Forest Soils Conservation

Alberta Forest Products Association/Land & Forest Service

Task Force Report

August, 1994

The Land and Forest Service and the Alberta Forest Products Association

Executive Summary

The Land & Forest Service and the Alberta Forest Products Association recognize that forest harvesting and reforestation operations disturb forest soils. This disturbance can range from beneficial to detrimental depending on the nature of the site and severity and extent of the disturbance. Because of the importance of the forest soil resource, the two organizations established a working committee to analyze and make recommendations to ensure the conservation of forest soils. The committee was responsible for developing guidelines to assist both the industry and the government on the management of temporary roads, decking areas and skid trails as it relates to the impacts on forest soils. Generally, the management of permanent roads will be through the license of occupation (LOC) process with emphasis on the ground rules and license conditions. Emphasis on planning and design is stressed to minimize potential concerns.

Forest soil conservation focuses on three main operational areas:

1. Roading and decking areas
2. Skidding
3. Reforestation site treatment

The working committee attempted to address the first two points as they relate to the impacts of harvesting on forest soils. A separate task force will examine the effects of reforestation site treatments on forest soils.

The Forest Soils Conservation Report is a guideline and working tool to address potential impacts on forest soils. It is to be used to assist in planning and making field assessments and to guide operational decisions.

IMPLEMENTATION

The schedule of tasks undertaken in the development of the Forest Soils Conservation report were:

1. Pilot projects with volunteers from a spectrum of company sizes for a two-year period.
2. Training sessions for industry and forest service field staff completed at joint sessions.
3. Program evaluation after the second pilot year.
4. Modification of management guidelines for future application.
5. Acceptance by Senior Management of the Alberta forest Products Association and the Land & Forest Service.
6. Implementation of guidelines on an industry-wide basis.

The working committee responsible for the development of the guidelines for the Forest Soils Conservation report included members from the timber industry, the government and the Alberta Forest Products Association. The Forest Soils Conservation Report will be reviewed by the working committee in February 1999.

Working Committee Membership

Dr. Dave McNabb
Barry Heinen
Wayne Mayan
Brian Davies
Archie Jacobs
Cyril Thaker
Cliff Henderson
Steve Ferdinand
Ed Kulcsar
Dave Patterson
Dave Darrah
Jim Kitz
John O'Brien
Wayne Johnson
Doug Schultz

MANAGEMENT GUIDELINES FOR TEMPORARY ROADS

I. OBJECTIVE

1. Temporary roads and bared decking areas will be managed to minimize the impact and be returned promptly to the productive land base. The duration temporary roads are out of timber production is to be tracked
2. To plan, construct, use, and reclaim roads within the requirements of the Public Lands Act (Sections 50 and 51), the Forests Act, T/M Regulation, appropriate timber harvesting ground rules and the annual operating plan (AOP).
3. To emphasize the avoidance and/or reduction of impacts by sound planning and design, construction and use, and prompt abandonment and reclamation.
4. To monitor the impacts on the soil and its capacity to grow timber.
5. To evaluate the impact of the cumulative areas of the temporary roads on the operable land base and the annual allowable cut (AAC). This will include the analysis of regenerated yield performance.
6. To provide and recommend strategies to improve the management of temporary roads.

II. PLANNING AND DESIGN CONSIDERATIONS

1. Minimize roading by optimizing economical skidding distance
2. Temporary road, bared landing areas and displaced soil should not exceed more than 5% of the cutblock area unless justified in the AOP process. Examples where areas may exceed 5% may include small block size, topography, or in-block chipping operations.
3. Temporary road width specifications are outlined by the applicable timber harvesting ground rules.
4. The use of appropriate seismic lines is encouraged, but recognizing they may not be in the best location or wide enough; therefore, they will only constitute a portion of the road area.

   If the road is built using existing seismic lines then the road area, for calculation purposes, would be considered 50% of the actual area.

   eg) **total area of road = 10 ha.**

   area of road on S/L's = 6 ha.

   area of new road = 4ha.

   calculated area = 4ha. + (6 ha. x .50) = 7 ha.

5. The use and duration of the temporary road should be outlined in the AOP process.
6. Topography and drainage will be considered in determining the term and season of use.
7. The reclamation portion of the AOP process will show the tactical level of treatment as well as the treatment schedule.

III. CONSTRUCTION AND USE

1. Overbuilding in terms of road density and standard should be avoided and/or discouraged.
2. Road use practices that recognize weather conditions will minimize road impacts (eg. Shut down during wet conditions).

IV. RECLAMATION AND MANAGEMENT OF TEMPORARY ROADS

1. Roads or roaded areas are to comprise less than 5% of the total block area. If the roaded area exceeds 5% of the block area, a justification in the AOP process must be submitted. Stripped landings and displaced soil areas will be measured as part of the roaded area.
2. Long-term use of roads for ATV access does not require the entire road surface. If the area is less than 3 meters in width, the road would not have to be tracked separately.
3. Temporary road or bared landing areas may be treated under the following options:
    i. Treat the area as part of the block and treat concurrently with the reforestation of the block including meeting the reforestation standards and timelines, or;
    ii. Take out a License of Occupation (LOC) for the long term use of the entire road surface, or;
    iii. Designate the roaded area as a polygon and track separately for reforestation purposes.
4. The time lines for road reclamation will be outlined in the reclamation plan. Time lines will start with the declared road abandonment.
5. The polygon will meet reforestation requirements in terms of time checkoffs. <u>Survey method, stocking and performance standards will be developed.</u>

SKIDDING GUIDELINES

I. OBJECTIVE

1. To skid trees to roadside or landings in a manner that the impacts on the soil are minimized and site productivity losses are reduced.

II. PLANNING

1. The target is to keep the rutting to less than 2% for the block area as measured by a linear transect system.
2. The planning system will evaluate soil, water, and landscape characteristics of the block and provide a means for assessing impact potential from rutting during skidding operations. Rutting is the major concern at this time.
3. A system for rating the susceptibility of soil to modification by machines is a critical component of any strategy to protect the soil (refer to Appendix 1). The rating system will address the effects of changing soil wetness on the deformation of soil, the risk that soil will be modified at any point in time and the length of time that a site remains in a specific risk category.
4. Impact ratings should be done by company planners at the time of AOP preparation and monitored during operations (Month of harvest will be known at this point, focus is on summer blocks). As indicated by the rating system, block rating potential may change following rainfall, therefore, flexibility in the number of blocks opened must be considered.
5. Frozen ground, change in harvest methods or change in block sequence can be used to operate on moderate to high damage potential sites.

III. ASSESSMENT SYSTEM

1. A multi-tiered system for the assessment of rutting is proposed. Ongoing visual monitoring of skidding operations will be the responsibility of company staff. The emphasis is to identify problems as early as possible for effective mitigation. If rutting approaches 2% of the block area, a line transect of the block will be completed to verify a formal impact assessment. The following procedures should be used for the assessment of the rutting impact:
   - i. The company will complete a visual assessment to categorize the block as satisfactory, unsatisfactory, or questionable for rutting impact.
   - ii. The company will complete a formal survey of the block, or portion of, that is questionable to determine whether the block is within the 2% range.
   - iii. A joint survey of blocks greater than 2% will be completed by representatives from the LFS and Industry to determine the actual percent of block rutted.

See appendix 2 for details of the survey systems.

IV. RECOMMENDATIONS

1. Implement a tracking and/or audit system for the applicable temporary roads and landings, which will identify the area and provide management information.

2. Initiate a study to analyze impacts of temporary roads and landings on seedling stocking and growth performance. There is a need for additional trials on spruce and aspen cutovers in the northern and southern portions of the Province. Companies in these regions will be approached to determine if there is interest in participating in these trails.

August, 1994

APPENDICES

APPENDIX 1

A System for Rating the Susceptibility of Soil to Rutting

Soil damage during forest harvesting and site preparation is reduced if protecting soil is an integral part of all forest operations. Soil protection begins during preharvest planning and does not end until damaged soil is rehabilitated and the last machine leaves the site. Protecting soil is an ongoing process because of the uncertainty that changing weather, particularly precipitation, has on the susceptibility for soil properties to be modified by machines.

A System to identify the susceptibility of a soil to modification by machines is a critical component of any strategy to protect soil. A rating system is needed as a planning tool as well as a tool to support daily decisions about equipment operation. For such a system to be successful, the rating system must address three issues:

1. the effects of changing soil wetness on the deformation of soil;
2. the risk that soil will be modified at any point in time, particularly during the operation; and
3. the length of time that a site remains in a specific risk category.

The following system was developed to help SRD and forest industry identify and rate the sites and conditions when soil is must susceptible to modification by machines. Machines can cause several types of soil modification, including compaction, displacement, puddling, rutting, and mixing of soil layers. But soil ruts, the modification of soil by the penetration of the soil by wheels or tracks because of a bearing capacity failure of the soil, is the focus of the current Forest Soils Conservation Guidelines. Soil rutting is of primary concern for several reasons:

1. Soil structure is destroyed and organic horizons mixed with mineral soil. This can reduce hydraulic conductivity, aeration, and decomposition of organic residues. Reduce decomposition may adversely affect the availability of nutrients later in stand development.
2. During rutting, the flow of soil away from the wheel or track can elevate more dense, mineral soil layers that impede the lateral flow of water through poorly drained soil. As a result, the elevation of the water table will increase and its recession slowed.
3. The presence of more than an occasional rut suggest that the site is very wet and that the entire area is susceptible to other forms of soil modification, particularly compaction.
4. Ruts are the most readily recognized form of soil modification; hence, they are a useful index for identifying situation where the operation of machines is causing soil damage.
5. Soil that has been rutted is extremely difficult to rehabilitate because the soil structure has been destroyed.

Therefore, the presence or absence of ruts is assumed to be a good, first approximation of whether forest equipment may be damaging the soil. Because ruts can be easily and quickly identified by all forestry personnel, from the machine operator the forest manager, the immediate implementation of corrective action can further reduce the amount of soil damage.

Rating System Parameters

The system to rate sites according to their susceptibility to rutting must be dynamic in order to meet an ever-changing array of site and soil situations. New research has shown that the texture of surface soil has less effect on soil strength than previously assumed. Changes in soil water content is the dominant factor affecting soil strength, particularly the strength of fine-textured soils. Dry soils, regardless of texture, are relatively strong and often quite resistance to deformation. In contrast, a high soil water content increases the probability of soil failure under wheels or tracks and the formation of ruts. Wet soil that is not rutted is likely to be severely compacted. Furthermore, previous systems that rely on differences in soil texture are difficult to implement because few personnel can accurately estimate soil texture in the field.

Soil water content can range from nearly saturated soil following a heavy rain to dry following a prolonged drought. The water content of soil between these two boundaries determines how susceptible a soil is to damage. The actual water content is affected by the amount of soil water transpired by trees and other vegetation. Without transpiration by vegetation, forest soils will not drain to water contents less than field capacity (water content of free-to-drain soil) except over a period of a few weeks. At water contents near field capacity, soil strength remains low and the soil may be severely compacted. At higher soil water contents, the soil may be rutted because the soil looses strength when an increasingly larger proportion of the stresses produced in soil by machine traffic is transferred to the water rather than directly to the soil particles.

Several factors affect how long soil at a specific site will remain wet including the amount of precipitation, frequency of precipitation, antecedent soil water content, hydraulic conductivity of the soil, position on slope, and location of the water table. A high water table or soil with a low hydraulic conductivity often requires that excess water move laterally through the surface soil layers; on gentle slopes this is a very slow process. Some preliminary data from west-central Alberta suggests that is can take at least a week for clay subsoils to drain 1 cm of precipitation under saturated conditions; additional time would be required to drain soil to field capacity. High soil moisture from frequent early summer precipitation tends to keep soils wet; the felling of trees and the termination of transpiration nearly guarantees that poorly drained soils will remain above field capacity for weeks at a time in early summer. As a consequence, water will accumulate and drain the slowest from flat landscapes and depressional areas. Slow draining sites can be identified by the depth to soil mottles, a thin or absence dark mineral soil surface horizon in fine-textures soils, and gleyed soil. A thick, dark mineral soil surface horizon generally does not have soils with mottles in the subsoil. When mottles are found closer to the surface, the drainage of the soil will be much slower, i.e., increasing from one or two days to a week or more. Soils without a dark mineral soil surface horizon are unlikely to drain to field capacity for a week or more, and frequently for months at a time once the trees are felled and the soil water is regularly replenished by precipitation.

Rating Soil for the Susceptibility to Rutting

Three factors affect the water content of soil that are important to rating soil according to its susceptibility to rutting; texture, the water content, and the position of the soil in the landscape. These three factors are the basis for rating the susceptibility to rutting. In general, organic soils tend to be wet; fine textured, mineral soils retain more water longer than do coarse-textured soils. The strength of fine-textured soils are more affected by differences water content than are coarse-textured soils. Flat and concave slopes tend to accumulate water or drain more slowly than adjacent slopes. Steep slopes have a high susceptibility because wheel slip is more likely to cause ruts.

Soil texture, water content, and landscape position are given a numerical rating of between one and three as outlined in the following table. Multiplying the rating for soil, water, and landscape together causes water to have an exponential effect on the numerical rating. Limiting the rating to only two textures of inorganic soil, fine and coarse, also places more emphasis on soil water. The two textural classes are justified by current research, which are finding that differences in soil modification attributed to texture are smaller than previously thought

Risk of Soil Rutting

Category/Class	**Rating**
Soil	
Coarse-textured mineral soil (less than 20% silt and clay)	1
Fine-textured mineral soil (greater than 20% silt and clay)	2
Organic soil	3
Soil Water Content	
Frozen soil with high water content	0
Dry (soil crumbles when crushed)	1
Moist (loose soil forms weak clod when compressed)	2
Wet (soil deforms when compressed)	3
Landscape	
Gentle slopes and convex slope positions	1
Flat and concave slope positions	2
Steep slopes (greater than 30%)	3
Multiply ratings together	
Risk of ruts forming:	
Low	1-4
Moderate	5-11
High	12-27

The low, moderate, and high damage potentials identify three field situations when different machines or more careful management of operations are likely to reduce rutting. According to these categories, no machine or forest operation should cause ruts at a low potential. A moderate potential should reflect situations where wide-tired skidders or other control of skidding is likely to prevent ruts. A high potential should identify sites where only the most careful operations will prevent ruts, harvesting should temporarily cease, or the site should be logged when the soil is frozen. Two summers of field-testing suggest that these three levels of the risk of rutting are reasonable.

The rating system is dynamic in that the susceptibility of a site to modification includes a range of values that depends on soil water. Calculation of the range is helpful in planning and scheduling harvesting operations. For example, a fine textured soil (2) in a flat landscape (2) will have a rating of 4 when the soil is dry (1), and a rating of 12 when the soil is wet (3); the same soil on an adjacent slope (1) will have a rating of 2 when dry and 6 when wet.

Soil protection will be most effective if sites with the highest rating are harvested in the winter and sites with the lowest rating are left for the wettest period of summer. This information is also helpful when locating cutblock boundaries. If the previous two sites were to be included in the same cutblock, the damage potential would nearly always be different. This increases the potential for soil modification in part of the cutblock, and consequently, increases the difficulty of managing harvest operations to prevent rutting. Therefore, the rating system may be helpful in locating cutblock boundaries during layout so that blocks are more homogenous.

As the time for harvesting a cutblock or group of blocks approaches, the rating of each block can be quickly reassessed. This allows supervisors to choose cutblocks according to the current conditions, i.e., high-risk blocks when it is dry and lower risk blocks when it is wetter. If it rains, the rating can again be reassessed to determine when operations may affect the oil or require a change in the operation.

This rating system was developed as a dynamic system to meet the ever-changing conditions, and needs of forestry personnel at all levels of the organization. However, a weakness of this system is that the probability, or length of time, that a site will have a specific rating is not considered. The dynamic response of the system to changing soil water would be lost if this were attempted. However, sites with a high rating are expected to remain wet longer than sites with a low to moderate rating.

Rate of Soil Drainage

The time that soil remains at a high water content, and the soil most susceptible to rutting, also affects forest operations. In particular, precipitation following the felling of trees will cause soil water content of fine-textured soils to approach saturation and remain wet for a prolonged period of time. The rate at which sites can be expected to drain determines how quickly operations can resume without causing ruts and severe soil compaction.

The factors determining how quickly a soil will drain are primarily affected by the texture (hydrologic properties), landscape position, and the amount and frequency of precipitation. The texture of soil affects the rate that water will move through a soil. The colour of the soil, specifically the presence of mottles and their depth and the depth of gleying, also determines how long soils remain saturated within the landscape. Soils that exhibit evidence of saturation are slow to drain regardless of the texture of the surface soil. Slopes and position on slopes also determine where lateral discharge and accumulation of surface water occurs.

The following rating system is suggested as one approach for estimating the period of time that soils within a landscape may remain very wet. The rating and risk system are similar to that evaluating the susceptibility of soil to rutting.

Estimate of time for wet soil to drain

Category/Class	Rating
Soil	
Coarse-textured mineral soil (less than 20% silt and clay)	1

Fine-textured mineral soil (greater than 20% silt and clay)	2
Organic soil	3

<u>Soil hydraulic conductivity</u>

No mottle near surface (greater than 50cm)	1
Mottles near surface (10-50cm)	2
Mottles at surface or gleyed surface horizons	3

<u>Landscape</u>

Steep (greater then 15%	1
Gentle slopes and convex slope positions (less than 15%)	2
Flat and concave slope positions	3

<u>Multiply ratings together</u>

Days for soil to drain to approximately field capacity (tentative scale):

Fast (Drains in 1 to 2 days)	1-4
Moderate (Drains in 3 to 7 days with low precipitation)	5-11
Poor (Drains in more than a week or not at all)	12-27

The number of days required for a site to drain has not been tested, but is a relative rating that identifies the critical factors involved. The actual days needed to drain in the fast, moderate, and poor level may change. High precipitation over a period of several days will also increase the number of days required for a soil to drain.

In conclusion, these rating systems were developed as tools to assist staff in the planning and executing forest operations so that they have less impact on soil. The scientific basis for rating the susceptibility of soil to rutting is very high compared to the rating systems for the time for soil to drain. Two years of use has generally validated the risk of rutting and its interpretation. However, the time for soil to drain has not been tested in the field. Some adjustments of both risk of rutting and time of drainage may be necessary for local conditions. Research in progress will provide a stronger scientific basis for these two systems in the future.

APPENDIX 2

Measurement

Visual Assessment	i)	Company staff visually appraises the amount of ruts when the area of the ruts approaches 2%, the company should take mitigative measures. They may proceed to the operational assessment to determine the actual percent impact.
Operational Assessment	ii)	Line transect to be carried out by Company staff to provide a common decision basis for go or no go skidding. Skidding should be discontinued when rutting exceeds limits at depth and area.
Joint Assessment	iii)	If impact exceeds 2%, a formal survey system completed jointly by SRD and Company staff will be completed to provide formal rut impact report and outline rehabilitation areas.

The survey method:

i) Regeneration survey grid with measurement taken every 3rd plot (i.e. start #3).

ii) 30 meter transect perpendicular to the skidding direction. Plot center is mid portion of transect line (30 meters).

iii) Road or landing move plot to next regeneration plot center location.

Procedures for the Assessment of Rutting Impact

i) Method for assessing **areas during active operations**

To be utilized on areas during active skidding operation, where ruts occur or rutting is perceived to be a concern on the remainder of the block. Primary purpose is to quantify the impact where visual estimate is difficult and to promote mitigation within the remainder of the skidding operation.

Methodology:

This method utilizes a series of 30 meter long transects positioned perpendicular to the direction of skidding. Transects are to be established at 10 plot centers evenly distributed throughout the entire logged area. The mid-point of the line transect will be placed at the spacing grid shown in Table 1. No part of a transect is to be run on a road.

To determine the percentage of the impacted are, divide the impacted distance by the total transect distance and multiply by 100.

Table 1. Transect Spacing by Area

Area ha	Spacing for Line Transect Mid-Points (Square)	Area ha	Spacing for Line Transect Mid-points (Square)
3	55 m	10	100 m
4	63 m	11	105 m
5	71 m	12	110 m
6	77 m	13	114 m
7	84 m	14	118 m
8	89 m	15	122 m
9	95 m		

ii) Method for assessing **entire logged blocks**

To be utilized on a block basis upon completion of skidding operations. Primary purpose is to resolve disputes regarding the level of skidding impact.

This method utilizes a series of 30-meter long transects positioned perpendicular to the direction of skidding. Transects are to be established at 22 plot centers evenly distributed throughout the block. The mid point of the transect will be placed at the spacing grid shown in Table 2. No part of a transect is to be run on a road.

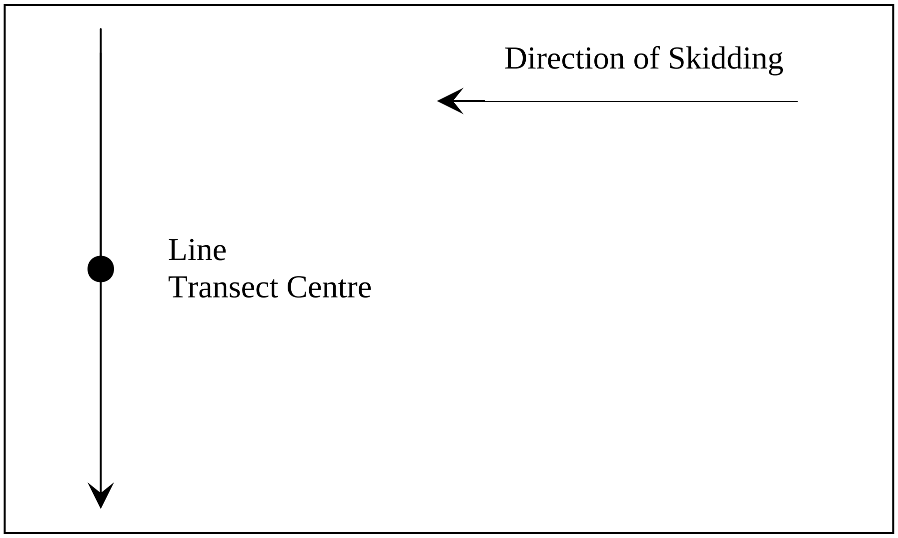
To determine the percentage of the impacted area, divide the impacted distance by the total transect distance and multiply by 100.

Table 2. Transect Spacing by Block Area

Block Area (ha)	Spacing for Line Transects Mid-points (Square)	Block Area (ha)	Spacing for Line Transects Mid-points (Square)
10	67 m	26	109 m
11	71 m	27	111 m
12	74 m	28	113 m
13	77 m	29	115 m
14	80 m	30	117 m
15	82 m	31	119 m
16	85 m	32	121 m
17	88 m	33	122 m
18	90 m	34	124 m
19	93 m	35	126 m
20	95 m	36	128 m
21	98 m	37	130 m
22	100 m	38	131 m
23	102 m	39	133 m
24	104 m	40	135 m
25	107 m		

At each mid-point, the transect is installed. The transect will run perpendicular to direction of skidding with the mid point serving as the center point of the transect.

Example:

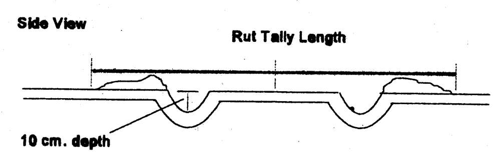


Transect survey procedure:

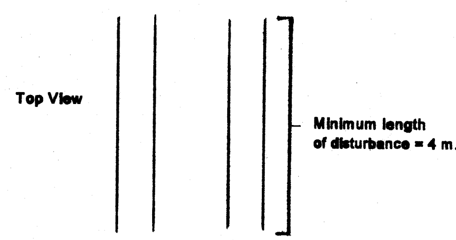
a) Transect to be perpendicular to the skid direction.
b) Cover the entire skidded area.
c) All roads and landings a separate polygon and rutting on these will not be considered as part of the cut over area.
d) Lineal landings to temporary roads – transects random and measured every other 100 meters.

Rut Displacement Measurement

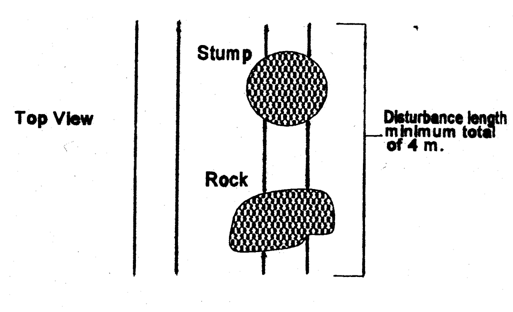
1. Measurement of rut in areas with an organic layer <30cm.
   - i) Rut more than 10cm into the mineral soil.
   - ii) Tally length of rut from the center of machine to outside edge of impact.
   - iii) Minimum length of rut for tally is 4 metres



Note: 4 meters is equivalent to the circumference of a skidder tire (i.e. One revolution of a tire).



2. Measurement of rut in areas with an organic layer > 30cm.
   - i) Rut that shears the organic matter layer to a depth of 20cm.
   - ii) Tally length of rut from the center of machine to outside edge of impact.
   - iii) Minimum length of rut for tally is 4 meters.



Rutting Assessment Tally Sheet

Example:

A Transect #	B Length of Transect	C Length of Transect Impacted by Rut
Total		

% Impact =C/B x 100

APPENDIX 3

DEFINITIONS

Rut- a rut is determined by its depth and length:

Where the depth of organic dark humus material is greater than 30cm., a rut is a depression that shears the organic layer of the soil (a sheared organic will expose a vertical face greater than 20 cm. of the organic layer).

Where the depth of the organic material is less than 30cm., a rut is a depression exceeding 10cm. into the mineral soil.

Length

An impacted area meeting the rut depth criteria that is greater than 4 meters long.

A continuous track with a rut less than 4 meters because of stumps, logs, or rocks lifting the vehicle will still count as a rut if the total length of the smaller "holes" is greater than 4 meters in length.

Skid trial

A clearly defined path over which logs have been dragged to decking areas.

Displaced soil

Mixed mineral, surface, and sub-surface horizons that have been deposited off the road or landing surface at a depth of 15cm. or greater.

AOP Process

The entire process involved from the preliminary AOP to the final AOP submission.

Soils Disturbance

Soil disturbance is defined in the context of the 5% maximum, includes bared landing areas, temporary roads, or displaced soil.