Current Treatment of Slope Stability Issues in the THP Process

Report to the Board of Forestry

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In November 1998, the Department was requested by the Board of Forestry to examine the current treatment of slope stability issues in the THP process and to make recommendations for any changes that might be needed in the process, including rule changes. For this report, we address the issue in terms of four different components.

1. Availability of basic information to RPFs and CDF reviewers – geologic and geomorphic base maps, aerial photography, published guidelines for assessing slope stability, training opportunities.
2. Accepted methods and tools for interpreting field level data and developing first and more refined analysis of potential slope stability problems.
3. To what extent are basic information, methods, and tools concerning slope stability used by RPFs in the THPs that are submitted.
4. How effective are the procedures of CDF, DMG, relevant licensing boards, and other reviewing agencies in assessing THPs.

We have not attempted to summarize a number of other related comprehensive efforts underway that will be relevant to the slope stability and attendant sedimentation issues when they are complete. A common goal of these efforts is to bring greater scientific clarity to the physical processes underlying the complex cumulative effects issues related to land use in forested watersheds. Four of the more significant efforts are the:

- Committee on the Scientific Basis for Evaluation of Cumulative Watershed Effects in Forested Landscapes, University of California Center for Forestry (September 1999)
- Watershed Protection and Restoration Council Science Panel to Review the Forest Practice Rules (June 1999)
- Noyo River Watershed Process-Based Plan, CDF/DFG/DMG (September 1999)
- Monitoring Study Group, CDF/BOF (April 1999)

Summary of Slope Stability Review

1. **Availability of basic information**

Available information varies greatly by watershed, quadrangle, and county. Sources include maps, aerial photos, technical models, and technical notes or articles. As of the writing of this report, the Division of Mines and Geology (DMG) has developed a map keyed to a database showing all slope stability mapping in the Coast Ranges covering private and State timberland. Work also will be completed this year on 10 meter digital elevation mapping that will facilitate use of technical models to predict shallow landslide hazards on North Coast watersheds. This will be published by DMG as an open-file report and displayed on their web page. The attached map illustrates where geologic information is and will be available for the North Coast.

2. **Accepted methods and tools**

The Forest Practice Rules focus on slope stability in the project setting, project design, and discussion of cumulative effects. Forest Practice Rules define "unstable area," "unstable soil" and "slide area." The thrust of the rules related to slope stability is to identify, map, avoid if possible, and mitigate. If necessary, a certified professional geologist must be consulted.

The CDF *Guidelines for Assessment of Cumulative Impacts* (1994) rely on past incidence of mass movements in harvested areas as an indicator of potential future landsliding, and do not include a detailed discussion of slope stability processes. The last detailed discussion of mass wasting processes related to Forest Practice Rules was in 1990. The Board abandoned the effort after comments by the Board of Registration for Geologists. Discussion is now in progress between the Board of Forestry and the Board of Registration for Geologists and Geophysists. DMG *Notes 45 (currently under revision)* and *50* contain much of the information developed in the 1990 discussion.

The Watershed Academies for foresters have had modules focussed on assessing slope stability risks and methods of mitigating and avoiding potential problem areas. Agency, private sector specialists and academic specialists have led these modules. Other training courses have been provided to the California Licensed Foresters Association by the Division of Mines and Geology. These programs have imparted increased understanding and skills to those that have attended but they have not been attended by a majority of RPFs.

An extensive body of literature relates to the impact of roads and landings to slope stability and soil erosion. A substantial body of literature also exists on the relationship between vegetation cover and landsliding, some of which focus specifically on root strength reductions and eventual recovery following harvesting. The *Proceedings of the Conference on Coastal Watersheds: The Caspar Creek Story* (1998) is the most recent summary of articles and authors working in the redwood region of California. CDF and DMG have compiled a bibliography and are now reviewing key articles for points that can improve understanding in California related to slope stability issues. DMG and CDF intend to disseminate the bibliographies and relevant conclusions. In addition, the U.C. Committee on the Scientific Basis for Evaluation of Cumulative Effects in Forested

Watersheds will complete work this year on the nature of cumulative watershed effects, the problem of identifying where they exist, and related matters.

3. **Quality of information and analysis submitted by RPFs in THPs**

RPFs appear to be considering slope stability issues in preparation of THPs. Based on a focused random sample of 1998 THPs where DMG requested a geologist be present on the preharvest inspection, RPFs will typically identify and map unstable slopes. RPFs identify their sources of information about 60 percent of the time. RPFs will request services of a geologist, but not on all of the plans that DMG recommends geologic review. Especially on plans on smaller ownerships, there appears to be a strong reliance by RPFs on DMG providing for geologic review.

The detail and quality of cumulative effects analysis related to watershed impacts and soil productivity (the areas where discussion of larger scale issues of slope stability are most likely) is highly varied by company and RPF. In some cases submitted THPs contain a substantive discussion of slope stability issues, especially where a geologist has been retained. Other plans do not contain much discussion or substantiation of conclusions. Information sources are not consistently cited and sometimes long lists of information are provided without relating information to conclusions about cumulative effects and mitigations. The mapping is not always sufficient, and often schematic diagrams are not included that would allow for analysis of how a mitigation measure will be applied.

4. **Agency effectiveness in interpreting information in THP**

DMG engineering geologists attended the pre-harvest inspection (PHI) on a quarter of the Timber Harvesting Plans (THPs) and Nonindustrial Timber Management Plans (NTMPs) submitted in 1998. DMG appears to have been able to visit about half of the plans where DMG itself believed it should have visited the site. DMG consistently visited a high percentage of sites with Extreme of High Erosion Hazard Rating or where there is significant public comment. In almost all cases the approved THP incorporates the recommendations of the geologist. The ability of DMG to visit more sites will increase substantially when they bring on new geologists provided for by a signed bill last year.

Regarding the implementation and effectiveness of slope stability rules, effectiveness studies conducted by DMG in 1981, 1984 and 1992 indicate that over 80 percent of the recommendations made by DMG are adopted by the Review Team and incorporated into the THPs. The rate of acceptance is progressively greater in the later study than during the original time of review. CDF is within a month of finishing the entry and analysis of data from the Monitoring Study Group. The data set will permit a quantitative evaluation of the implementation of the rules related to mass failures and large erosion events. The data set being developed will not specifically address whether site specific mitigation measures developed for potentially unstable areas were actually either implemented correctly or effective if implemented.

Initial areas that CDF believes the Board could focus on include:

- Continue to build geological resources in DMG and the private sector working with the forestry community.

- Reemphasize that it is critical to keep improving the ability to predict, verify with field review, and either avoid or design effective mitigations for unstable or potentially unstable areas that may affect beneficial uses of water or threaten public safety.

- Reemphasize the need for registered professional foresters to cite their information sources, to refine cumulative impact analysis by fully documenting existing conditions, and to focus discussion on how mitigations relate to potential impacts.

- Increase training of CDF field inspectors and RPFs in matters related to slope stability, especially shallow landsliding. It is important to know where shallow landslides are most likely to occur and the possible impacts of harvesting and not harvesting on such areas.

- Finish the joint review with the Board of Registration of Geologists and Geophysists to clarify the roles of RPFs and Geologists.

Existing Information Sets Related to Slope Stability and Their Availability

Existing information sets available to RPFs for preparation of various planning documents include maps, aerial photos, technical models, and related technical information related to slope stability. At best, maps point out areas where field review may be needed and are no substitute for site inspection by the RPF preparing the plan.

DMG has finished reviewing available maps related to geology and slope stability for each quadrangle on the North Coast. This information is being entered and will be available over the Web by the end of February.

Maps include:

Published DMG geology maps (available through DMG); DMG has completed a map keyed to a database showing all slope stability mapping in the Coast Ranges for most privately owned timberland between Monterey County and Oregon. This will be made available on the DMG web site and can be consulted by foresters and other interested parties;

Published DMG slope stability maps for portions of the North Coast (7 1/2 minute quads); 61 maps available published, 33 on DMG web site as of January 1999);

Site maps in previous THPs (available in CDF files and in some landowner records);

County or watershed specific maps such as the map of the Freshwater Creek watershed being prepared by DMG, and slope stability maps included in the general plans for the Sonoma, San Mateo, and Santa Cruz Counties; and

Watershed and site maps developed by landowners for planning documents such as SYPs or NTMPs (availability depends on landowner records or stage of CDF review).

Aerial photographs are available.

Historic air photos exist in many CDF offices and other locations. CDF Ranger Unit offices, as well as Region offices have prints of aerial photos. The most recent are 1996 and some photos date back to the 1940s. While these can not be checked out, they are available for use if persons bring their own stereoscopes.

Several timber companies in Humboldt County purchased even more recent photos following the 1996-97 New Year's storm and flown in 1997.

System-wide assessment approaches include:

Redwood Creek Watershed Analysis Format (1997) – done for Redwood National and State Parks by the Division of Resource Management and Science, the study in part examines floods, sediment, and land use. It focuses on erosion and sediment yield (landslides, fluvial hillslope erosion, channel storage, and sediment budget), recent trends in sediment loads (suspended sediment and bedload), and land uses (including timber harvesting and roads).

Federal Watershed Analysis (FEMAT-McKinleyville) - is a tiered, 8-step method for developing and documenting a scientifically based understanding of the processes and interactions occurring within a watershed. Primarily employs the corporate database being developed for National Forest System (NFS) lands, which in turn incorporates such things as Forest road inventories, NFS soil surveys, NFS geologic hazard maps, logging histories (formerly known as stand record cards). This includes some information on private inholdings. Currently land stability modeling is not used, but may be at a future time when 10 meter digital elevation mapping become available for NFS lands.

Washington State Department of Natural Resources Level II Watershed Analysis - is a more prescriptive variant of the above. Specifies resource topics that must be assessed, including: mass wasting, surface erosion, hydrology, riparian areas, stream channels, fish habitat, water quality, water supply/public works, and routing of sediment and water in the stream system. It is used to produce area-specific prescriptions (both regulatory and voluntary).

Assessment modules include:

Pacific Watershed Associates' Field Inventory Approach – identifies and prioritizes sites, such as perched fills that are a high-risk of delivering large amounts of sediment into a stream network.

SHALSTAB – developed by Dr. William Dietrich and colleagues at the University of California, Berkeley as a parameter free model to locate places where shallow landslides are most likely to occur. It uses digital topography to create a probability map of the areas at greater risk for shallow landslides based primarily on the degree of concavity of the surface and the amount of upslope area that will add water runoff to any specific site. In detailed field verifications, the 80 percent of actual debris flows occurred in areas with a predicted high potential. Dietrich is working on refinements to link a set of models that uses a process-based model to predict spatial variation in soil depth, the pattern of which is then used with a hydrologic-slope stability model. The performance of the model is acceptable for site specific mapping when used with 10 meter or finer digital elevation maps (DEM) data. Louisiana Pacific used this model in their Sustained Yield Plan to suggest when an engineering geologist should be consulted.

CDF's contractors for the Jackson Demonstration State Forest also used the Shalstab model. CDF also has entered into a cost share agreement with the U.S. Geological Survey to obtain 10 meter DEM for 166 quads covering the North Coast. The attached map illustrates where the DMG geology and geomorphic maps are available, where 10 meter DEMs are presently available from public sources, and where 10 meter DEM coverage will be available by mid 1999. CDF also has a contract with the University of California, Berkeley to convert SHALSTAB from the present UNIX platform to a format that can be used with Arcview on personal computers with a user-friendly interface. CDF and DMG will then be able to create a reference set of SHALSTAB based shallow landslide probability maps for the whole region covered by the 10 meter DEMs in 1999. These will be part of the public database available for making initial determinations on relative shallow landsliding risks.

SINMAP – A computer model based on SHALSTAB with additional variables to account for cohesion/soil depth, friction angle, and hydrologic factors. The model was developed for the Government of British Columbia. It has been used on some trial plots in the North Coast region. Compared to SHALSTAB, it is much more dependent on the information specific to the soil mantle. In most areas, this information is unavailable and it has proven difficult to calibrate SINMAP.

Rapid Evaluation of Sediment Budgets – A practical and medium term approach to sediment analysis published by Dr. Leslie Reid and Dr. Thomas Dunne (1996) to estimate the volume and sources of sediment that a watershed is producing and transporting. This approach depends heavily on sequences of aerial photos to identify sediment sources. Identified sources are then stratified by type and randomly sampled to draw conclusions

about how much sediment is produced. Volume estimates can be extrapolated to an overall estimate of sediment.

Technical assessment information includes:

DMG has produced three "Notes" that deal with technical and other aspects of mass wasting and THPs:

"Watersheds Mapping," *Note 40*, revised 3/97;
"Guidelines for Geologic Reports for Timber Harvesting Plans," *Note 45*, revised 7/97 (currently under revision); and "Factors Affecting Landslides in Forested Terrain," *Note 50*, revised 6/97.

Chatwin, et al., *A Guide for Management of Landslide-prone Terrain in the Pacific Northwest* –uses a procedure to recognize and identify landslide areas based on an office evaluation of existing information, a field review, and a simple method of assessing slope stability hazard.

Forest Practice Rule definitions for field identification of unstable areas, unstable soils, and slide areas.

Slope Stability in the THP Process

For purposes of this report, CDF is examining 1998 plans from the North Coast that DMG recommended for field review. Eighty seven out of 479 THPs and NTMPs were recommended for field review. For this independent assessment, geology students under the supervision of CDF and DMG staff are reviewing plans in random order. Each plan is being reviewed so see what geologic concerns were discussed and mapped, information sources used, and mitigations proposed. To date, a total of 24 plans have been reviewed. Of this number, 21 have been completed and entered in the data set summarized in Tables 1 and 2. The review of 2 other plans was not complete and one was rejected for filing; hence they were not included in the sample.

The tables indicate a number of things. First, RPFs are aware of slope stability issues in each of the plans. They mapped unstable slopes 81 percent of the time, but only cited information sources 62 percent of the time. DMG engineering geologists in this sample were requested 100 percent of the time to attend the PHI, but could attend only 43 percent of the time. Geologist recommendations were almost always accepted in the approved THP. Typical recommendations may include: avoidance of unstable areas; outsloping roads; installing water bars, culverts, or rocked crossings; repairing damaged roads; endhauling of spills to stable areas; and design of temporary diversions of water at stream crossings.

It should be noted, however, engineering geologists were recommended if deemed necessary by CDF Forest Practice Inspectors on 199 plans. A total of 129 Preharvest inspections were conducted in 1998 by DMG.

It appears that geologists almost always go on plans involving extreme or high EHR. They also appear to often go when public concerns are expressed.

THP Review Summary Table 1

THP included some area with EHR = Low	3	14%
THP included some area with EHR = Moderate	19	90%
THP included some area with EHR = High	14	67%
THP included some area with EHR = Extreme	2	10%
Unstable slopes identified by RPF	21	100%
Landslides mapped by RPF	17	81%
Slope stability references cited by RPF	13	62%
Geologist requested at PHI	21	100%
Geologist present at PHI	9	43%
Geologist recommendations included in THP which were made ***prior*** to the PHI	2	10%
Slope stability discussed in Cumulative Effects Section	20	95%
Public concerns expressed regarding slope stability	6	29%

THP Review Summary Table 2

Sample Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
EHR = Moderate	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	
EHR = High				**x**		**x**	**x**	**x**	**x**	**x**
EHR = Extreme				**x**						**x**
Geologist present at PHI				**x**		**x**	**x**	**x**	**x**	**x**
Geologist's recommendations implemented in THP				**x**		**x**	**x**		**x**	**x**
Public concerns expressed	**x**			**x**	**x**			**x**	**x**	

(table 2, continued)

Sample Number	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
EHR = Moderate	**x**	**x**		**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
EHR = High	**x**	**x**	**x**		**x**	**x**		**x**		**x**	**x**
EHR = Extreme											
Geologist present at PHI		**x**	**x**								**x**
Geologist's recommendations implemented in THP		**x**	**x**					**x**	**x**		**x**
Public concerns expressed			**x**								

Extent of DMG/CDF Geologic and 10-meter DEM Mapping