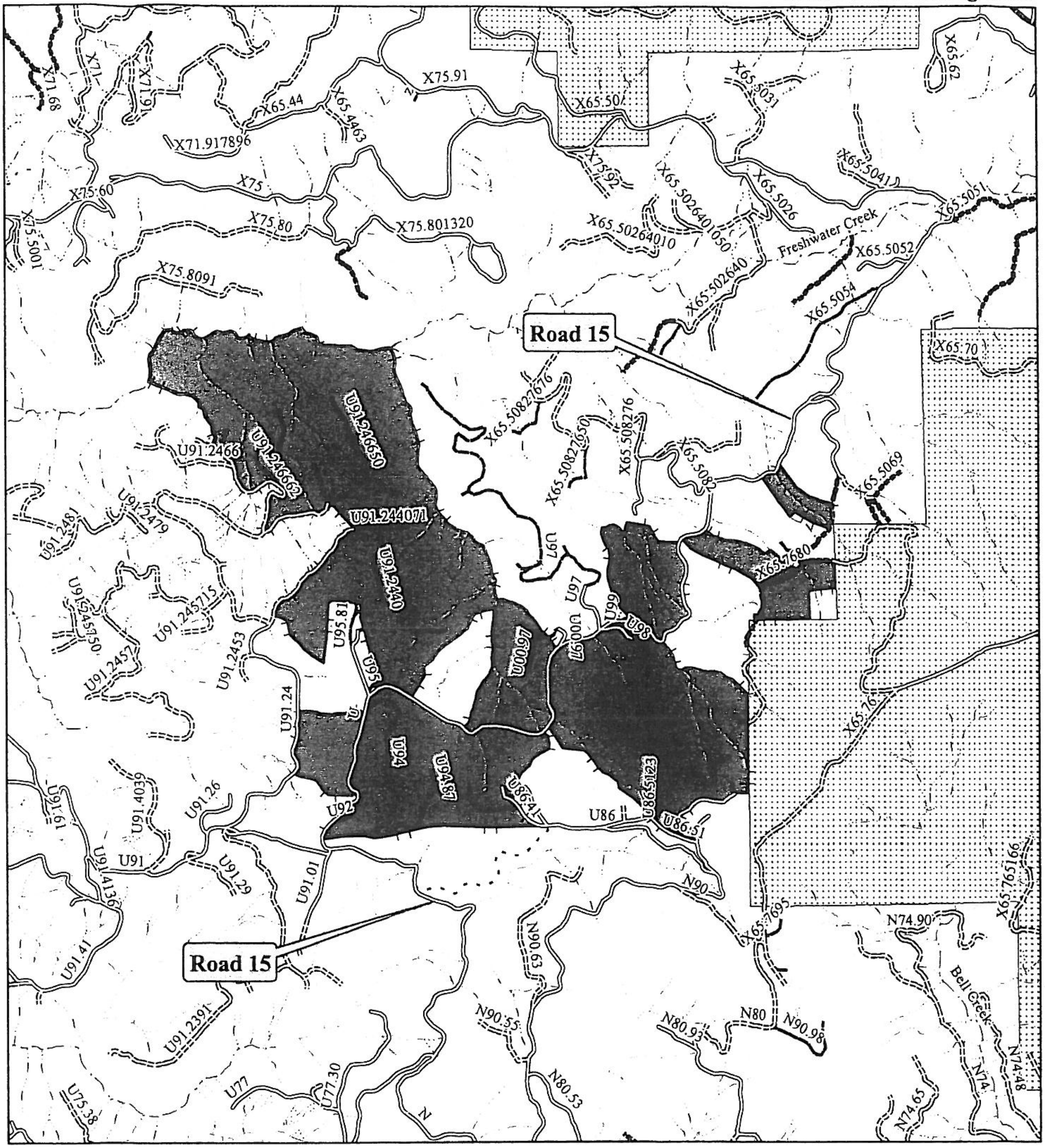
Next Becks Thing THP



Roads

- Paved Roads
- Rocked Roads
- Dirt Roads
- Jeep Trail
- Proposed Roads
- Reconstruction
- Decommissioned Roads
- Closed Dirt Roads
- Closed Rocked Roads

Watercourses

- Class 1
- class 2
- class 3

Ownership

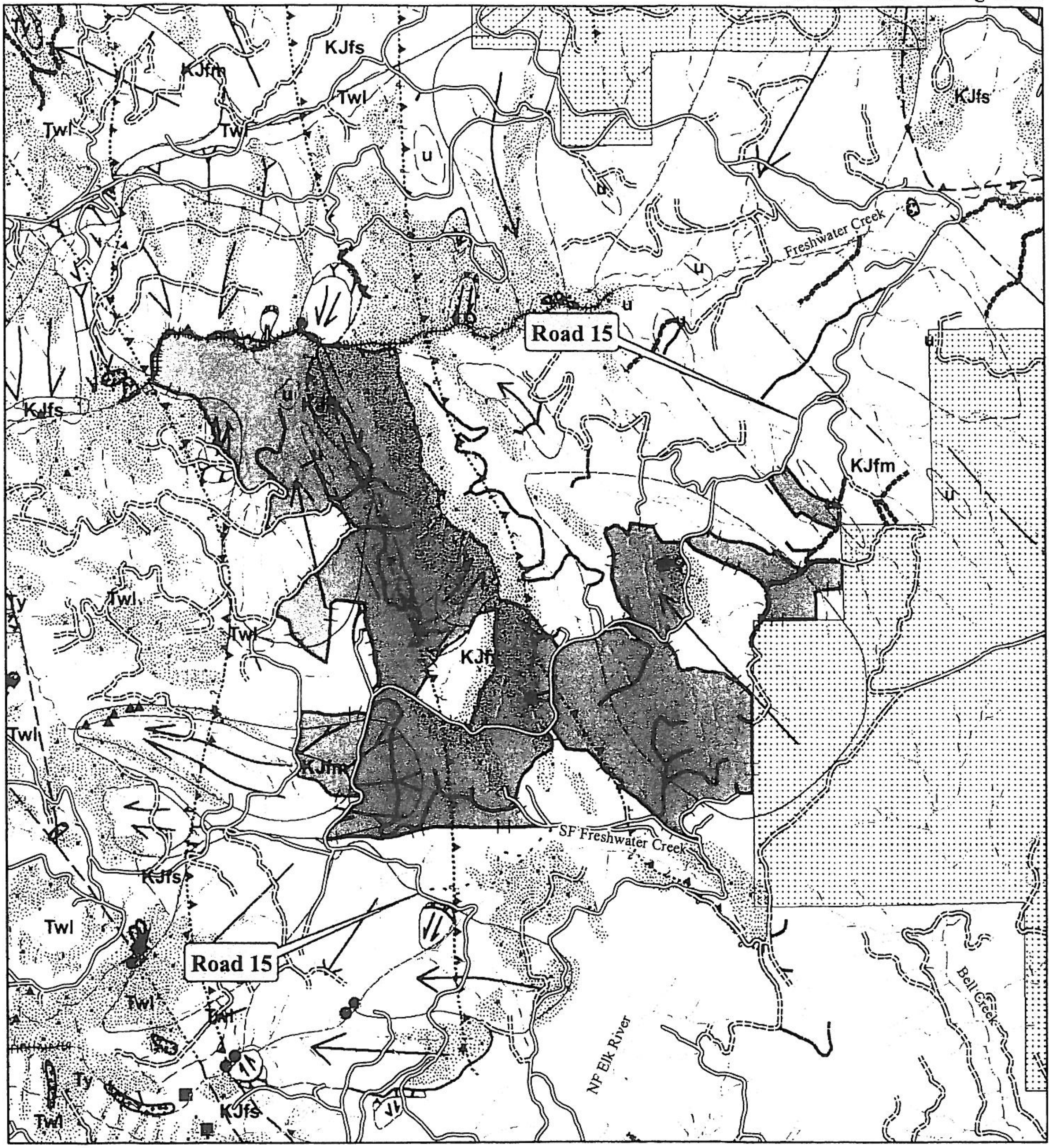
- OUT
- HRC

THP Boundary

- Nest Becks Thing

HRC Geology Department	N	Feet 0 1,000 2,000 4,000	Figure 1: Location Map
Drawn by: smw			
Date: 8/2/2012			

Next Becks Thing THP



Roads		Watercourses	Ownership
Paved Roads	Proposed Roads	Class 1	OUT
Rocked Roads	Reconstruction	class 2	HRC
Dirt Roads	Decommissioned Roads	class 3	
Jeep Trail	Closed Dirt Roads		
	Closed Rocked Roads		

HRC Geology Department

Drawn by: smw

Date: 8/2/2012

N

Feet

0 1,000 2,000 4,000

326

Figure 2a: Geologic and Geomorphology Features Related to Landsliding.

modified from Falls, 1999

Next Becks Thing THP

CGS Freshwater LS pts

air photo. observed

- 1942
- 1948
- 1954
- 1962
- 1966
- 1974
- 1984
- 1996
- 1997
- 1998
- 1999

CGS Freshwater structure

structure

- anticline, approx. loc.
- fault, approx. loc.
- fault, concealed
- thrust fault, approx. loc.
- thrust fault, concealed
- ?thrust fault, queried
- lineament

CGS Freshwater lines

- inner gorge
- torrent track

CGS Freshwater LS

failure mode, activity

- debris flow, historic
- debris slide, dormant
- debris slide, historic
- earthflow, dormant
- earthflow, historic
- translational/rotational, dormant
- translational/roatational, historic
- debris slide slopes

CGS Freshwater symbols

LS line

- active to historically active
- dormant

CGS Freshwater contacts

Contact

- approimately located
- certain location
- ---?--- queried location

CGS Freshwater geology

Q Recent Alluvium: Holocene (less than 10,000 years old). Interbedded gravel, sand, silt and clay within active stream channel and adjoining flood plain. Dike-protected pastures may be underlain by bay mud at northwestern end of flood plain.

Qfa Falor Formation (Knudsen, 1993): Late Pleistocene to late Pliocene (approximately 0.4 to 1.6 m.y.). Reddish-yellow pebbly conglomerate, sandstone and silt. Contains abundant animal and plant remains locally. May lie in gradational contact with Wildcat Group Upper Unit of Knudsen (1993). Fluvial and shallow marine depositional environment.

Qrt Alluvial Terrace Deposits: Probably late Pleistocene (more than 10,000 years old). Poorly consolidated flat-lying deposits of gravel, sand, silt and clay elevated above present streams.

TWu Wildcat Group- Upper Unit (Knudsen, 1993): Late Pleistocene to Late Pliocene (approximately 0.4 to 1.6 m.y.). Reddish-yellow fine- to medium-grained sandstone containing scattered pebble layers (<10%). Previously mapped as Hookton Formation in the southwest portion of the drainage and Falor Formation in the northeast. Depositional environment is generally shallow marine.

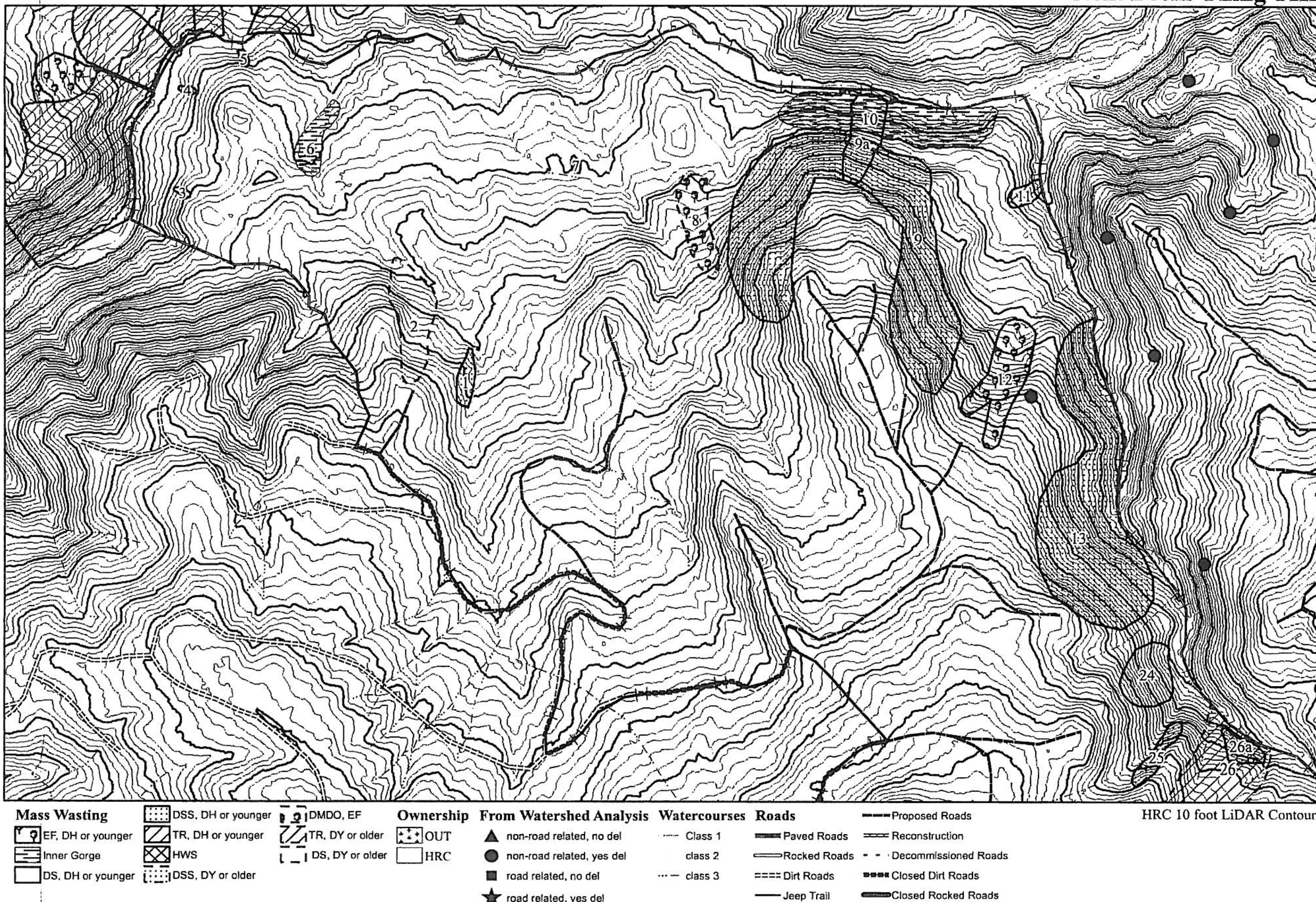
Twl Wildcat Group-Lower Unit (Knudsen, 1993): Middle Miocene to Late Pliocene (approximately 1.6 to 13 m.y.). Interbedded mudstone, silty, very fine sandstone and sandy siltstone. Upper portions of the unit are typically reddish-yellow, lower portions are gray to dark gray. Lower protions sandier and contain occasional pebble and conglomerate lenses.

Ty Yager Formation: Early Tertiary (approximately 50 to 60 m.y.) Interbedded well-consolidated silty shale, siltstone, sandstone, mudstone and conglomerate. Clasts of the shale and mudstone disaggregate over the course of several seasons by repeated wetting and dryig cycles. Sandstone units are generally massive (no visible bedding) and contain detrital muscovite. Medium gray where fresh. Finer grained materials are often well bedded. The unit in this locality is mapped as dipping steeply to the northeast.

Kjfs Central Belt of the Franciscan Complex, Sedimentary Rocks: Cretaceous/Jurassic (approximately 145 m.y.). Well consolidated sandstone, siltstone, and shale with minor amounts of conglomerate. Medium to dark gray where fresh. This unit is described as moderately to highly deformed and highly sheared locally.

Kjfm Melange: Highly sheared shale matrix containing individual blocks of graywacke, mudtone, conglomerate, greenstone, chert, blueschist, greenschist, actinolite, talc and serpentinite.

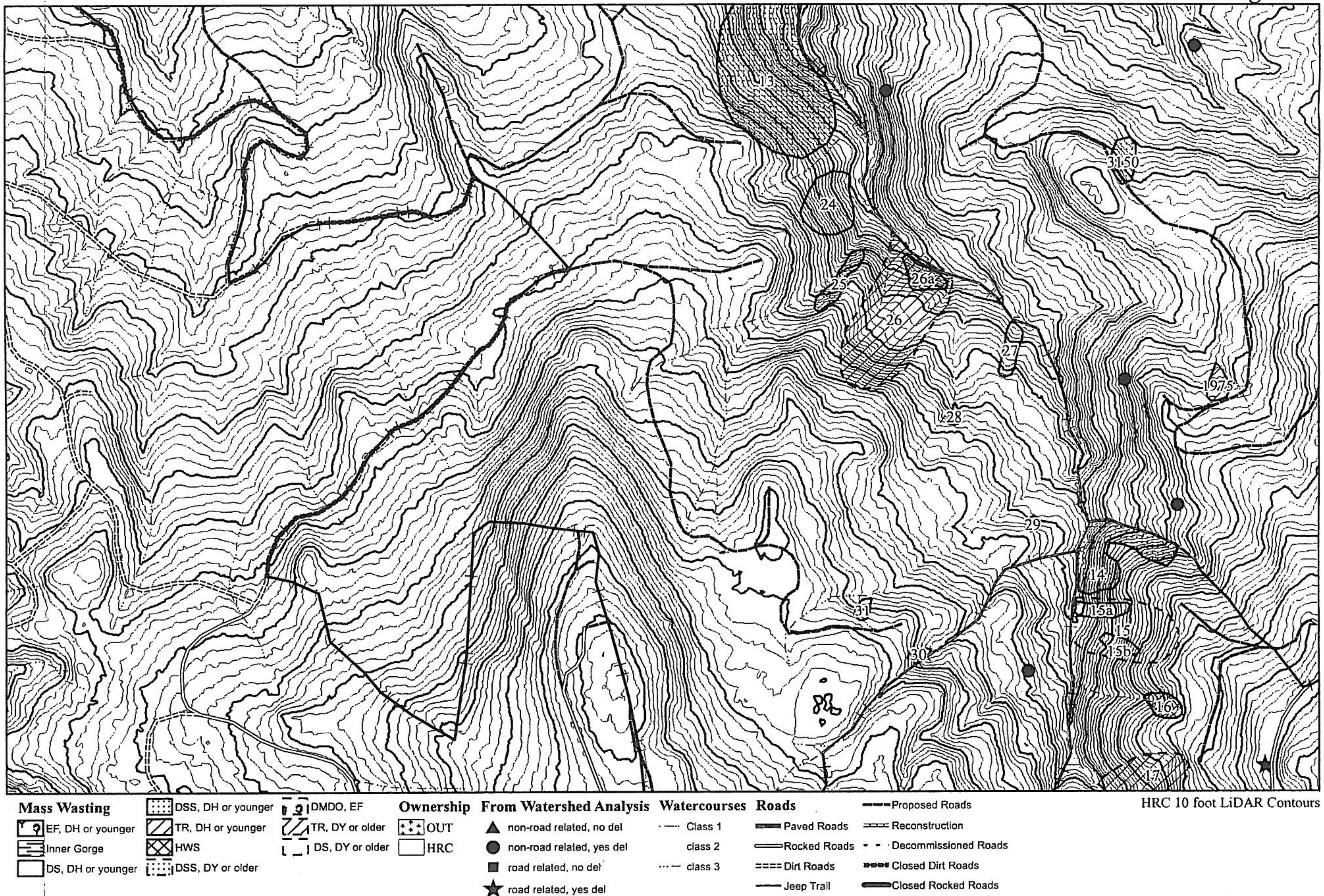
HRC Geology Department	Figure 2b: Key to Geologic and Geomorphic Features Related to Landsliding (Falls 1999)
Drawn By: swatkins	
Date: 8/2/2012	



HRC Geology Department
Drawn by: smw
Date: 8/27/2012

Figure 3a: Mass Wasting Location map, northern

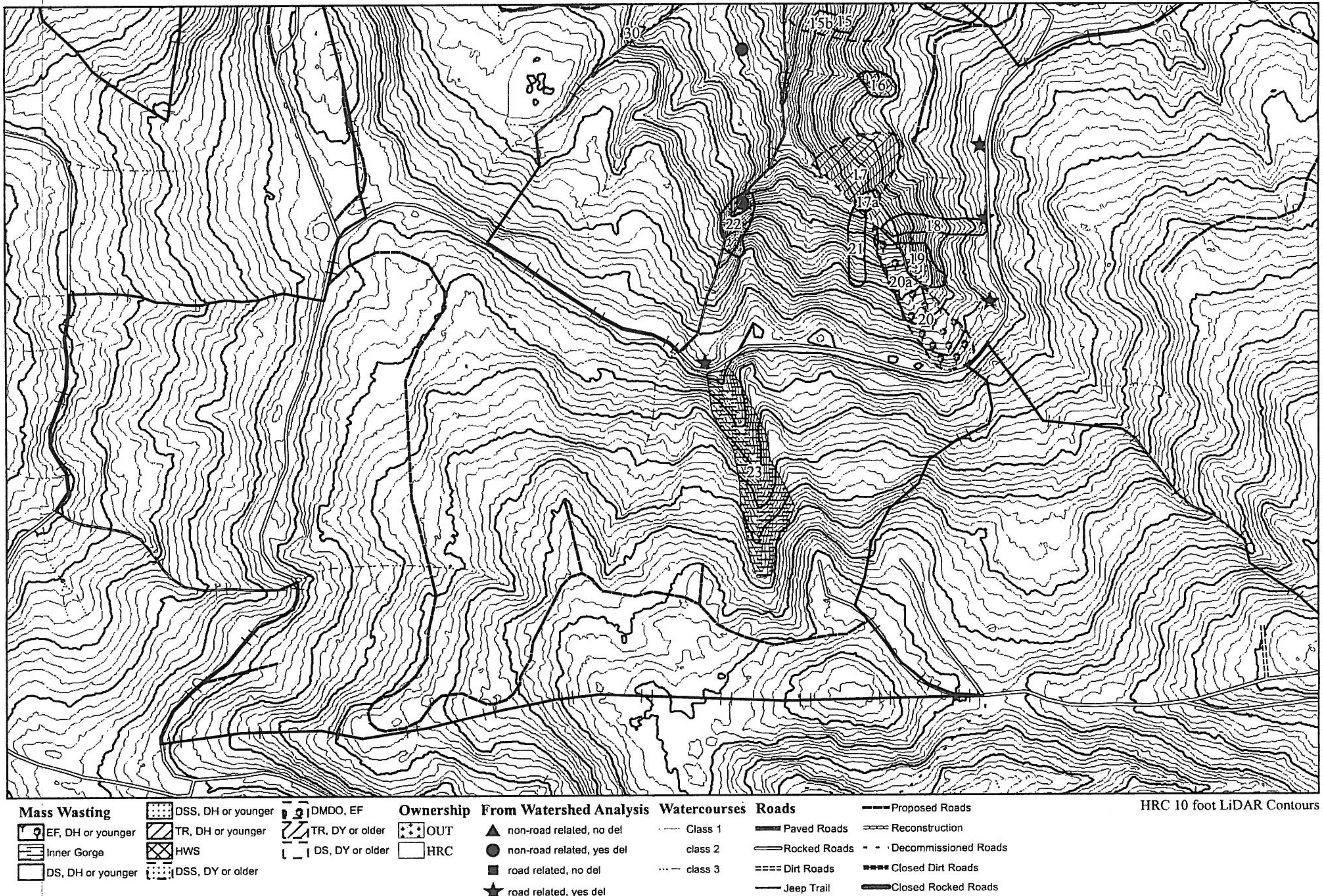
Next Becks Thing THP



HRC Geology Department
Drawn by: smw
Date: 8/27/2012

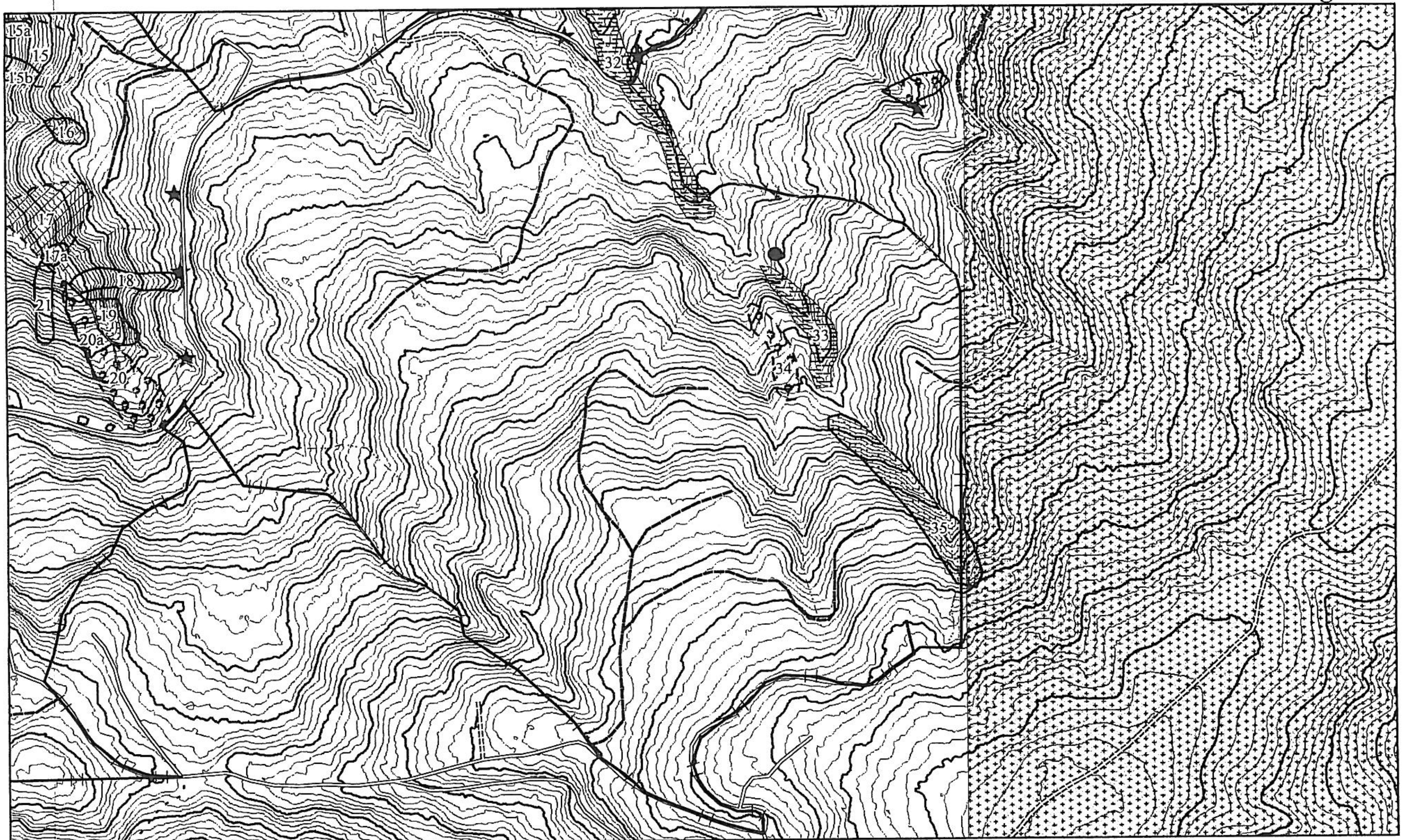
Figure 3b: Mass Wasting Location map, central

Next Becks Thing THP



HRC Geology Department Drawn by: smw Date: 8/27/2012	N	Feet 500 250 0 500	**Figure 3c: Mass Wasting Location map, southwestern**

Next Becks Thing THP



Mass Wasting
- EF, DH or younger
- Inner Gorge
- DS, DH or younger
- DSS, DH or younger
- TR, DH or younger
- HWS
- DSS, DY or older
- DMDO, EF
- TR, DY or older
- DS, DY or older

Ownership
- OUT
- HRC

From Watershed Analysis
- non-road related, no del
- non-road related, yes del
- road related, no del
- road related, yes del

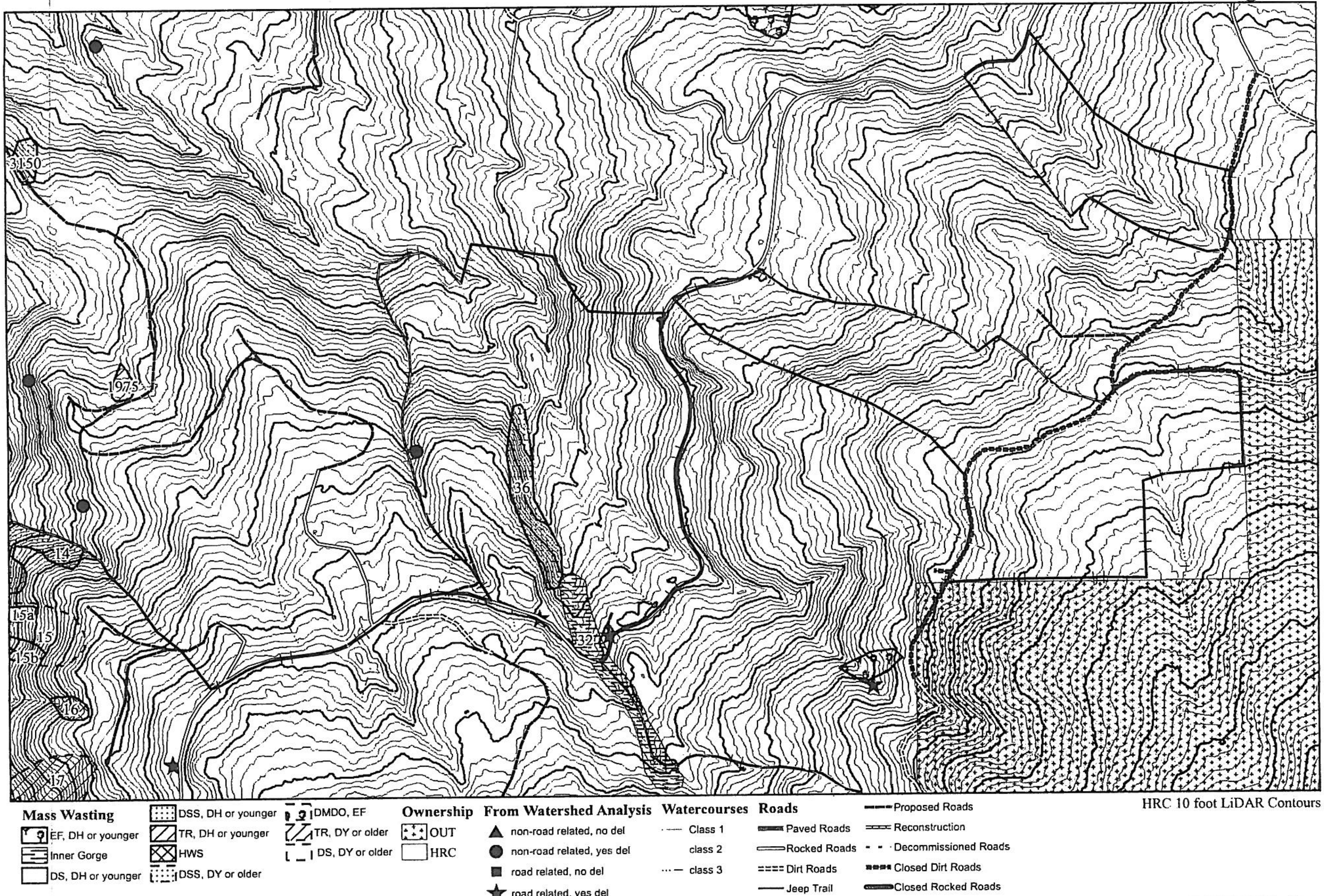
Watercourses
- Class 1
- class 2
- class 3

Roads
- Paved Roads
- Rocked Roads
- Dirt Roads
- Jeep Trail
- Proposed Roads
- Reconstruction
- Decommissioned Roads
- Closed Dirt Roads
- Closed Rocked Roads

HRC Geology Department	N	Feet: 500 250 0 500
Drawn by: smw		
Date: 8/27/2012		

Figure 3d: Mass Wasting Location map, south central

Next Becks Thing THP



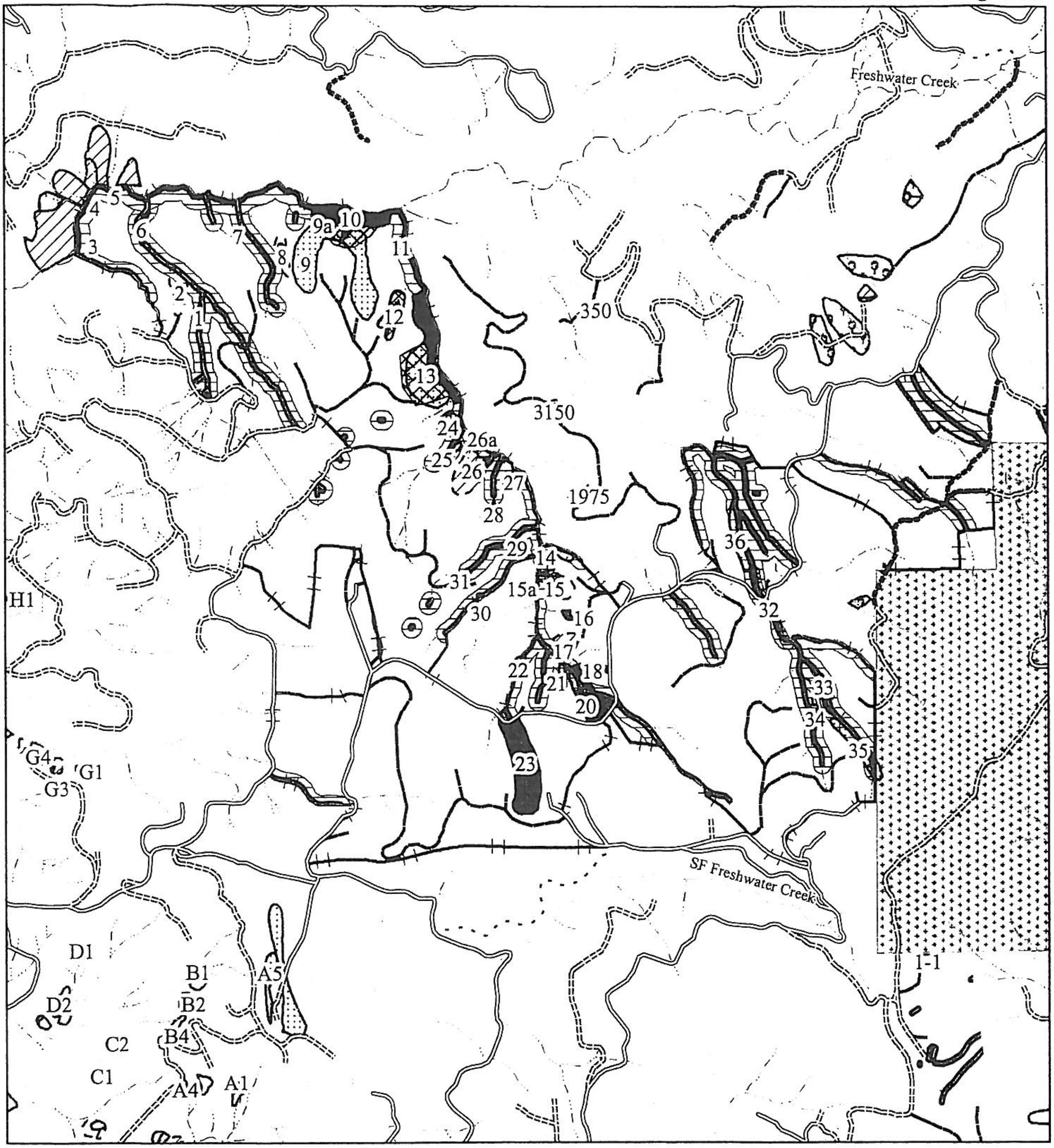
HRC Geology Department

Drawn by: smw

Date: 8/27/2012

Figure 3e: Mass Wasting Location map, southeastern

Next Becks Thing THP



Roads

- Paved Roads
- Rocked Roads
- Dirt Roads
- Jeep Trail
- Proposed Roads
- Reconstruction
- Decommissioned Roads
- Closed Dirt Roads
- Closed Rocked Roads

Watercourses

- Class 1
- class 2
- class 3

Ownership

- OUT
- HRC

Harvest Restrictions

- No Cut
- RMZ, Single Tree Selection
- Potentially Unstable, Single Tree Selection

HRC Geology Department	N	Feet 0 750 1,500 3,000	**Figure 4: Harvest Restrictions Map**
Drawn by: smw			
Date: 8/16/2012			

Next Becks Thing THP

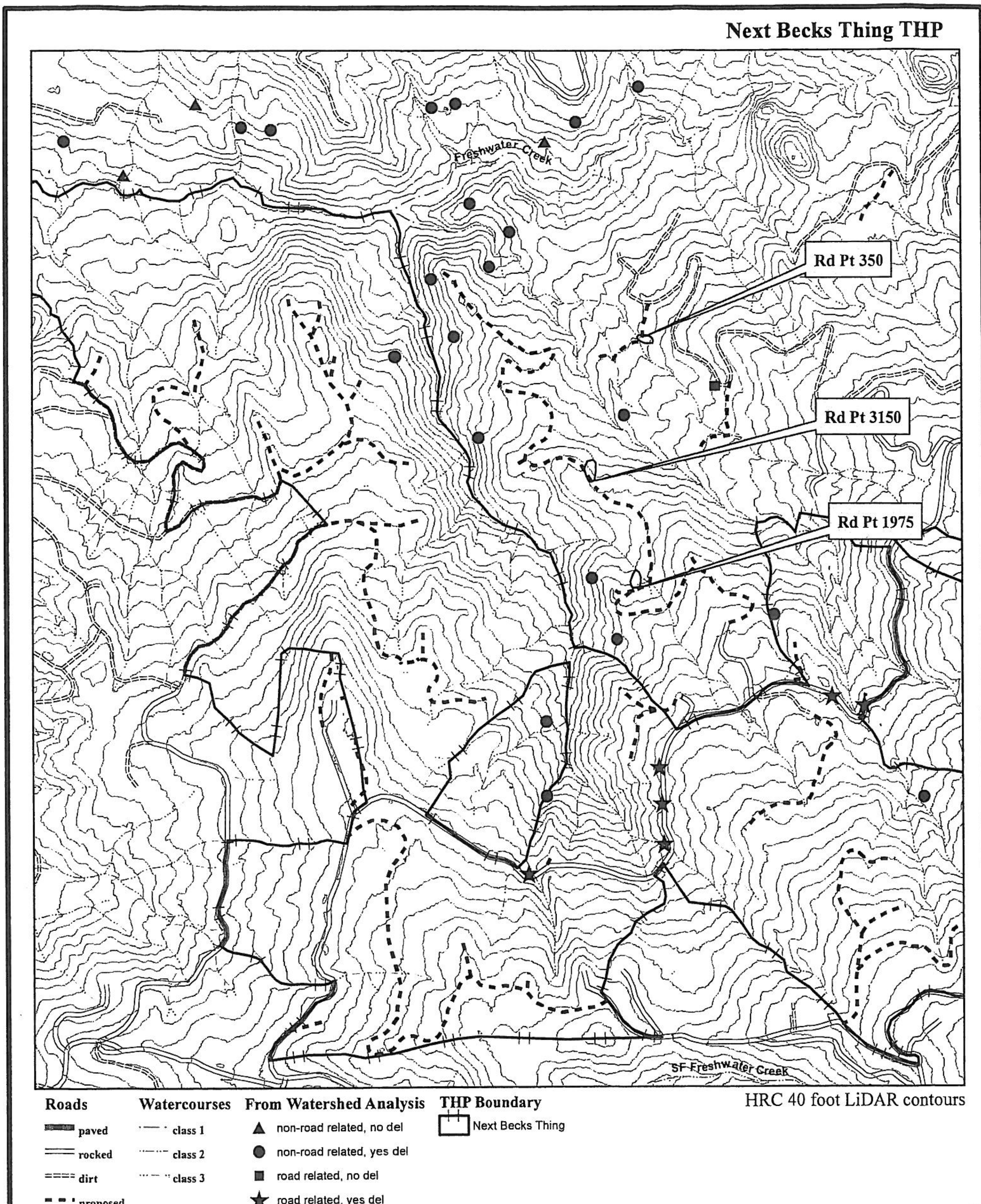
Roads
- Paved Roads
- Rocked Roads
- Dirt Roads
- Jeep Trail
- Proposed Roads
- Reconstruction
- Decommissioned Roads
- Closed Dirt Roads
- Closed Rocked Roads

Watercourses
- Class 1
- class 2
- class 3

Ownership
- OUT
- HRC

Harvest Restrictions
- No Cut
- RMZ, Single Tree Selection
- Potentially Unstable, Single Tree Selection

HRC Geology Department Drawn by: smw Date: 8/16/2012	N	Feet 0 500 1,000 2,000	**Figure 4a: Harvest Restrictions Map Expanded View**



HRC Geology Department

Drawn by: swatkins

Date: 8/27/2012

Figure 5: Road Point Location Map

Appendix A: Mass Wasting Inventory Table

LANDSLIIDE LABEL	FAILURE MODE	ACTVITY SATUS	DEPTH	WIDTH	LENGTH	CERTAINTY	PREVIOUS ACTIVITY	SEDIMENT DELIVERY	STREAM CLASS
1	DSS	DH	4	220	60	Definite	No	Yes	2
2	DS	DMDO	7	190	430	Probable	Yes	No	
3	DS	DH	5	30	70	Definite	No	No	
4	DS	DH	4	40	70	Definite	No	No	
5	DS	DH	4	30	65	Definite	No	Intermediate	1
6	IG	ASDH	4	300	90	Definite	No	Yes	2
7	EF	DH	2	30	70	Definite	No	Intermediate	2
8	EF	DMDO	5	100	419	Probable	Yes	No	
9	DSS	DH	3	900	275	Definite	No	No	
9a	DS	DH	5	120	350	Definite	No	Yes	1
10	IG	ASDH	6	850	150	Definite	Yes	Yes	1
11	TR	DH	6	60	130	Definite	No	Intermediate	1
12	EF	ASDH	6	125	375	Definite	No	Yes	3
13	DSS	DH	4	1160	375	Definite	Yes	Yes	1
14	DSS	ASDH	4	570	190	Definite	No	Yes	2
15	DS	DMDO	8	240	420	Probable	No	No	
15a	DS	DH	5	70	215	Definite	Yes	Yes	2
15b	DS	DH	4	60	160	Definite	Yes	No	
16	HWS	DH		90	160	Definite	No	No	3
17	TR	DMDO	8	200	315	Probable	No	No	
17a	DS	DH	4	60	100	Definite	Yes	Yes	2

Appendix A: Mass Wasting Inventory Table

LANDSLIIDE LABEL	FAILURE MODE	ACTVITY SATUS	DEPTH	WIDTH	LENGTH	CERTAINTY	PREVIOUS ACTIVITY	SEDIMENT DELIVERY	STREAM CLASS
18	DS	DH	4	70	400	Definite	No	Yes	2
19	DSS	ASDH	3	190	150	Definite	No	Yes	2
20	EF	DMDO	6	150	650	Probable	No	No	
20a	EF	AAS	5	100	420	Definite	Yes	Yes	2
21	DS	DH	5	70	300	Definite	No	Yes	2
22	DSS	ASDH	4	150	100	Definite	No	Yes	2
23	IG	ASDH	5	780	860	Definite	No	Yes	2
24	DS	DH	5	240	200	Definite	No	Intermediate	2
25	DSS	DH	3	300	65	Definite	No	Yes	3
26	TR	DMDO	10	280	570	Definite	No	No	
26a	DSS	DH	4	200	100	Definite	Yes	Yes	2
27	DS	DH	4	60	215	Probable	No	Yes	2
28	DS	DH	4	50	80	Definite	No	Yes	3
29	DS	DH	3	30	60	Definite	No	No	
30	DS	DH	3	40	85	Definite	No	Yes	2
31	DS	DH	4	50	85	Definite	No	Yes	2
32	IG	ASDH	4	950	90	Definite	Yes	Yes	2
33	IG	ASDH	3	550	80	Definite	Yes	Yes	2
34	EF	DMDO	5	100	170	Definite	No	No	
35	DSS	DH	4	800	160	Definite	No	Yes	2
36	DSS	DH	4	700	120	Definite	No	Yes	2

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Appendix A: Mass Wasting Inventory Table

LANDSLIIDE LABEL	GEOMORPHIC ASSOCIATION	ROAD TYPE	NOTES
1	SS		within WLPZ
2	SW		subdued landslide morphology
3	BIS		very hard crystaline bedrock exposed in vicinity
4	SW		within WLPZ
5	SS		within WLPZ
6	IGS	AH	within WLPZ, down cut through train grade
7	RRF	AH	fill from train grade mobilized on gently inclined slope
8	SW		hummocky morphology, in situ old growth stumps
9	BIS		oversteepened slopes likely from faulting
9a	SS	AH	within no cut, evacutated train grade, tall cut from grade likely contrubuted
10	IGS	AH	within no cut
11	SS	AH	slumping associated with train grade, within WLPZ
12	SW		split stump with ~15' lateral offset, "L" tree retention zone
13	SS		abundent conifer regen, oversteepened SS slopes likely from faulting
14	SS		mostly within WLPZ
15	SW		subdued landslide morphology
15a	SS		no merch on body
15b	O		no merch on landslide
16	HD		within no cut
17	SW		subdued step-riser morphology
17a	SS		within WLPZ

Appendix A: Mass Wasting Inventory Table

LANDSLIIDE LABEL	GEOMORPHIC ASSOCIATION	ROAD TYPE	NOTES
18	SW	PH	previously mapped for WA analysis, no merch on slide
19	SS		within WLPZ, few merch = default no cut
20	CV		subduded landslide morphology
20a	SW		within no cut for Class II RMZ
21	SW		"L" tree retention at head
22	SS		within WLPZ, few merch
23	IGS		within Class II RMZ, no harvest proposed
24	PL		nostly within WLPZ, straight 2nd growth, bench at base of slope
25	SS		few OG stumps, straight 2nd growth, watercourse not eroding base of hillslope
26	CV		topographic expression of dormant landslide
26a	SS		within WLPZ
27	SW		subtle landslide morphology, no OG stumps
28	SS		no merch on body, some timber on perimiter will be retained due to selection harvest
29	BIS		
30	SS		within WLPZ
31	SS		within WLPZ
32	IGS	PH	within WLPZ, road crossing appears stable
33	IGS		within WLPZ, few merch
34	SS		subdued landslide morphology
35	SS		within WLPZ
36	SS		within WLPZ

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Mass Wasting Inventory Explanation

Landslide: Code corresponding to the landslide designation used in the THP geologic assessment report and maps. Composed of the harvest unit number followed by a dash and the number of the mass-wasting feature in the order the features were mapped in that unit.

Aerial Photo: Year of the aerial photo in which the mass-wasting feature was first observed. For dormant-young and older landslides beyond aerial photo age, year of photo where landslide is most visible is cited. A "0" is entered if the landslide was not observed in aerial photography but ground discovered.

Failure Mode: Description of the failure mode of the mass-wasting feature or the geomorphic feature formed by multiple landslide processes.

DS	Debris slide: Characterized by unconsolidated rock, colluvium, and soil that has moved downslope along a relatively shallow translational failure plane. May form steep, unvegetated scars in the head region and irregular, hummocky deposits in the toe region.
DFTT	Debris flow/Torrent track: Often begin as saturated debris slides and are characterized by long stretches of bare, generally unstable stream channel banks that have been scoured and eroded by the extremely rapid movement of water-laden debris. Generally shallow, rapid translational slides that commonly initiate on steep slopes.
TR	Translational/Rotational slide: Characterized by a somewhat cohesive slide mass and a failure plane that is relatively deep when compared to that of a debris slide of similar areal extent. The sense of motion is linear (translational) or arcuate (rotational). Can be relatively small (few square yards) to very large (hundreds of acres).
EF	Earthflow: Movement along failure surfaces that are short lived, generally closely spaced, and many times not preserved. The slide mass is not preserved as an intact, cohesive unit but instead falls apart and becomes a mix of soil and rock debris. The mass moves or flows as a semi-viscous, plastic-state, saturated material. Earthflows can vary in size from small shallow failures to very large, deep-seated slides that involve entire hillsides. Frequently exhibit a long lobe-like morphology.
LS	Landslide: Designation for mass-wasting features that exhibit multiple failure modes. Observed failure modes and other types of features are recorded in the notes column. Also used for mass wasting features for which a mode cannot be determined from the aerial photographs and were not observed in the field.
DSS	Debris Slide Slope: Slopes sculpted by numerous debris slide events.
IG	Inner Gorge: A geomorphic feature formed by coalescing scars originating from landsliding and slope erosional processes that is caused by a stream actively eroding down through a previously well-established base level where erosion and deposition was in equilibrium. The feature consists of slopes that are situated immediately adjacent to a stream channel and below the first break in slope above the stream channel. The break in slope that defines the top of the inner gorge shall be where the change in slope extends over a slope-distance of 100 feet.

DG Disturbed ground: An area heavily modified by ground based logging. Usually low gradient slopes with evidence of steam powered cable yarding (long, linear furrows; saw-cut large woody debris; old cables and tail-holds) or earthwork from bulldozers (mounds of debris; cut slopes, skid trails, layouts).

HWS Headwall Swale: A concave depression, with convergent slopes of 65 percent or greater, that is connected to waters via a continuous linear depression (a linear depression interrupted by a landslide deposit is considered continuous for this definition; HRC, 2011).

UA Unstable Area: Characterized by slide areas or by some or all of the following: hummocky topography consisting of rolling bumpy ground, frequent benches, and depressions; short irregular surface drainages that begin and end on the slope; tension cracks and head wall scarps; slopes that are irregular and may be slightly concave in the upper half and convex in the lower half from previous slope failure; evidence of impaired groundwater movement resulting in local zones of saturation within the soil mass which are indicated at the surface of sag ponds with standing water, springs, or patches of wet ground. Some or all of the following may be present: hydrophytic vegetation prevalent; leaning, jackstrawed, or split trees are common; pistol butted trees with excessive sweep may occur in areas of hummocky topography (leaning and pistol butted tress are indicators of unstable areas only in the presence of other indicators; HRC, 2011).

Activity Status: Classification of the activity of the mass-wasting feature following guidelines modified from Keaton and DeGraff (1996). Ranges in activity status may be used. The activity states and the corresponding geomorphic characteristics are presented in Appendix A.

A Active: Landslides that are currently moving, includes first time movements and reactivations.

AS Suspended: Landslides that are not currently moving but have moved within the last annual cycle of seasons.

DH Dormant Historic: Landslides not currently moving but show deformation of historical failure.

DY Dormant Young: Distinct but weathered characteristics, in situ OG stumps and straight growing timber.

DM Dormant Mature: Highly weathered to muted characteristics.

DO Dormant Old or Relict: Subtle topographic expression of a landslide.

TABLE ERROR! NO TEXT OF SPECIFIED STYLE IN DOCUMENT.-1: GEOMORPHIC CHARECTARISTICS OF ACTIVITY STATES					
Activity State	**Main Scarp**	**Lateral Flanks**	**Internal Morphology**	**Vegetation**	**Toe Relationships**
Active, Suspended, or dormant historic	Sharp; unvegetated	Sharp; unvegetated streams at edge	Undrained depressions; hummocky topography; angular blocks separated by scarps	Absent or sparse on lateral and internal scarps; trees tilted and/or bent	Main valley stream pushed by landslide; floodplain covered by debris; lake may be present
Dormant-young	Sharp; partly vegetated	Sharp; partly vegetated; small tributaries to lateral streams	Undrained and drained depressions; hummocky topography; internal cracks vegetated	Younger or different type or density than adjacent terrain; older tree trunks may be bent	Same as for active class but toe may be modified by modern stream
Dormant-mature	Smooth; vegetated	Tributaries extend onto body of slide	Smooth, rolling topography; disturbed internal drainage network;	Different type or density than adjacent terrain but same age	Terraces covered by slide debris; modern stream not constricted but wider upstream floodplain
Dormant-old or relict	Dissected; vegetated	Vague lateral margins; no lateral drainage	Smooth, undulating topography; normal stream pattern	Same age, type, and density as adjacent terrain	Terraces cut into slide debris; uniform modern floodplain
Modified from Keaton and DeGraff (1996)					

Feature Certainty: Degree of confidence in the interpretation of the feature presence.

D Definite

P Probable

Q Questionable

Previous Activity: Indicates whether the mass-wasting feature occurred on or a reactivation of an existing landslide.

Y	Yes
N	No

Length: Average dimension (feet) of the mass-wasting feature measured parallel to slope dip. In lieu of field measurements or mapping, this column will display the average length of the mass-wasting feature as the observed length of the area of high albedo or movement as measured from aerial photographs. Not applicable for geomorphic feature formed by multiple landslide processes.

Width: Average dimension (feet) of the mass-wasting feature measured perpendicular to slope dip. In lieu of field measurements or mapping, this column will display the average width of the mass-wasting feature as the observed width of the area of high albedo or movement as measured from aerial photographs. Not applicable for geomorphic feature formed by multiple landslide processes.

Depth: Estimated average depth (feet) of the failure plane of the mass-wasting feature. "NO" is entered if the mass-wasting feature was not observed in the field (aerial photograph only). Not applicable for geomorphic feature formed by multiple landslide processes.

Sediment Delivery: Indicates whether sediment was to stream.

Y	Yes - Sediment delivered to stream.
I	Indeterminate - The landslide stops very near the stream but there is no visual evidence that the sediment actually entered the stream.
N	No - Sediment was not delivered to the stream.

Stream Class: Class of the nearest watercourse that is downslope of the mass-wasting feature.

1	Class I - Fish bearing at some time of the year.
2	Class II - Insect and/or amphibian habitat at some time of the year.
3	Class III - Move sediment but does not provide habitat for insects or amphibians.

Land use history: Classification of the land use activities based on air photo interpretation or historic information that took place near the initiation point of the mass-wasting feature (usually the upper-most point on landslide) and that preceded the appearance of the mass-wasting feature.

RA	Ranching
AG	Farming
RES	Residential
IT	Industrial Timberlands
IN	Industrial
UI	Unknown

Harvest history: Classification of the management activities based on air photo interpretation or historic logging information that took place near the initiation point of the mass-wasting feature (usually the upper-most point on landslide) and that preceded the appearance of the mass-wasting feature.

TC	Tractor clearcut - crown density reduced by ~ 98%
CC	Cable clearcut - crown density reduced by ~ 98%
ST	Seed tree tractor cut - crown density reduced by~ 80-98%
MPC	Moderate partial or selection cable harvest - (crown density reduced by 50-80%)
LPC	Light partial or selection cable harvest - (crown density reduced by 50 or less)
MPT	Moderate partial or selection tractor harvest - (crown density reduced by 50-80%)
LPT	Light partial or selection tractor harvest - (crown density reduced by 50 or less)
ASG	Advanced second growth
NO	No apparent management activities

Geomorphic Association: Observed geomorphology at the initiation point (upper-most point) of the mass-wasting feature.

IGS	Inner Gorge Slope
SS	Stream Side
ST	Stream Channel
SW	Swale Channel
HD	Headwall Area
BIS	Major Break-In-Slope on hillslope, not inner gorge
PL	Planar
CV	Convergent
DV	Divergent
BL	Bluff
O	Other - Details in notes attribute
RRF	Road location - Road Fill
RLF	Road location - Landing Fill
RCB	Road location - Cutbank
RQ	Road location - Quarry
RC	Road location - Culvert
SK	Skid Trail Location

Road Type: Type of road observed in aerial photograph on which the mass-wasting feature was first observed.

PH	Primary Haul Road
SA	Secondary Access Road
RS	Recent Skid Trail
AS	Abandoned Skid Trail
AH	Abandoned Haul Road

Data Source:

AP	Aerial Photo Data
FV	Field Verified Data

Notes: Includes generalized observations and may include the following abbreviations to further characterize the mass-wasting feature.

CBF/CSF	Cut-Bank/ Cut-Slope Failure: Rock or soil cut-bank or cut-slope failures adjacent to watercourses or roads, respectively.
RF	Rock Fall - Slope failures characterized by sudden catastrophic failure of relatively steep rock slopes. The failure mass descends mostly through the air and/or along a very steep surface with little or no shearing. They can be quite variable in size. Generally, rock debris accumulates at the toe of the slope, where it can be removed by other processes (i.e. stream erosion).
RT	Rock Topple - Forward rotation of blocks of earth, debris or rock. The debris accumulates at the base of the slope and can be removed by other processes.
TS	Talus Slope - Rock fragments of any size or shape (usually coarse and angular) lying at the base of and derived from a cliff or very steep, rocky slope.

Next's Becks Thing Review

For

Tier 2 Enrollment

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THP: Next Becks Thing

August 24, 2012

Tools Used in This Assessment	Figure Number
Elevation Map with 10 ft Contours (HRC LiDAR)	1
SHALSTAB (Montgomery and Dietrich, 1994 and Palco, 2006) / Slope Class / Hillshade Maps	2
CGS Geology and Geomorphic Features (CGS, 1999)	3
Mass Wasting Potential Map (HRC, 1999)	4
Aerial Photo Map (HRC, 2007)	5
HRC Elk River and Salmon Creek WA deep-seated LS inventory (HRC, 2004)	6
Road Condition Map	7

Please see back of enrollment for references

Summary of Changes to THP Prescriptions Based on Tier II Analysis in this Unit:

Geologic Review	Forestry Silviculture/Site Prep Plan	Operational Design Plan
Entire plan area	THP proposed silviculture within the plan is single tree and group selection. No site preparation will occur due to partial harvesting.	The THP proposes ground based and cable yarding where appropriate. No change to approved yarding methods.

Geological Summary (information presented from existing bodies of work):

The THP overprints a significant thrust fault zone. A significant increase in elevation occurs from west to east. This is expressed as a series of steps to the east. The areas underlain by the Wildcat Group sediments, west of the THP, include slopes that are typically smooth with deeply incised prominent watercourses. The drainage patterns, ridge-top elevations, and subsequent channel incision suggest a somewhat uniform underlying strata resulting in uniform slope weathering and channel development. Areas underlain by the Central Belt of the Franciscan Complex and Mélange exhibit regional, random hummocky surfaces and occasional hard rock outcrops. Slope inclinations range from nearly flat to nearly vertical in response to the faulting, failing, or irregular weathering that is common to heterogeneous rock matrixes. The eastern portion of the THP, underlain by the Central Belt of the Franciscan complex, exhibits the greatest relief, moderate to well incised watercourses, and typically more steeply inclined slopes. Due to shearing, slope breaks are often sharply defined. Observations of the underlying soils typically show variable mixing of the prominent lithologies. It is common in the eastern portions of the unit to observe, greenstone, chert, hard indurated sandstone within an apparent Wildcat group silty sand matrix. CGS (1999) maps debris slide slopes that correlate regionally and locally with watercourses (Figure 3). CGS (1999) also maps large, deep-seated dormant landslides that typically coincide with Class II and Class III tributaries.

Mapping from Watershed Analysis (Figure 6) identifies numerous areas of low to moderate hazard for reactivation that generally correlate with CGS (1999) mapping of the deep-seated landslides. Watershed Analysis (Figure 6) identifies two areas of high hazard for reactivation within the THP. One small area mapped as high hazard in the southwestern portion of the plan poses a low risk of sediment delivery based on the distance to the nearest watercourse. This area is mapped approximately 600 feet upslope of the nearest watercourse. Also, a rock quarry is located at the mapped location and likely misinterpreted as a landslide during aerial photographic review. The second, much larger, area mapped as high hazard for reactivation is located in the northwestern portion of the plan area. This area correlates well with CGS (1999) mapping of a dormant earthflow. During field review of this area we observed moderate and gently inclined slopes with isolated exceptions of steep slopes. Class II and Class III watercourses are well defined and display a dendritic pattern. Within this area low gradient and steeply inclined train grades, constructed prior to 1930, are intact and do not show evidence of displacement. We did not observe a head scarp or clearly defined lateral margins. Our evaluation of this slope did not identify evidence to suggest a high potential for reactivation exists at this location.

Review of Figure 2 (Hillslope Shade) highlights the contrast between low gradient and steeply inclined slopes. Hillslope Shade maps show moderate to steep slopes are most prominent where Class II and Class III watercourses are present. The Class II watercourses appear well entrenched with a consistent channel gradient.

A geologic evaluation was conducted for the THP in accordance with Note 45 guidelines. Unstable areas identified within the plan are discussed where potential for sediment delivery exists. In many instances the Forester expanded the Riparian Mitigation Zone (RMZ) to

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encompass potentially unstable areas. No group openings will occur on mapped unstable areas that lead to a watercourse. The project geologist worked with the Forester to mark trees for harvest on unstable slopes that lead towards a watercourse. The THP will be reviewed by various agencies, prior to approval, to insure compliance with the Forest Practice Rules and Habitat Conservation Plan with respect to disclosure of all known unstable areas. Detailed characterizations and justification for the proposed harvest is provided in the geology report in Section V of the THP.

For this evaluation, the harvest units have each been reviewed as one polygon. We validate this decision based on the slope morphology, results from field review, and slope performance in response to the previous harvest entry.

THP: Next Becks Thing

A) General Observations

The THP is bound by roads, watercourses, property lines, and previous harvest plans.

The THP occupies convergent and divergent slopes with inclinations that vary from gently inclined to over 80%. The slopes exceeding 60% typically define the flanking slopes of watercourses.

A Class I watercourse (Freshwater Creek) defines the down slope (northern) harvest boundary. The plan area drains to the Class I watercourses via numerous Class II and Class III watercourses that extend upslope into the unit. The Class II watercourses are flanked by gentle and steeply inclined hill slopes. The flanking slopes appear planar to broadly convergent where deeply incised. Class III tributaries are notable less incised and typically lack potentially unstable streamside slopes. Slopes inclined greater than 60% are scatted in distribution, limited in acreage, and appear to correlate with watercourse incision and/or uplifted blocks derived from thrust faulting.

Areas of elevated SHALSTAB (Values 1 and 2) correlate well with slopes that are 50% and greater (Figure 2). Generally, pixels of elevated SHALSTAB (values 1 and 2) also correlate with landslides identified in the geologic evaluation for the THP. Conversely, areas of reduced SHALSTAB (value 5) are shown within landslide **20a** (an active suspended earthflow), landform **23** (an inner gorge slope) and, landform **16** (a headwall swale). All these features have been removed from harvest. Our review of the SHALSTAB Hazard Map reveals good correlation between steep slopes and elevated SHALSTAB values.

Debris slide slopes mapped (Figure 3) within the unit are, for the most part, limited to streamside slopes. We observed good correlation between debris slide slopes mapped on Figure 3 and mapping conducted for the Geologic Evaluations in Section V of the THP.

A) General Observations

Mass Wasting Potential (MWP) modeled for the unit (Figure 4) is regionally low. Within the proposed plan moderate, high, and very high MWP has been modeled principally on streamside slopes. The areas matching high and very high MWP appears related to the inclusion within the model the values form Figure 3 mapped debris slide slopes. Moderate MWP mapped within the plan correlates well with the dormant landslides mapped on Figure 3.

The stand is predominantly mature redwood with pockets dominated by fir and occasional hardwoods. The original harvest was a steam powered ground based clearcut yarded either to the down slope or mid-slope train grades that were constructed prior to 1930.

B) Harvest Related Impacts and Hillslope Sensitivity

Debris slide slopes mapped (Figure 3) within the unit generally correlate with field mapping conducted for the Geologic Evaluation presented in Section V of the THP. Where potential for sediment delivery exists the Geologic Evaluation provides recommendations that restrict group openings and increase basal area retention.

Surface disturbance has occurred within the unit in response to past logging activites. The disturbance is the culmination of large diameter timber dragged within naturally occurring swales and watercourses via steam donkey. Following that impact, the area appears to have responded well and adjusted through minor slumping, settling and the infrequent failures.

The level of mass wasting delivered sediment within the watercourses appears insignificant when compared to the construction of roads and crossings within channels as observed in other nearby sub-basins. Current planned operations will result in less ground disturbance than previous operations, especially where adjacent to watercourses, and are specifically designed to minimize potential for mass wasting-related discharge.

The extensive RMZs were designed to provide sediment filtration bands adjacent the watercourses should extensive sediment be generated from the clearcut harvesting. The current level of harvest will retain both canopy closure and slash from the harvested trees potentially increasing the effectiveness of the sediment filtration band.

Overall hillslope sensitivity to harvest activities appears minimal with respect to mass wasting. Please see the THP Geology Evaluation for a more comprehensive assessment of the role that timber harvesting has on slope stability.

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C) Forestry / Silviculture Plan
We have not changed the silviculture in response to this evaluation. The Geologic Evaluation recommends areas of no group openings and expanded harvest exclusion zones presented on Figures 4 and 4a in Section V of the THP.

D) Operational Design Plan
THP approved yarding method is both cable and ground based. As delineated, the proposed yarding methods appear appropriate.

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References:

CGS, 1999, Geologic and Geomorphic Features Related to Landsliding, Freshwater Creek, Humboldt County, California. DMG Open-File Report 99-10. Available via the web at http://www.conservation.ca.gov/cgs/fwgp/Pages/fresh.aspx

Montgomery, D.R. and W.E. Dietrich, 1994. A physically based model for the topographic control on shallow landsliding. Wat. Resour. Res. 30: 1153-1171. For specific details regarding the model used in this evaluation, please see Palco, 2006. Additional information from the model authors is available at the following website: http://socrates.berkeley.edu/~geomorph/shalstab

HRC, 2007, Ortho-photo rectified aerial photographs flown by 3Di West, Eugene Oregon,

HRC, 2008. Freshwater Creek and Elk River WDR Permit Acreage Enrollment and Compliant Monitoring Program, NCRWQCB R1-2006—0039 and R1-2006-0041, Quality Assurance Project Plan, Version 3.0. Policy document submitted to NCRWQCB dated June 7, 2006.

HRC, 2004, Elk River / Salmon Creek Watershed Analysis, Scotia, California, prepared for Pacific Lumber Company (PALCO) dated 2004?, and acquired by Humboldt Redwood Company, LLC in 2008.

HRC, 2005, (Policy Acquired from The Pacific Lumber Company (PALCO)) Prescriptions Based on Watershed Analysis for Freshwater Creek, California, August 15, 2002.

HRC, 1999, The Pacific Lumber Company's Habitat Conservation Plan, Vol. 2 Part D, Landscape Assessment of Geomorphic Sensitivity, Public Review Draft.

Brief descriptions of the models used in this evaluation:

SHALSTAB was first described in Dietrich and Montgomery (1994). SHALSTAB is a simple, physically-based model based on the Mohr-Coulomb failure law that can be used to map shallow landslide potential. The model calculates the potential for failure using gridded digital elevation data. The simplicity of the model lies in the formulation of slope stability parameters that allow the model to be run parameter-free using default values suggested by the authors or determined by local measurement. Because the model uses no field measurements of critical characteristics that determine slope stability, the evaluation of potential instability is only an approximation. In applying SHALSTAB for Tier 2 enrollment, HRC has run the model on a 10-m spatial grid using LiDAR elevation data and applied the parameters as suggested by the model authors. HRC's application of the method and parameters is described in HRC (2008).

Mass Wasting Potential (MWP) modeling is a cursory regional assessment that numerically values soil, slope inclination, geology type, and geomorphology with respect to past mass wasting (HRC, 1999). The sums of the values specific to an area are measured against a set ranking system that extends from very low to extreme. The models intent is to highlight areas of high potential for instability at the planning level. The model's use at the site specific level is limited in that pedogenic soil types are used, not textures, the geologic formations utilized provide one value for all of the incorporated facies, and the model is heavily biased if past mass wasting has occurred or has been mapped as occurring in the area.

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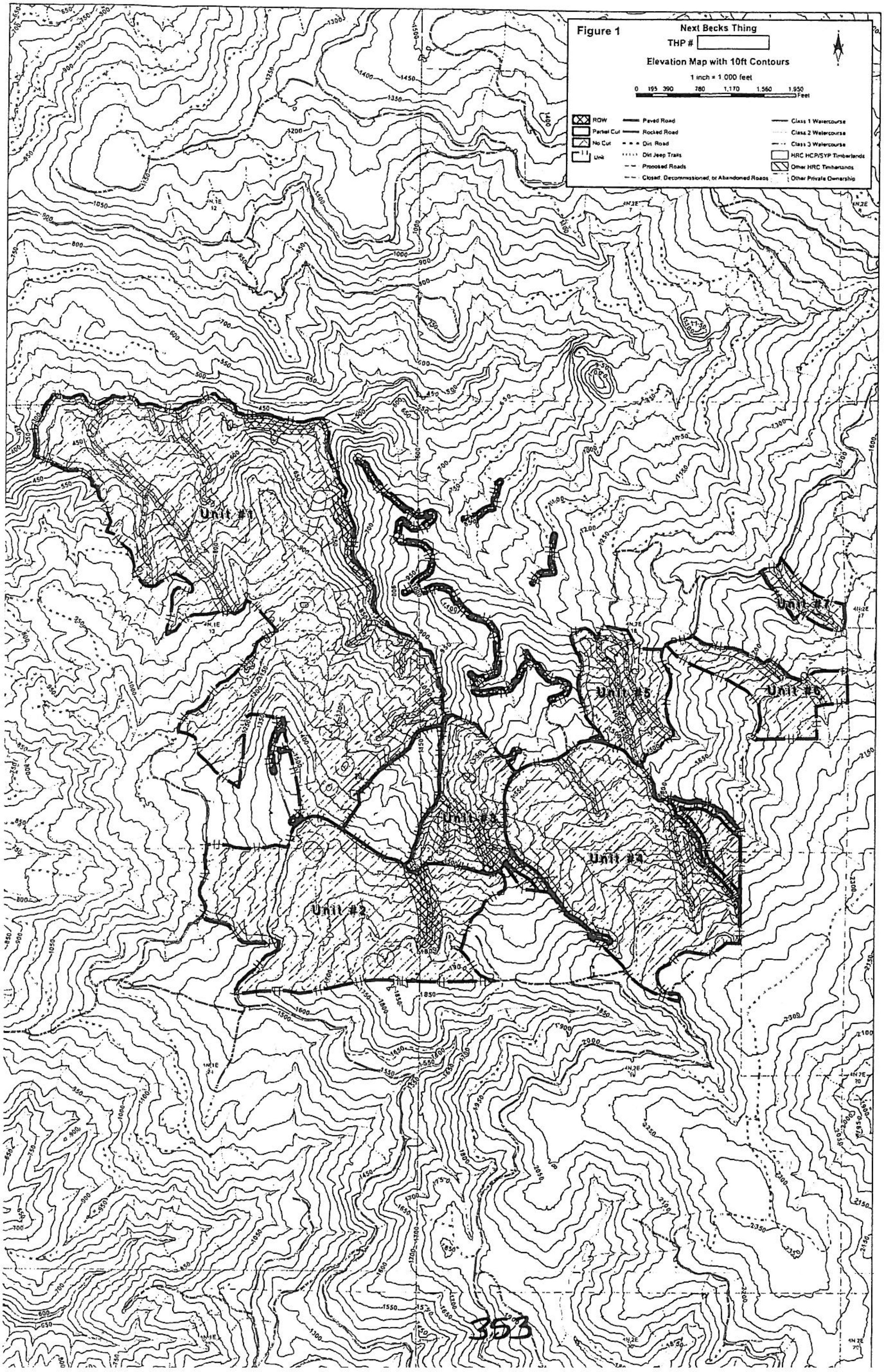
Figure 1
Next Becks Thing
THP #
Elevation Map with 10ft Contours
1 inch = 1,000 feet
0 195 390 780 1,170 1,560 1,950 Feet
ROW
Partial Cut
No Cut
Unit
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
Unit #1
Unit #2
Unit #3
Unit #4
Unit #5
Unit #6
Unit #7

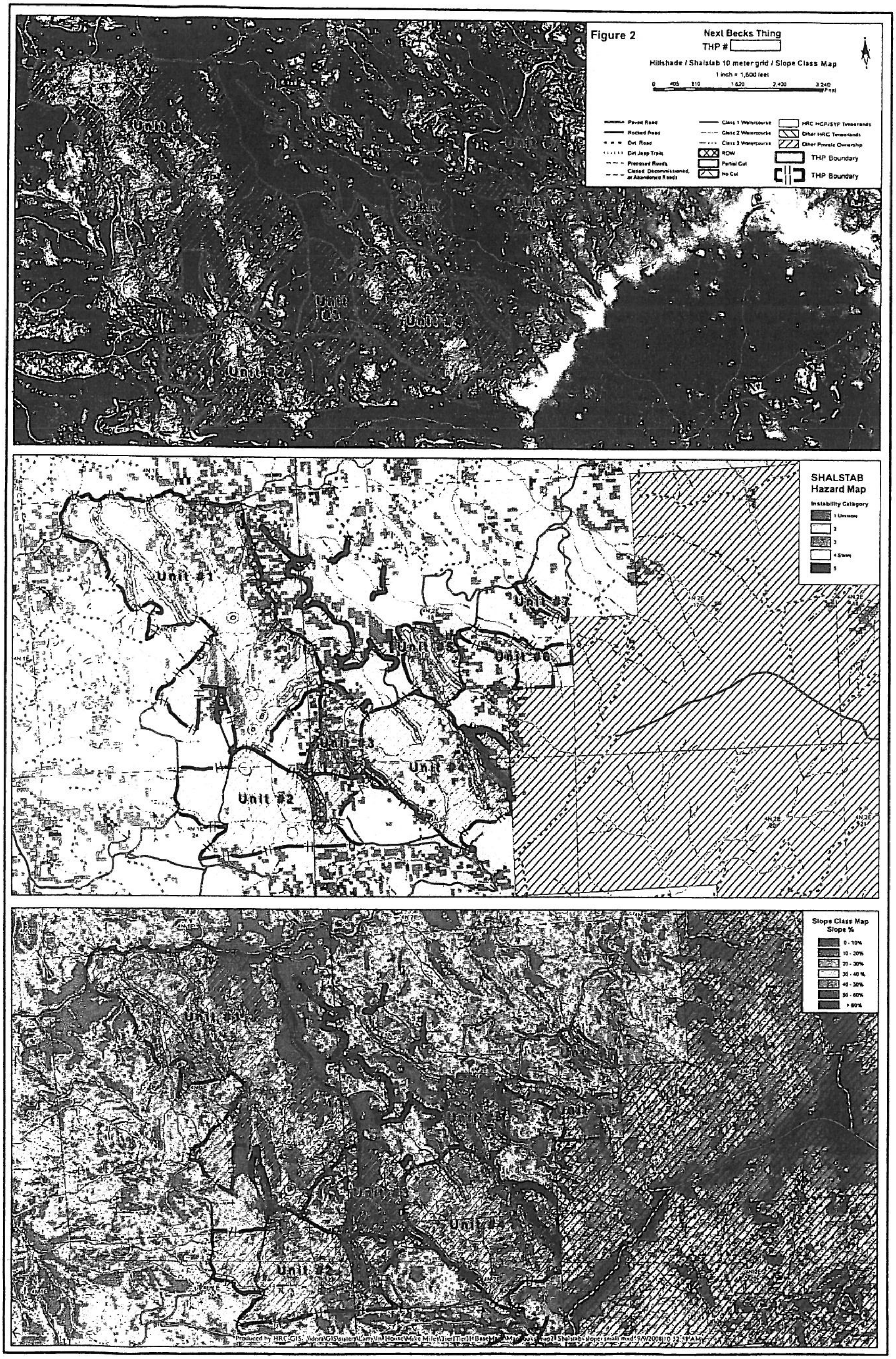
Figure 2
Next Becks Thing
THP #
Hillshade / Shalstab 10 meter grid / Slope Class Map
1 inch = 1,600 feet
0 405 810 1,620 2,430 3,240 Feet
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
ROW
Partial Cut
No Cut
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
THP Boundary
THP Boundary
SHALSTAB Hazard Map
Instability Category
Unit #1
Unit #2
Unit #3
Unit #4
Unit #5
Unit #6
Unit #7
Slope Class Map Slope %
0 - 10%
10 - 20%
20 - 30%
30 - 40 %
40 - 50%
50 - 60%
> 60%

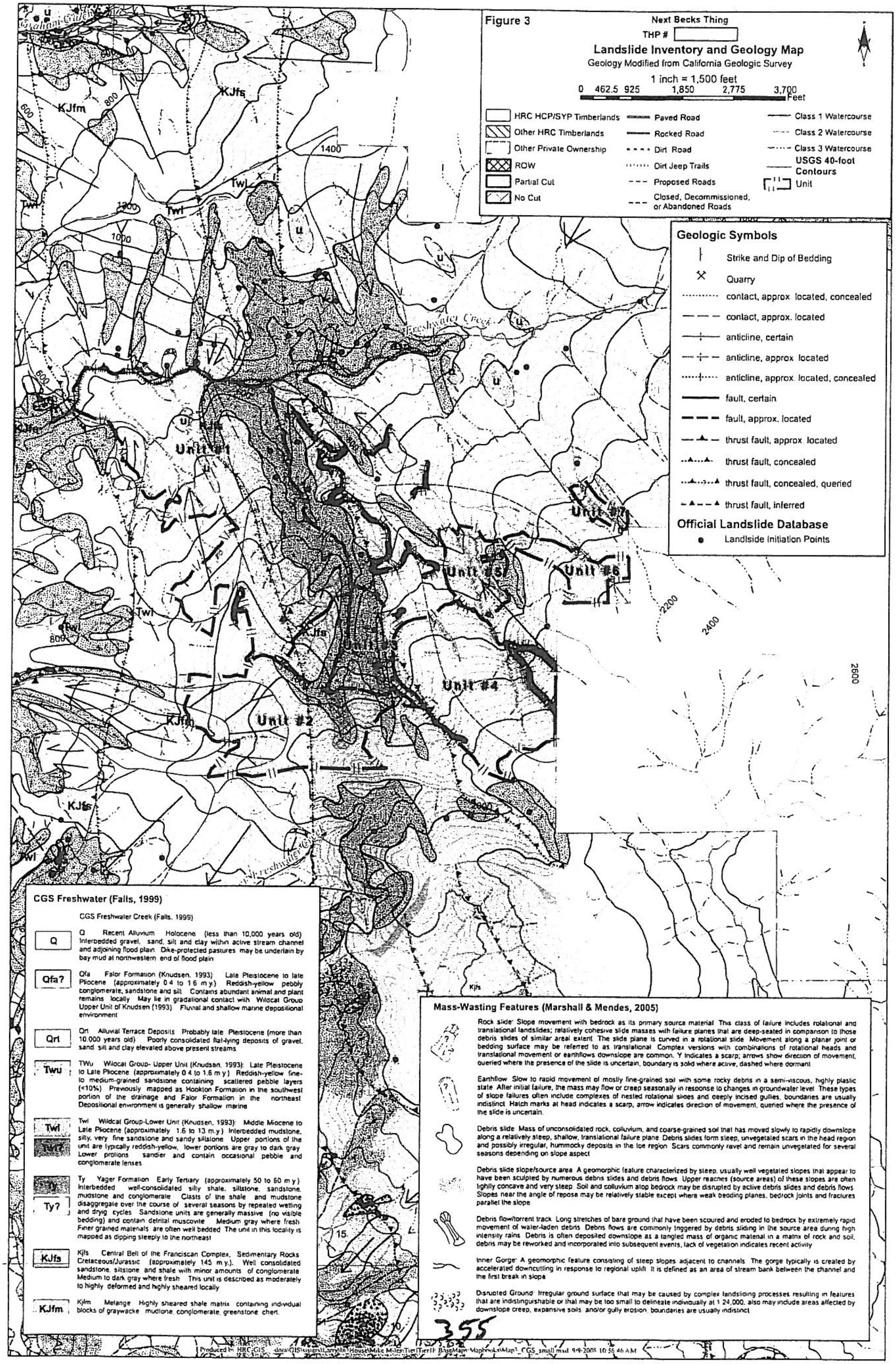

Figure 3
Next Becks Thing
THP #
Landslide Inventory and Geology Map
Geology Modified from California Geologic Survey
1 inch = 1,500 feet
0 462.5 925 1,850 2,775 3,700 Feet
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
ROW
Partial Cut
No Cut
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
USGS 40-foot Contours
Unit
Geologic Symbols
Strike and Dip of Bedding
Quarry
contact, approx located, concealed
contact, approx. located
anticline, certain
anticline, approx located
anticline, approx. located, concealed
fault, certain
fault, approx. located
thrust fault, approx located
thrust fault, concealed
thrust fault, concealed, queried
thrust fault, inferred
Official Landslide Database
Landlside Initiation Points
Unit #1
Unit #2
Unit #3
Unit #4
Unit #5
Unit #6
Unit #7
Freshwater Creek
KJfm
KJfs
Twl
CGS Freshwater (Falls, 1999)
CGS Freshwater Creek (Falls, 1999)
Q
Q Recent Alluvium Holocene (less than 10,000 years old) Interbedded gravel, sand, silt and clay within active stream channel and adjoining flood plain Dike-protected pastures may be underlain by bay mud at northwestern end of flood plain
Qfa?
Qfa Falor Formation (Knudsen, 1993) Late Pleistocene to late Pliocene (approximately 0 4 to 1 6 m y.) Reddish-yellow pebbly conglomerate, sandstone and silt Contains abundant animal and plant remains locally May lie in gradational contact with Wildcat Group Upper Unit of Knudsen (1993) Fluvial and shallow marine depositional environment
Qrt
Qrt Alluvial Terrace Deposits Probably late Pleistocene (more than 10,000 years old) Poorly consolidated flat-lying deposits of gravel, sand silt and clay elevated above present streams
Twu
TWu Wildcat Group- Upper Unit (Knudsen, 1993): Late Pleistocene to Late Pliocene (approximately 0 4 to 1.6 m y) Reddish-yellow fine- to medium-grained sandstone containing scattered pebble layers (<10%) Previously mapped as Hookton Formation in the southwest portion of the drainage and Falor Formation in the northeast Depositional environment is generally shallow marine
Twl
Twl?
Twl Wildcat Group-Lower Unit (Knudsen, 1993): Middle Miocene to Late Pliocene (approximately 1.6 to 13 m.y) Interbedded mudstone, silty, very fine sandstone and sandy siltstone Upper portions of the unit are typically reddish-yellow, lower portions are gray to dark gray Lower protions sandier and contain occasional pebble and conglomerate lenses
Ty
Ty?
Ty Yager Formation Early Tertiary (approximately 50 to 60 m y) Interbedded well-consolidated silty shale, siltstone, sandstone, mudstone and conglomerate Clasts of the shale and mudstone disaggregate over the course of several seasons by repeated wetting and dryig cycles Sandstone units are generally massive (no visible bedding) and contain detrital muscovite Medium gray where fresh Finer grained materials are often well bedded The unit in this locality is mapped as dipping steeply to the northeast
KJfs
Kjfs Central Belt of the Franciscan Complex, Sedimentary Rocks Cretaceous/Jurassic (approximately 145 m y.). Well consolidated sandstone, siltstone and shale with minor amounts of conglomerate Medium to dark gray where fresh This unit is described as moderately to highly deformed and highly sheared locally
KJfm
Kjfm Melange Highly sheared shale matrix containing individual blocks of graywacke mudtone, conglomerate, greenstone chert.
Mass-Wasting Features (Marshall & Mendes, 2005)
Rock slide: Slope movement with bedrock as its primary source material This class of failure includes rotational and translational landslides; relatively cohesive slide masses with failure planes that are deep-seated in comparison to those debris slides of similar areal extent The slide plane is curved in a rotational slide Movement along a planar joint or bedding surface may be referred to as translational Complex versions with combinations of rotational heads and translational movement or earthflows downslope are common. Y indicates a scarp; arrows show direction of movement, queried where the presence of the slide is uncertain, boundary is solid where active, dashed where dormant
Earthflow Slow to rapid movement of mostly fine-grained soil with some rocky debris in a semi-viscous, highly plastic state After initial failure, the mass may flow or creep seasonally in response to changes in groundwater level These types of slope failures often include complexes of nested rotational slides and deeply incised gullies, boundaries are usually indistinct Hatch marks at head indicates a scarp, arrow indicates direction of movement, queried where the presence of the slide is uncertain.
Debris slide Mass of unconsolidated rock, colluvium, and coarse-grained soil that has moved slowly to rapidly downslope along a relatively steep, shallow, translational failure plane Debris slides form steep, unvegetated scars in the head region and possibly irregular, hummocky deposits in the toe region Scars commonly ravel and remain unvegetated for several seasons depending on slope aspect
Debris slide slope/source area A geomorphic feature characterized by steep, usually well vegetated slopes that appear to have been sculpted by numerous debris slides and debris flows Upper reaches (source areas) of these slopes are often tightly concave and very steep Soil and colluvium atop bedrock may be disrupted by active debris slides and debris flows Slopes near the angle of repose may be relatively stable except where weak bedding planes, bedrock joints and fractures parallel the slope
Debris flow/torrent track Long stretches of bare ground that have been scoured and eroded to bedrock by extremely rapid movement of water-laden debris Debris flows are commonly triggered by debris sliding in the source area during high intensity rains Debris is often deposited downslope as a tangled mass of organic material in a matrix of rock and soil, debris may be reworked and incorporated into subsequent events, lack of vegetation indicates recent activity
Inner Gorge: A geomorphic feature consisting of steep slopes adjacent to channels The gorge typically is created by accelerated downcutting in response to regional uplift It is defined as an area of stream bank between the channel and the first break in slope
Disrupted Ground: Irregular ground surface that may be caused by complex landsliding processes resulting in features that are indistinguishable or that may be too small to delineate individually at 1 24,000, also may include areas affected by downslope creep, expansive soils and/or gully erosion, boundaries are usually indistinct
355
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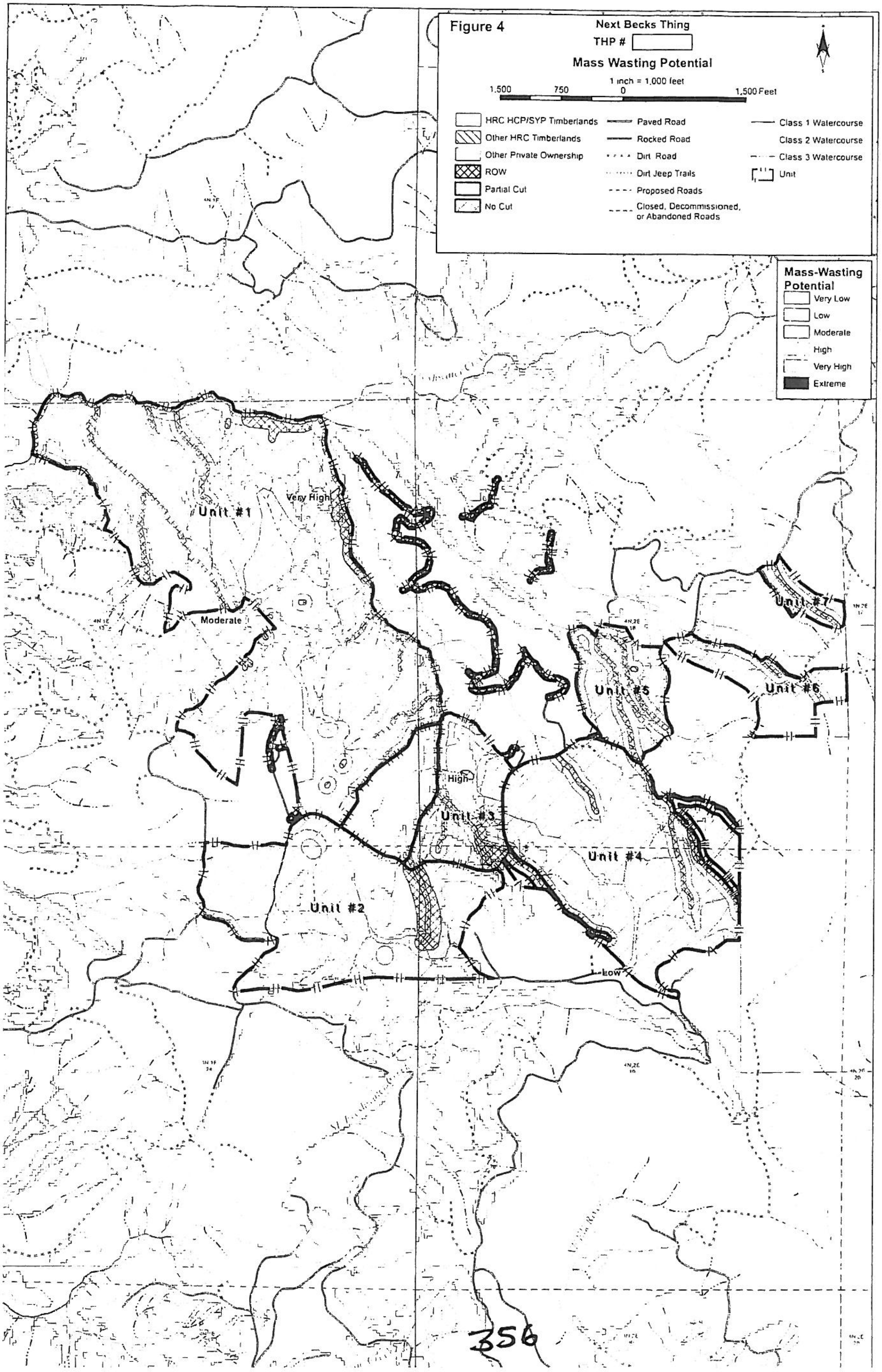

Figure 4
Next Becks Thing
THP #
Mass Wasting Potential
1 inch = 1,000 feet
1,500
750
0
1,500 Feet
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
ROW
Partial Cut
No Cut
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
Unit
Mass-Wasting Potential
Very Low
Low
Moderate
High
Very High
Extreme
Unit #1
Very High
Moderate
Unit #2
Unit #3
High
Unit #4
Low
Unit #5
Unit #6
Unit #7

356

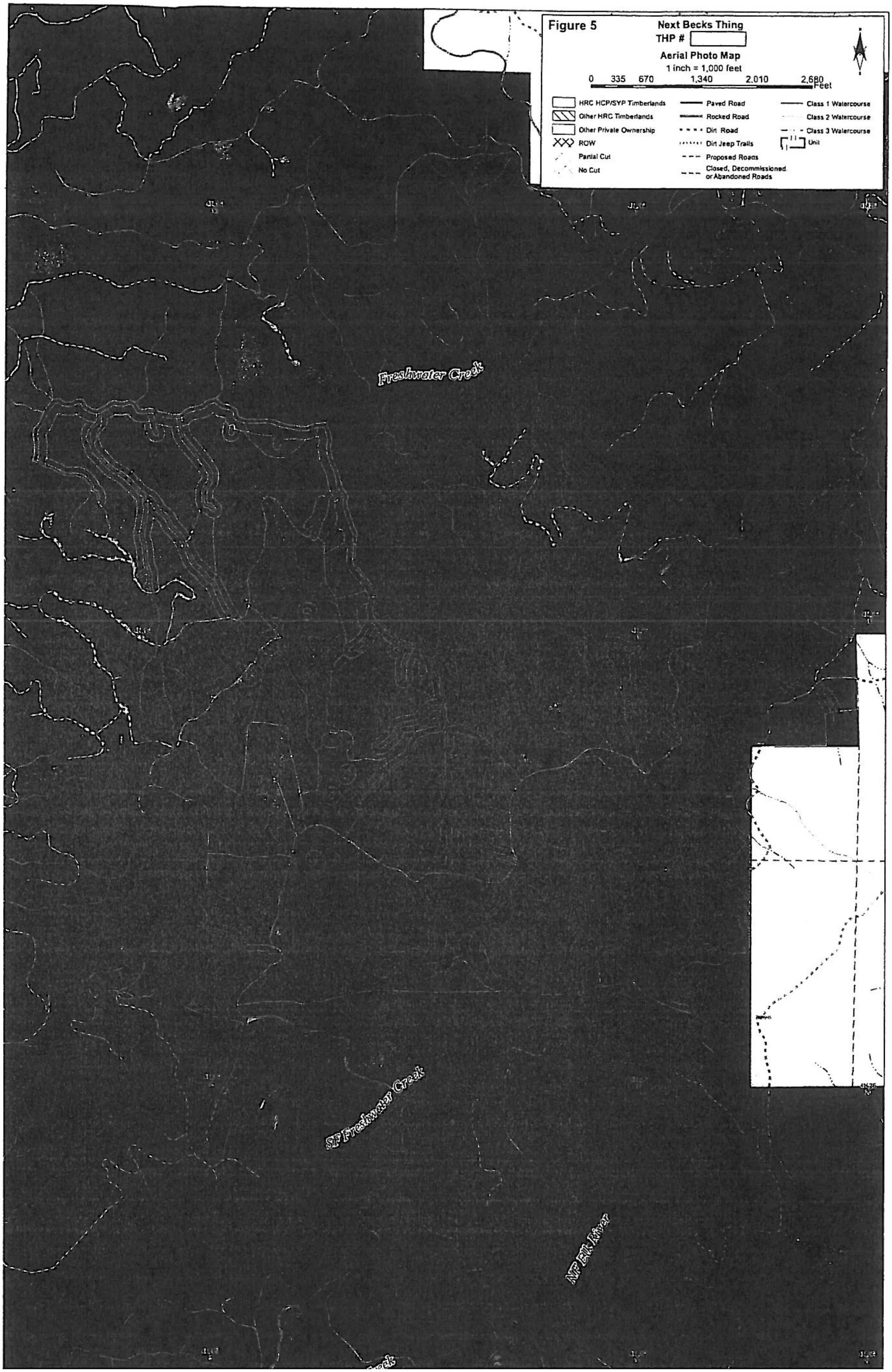
Figure 5
Next Becks Thing
THP #
Aerial Photo Map
1 inch = 1,000 feet
0 335 670 1,340 2,010 2,680 Feet
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
ROW
Partial Cut
No Cut
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
Unit
Freshwater Creek
SF Freshwater Creek
NF Elk River

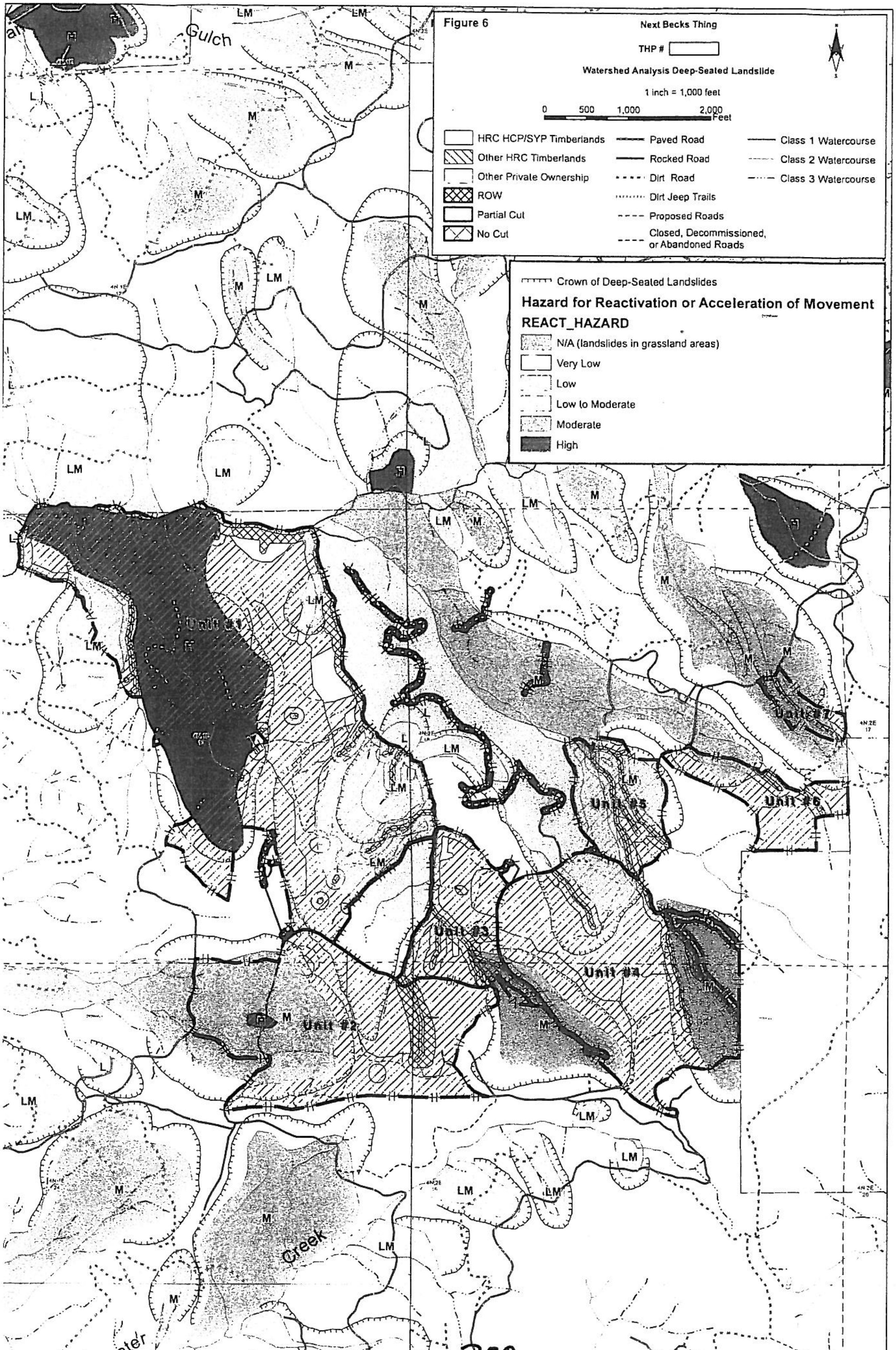
Figure 6
Next Becks Thing
THP #
Watershed Analysis Deep-Seated Landslide
1 inch = 1,000 feet
0 500 1,000 2,000 Feet
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
ROW
Partial Cut
No Cut
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
Crown of Deep-Seated Landslides
Hazard for Reactivation or Acceleration of Movement
REACT_HAZARD
N/A (landslides in grassland areas)
Very Low
Low
Low to Moderate
Moderate
High
Gulch
Creek
Unit #1
Unit #2
Unit #3
Unit #4
Unit #5
Unit #6
Unit #7

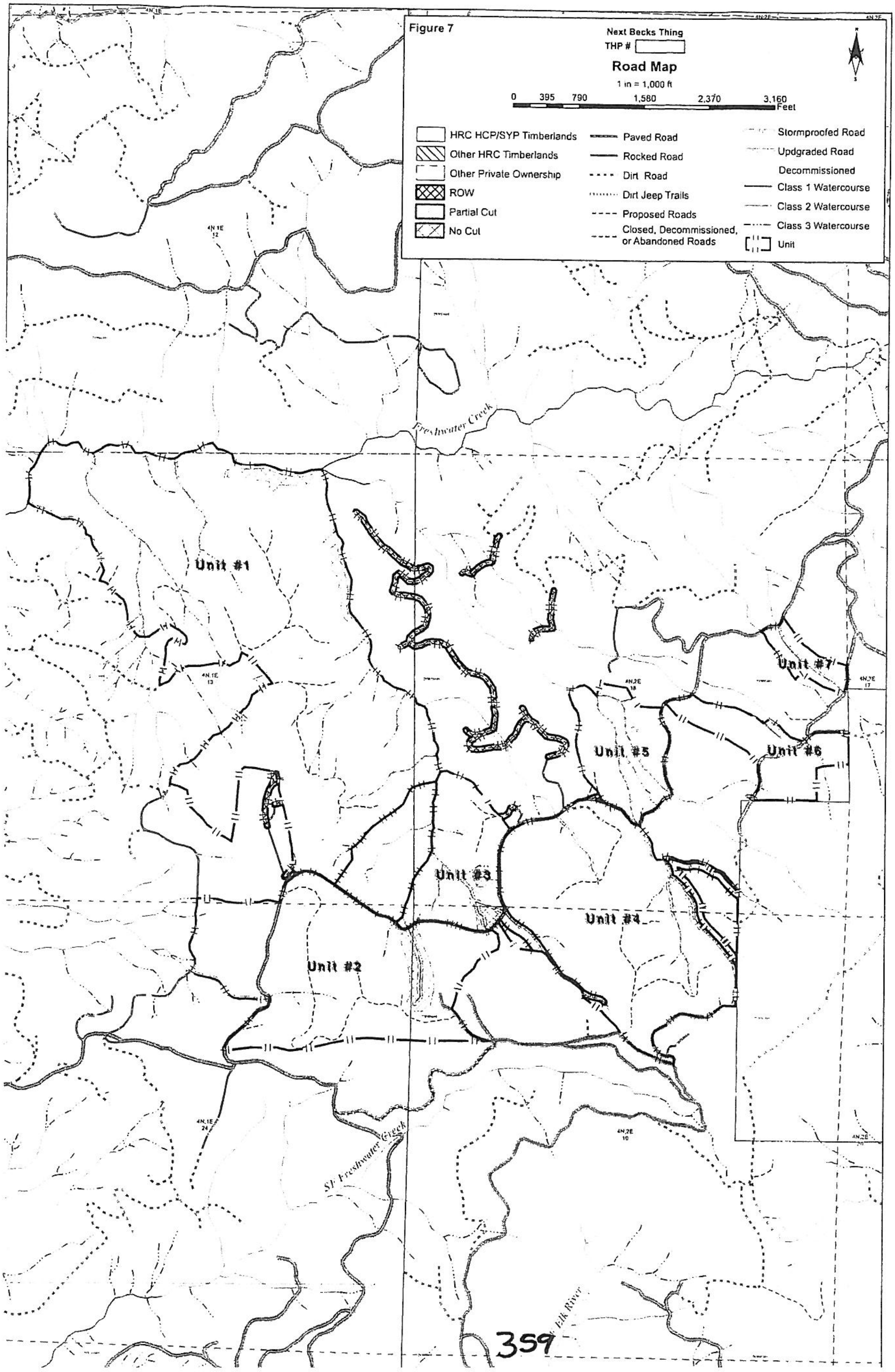
Figure 7
Next Becks Thing
THP #
Road Map
1 in = 1,000 ft
0 395 790 1,580 2,370 3,160
Feet
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
ROW
Partial Cut
No Cut
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Stormproofed Road
Updgraded Road
Decommissioned
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
Unit
Freshwater Creek
Unit #1
Unit #2
Unit #3
Unit #4
Unit #5
Unit #6
Unit #7
SF Freshwater Creek
Elk River

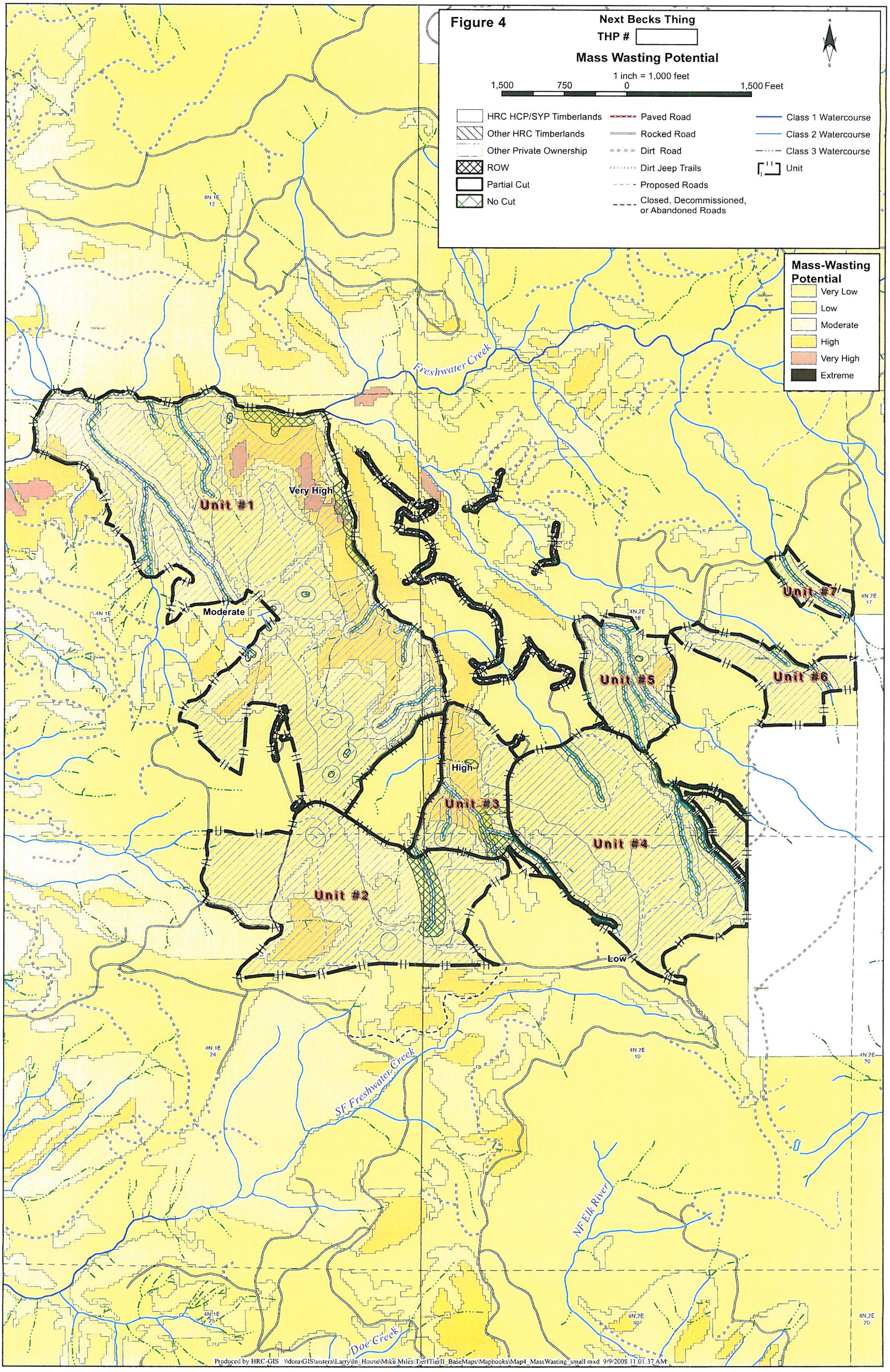

Figure 4
Next Becks Thing
THP #
Mass Wasting Potential
1 inch = 1,000 feet
1,500
750
0
1,500 Feet
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
ROW
Partial Cut
No Cut
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
Unit
Mass-Wasting Potential
Very Low
Low
Moderate
High
Very High
Extreme
Freshwater Creek
Unit #1
Very High
Moderate
Unit #2
Unit #3
High
Unit #4
Low
Unit #5
Unit #6
Unit #7
SF Freshwater Creek
NF Elk River
Doe Creek
4N 1E 12
4N 1E 13
4N 1E 24
4N 1E 25
4N 2E 18
4N 2E 17
4N 2E 19
4N 2E 20
4N 2E 30
4N 2E 29
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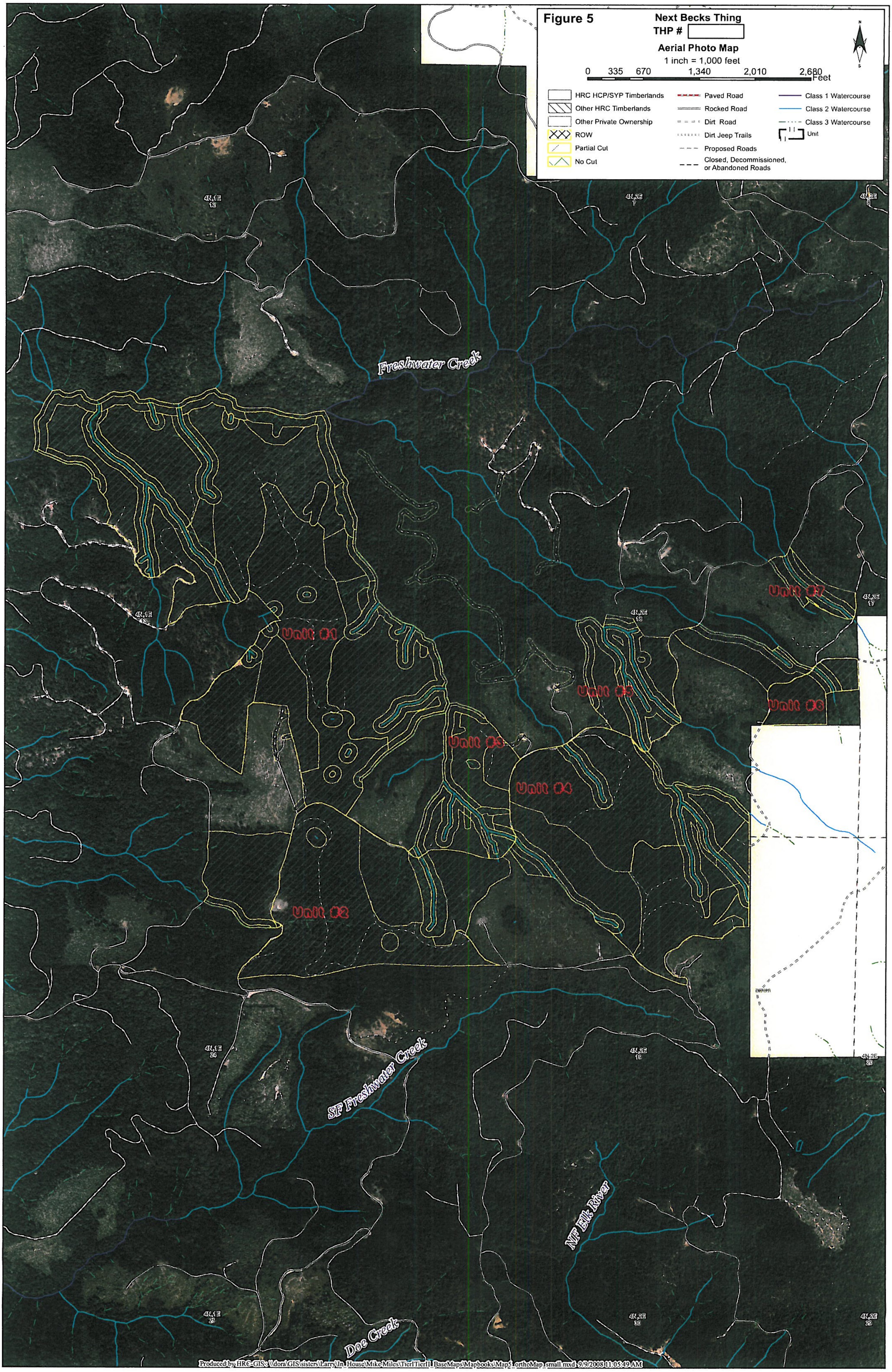
Figure 5
Next Becks Thing
THP #
Aerial Photo Map
1 inch = 1,000 feet
0 335 670 1,340 2,010 2,680 Feet
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
ROW
Partial Cut
No Cut
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
Unit
Freshwater Creek
SF Freshwater Creek
NF Elk River
Doe Creek
Unit #1
Unit #2
Unit #3
Unit #4
Unit #5
Unit #6
Unit #7
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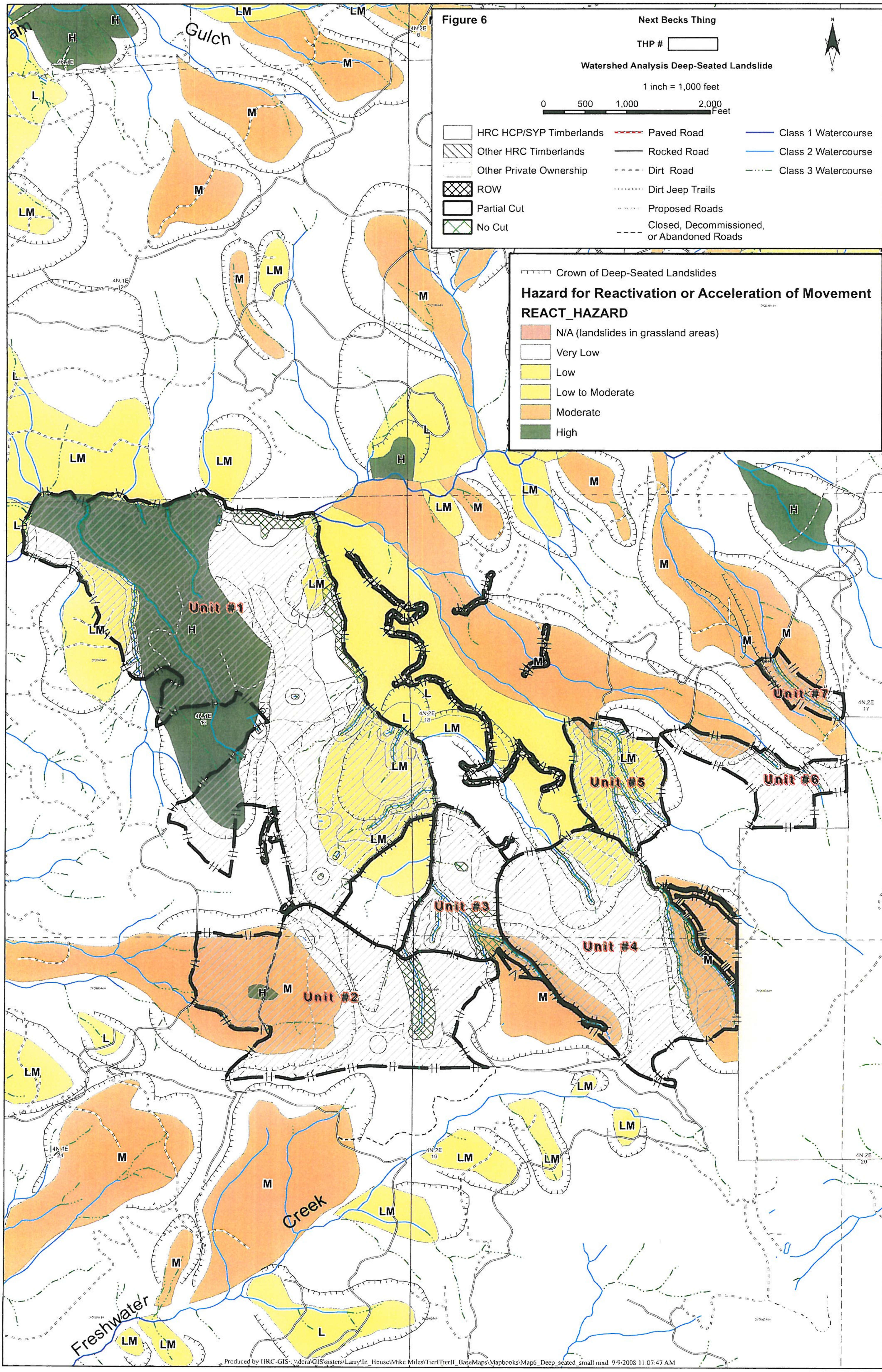

Figure 6
Next Becks Thing
THP #
Watershed Analysis Deep-Seated Landslide
1 inch = 1,000 feet
0 500 1,000 2,000 Feet
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
ROW
Partial Cut
No Cut
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
Crown of Deep-Seated Landslides
Hazard for Reactivation or Acceleration of Movement
REACT_HAZARD
N/A (landslides in grassland areas)
Very Low
Low
Low to Moderate
Moderate
High
Unit #1
Unit #2
Unit #3
Unit #4
Unit #5
Unit #6
Unit #7
Gulch
Freshwater
Creek
4N,1E 13
4N,2E 18
4N,2E 17
4N,2E 19
4N,2E 20
4N,1E 24
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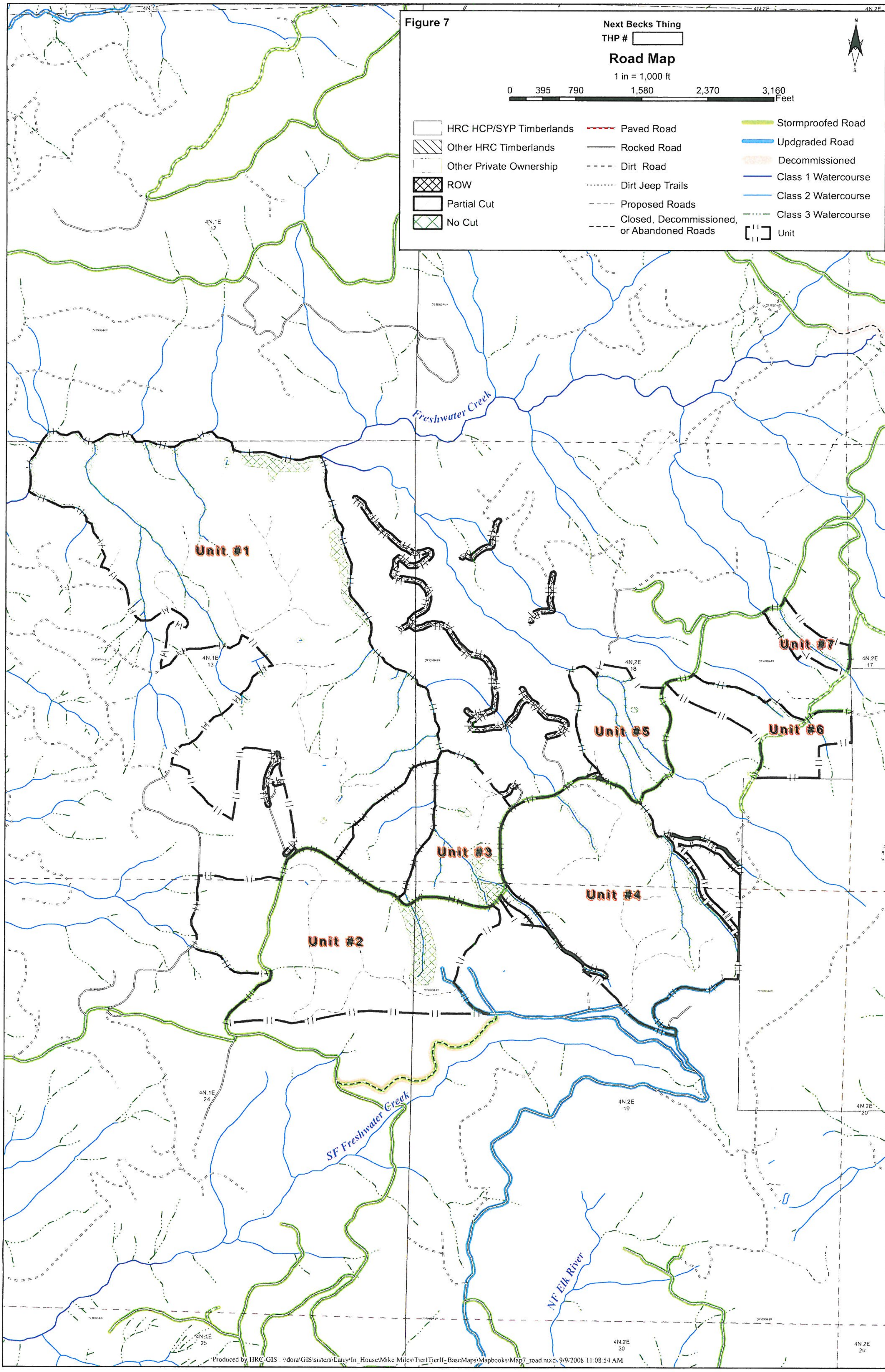

Figure 7
Next Becks Thing
THP #
Road Map
1 in = 1,000 ft
0 395 790 1,580 2,370 3,160 Feet
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
ROW
Partial Cut
No Cut
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Stormproofed Road
Updgraded Road
Decommissioned
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
Unit
Freshwater Creek
Unit #1
Unit #2
Unit #3
Unit #4
Unit #5
Unit #6
Unit #7
SF Freshwater Creek
NF Elk River
4N,1E 12
4N,1E 13
4N,1E 24
4N,1E 25
4N,2E 18
4N,2E 17
4N,2E 19
4N,2E 20
4N,2E 30
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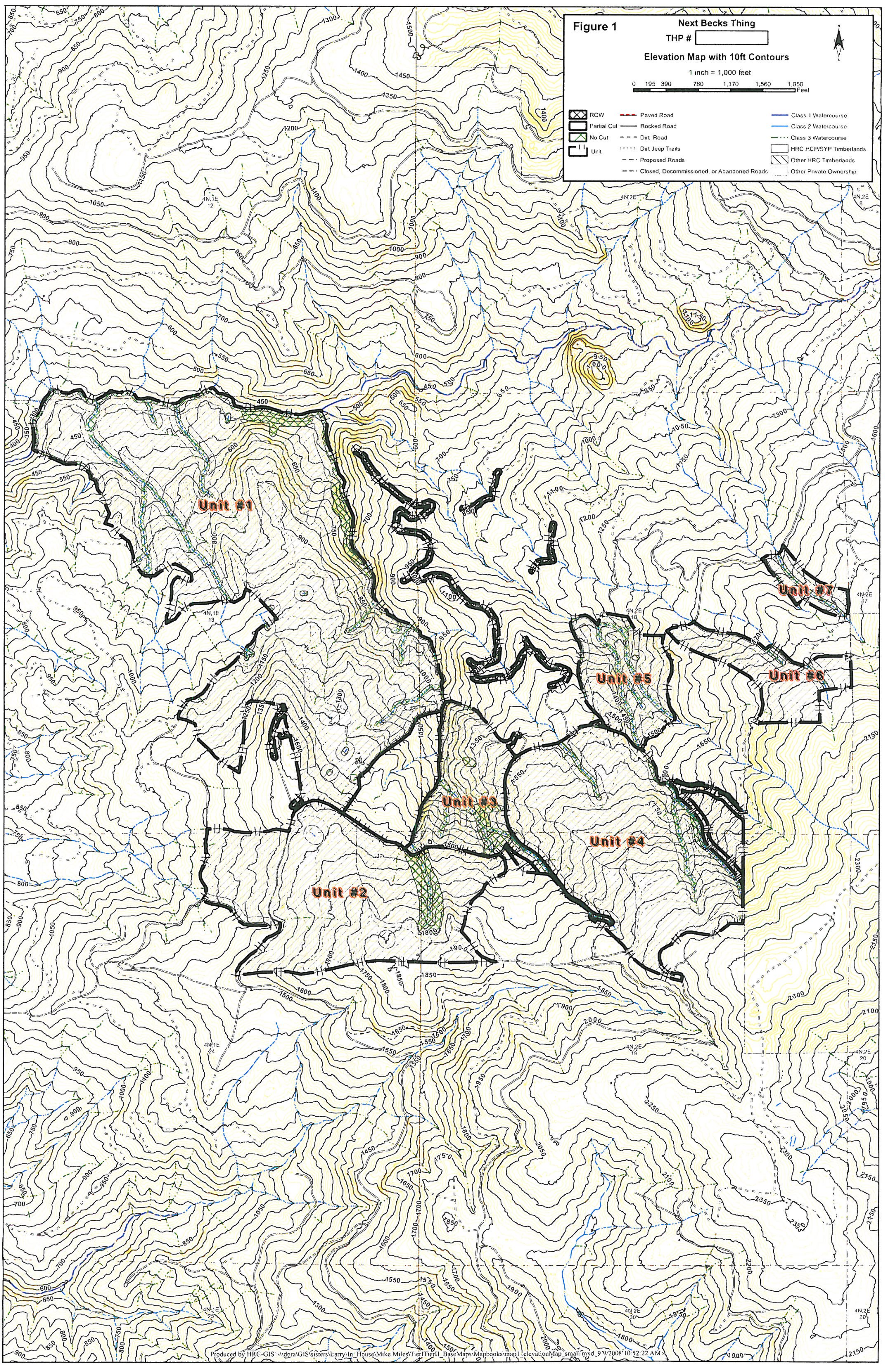

Figure 1
Next Becks Thing
THP #
Elevation Map with 10ft Contours
1 inch = 1,000 feet
0 195 390 780 1,170 1,560 1,950 Feet
ROW
Partial Cut
No Cut
Unit
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
Unit #1
Unit #2
Unit #3
Unit #4
Unit #5
Unit #6
Unit #7

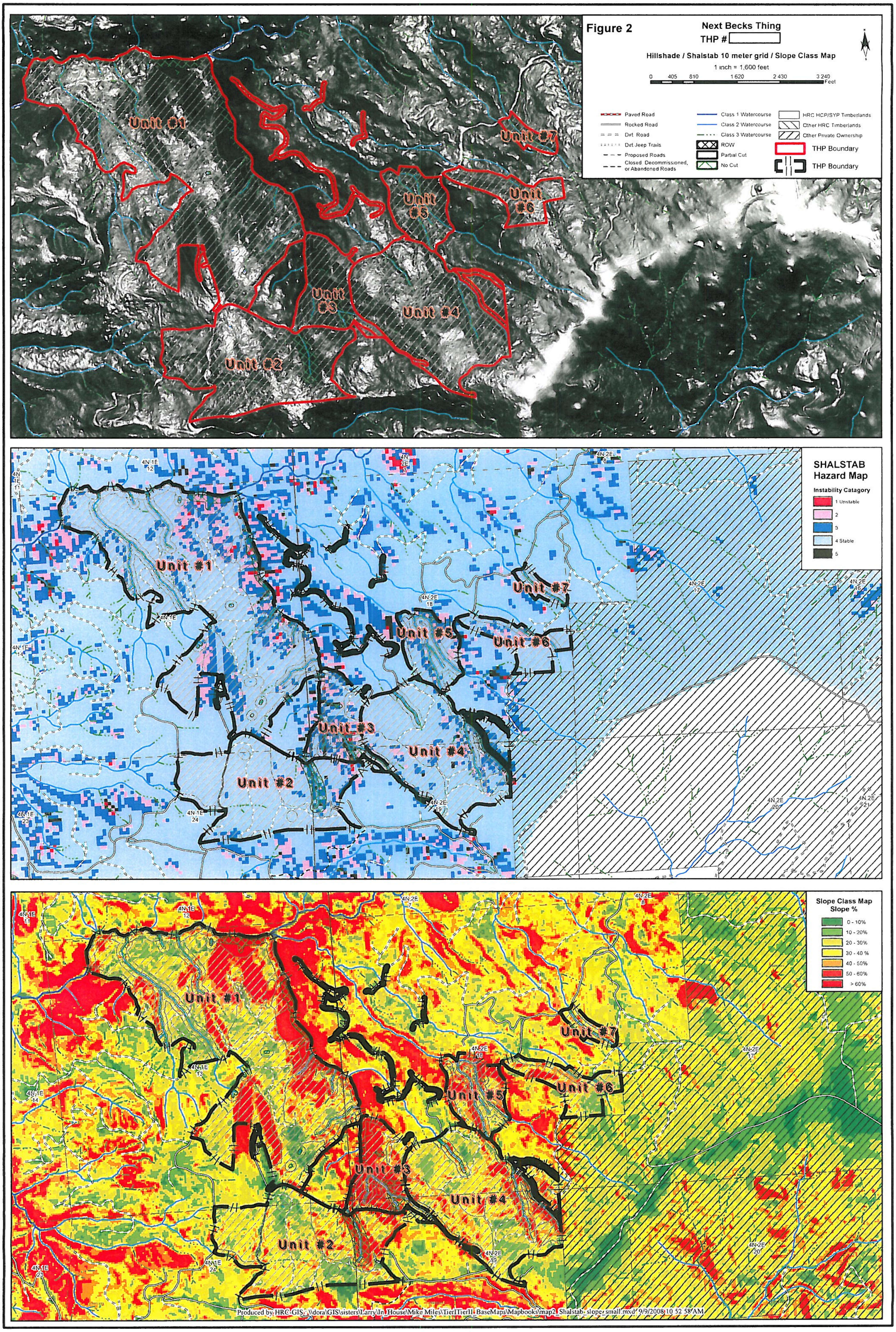
Figure 2
Next Becks Thing
THP #
Hillshade / Shalstab 10 meter grid / Slope Class Map
1 inch = 1,600 feet
0 405 810 1 620 2 430 3 240 Feet
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
ROW
Partial Cut
No Cut
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
THP Boundary
THP Boundary
Unit #1
Unit #2
Unit #3
Unit #4
Unit #5
Unit #6
Unit #7
SHALSTAB
Hazard Map
Instability Catagory
1 Unstable
2
3
4 Stable
5
Slope Class Map
Slope %
0 - 10%
10 - 20%
20 - 30%
30 - 40 %
40 - 50%
50 - 60%
> 60%
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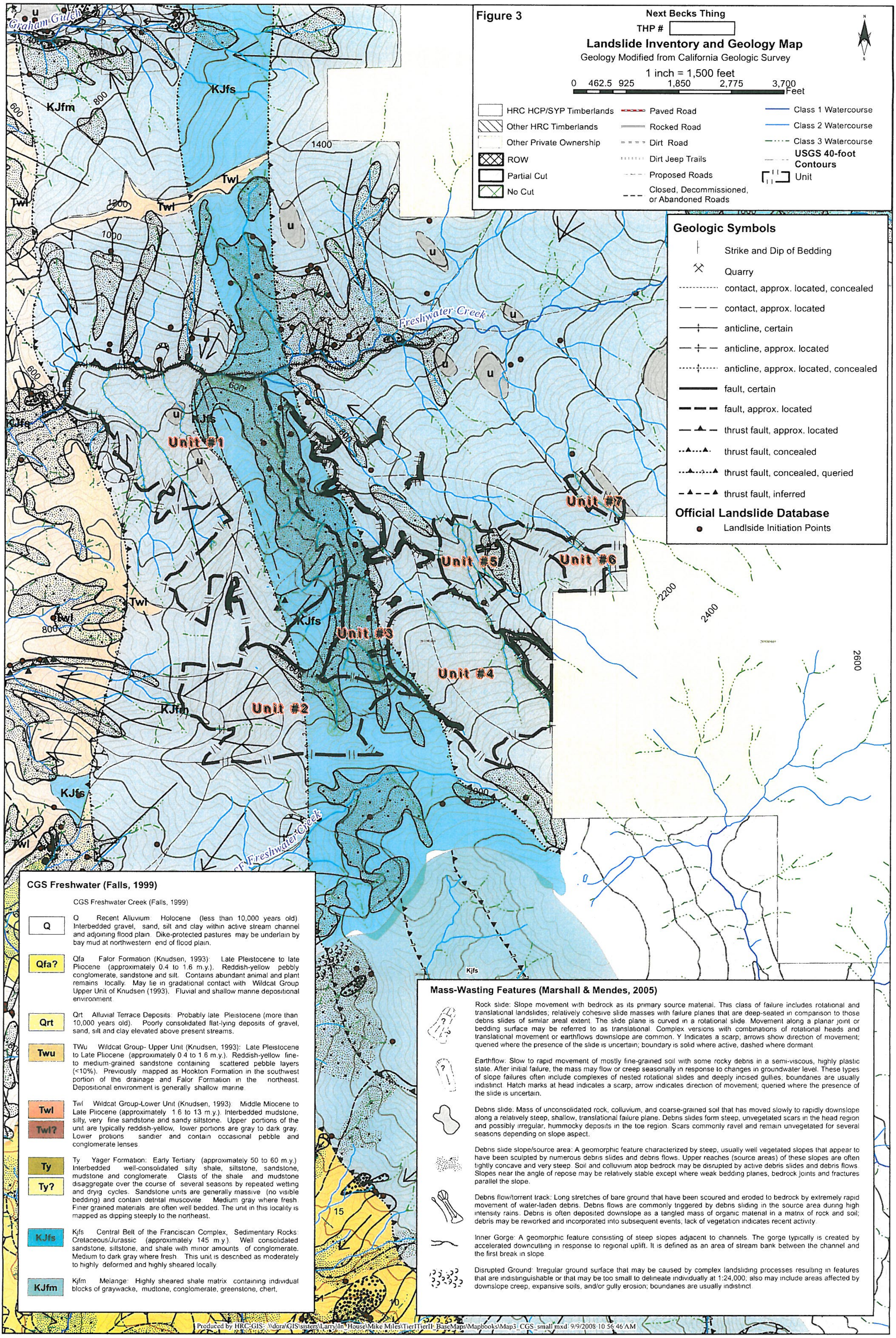
Figure 3
Next Becks Thing
THP #
Landslide Inventory and Geology Map
Geology Modified from California Geologic Survey
1 inch = 1,500 feet
0 462.5 925 1,850 2,775 3,700 Feet
HRC HCP/SYP Timberlands
Other HRC Timberlands
Other Private Ownership
ROW
Partial Cut
No Cut
Paved Road
Rocked Road
Dirt Road
Dirt Jeep Trails
Proposed Roads
Closed, Decommissioned, or Abandoned Roads
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
USGS 40-foot Contours
Unit
Geologic Symbols
Strike and Dip of Bedding
Quarry
contact, approx. located, concealed
contact, approx. located
anticline, certain
anticline, approx. located
anticline, approx. located, concealed
fault, certain
fault, approx. located
thrust fault, approx. located
thrust fault, concealed
thrust fault, concealed, queried
thrust fault, inferred
Official Landslide Database
Landslide Initiation Points
Graham Gulch
Freshwater Creek
KJfs
KJfm
Twl
Kjfs
Unit #1
Unit #2
Unit #3
Unit #4
Unit #5
Unit #6
Unit #7
400
600
800
1000
1200
1400
2000
2200
2400
2600
15
10
CGS Freshwater (Falls, 1999)
CGS Freshwater Creek (Falls, 1999)
Q
Q Recent Alluvium: Holocene (less than 10,000 years old). Interbedded gravel, sand, silt and clay within active stream channel and adjoining flood plain. Dike-protected pastures may be underlain by bay mud at northwestern end of flood plain.
Qfa?
Qfa Falor Formation (Knudsen, 1993): Late Pleistocene to late Pliocene (approximately 0.4 to 1.6 m.y.). Reddish-yellow pebbly conglomerate, sandstone and silt. Contains abundant animal and plant remains locally. May lie in gradational contact with Wildcat Group Upper Unit of Knudsen (1993). Fluvial and shallow marine depositional environment.
Qrt
Qrt Alluvial Terrace Deposits: Probably late Pleistocene (more than 10,000 years old). Poorly consolidated flat-lying deposits of gravel, sand, silt and clay elevated above present streams.
Twu
TWu Wildcat Group- Upper Unit (Knudsen, 1993): Late Pleistocene to Late Pliocene (approximately 0.4 to 1.6 m.y.). Reddish-yellow fine- to medium-grained sandstone containing scattered pebble layers (<10%). Previously mapped as Hookton Formation in the southwest portion of the drainage and Falor Formation in the northeast. Depositional environment is generally shallow marine.
Twl
Twl?
Twl Wildcat Group-Lower Unit (Knudsen, 1993): Middle Miocene to Late Pliocene (approximately 1.6 to 13 m.y.). Interbedded mudstone, silty, very fine sandstone and sandy siltstone. Upper portions of the unit are typically reddish-yellow, lower portions are gray to dark gray. Lower protions sandier and contain occasional pebble and conglomerate lenses.
Ty
Ty?
Ty Yager Formation: Early Tertiary (approximately 50 to 60 m.y.). Interbedded well-consolidated silty shale, siltstone, sandstone, mudstone and conglomerate. Clasts of the shale and mudstone disaggregate over the course of several seasons by repeated wetting and dryig cycles. Sandstone units are generally massive (no visible bedding) and contain detrital muscovite. Medium gray where fresh. Finer grained materials are often well bedded. The unit in this locality is mapped as dipping steeply to the northeast.
KJfs
Kjfs Central Belt of the Franciscan Complex, Sedimentary Rocks: Cretaceous/Jurassic (approximately 145 m.y.). Well consolidated sandstone, siltstone, and shale with minor amounts of conglomerate. Medium to dark gray where fresh. This unit is described as moderately to highly deformed and highly sheared locally.
KJfm
Kjfm Melange: Highly sheared shale matrix containing individual blocks of graywacke, mudtone, conglomerate, greenstone, chert.
Mass-Wasting Features (Marshall & Mendes, 2005)
Rock slide: Slope movement with bedrock as its primary source material. This class of failure includes rotational and translational landslides, relatively cohesive slide masses with failure planes that are deep-seated in comparison to those debris slides of similar areal extent. The slide plane is curved in a rotational slide. Movement along a planar joint or bedding surface may be referred to as translational. Complex versions with combinations of rotational heads and translational movement or earthflows downslope are common. Y Indicates a scarp; arrows show direction of movement; queried where the presence of the slide is uncertain; boundary is solid where active, dashed where dormant.
Earthflow: Slow to rapid movement of mostly fine-grained soil with some rocky debris in a semi-viscous, highly plastic state. After initial failure, the mass may flow or creep seasonally in response to changes in groundwater level. These types of slope failures often include complexes of nested rotational slides and deeply incised gullies; boundaries are usually indistinct. Hatch marks at head indicates a scarp; arrow indicates direction of movement; queried where the presence of the slide is uncertain.
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Debris flow/torrent track: Long stretches of bare ground that have been scoured and eroded to bedrock by extremely rapid movement of water-laden debris. Debris flows are commonly triggered by debris sliding in the source area during high intensity rains. Debris is often deposited downslope as a tangled mass of organic material in a matrix of rock and soil; debris may be reworked and incorporated into subsequent events; lack of vegetation indicates recent activity.
Inner Gorge: A geomorphic feature consisting of steep slopes adjacent to channels. The gorge typically is created by accelerated downcutting in response to regional uplift. It is defined as an area of stream bank between the channel and the first break in slope.
Disrupted Ground: Irregular ground surface that may be caused by complex landsliding processes resulting in features that are indistinguishable or that may be too small to delineate individually at 1:24,000; also may include areas affected by downslope creep, expansive soils, and/or gully erosion; boundaries are usually indistinct.
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