STUDY DESIGN

EFFECTIVENESS OF UNSTABLE LANDFORM IDENTIFICATION PROJECT

Initial Draft 8/30/04
Revision 1 10/11/04
(Revision 1 follows the design in Chapter 7 Project Management of the Draft Protocols and Standards Manual (September 28, 2004; all underlined headings are derived from the Manual guidelines.)
Revision 2 1/23/06, 3/08/06, 7/13/06, 2/7/2007, 3/18/07, 4/17/07, 8/2/07, 8/27/07

PROJECT IDENTIFICATION

Project Name: Effectiveness of Unstable Landform Identification Project
Sponsoring Scientific Advisory Group: Upslope Processes Scientific Advisory Group (UPSAG)
Project Manager: To be determined
Lead Author: Laura Vaugeois, Julie Dieu, Abby Hook, Curt Veldhuisen, Greg Stewart
Rule Group: Mass Wasting
Program: Mass Wasting Effectiveness Monitoring
Fiscal Year: 2007-2009
Budget: $500,000

ISSUE STATEMENT

The function of this project is to evaluate whether unstable landforms are being correctly and uniformly identified and evaluated for potential hazard during the forest practice application process and subsequent implementation. Unstable landforms are defined as those with a high risk of failure and with the potential to deliver to typed waters or other public resources or threaten public safety. The degree to which variability and/or bias is occurring in the field are unknown. Failure to accurately and consistently identify and delineate unstable landforms and to assess their potential hazards undermines the rule strategy, and has the potential to degrade habitat and lower water quality. Additionally, failure to properly identify unstable slopes makes it very difficult to test the effectiveness of the unstable slopes rules. This project originates from an outstanding question for further study on Schedule L-1 developed during the Forests & Fish Negotiations and included in the Forests & Fish Report (FFR).

The FFR strategy for unstable slopes requires that unstable landforms with potential to deliver to public resources or threaten public safety are completely identified during the development and review of a forest practice application. To the extent practical, unstable slopes are avoided in harvest unit layout and roads are engineered to avoid crossing unstable slopes where there is a potential impact to resources or public safety. Where avoidance is not possible, a risk evaluation of the proposed operation on an unstable slope is reviewed through the SEPA process. Correct implementation of the FFR strategy is predicated on the ability of forest managers, regulators and other stakeholders, who develop and review forest practices applications, to correctly identify unstable slopes. This project addresses the critical question that appears in the 2006 CMER Work Plan (Table 6) "Are unstable landforms being correctly and uniformly identified and evaluated for potential hazard?"

Statewide, rule-identified unstable landforms and descriptions for identifying unstable slopes were established during the FFR negotiations by reviewing watershed analyses. These are defined in WAC 222-16, and are more fully described in Chapter 16 of the Forest Practices Board Manual. Rules relating to unstable slopes include WAC 222-16-050 and WAC 222-10-030 which describe classes of forest practices and the SEPA process respectively.

PROJECT PURPOSE

This project tests the accuracy and bias in the identification and delineation of potentially unstable landforms (i.e., those with a high risk of failure and with the potential to deliver to typed waters or other public resources or threaten public safety). This project will not directly inform either best available science or the Unstable Slopes Rules, but rather will inform FFR stakeholders of factors affecting the consistency of implementation of the Unstable Slopes Rules and whether variability in rule implementation is significantly different than what is assumed to be occurring under the current rules.

This project compliments but is distinctly different from compliance monitoring. Compliance monitoring determines if a landowner correctly implemented an approved Forest Practices Permit with respect to all rules. This study is designed to quantify the variability associated with unstable slope delineation and to test whether errors in unstable slope delineation (detected by compliance monitoring or this study) are significantly different than what could be expected if a geotechnical expert has assisted in preparing the harvest unit. In addition, this study will identify the factors that may be contributing to misidentification.

Relationship to other CMER programs and projects

This project is part of CMER's Mass Wasting Effectiveness Monitoring Program. This program consists of three projects that address the effectiveness of the FFR mass wasting strategy. The approach appearing in the 2006 CMER Work Plan contains two elements. First, this project assesses the effectiveness of unstable landform identification. It is followed by two projects that assess the effectiveness of the mass wasting strategy at the prescription- and landscape-scale. All three studies inform Schedule L-1, Sediment Priority Research. The two complementary projects' relationships to the Effectiveness of Unstable Landform Identification Project are described below.

Mass Wasting Prescription-Scale Effectiveness Monitoring

- Mass Wasting Prescription-Scale Effectiveness Monitoring will help determine if the Unstable Slopes Rules and the implementation of RMAPs are effective at reducing landslides from forest practices at the site-scale.

- The Effectiveness of Unstable Landform Identification Project may provide detailed information about specific Best Management Practices (BMP) within a set of Forest Practice Applications (FPA) subsequently evaluated by the Mass Wasting Prescription-Scale Effectiveness Monitoring Project. This could increase confidence in the results derived from the latter project.

Mass Wasting Landscape-Scale Effectiveness Monitoring

- Mass Wasting Landscape-Scale Effectiveness Monitoring will help determine if the Unstable Slopes Rules and the implementation of RMAPs are causing a downward trend in landslide rates that will approach natural rates in the near-term.

The Effectiveness of Unstable Landform Identification Project should be completed before beginning the Landscape-Scale Effectiveness Monitoring as it is necessary to know whether rules are being correctly implemented before monitoring the effectiveness of the rules.

In addition to the relationships described above, CMER has been working on two FFR-identified projects that are mapping unstable landforms. Several landforms that occur regionally (i.e., are not statewide, rule-identified landforms) have been identified through the Regional Landform Identification Project (RLIP). The rule-identified landforms, RLIP-identified landforms, and more local landforms of concern are being identified and mapped through the Landslide Hazard Zonation Project. These screening tools will be utilized during the office review of this project, and will help answer the first basic question – "Are unstable slopes present within or adjacent to the FPA?"

<u>Contribution toward solving the stated problem(s)</u>

The contribution of this project will be an assessment of the degree to which the Unstable Slopes Rules and the Forest Practice Application (FPA) process decreases variability and bias in the identification and delineation of high risk unstable landforms, and whether this process leads to consistent implementation of the Unstable Slopes Rules. This assessment may be used to determine the degree to which modifications in the FPA process and/or training is required to meet FFR expectations.

OBJECTIVES

To assess the accuracy of unstable slope identification, the study should determine:

1) The degree to which potentially unstable landforms are being recognized;
2) The degree to which potentially unstable landforms are being accurately delineated on the ground;
3) Factors that may be contributing to discrepancies in unstable landform identification.

The project's achievement measures, schematically represented in Figure 1 will be:

1. Number and type of unstable landforms recognized both by participants in the FPA process and by the review team;
2. Number and type of unstable landforms identified by the review team but not by the participants in the FPA process;
3. Number and type of unstable landforms correctly delineated by participants in the FPA process;
4. Number and type of unstable landforms identified but not correctly delineated by participants in the FPA process;
5. Number and type of unstable landforms where operations occurred and their Classification status (i.e., did the FPA go through the SEPA process?).

CRITICAL QUESTIONS

This project and its objectives address the critical question that appears in Table 6 of the 2005 CMER Work plan, which is:

> *"Are unstable landforms being correctly and uniformly identified and evaluated for potential hazard [including delivery]?"*

This question is based on the FFR Schedule L-1 priority research item, which is:

> *"Test the accuracy and lack of bias of the criteria for identifying unstable landforms in predicting areas with a high risk of instability."*

Study Options

This project differs from most CMER projects in that it addresses the effectiveness of an administrative process rather than the effectiveness of a rule. As such, the range of approaches is limited. One option is to randomly select forest practices across the landscape and field evaluate the correctness of the buffering of potentially unstable slopes within or adjacent to these FPAs. Another approach is to create a test facility (i.e., a hillslope that contains unstable landforms) with a fixed standard established by a group of qualified experts and to test individuals against that standard. (Note: Both of these options predicate on field work. Remote evaluation was never seriously considered because it has been the long-standing belief of FFR stakeholders that final identification of unstable slopes must be done in the field – this belief is inherent in the Unstable Slopes Rules today, and is the reason LHZ remains a screening tool and not "the answer.")

The first option, a field evaluation of forest practices that are conducted on or adjacent to unstable slopes, would be most effective for analyzing the range of processes involved with the implementation of the Unstable Slopes Rules, from layout and review through the administrative process to the harvest. Unstable slope delineation involves a land manager and possibly geotechnical experts who participate in FPA development; a forest practice forester and other stakeholders involved in FPA review, and operators who cut the trees and build the roads. Deviations from the Unstable Slope Rules can result in misidentification of landforms, inadequate application review, or operating outside of what was permitted (non-compliance).

The second option, a facility where foresters, geotechnical experts, and other groups could be tested, has the advantage that it may provide a more complete understanding of the nature of bias by directly evaluating individuals in a test of field interpretation by profession, skill level and/or stakeholder affiliation. Two approaches for the use of a test facility include:

1) Directly testing the ability of key groups of people (such as forest engineers, regulators, forest operators, and geotechnical experts) to identify and delineate unstable slopes, or;
2) Test individuals who take the DNR Unstable Slopes Training at the end of each training session.

Either "test facility" approach has the potential to provide a clearer view of differences in interpretation between individuals and key groups than might be identified in the preferred option, but they are likely to be limited in the size and type of unstable slope evaluated and cannot be used to identify differences that are the result of on-the-ground operations. In addition, large numbers of people visiting a test locality would result in the creation of trails that are likely to bias the results of those being tested later in the study.

The field evaluation of forest practices has been chosen as the primary approach for this study design. The test facility option has been rejected as the primary approach, but it will be utilized in a limited manner to establish the inherent variability between qualified experts (used in the statistical analysis) and to train the field crew who will do the field evaluation.

Best-Available-Science Comparison

A best available science comparison is not strictly applicable to this project as it addresses an assumed state of administrative effectiveness. This is not a study that will result in a rule change, but may document challenges with the current rule implementation.

The last published TFW compliance monitoring in 1992 did not include an unstable slope element, as that was not part of the rule package at that time. No current study includes this type of accuracy and bias question. The source of this question is from the FFR Schedule L-1.

A short-term study of the effectiveness of rule implementation and the effect of landslide hazard mapping on reducing landslides associated with forest practices was conducted in British Columbia (FPB/SIR/14, 2005), however, no attempt was made in that study to determine either accuracy of unstable slope delineation or bias in interpretation, only whether harvest units were compliant with the British Columbia timber harvest rules and whether "compliant" units were more or less likely to have landslides (as compared to pre-BC rule harvested areas).

Spatial Scale: This is a statewide study of forest practices that occur on and adjacent to unstable slopes. The data will be stratified by region.

Temporal Scale: There is no document or study available to guide us in our determination of temporal scale. Forest practice applications approved in 2004 and 2005 have been selected because unstable slope training had been widely conducted by then and because the permitted work will have been completed at many sites.

Recommended Study Approach

The recommended study approach blends aspects of the test facility and field evaluation of FPAs. The proposed design uses a test facility for the purposes of standardizing a field crew's determinations and quantifying the inherent variability in unstable landform delineation between qualified experts. A field evaluation of FPAs across the FFR landscape determines the range of variability in implementation of the Unstable Slopes Rules for a variety of groups and process steps. Statistical tests determine whether the deviation in landform identification and delineation is greater than would be expected had a qualified expert identified and delineated the landforms (see Project Design for more details). The study is to be conducted in three phases:

Phase 1. Quantify variability among qualified experts at a test facility.

Phase 2. Quantify variability in unstable slopes delineation in FPAs.

Phase 3. Determine whether differences in field operations are significantly greater than what could be expected for a group of qualified experts (accuracy) and whether differences appear to show a bias (difference in mean values) by region, landform, etc…

There will be several different groups of participants used in this study. A set of working definitions of these groups is provided below:

- **Project team** - Qualified Experts (QEs) and Geologists-In-Training (GITs) who are the team of people hired to do the work involved in Phases 2 and 3 of this study. After training and testing, it is expected there should be very low variability in their calls of landform boundaries. The project team determines where forest practices have deviated from unstable slopes rules in the field. For the purposes of this study, it is assumed that the project team correctly identifies and delineates all unstable landforms within and adjacent to the randomly selected FPAs.
- **QE volunteers** - Qualified Experts (QEs) who agree to be tested in the test facility to determine the variation within QE work. It is assumed that there will be some variability among QEs. QE volunteers will be used to determine the range of 'expert' calls. This group will include some members of UPSAG, some members of DNR's Forest Practices Science Team, and some other members of the QE list. UPSAG is aiming for range of stakeholder groups and regional experience.
- **Field practitioners** (AKA: sample group) - all other personnel involved in layout, regulation, and harvest. This is the group being tested in Phase 3; they are the subjects of the study.

Assumptions

The successful implementation of the project and its ability to assess the degree to which unstable landforms are being correctly identified, delineated, and protected is based on four assumptions:

1. The proportion of FPA classes, numbers of FPAs in each DNR region, and layout methods do not change significantly between years during the period of the current unstable slopes rules;
2. Unprotected unstable slopes that clearly have no potential to deliver to public resources or threaten public safety are not considered regulated landforms;
3. It is not appropriate to "second guess" the SEPA process (i.e., forest practice activities that were allowed under the FPA through the SEPA process are assumed to be acceptable);
4. It is possible to determine where in the FPA process deviations in unstable slope identification occur.

Hypotheses

Hypotheses to be tested by this project are based on its objectives and assumptions. For Phase 1, hypotheses are:

1. The FFR definitions of unstable landforms are sufficiently clear and there should be no variability among qualified experts.

For Phase 2, hypotheses are:

2. The identification of unstable landforms is consistent, both by FPA class and by region (i.e., the field practitioners consistently see the landforms).
3. The delineation of unstable landforms is consistent, both by FPA class and by region (i.e.,, the field practitioners accurately delineate the landforms).
4. All unstable landforms are equally identifiable, both by FPA class and by region (e.g., bedrock hollows are as easy to identify as inner gorges).

In Phase 3, a post hoc analysis will be done to evaluate where in the FPA process deviations are occurring. Phase 3 hypotheses are:

5. Unstable slopes training increases a persons' ability to recognize unstable slopes and rule-identified landforms.
6. Geotechnical assistance leads to fewer missed landforms and less inadequate unstable slope buffering.

PROJECT DESIGN

An overview of the design is presented herein. The reader is encouraged to review Appendix A for further details.

Phase 1. Quantify variability among qualified experts at a test facility.

This project is designed to determine whether there are statistically significant differences in the percentage of delineated unstable slope buffer length and area of unstable slope harvested relative to what is prescribed by rule. To determine this difference, someone will need to visit the field site and measure deviations from forest practice rules.

Although, it is generally assumed that unstable slopes rules are unambiguous and their delineation across the landscape by qualified experts is consistent, the reality is that experience, field conditions, and other factors result in some variability among qualified experts. In order to test whether the deviations in unstable slopes delineation are greater than what would be expected as a result of variability among qualified experts, variability among qualified experts must first be determined.

During Phase 1, variability among the QE volunteers will be determined on a test facility. Experts, including members of UPSAG, will be asked to delineate unstable slopes that encompass the range of rule-identified features. After the experts have been tested, the "true" delineation of the unstable slope features will be established at the sites by consensus among the QE volunteers. Measurements taken by the QE volunteers will then be compared to "truth" to determine the variability among experts. The variation among the QE volunteers will be assumed to be inherent to the exercise of unstable slope identification and will be used as the standard against which all other groups are compared.

Phase 1 will also be used for QA of the project team (see QA/QC below), and the consensus of "truth" will serve as the final part of their training before Phase 2 commences.

Phase 2. Quantify variability in unstable slopes delineation in actual FPAs.

In Phase 2, variability in unstable slopes delineation among sites for which a recent forest practices application was submitted will be quantified. The target population is the approved FPAs for harvest and roads during an interval of two years. A random sample of 2004 and 2005 FPAs, stratified by DNR region and FPA class, will be evaluated from ordered lists to determine if unstable slopes were correctly identified. The data required are the FPAs and the associated documentation (e.g., geotechnical reports, Informal Conference Notes) that record efforts to verify the identification and delineation of unstable landforms and hazard evaluations.

Within Phase 2, there is a 3-level process for evaluating the applications. Briefly, Level 1 Screening is a desk review of applications using existing screening tools (i.e., SLPSTAB, Landslide Hazard Zonation products, LiDAR, and Soils maps). Level 1 Screening determines whether unstable slopes are likely to exist within or adjacent to a FPA. If unstable slopes appear to be absent within and adjacent to the FPA, then no further work is done; all other FPAs proceed to Level 2 Office Evaluation. Level 2 Office Evaluation is a desk evaluation that includes photoreconnaissance and preliminary mapping of unstable landforms; the results of this step will guide the field review, called Level 3 Field Evaluation. Level 3 Field Evaluation is the field work to verify unstable landform presence, delivery characteristics, and buffering strategy. It will be followed by interviews with the layout forester and the DNR-FP forester. Problems in rule implementation will be identified by landform, by region and by administrative process. This stratification is designed to allow problem-appropriate solutions to be created and implemented.

The sample population will be proportional to the number applications approved by FPA class. Only forest practice applications classified as II, III, and IV-S will be sampled. Approximately 6,000 FPAs are processed annually (see Table 1).

For those regions that process less than 100 Class II applications per year (SW, SPS, NE), 10% of the applications will be randomly selected; for those regions that process more than 100 per year (NW, OLY, SE) 20 will be randomly selected. This will result in 183 Class II applications. It is anticipated that Level 1 Screening of most Class II applications will verify a lack of water and/or unstable slopes; a small subset of the 183 Class II FPAs may require further review.

A 10% random sample of Class III applications will be selected from each DNR Region and six ordered lists will be created. Level 1 Screening will occur in order until at least 1% of the total applications of each region has been determined to need further review. For the three DNR Regions with less than 1000 Class II applications (NW, SPS and SE), at least 10 applications will be identified for further review. These will all receive Level 2 Office Evaluation and Level 3 Field Evaluation (or will be replaced by the next ones on the ordered lists if landowner access is not granted). It is anticipated that between 80 and 100 Class III applications will be field reviewed.

All Class IV-S applications will undergo Level 1 Screening to discard those that do not contain unstable slopes (e.g., an application might be Class IV-S because of the presence of marbled murrelets). It is anticipated that about 80 of the 99 Class IV-S applications do include or lie adjacent to unstable slopes. From the randomly ordered list for each region, 50% of Class IV-S applications including unstable slopes will undergo Level 2 Office Evaluation and Level 3 Field Evaluation. (All of Northeast Region's Class IV-S applications including unstable slopes will undergo additional review). It is anticipated that approximately 45 applications will be field reviewed.

Region	II	III	IV-S	Total
NE	563	1691	6	2260
NW	78	895	13	986
OLY	74	1085	25	1184
PC	374	3299	33	3706
SPS	298	995	11	1304
SE	72	507	11	590
Total	*1459*	*8472*	*99*	*10030*

Table 1. Applications by Class by DNR Region for the calendar years 2004 and 2005.

For more details about Phase 2, see Appendix A.

Phase 3. Determine whether differences in field operations are significantly greater than what could be expected for a group of qualified experts (accuracy) and whether differences appear to show a bias (difference in mean values) by region, landform, etc:

Statistical analyses will be designed to address the hypotheses and their objective measures. Three different statistical tests will be used:

1) Two-Sample Test for Equal Variances: The null hypothesis is that the variability in unstable slope delineation will be limited to the inherent variability among qualified experts. The variances of the two populations of interest (FPAs and QE volunteers) will be tested to determine if they are equal to each other. The test will determine whether the ratio of the variances of the two samples is equal to one and will include summary statistics as well as the F statistic and p-value. The p-value is the probability, if the null hypothesis is true, of obtaining a result that is at least as extreme as the one given by the data.

2) Two-Sample t-Test for Means: A two-sample t-test will be used to determine whether total number of unstable slopes identified, percent of buffer length correctly identified, and percent area of unstable slope identified for harvested are equal is among two populations (FPAs and QE volunteers). Two-sample tests are appropriate when two independent samples are observed, possibly with different sample sizes. Comparisons are planned for the following sub-groups of FPAs:
   i. FPAs where a forester laid out the harvest buffer without any landowner-sponsored geotechnical assistance;
   ii. FPAs where a forester laid out the harvest buffer with the assistance of a forest practices forester or forest practices geotechnical expert;
   iii. FPAs where a forester laid out the harvest buffer with assistance from a landowner-sponsored qualified geotechnical expert;
   iv. FPAs that went through SEPA versus those that did not;
   v. Whether the foresters involved in the process have ever been to the unstable slopes training.
3) One way ANOVA and multiple comparison tests: To determine what administrative or other factors may be leading to misidentification of unstable slopes, a One-way ANOVA and multiple comparisons tests will be used to test for differences within the FPA sample dataset. Planned comparisons include analysis by FPA class, DNR region, and by FPA process stage with an emphasis on the type of personnel who contributed to or reviewed the layout.,

Levene's test will be used to test the homogeneity of variances assumption necessary for ANOVA . Standard ANOVA methods will be used when Levene's homogeneity of variances test does not reject the hypothesis of equal group variances at ($P > 0.1$). If Levene's test is significant ($P \leq 0.1$), transformations will be applied to the data. If Levene's test for the equality of variances among groups was still significant for the transformed data, the non-parametric Kruskal-Wallis (KW) test will be used to evaluate overall differences among sample groups. The KW test is based on ranks and does not require the homogeneity of variances assumption.

If an ANOVA was significant ($P \leq 0.05$), multiple comparisons between group means will be performed using Westfall and Young step-down bootstrap resampling method. The Westfall and Young step-down bootstrap procedure requires no assumption about the data being normally distributed and it controls the "maximum overall Type I error rate" (also known as Maximum Experiment wise Error Rate or MEER) while being more powerful than a single-step like the Bonferroni. If the KW test was used for the comparison of groups, the Westfall and Young step-down bootstrap resampling method will be used to perform nonparametric tests by first ranking the data and applying the test to the ranks (as opposed to the actual means).

Project Conceptual Results

The successful completion of the project will provide the following information:

1. The percentage of unstable landform buffers that are correctly delineated (quantitative);
2. Number and acreage of landforms by type that were missed (not identified as unstable) (quantitative);
3. Percentage of inadequate buffering (buffers smaller than required and application did not go through SEPA) (quantitative);
4. Percentage of missed buffer length to total buffer length (quantitative);
5. The degree to which training is a factor in the correct identification and delineation of unstable landforms (qualitative);
6. The degree to which geotechnical assistance was used in identification and delineation of unstable landforms (qualitative);
7. The extent to which the identification and delineation differ between DNR regions (semi-quantitative to quantitative);
8. The extent to which the identification and delineation differ between FPA classes (semi-quantitative);
9. The degree to which the correct identification and delineation of unstable landforms differ between landform types (semi-quantitative to quantitative).

Management Plan

The management plan presents the project team and its desired qualification, the project schedule, QA/QC procedures, reporting schedule, and budget.

Project Team

It is anticipated that the project team will consist of a mix of CMER staff and contractors. The project manager will be CMER staff or equivalent state agency personnel. The principle investigator, field/office crew, QA/QC, and analytical services will be provided by contractor. The principle investigator and field/office team will have forest practice experience and the principle investigator and most members of the field review team must have a Washington State Engineering Geologist license. It is likely that CMER-UPSAG and DNR-Forest Practices staff, both foresters and scientists, will be involved in interviews, assisting with landowner access, and providing maps, air photos, staff introductions, etc. DNR-Forest Practices will also conduct an unstable slopes training specifically for this team.

Project Schedule

The project schedule is developed around a field season, which extends from April through October. The report of results will be produced by the end of February. UPSAG will have 2 months to review and provide critical and editorial comments to the report. A final draft report incorporating UPSAG comments will be produced by the end of May, with the expectation that this draft report will arrive at CMER in June. Based on comments received by CMER (and potentially ISPR), some further editing of the final draft may be necessary.

QA/QC

It is anticipated that approximately six individuals or teams will conduct both office and field inspection of selected FPA sites. A QA/QC program is a necessary part of the project to assure that these teams identify and delineate unstable landforms in a consistent, uniform, and unbiased manner.

The QA program will include DNR-Forest Practices unstable slopes training for all team members followed by intensive practice identifying and delineating all forms of unstable slopes and landforms at one or more test sites. The results of this exercise will be discussed with the team to develop a uniform and consistent approach to the identification and delineation of unstable landforms as well as a discussion of delivery. Prior to field work, the teams will identify, evaluate, and delineate the unstable landforms at a calibration site. The results of this exercise will remain confidential and will be used to calibrate differences between individuals or teams. This test will be repeated at the end of the field season to assess the degree of drift, if present.

Truth is defined here as the 'true' delineation of the unstable slope feature. It will be a mean of variability of the QE team. It is assumed that there will be an acceptable range of variability among experts, not one "truth", otherwise one individual would have to look at each unit. Where the harvest boundary line 'should' be will be determined by the consensus of the group after Phase I testing is complete. Once an acceptable level of error is determined, that would be deemed 100% compliant or undetectable from compliant.

The QC program will consist of repeat visits to a random selection of sites by different team members (i.e., different individuals or teams visit field sites that have been visited by previous individuals or teams). Five percent of the sites will be revisited by two or more teams (e.g., three reviews per site). The principle investigator will participate in at least 10 percent of the total site reviews (i.e., not just the random reviews) to assess the degree to which the field crew is correctly identifying unstable landforms and to maintain uniformity between crews.

Reporting Schedule

The principal investigator (PI) will submit monthly report in writing to the project manager. The PI will appear at three UPSAG meetings to report on progress and answer questions. The PI will make one science afternoon presentation to CMER. The science afternoon presentation will follow submittal of the draft report to CMER and precede preparation of the final report.

Budget

The budget for this project as presented in the 2007 through 2009 CMER budget is presented below.

FY 2007	FY 2008	FY 2009
0	$250,000	$250,000

Phase 1. Test Variability of QEs	
DNR Unstable Slopes Training for consultants (2 days)	$8,000
Consultant testing and consensus (2 days, post-training)	$8,000
Survey Crew (16 days)	$24,500
Phase 2. FPA Evaluation	
Level 1. Screening (12 days)	$7680
Level 2. Office Evaluation (32 days)	$20,480
Level 3. Field Evaluation (270 days)	$425,000
Phase 3. Statistical Analysis	
Statistician (7 days)	$4,760
Supplies (maps, photos, xerox)	$1,580
TOTAL	**$500,000**

Budget Assumptions:

- *DNR-Forest Practices Division will provide the DNR Unstable Slopes Training and locate the test facility.*
- *Consultant costs are $80/hour/person for geotechnical experts.*
- *Consultant costs are $85/hour/person for statisticians.*
- *Survey crew costs are $191/hour.*
- *Phase costs: Level1, screening can screen about 40/day; Level 2, office review can review about 5 per day; Level 3, field review can review about 0.5 per day (more for simple applications, but expecting difficult IIIs and IV-S to take 2 days).*
- *A 10% overhead cost is already calculated into the budget.*

Deliverables

The project will result in a final report and a database in electronic format as well as monthly progress reports and presentations as described under Reporting. The format of the final report and database will follow CMER guidelines. The final report will not be accepted until it has been subject to CMER (and potentially ISPR) review and all recommended and CMER-approved changes have been made. The final report and database will be submitted to CMER on the electronic media and in the numbers required by the contract.

CMER/Policy Interaction

This section addresses the six questions required by Policy for each CMER project. Some of the answers at this point must be incomplete pending further development of the project.

1. Does the study inform a rule, numeric target, performance target, or resource objectives?

> The study addresses the assumption that the Forest Practices administrative process is capable of insuring accuracy and consistency in the identification, delineation, and hazard evaluation of unstable landforms.

2. Does the study inform the Forest Practice Rules, the Forest Practices Board Manual guidelines, or Schedules L-1 or L-2?

> The study is in response to a high priority research question in Schedule L-1 "*Test the accuracy and lack of bias of the criteria for identifying unstable landforms in predicting areas with a high risk of instability.*"

3. Was the study carried out pursuant to CMER scientific protocols (i.e. study design, peer review)?

> Yes, the study followed the guidelines set forth in the CMER Protocol and Standards Manual.

4. What does the study tell us? What does the study not tell us?

The study is anticipated to inform CMER and Policy of the following:

1. The percentage of unstable landforms that are correctly identified and evaluated;
2. The percentage of buffered, unstable landforms that are correctly delineated;
3. The degree to which training is a factor in the correct identification, evaluation, and delineation of unstable landforms;
4. The degree to which geotechnical assistance is a factor in correct identification, evaluation, and delineation of unstable landforms;
5. The extent to which the identification, delineation, and evaluation differ between DNR regions;
6. The extent to which the identification, evaluation, and delineation differ between FPA classes;
7. The degree to which the correct identification, evaluation and delineation of unstable landforms differ between landform type, size, and deliverability.

5. What is the relationship between this study and any other others that may be planned, underway, or recently completed?

This study is part of a series that address the definition, identification and distribution of unstable landforms. It is the only one that addresses administrative issues and effectiveness and, in this respect, is not informed by other studies.

6. What is the scientific basis that underlines the rule, numeric target, performance target, or resource objective that the study informs? How much of an incremental gain in understanding do the study results represent?

This project addresses an assumption that the rule definitions for unstable slopes and the administrative process for addressing unstable slopes is adequate for capturing the problem areas. However, no information presently exists about this assumption. The project results will therefore represent a large incremental gain in our knowledge about the underlying assumptions regarding rule implementation.

Appendix A - Phase 1 and 2 Protocols

Phase I: Qualified Expert/Consultant Test

Definitions:

- **Project team** - Qualified Experts (QEs) and Geologists-In-Training (GITs) who are the team of people hired to do the work involved in Phases 2 and 3 of this study. After training and testing, it is expected there should be very low variability in their calls of landform boundaries.
- **QE volunteers** - Qualified Experts (QEs) who agree to be tested in the test facility to determine the variation within QE work. It is assumed that there will be some variability among QEs. QE volunteers will be used to determine the range of 'expert' calls. This group will include some members of UPSAG, some members of DNR's Forest Practices Science Team, and some other members of the QE list. UPSAG is aiming for range of stakeholder groups and regional experience.

Goals for Phase 1:

- Determine variability among QE volunteers to be used in recognition of inherent variability.
- Determine variability among members of the project team who will implement the study.

Steps:

1) DNR Unstable Slopes Training

The first step is to send the members of the project team to the DNR unstable slopes training classes. Even if they have been through the training before, a special training will be held to ensure that their understanding of the unstable slopes rules is freshly reviewed.

2) Field layout at test site by qualified experts and consultants

A test site will be selected that has clear boundaries such as mapped/verified streams, roads, property lines, and/or obvious timber type breaks. The site will contain at least one bedrock hollow, deep-seated landslide, and inner gorge. If a site can be located with additional unstable slope types, they will also be included.

The QE volunteers and the members of the project team will be provided with base materials generally used in field reviews, including: a 1":400' topography map, SLPSTAB, LHZ and LiDAR (if available), and air photos. The two groups will also be given clear instructions on how to buffer the unstable slopes they find on the ground and that the field layout will be designed for a Class III application, not a Class IV-S. They will be asked to approximately draw the unstable slopes boundaries on a map and they will be asked to flag a no cut line at exactly the boundary location with florescent survey markers on the ground, if a tree is not available to flag at the exact boundary location.

3) Survey Team

A survey team will follow each individual (one per day) and survey the exact location of the no cut lines. This means the survey crew will be out every other day. After surveying the boundaries, the crew will remove the previous boundary markers in preparation for the next participant. The last participant to lay out the unit will be one of the more experienced QE volunteers. While surveying the final participant's flagline, the survey crew will leave that QE volunteer's survey stakes to act as a reference for field discussions.

Following all layouts, the survey crew will produce GIS data and maps for UPSAG that show the locations of all participants' no cut lines. This will provide UPSAG with an idea of variation among qualified experts (represented by the QE volunteers) and between qualified experts and the members of the project team.

4) Group consensus in field about truth and discussion of differences

The group will then revisit the site and determine "truth" on all features with necessary discussion, adjusting the final no cut line. The traverse crew will be present to survey this consensus decision from the last participant's flagline. UPSAG will calculate differences in real units such as buffer lengths, amount of spatial dislocation, and whether there is a landform bias in spatial dislocation. It is against this backdrop of known differences between qualified experts that the differences between the FPA and the project team will be measured.

Phase 2: Office/Field Evaluation of Forest Practices Applications

Phase 2 is divided into three levels. During Level 1 Screening, some very basic tabular data is collected and it is decided if the FPA should proceed to Level 2 Office Evaluation. During Level 2 Office Evaluation, a detailed map that will guide Level 3 Field Evaluation is developed. Level 3 Field Evaluation is a field visit to the FPA to directly measure the identification and delineation of unstable slopes with respect to the standard as represented by the well-trained and tested project team. Level 1 Screening, Level 2 Office Evaluation and Level 3 Field Evaluation are described in more detail below, following an explanation of FPA selection.

FPA Selection:

Select the pool of forest practices applications (FPA) to be used for this study in the following manner:

- Establish the total list of Class II, III and IV-Special FPA approved by the Washington Department of Natural Resources (DNR) in calendar years 2004 and 2005.
- By DNR Region and by FPA Class, develop randomly ordered lists of FPA. (For example, there should be a randomly ordered list of Northwest Region Class II applications.)

Conduct an office evaluation (Level 1 Screening and, where appropriate, Level 2 Office Evaluation) on all selected FPA plus an additional number to compensate for landowner access refusals. "Selected" FPA means beginning at the top of each of the randomly ordered lists and working down through each list until the proper number of FPA have received an office evaluation or the proper number of FPA have been selected for a field visit. The proper number of FPA is described in Table A-1.

Table A-1. The number of FPA to receive, by Class office evaluation for each Region.

FPA Class	# Needing Office Evaluation	Extra In Case of Access Refusal	Rationale
Class II	Do 10% (if less than 10, then do 10 total).*	If an access refusal occurs, evaluate the next 10 FPA on the ordered list, and do field visits as required by protocol. Do not repeat this step if there is a second refusal.	Few Class II FPA should require field visits. In the interest of understanding Class II issues, a small attempt will be made to replace the first refused field visit.
Class III	Do Level 1 Screening until at least 1% of the Region's list has been selected for field review.	Do office evaluation until an additional 5 FPA have been selected for field review.	At least 1% of the Class III FPA are needed for a reasonable statistical power, and those lost to access refusal must be replaced.
Class IV-S	Do Level 1 Screening of all Class IV-S FPA to determine # that were Class IV-S for geotechnical reasons.** The first 50% of these will be field reviewed.	Do Level 2 Office Evaluation on an additional 5 FPA. Also, do all of the geotechnical Class IV-S FPA for Northeast Region.	About 50% of the Class IV-S applications that involve geotechnical issues will be field reviewed. This includes all NE Region FPA because there are so few.

*Three DNR Regions approved fewer than 100 Class II FPA.
**Some Class IV-S FPA were classified for non-geotechnical issues such as the presence or proximity of marbled murrelets.

Level 1 Screening:

For each selected FPA, add several basic data to the provided database. These are 1) a unique identifier (usually a simple counter provided as a key code by the database), 2) the FPA number issued by the DNR, 3) the FPA Class (II, III or IV-S), 4) the DNR Region (Northeast, Northwest, Olympic, Pacific-Cascade, South Puget Sound, and Southeast), and 5) the Township, Range and Section (written as 12N 09W 03).

Use topographic maps (real USGS quadrangles, NOT topography derived from digital elevation models) and aerial photos to determine if there are potentially unstable slopes within or adjacent to the FPA. Where available, use SLPSTAB, Landslide Hazard Zonation (LHZ) or watershed analysis (WA) results, and LiDAR to better make this determination. Fill in 9 additional columns in the database, each with a YES or NO. These are 6) SLPSTAB available, 7) LHZ/WA available, 8) LiDAR available, 9) Bedrock Hollows present, 10) Inner Gorges present, 11) Convergent Headwalls present, 11) Deep-Seated Landslides present, 12) Groundwater Recharge Area present, and 12) Other Potentially Unstable Landform present. For purposes of the office evaluation "present" always means "appear to be present."

Note in Column 13 "Field" or "No Field" to indicate if a field visit is warranted. If there are potentially unstable slopes within or adjacent to the FPA AND there appears to be delivery potential from one or more of these, then a field visit is warranted. No field visit is necessary only when no potentially unstable slopes with delivery potential lie within or adjacent to the FPA. "Adjacent" means immediately adjacent to an edge of the FPA. Strict adherence to these simple criteria for choosing FPA for field visits is important to maintain the random nature of the sampling without wasting field time on FPA with no potentially unstable slopes. However, it is the clear decision of this study's authors that field sampling not be biased in any way such as by preferentially choosing FPA that appear to have inadequate buffering.

When a field visit is warranted, note in Column 14 the landowner listed on the FPA.

Level 2 Office Evaluation:

For those FPA selected for field review, a field map must be developed. In some cases, it may be possible to use a high quality map from the FPA, or to ask a landowner with geographic information systems (GIS) capability for such a map, but in other cases it will be necessary to digitize the harvest boundaries and road locations from the FPA map. The final field map should be at a scale of 1" = 400' (1:4800). It might be permissible to utilize high quality FPA maps at a different scale, but this should be discussed with the Project Manager and UPSAG.

On the field map, demark all cutting boundary near any potentially unstable slopes. It is permissible to not mark (and subsequently not walk) significant lengths of cutting boundary that clearly avoid proximity to unstable slopes, such as a riparian management zone (RMZ) on low floodplain or the edge of a harvest unit with gentle slopes. However, if there appears to be a small inner gorge within a wider RMZ buffer, this should still be demarked (and walked to evaluate "over buffering" for the reason of RMZ).

Delineate any suspected unstable slope omissions using a code. Establish this code using color pens, or hachure/fill types, or labels such as BH and IG for Bedrock Hollow and Inner Gorge respectively. This code should be consistent between individuals participating in the office evaluation.

Make copies of topographic, SLPSTAB, and LHZ or WA maps, and at least 1 set of stereo air photos. Place these, the field map, a report of the data collected during office evaluation, and any handwritten comments or questions into a folder, ready to be used by the qualified expert conducting the field evaluation. Obtain or make 1:400 map for area of interest. Transfer harvest unit boundary onto 1:400 map (if needed). Mark all boundaries with any unstable slope potential (this is what must be field reviewed) delineate any suspected unstable slope omissions from a code the project team will establish (e.g. red is bedrock hollow, green is inner gorge, or different hachure to identify areas by type, or label by type). (UPSAG is willing to allow the contractors to establish this 'code' to accommodate color-blindness or other techniques – see Figure 2 for an example).

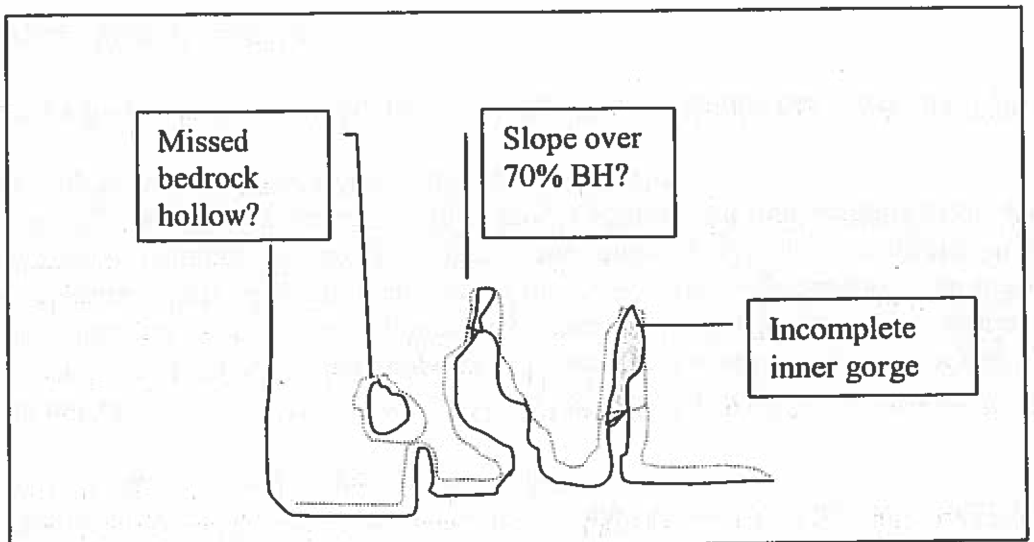


Figure A-1. Example of Level 2 Office Evaluation product. The solid line represents the harvest unit boundary, the dotted line represents boundary that must be traversed and references are to likely unstable slope challenges observed in the photo reconnaissance or from the screening tools.

Finalize Landowner Permissions:

Advance preparation will help in making landowner permissions for the study as efficient as possible. The experience with the Road Subbasin Monitoring Project (RSBM) can inform this preparation.

As the FPA that warrant field review are identified, obtain landowner permissions and permits in advance. It may be helpful to notify large landowners in the Region very early on, as one of more FPA are likely to lie on their lands. Existing permits for the RSBM Project are written such that they are valid for all CMER projects when possible. The project manager will still need to obtain permission for this specific project, but paperwork and time may be reduced.

Have a one-page project description ready (adapt from CMER web site).

Have a one-page landowner letter ready (adapt from Roads study).

When the study sites have been identified:

1. Send out landowner letters noting FPA #, parcel ID, legal, and property description, along with project description.
2. Locate telephone numbers for landowners where possible.
3. Follow up with phone calls to obtain access permission and instructions.
4. Contact landowners again to inform them when crews will be accessing their land.
6. Send a thank you letter informing landowners when data collection is completed on their property.

Obtaining landowner permission has proven to be a long and complicated process for the Road Sub-basin Monitoring Project, and certain difficulties are expected. Although this project will certainly face many of the same difficulties including determining the appropriate contact, establishing rapport and clearly communicating about the nature of the study, and following through with the landowners, it should be somewhat simpler and more efficient than that of the Road Sub-basin Monitoring Project for two reasons. Firstly, by definition an FPA has a single landowner, thus avoiding piecing together multiple permissions for a sample. Secondly, ownership is listed on the FPA.

Level 3 Field Evaluation:

Note: There may be units that are not yet harvested. If unit is not harvested, it may be sampled, with the expectation that the flag line is the cutting line, however, it must be noted in the data collection sheets that the sample unit is not yet harvested.

Overview:

Analysts will walk all cutting boundaries with potentially unstable slopes *and* any areas that were identified during the desk review as 'potentially missed'. Record total length of each landform, measure the area of "missed" landforms (including partially missed landforms), and measure areas that are 'overprotected'. Measurements may be done with string box, hip chain or with GPS.

Process:

During the Level 2 Office Evaluation, locations where unstable slopes are likely to occur have been identified. Prior to beginning the field work, the project team member reviews the information provided by the office evaluation and determines the best route to maximize field efficiency. The project team member walks the full extent of all cutting boundaries that have unstable landform features in the harvest unit, identifying the type of feature, measuring the length of the feature (Note: Features like inner gorges will have lengths identified for both sides, unless the inner gorge is used as a harvest unit boundary).

Landform Omissions and Under-protected:

In some instances, unstable slopes or rule-identified landforms will be under-protected, that is, the location of the harvest boundary will include portions of the landform. Measure the area that has been under-protected. If unstable slopes or rule identified landforms are found during the traverse that were not avoided (i.e., missed bedrock hollow) or were under-protected (e.g., an inner gorge leave area that is below the break in slope), measure the areas of the feature missed or under-protected. For rule-identified landforms, the most common type of omission is expected to be that the applicant missed a few trees along the edge of the feature. A single tree is not usually considered as under protected, but a row of trees indicates consistent under-protection. Other common omissions:

- didn't identify a historic failure that initiated above an inner gorge;
- missed bedrock hollow (or several);

- didn't identify a bedrock hollow, adjacent to an inner gorge.

Landform Over-Protection:

In some instances there will be leave areas that appear to be 'overprotected'. These are areas that are not part of a landform and do not appear to be otherwise unstable. Often these areas are left unharvested due to operational or HCP constraints, not rule-required unstable slope avoidance. Measure the overprotected area. The team is not expected to know why the 'overprotected' area exists, but that an area has been left unharvested that, by ***only*** applying the Unstable Slopes Rules, could have been harvested.
Common types of 'overprotection':

- Ridge between closely spaced landforms (too small an area /too difficult to yard/operational constraints);
- RMZ larger than landform (technically not overprotected by rule, but is superseded by another rule);
- No clear reason (other);
- Connecting inner gorge to bedrock hollow following a length of valley not meeting inner gorge definition.

'Overprotected' is a term of art that we are using to describe those areas that by rule could have been harvested but were not, for whatever reason. We provide these general guidelines for identifying over protection:

- Rule-identified landforms beyond one crown width of the break in slope;
- The small area that sometimes exists between the bedrock hollow and the inner gorge that may not be a rule-identified feature but is left due to operational constraints. If this area is greater than 0.1 acre, it should be measured.

Parsing Landform Features:

Each landform is to be measured and reported individually; however, a geomorphically continuous landform that is interrupted by other landforms should have all parts of the landform 'counted' together (Figure A-2). For example, a mainstem inner gorge feature that is interrupted by tributary inner gorges. All parts of the mainstem inner gorge get counted together. Each tributary inner gorge is counted individually. It is important to show caution during the parsing of the landscape. If uncertain, prefer lumping to splitting. If a rule is created for parsing features, it is to be noted and discussed with the Project Manager.

When inner gorges bifurcate, identify the bifurcation as the start of new inner gorge when there is at least 100 feet of channelized stream.

Field Mapping and Data Collection:

Map every landform as identified in field. Note on the map and in a tracking spreadsheet what type of feature has been mapped and its protection status (over, under, appropriate protection). In the tracking spreadsheet, for every landform feature, in addition to its length or area, identify whether the buffer over protects, under protects, or if the buffer is appropriate. See Table A-2 below.

Table A-2: Phase 2-Level 3-Sample Field Form

Unique ID	FPA#	Total unstable buffer length (existing)	Total length of unstable buffer traversed	Landform	Operation/ Strategy on unstable slope	SEPA approval for operation	Length affected	Area of landform	Area Har-vested	Over-Protection type
				IG, BH, CH, Toe, OTHER (if other, see comments)	-Clear cut -Partial cut (incomplete buffer) -Yarding corridor -Road crossing	Yes/No				-Other Rule -Beyond 1 crown width -IG to BH connection -Operational problem -Other

The field review will start with a good map of the harvest unit onto which the analyst has identified a set of areas to review (see Level 2 Office Evaluation). On the map, the analyst will field visit all of the identified unstable slopes and evaluate the buffering strategy for each unstable landform, identify areas that are deficient, those areas that are acceptable, and draw on the map those areas that were missed (as needed), complete with a site description of the missed landform. Each incident gets a line in the field form.

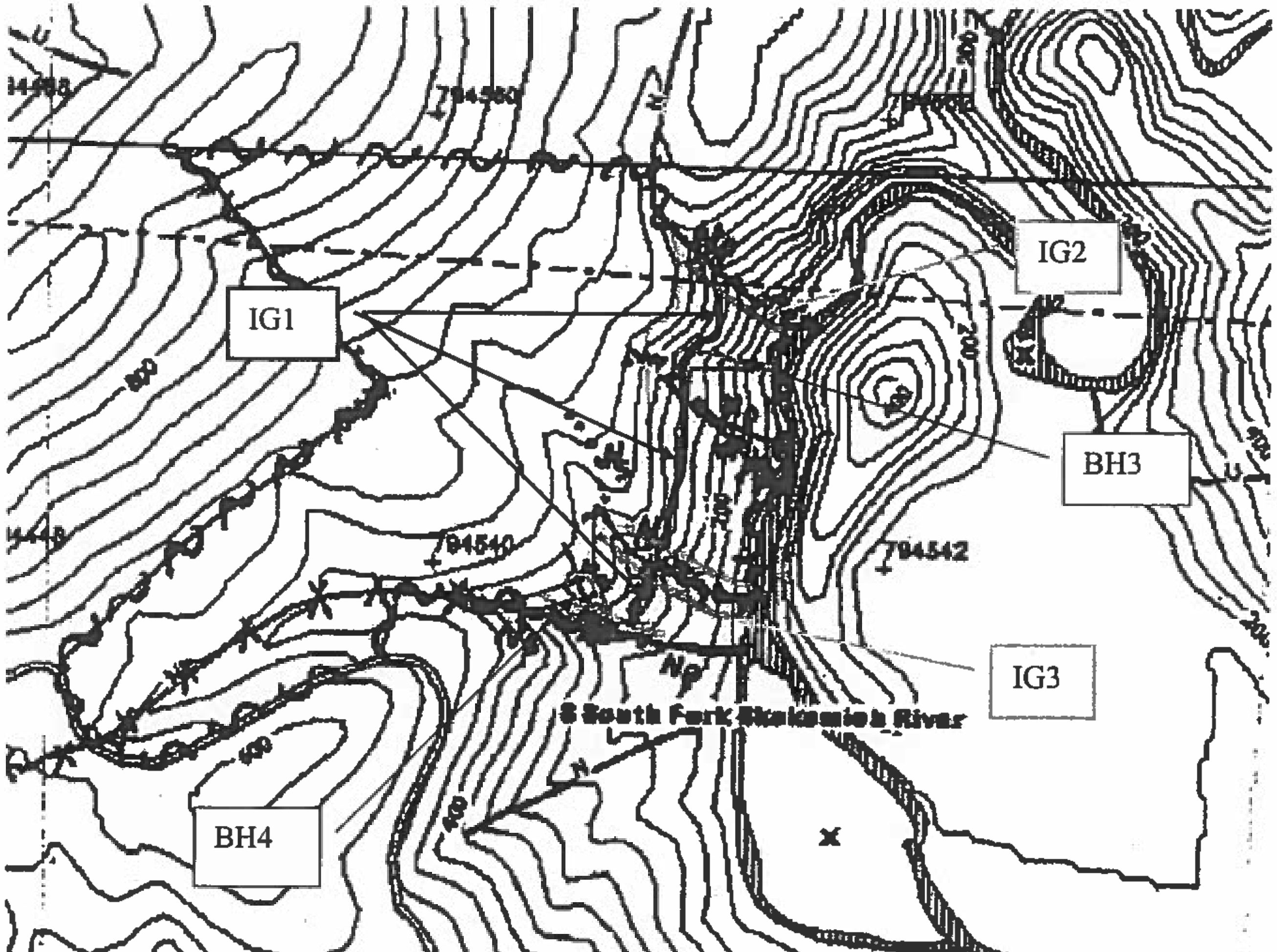
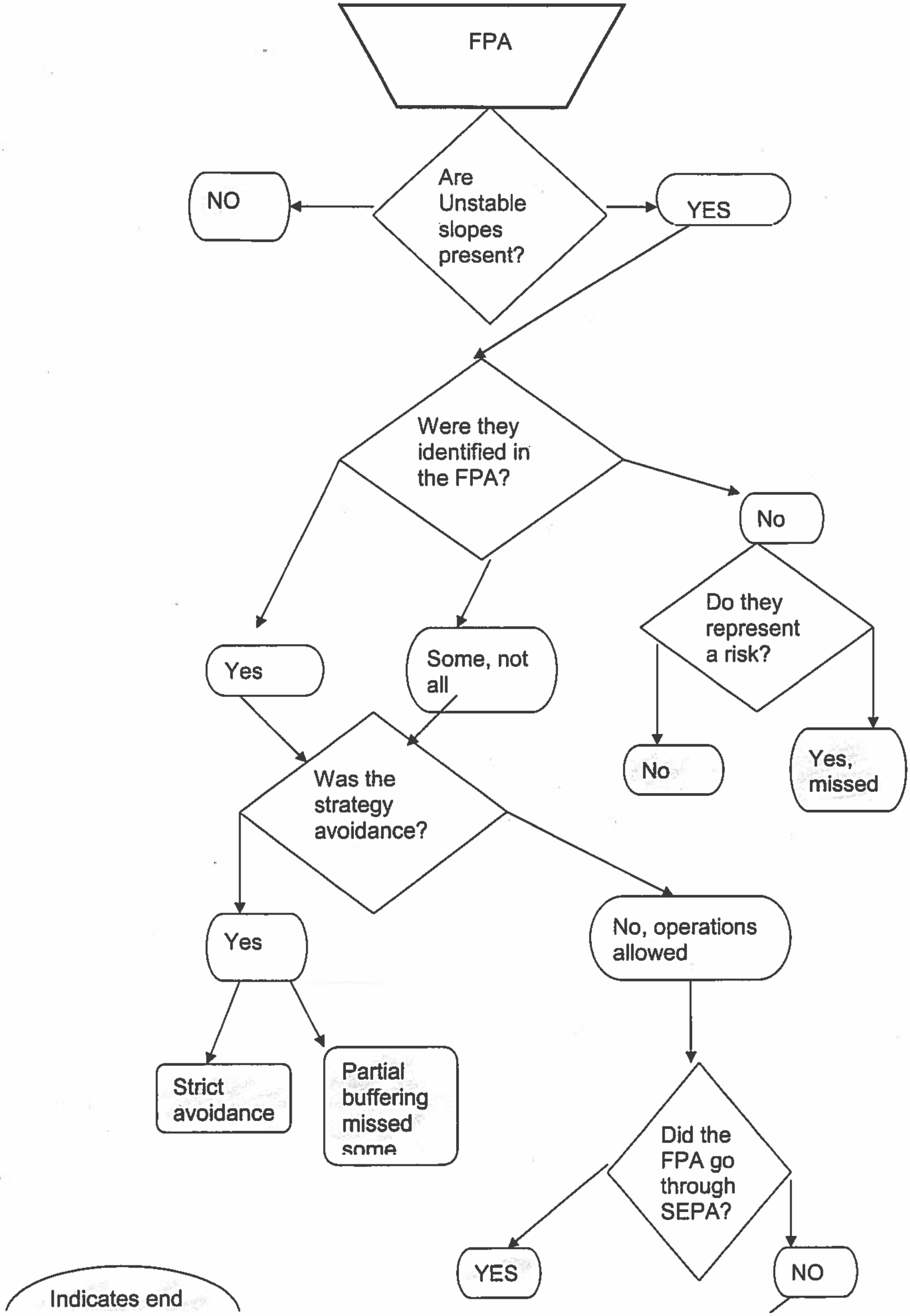


Figure A-2. The green line indicates the area of concern. The deep green line indicates the main inner gorge. The purple lines indicate smaller inner gorges that were buffered in the application. Blue lines indicate hollows that were not buffered in the application.


FPA
Are Unstable slopes present?
NO
YES
Were they identified in the FPA?
No
Do they represent a risk?
No
Yes, missed
Yes
Some, not all
Was the strategy avoidance?
Yes
Strict avoidance
Partial buffering missed some
No, operations allowed
Did the FPA go through SEPA?
YES
NO
Indicates end