Ontario
Ministry of
Natural
Resources

Subject		Policy
ENGINEERING AND DETAILED DESIGN		**PL 10.07.00**
Compiled by - Branch Lands & Waters	Section Land Management	Date Issued August, 1992
Formerly Referenced As Access Roads Manual: Engineering and Detailed Design		Number RA 3-2

The construction of access roads requires a thorough knowledge of engineering and construction practices in order to provide maximum benefit to the user and at the same time limit the impact to the environment.

The standard of road to be designed will dictate the level of knowledge or expertise required. Depending on the resources available, some or all activities in the process of the design may be better contracted to outside consultants, especially for the higher standard roads.

Detailed design should be done only after all available Engineering, Planning, Funding, and Program Use data has been collected so that design decisions are correct and the most cost effective. A well designed road addresses everyone's concerns.

All road designs should be consistent with the information contained in MNR Guidelines and Policy Manuals such as the Environmental Guidelines for Access Roads and Water Crossings, "A Description of Road Access for Timber Management Planning Guidelines", and the Crown land, Bridge Management Report.

ENGINEERING

The engineering for road construction will take place within the approved road corridor and shall conform with the approved road design standard. The level of engineering may vary from a full instrument layout and ground profile to flagging a line by compass.

Consulting engineers retained by either the Region or District may be called upon to provide engineering services in instances where internal resources are not available to undertake the work.

The amount of engineering work required for a specific road construction project depends on many factors, such as:

- road standard and long-term intended use
- terrain difficulty and extent of grading required

- length of the road

- particular physical constraints requiring detailed investigation, e.g. swamps, rock ridges

- preference and previous experience of the local District staff managing construction

- staff resources and knowledge

- construction strategy proposed (e.g. contract or equipment rental)

- requirements identified during the Environmental Assessment process

- bridges, railway crossings

Budgetary needs are best met when pre-engineering and the detailed design are done prior to the fiscal year in which the construction is to be undertaken. Under these conditions engineering could include:

- identificaiton of road corridor 5-6 years in advance in TMP's

- gathering of field information about major water crossings including:

    - stream bed profile and cross sections
    - flow measurement
    - determination of high water mark
    - stream bed material samples
    - layout and clearing of the centre line
    - soils investigation with hand auger
    - sounding of swamps

This information would then be used to assist in the completion of the detailed design and preparation of tender documents to be ready for an early start in the following fiscal year.

LEVEL OF ENGINEERING AND DESIGN

The level of detail and the source of engineering expertise required for road projects shall be determined by the District Manager in consultation with the Regional Engineer.

RESPONSIBILITY

1. District Manager

   - assumes full responsibility for the carrying out of the project in accordance with ministry policies and guidelines

   - consults with the Regional Engineer to determine extent of required Engineering and Design work.

2. Regional Engineer

   - ensures the Districts receive the necessary engineering expertise required

   - reviews all bridge and large culvert design prior to construction

The following methods are used for providing the necessary engineering:

1. Internal District staff perform all engineering with the exception of the design of large culverts and bridges. This procedure is followed in Districts with experienced staff and for lower standard roads.

2. Regional Engineering Services staff carry out engineering work at the request of a District. Where the resources at the Regional level are available, this procedure would normally involve using seasonal survey staff for road layout and profile preparation throughout the Region. The cost of this engineering is normally about 3% to 5% of road construction costs.

3. Consultant engineers retained by either the Region or District to provide engineering services in instances where internal resources are not available to undertake the work. The Ministry Policy and Procedure Directive No. SE 3.08.01 for Technical Consulting Services - Field Offices, contained in the Supply Management Manual, details the requirements in using technical consultants. The cost for pre-engineering work undertaken by a consultant engineering firm would normally be 6% to 10% of construction costs.

The following is an outline of engineering and design services which may be required for projects. Note that they are not meant to be mandatory for all projects, but simply represent those services available as required.

Bridge Designs & Culvert Designs

- Hydraulic Studies
- Hydrology Studies
- Structural Design
- Site Survey / Topography & Soils & Fish Habitat

Railway Crossing Designs

Engineering & Design

- Corridor Selection (and associated Environmental Impacts)
- Aerial Photography
- Topographic Manuscripts
- Centre Line Location
- Level Survey
- Preparation of Contract Drawings and Specifications
- Construction Estimates

Geotechnical Investigations

- Soil Tests
- Aggregate Searches
- Bridge Foundation Designs

Cost Benefit Analysis

- Social Impact Studies

Cost Validations

- Construction Inspections / Compliance Monitoring

THE DESIGN

The design of a road can be broken down into a number of components that are pieced together to achieve the final design. The number of components and the extent of detail to which they are designed are job specific and are to fit into the tolerances specified in the Geometric Standards section. (RA3-1)

ROAD LOCATION (CORRIDOR)

The proposed road corridor decision is influenced by both non-engineering factors, such as the protection of tourism values and the engineering factors such as those identified below.

ENGINEERING FACTORS

o The designed road must provide economical access and operate in the capacity for which it was intended.

o The road must avoid or minimize disruption to all sensitive areas such as:

  - Critical Fish & Wildlife Habitat
  - Public Use Areas (Tourism and cottage)
  - Historical and Archaeological sites
  - Private property (Municipal Boundaries)

o Physical Features

  - Topography and Landforms
  - Lakes, Rivers and Creeks
    (natural drainage patterns)

- Granular Deposits
- Swamps
- Rock Outcrops and Ridges
- Soil Conditions

The designed road must satisfy classification design standards as detailed in the Geometric Standards section. (RA3-1)

ROAD CLASSIFICATION

The three major classifications of roads are primary, secondary, tertiary. The design standards associated with these classifications are as per the Geometric Standards section (RA3-1) which defines the parameters to which the road is to be designed.

HORIZONTAL CURVES

Horizontal curves are a crucial component that deserve a lot of consideration for two reasons. A) there are more accidents on curves and B) curves take you away from the straight line desired. The design considerations for horizontal curves are:

- topography (landforms)
- design speeds
- sight distance

Note: Avoid combinations of vertical and horizontal curves.

VERTICAL CURVES

The function of a vertical curve is to allow for required sight distances and to allow for a smooth transition through changes in the vertical alignment. The design considerations for vertical curves are:

- design speeds
- sight distances
- riding comfort

Note: Avoid combinations of horizontal and vertical curves.

BALANCE CUTS AND FILLS

Usually the most cost effective construction project limits the importing and exporting of material and minimizes the handling of existing material. (The quantity of required fill and the quantity of excavated material are approximately equal) This is not always the case where low cost borrow material can be imported to build the road up to required grade. The easiest means of achieving this cut and fill balance is to follow existing terrain as close as possible.

Balancing volumes of cut and fill material:

- can be done in the field with experienced road building equipment operators
- can be calculated manually using Mass Diagrams (Regional Engineering staff can assist with this method).
- can be calculated using available design computer software (Regional Engineering staff can assist with this method).

GRADIENTS

The maximum gradient is the steepest hill acceptable on the road. The degree of steepness can be reduced by cutting the top of the hill off and placing the material at the bottom of the hill.

Design considerations other than topographic are:

- type of vehicle using road (haul trucks)
- seasons of use (ice and snow)
- stopping distances
- design speed

ROAD STRUCTURE

The road structure is designed to support the maximum vehicle load on the road and provide a smooth, low maintenance surface. This may include subgrade preparation such as soil stabilization, adequate granular thickness to carry load and a riding surface suited to traffic conditions.

DRAINAGE

The function of drainage system is to remove water from first the travel surface and second the road structure and subgrade where there is the possibility of frost susceptible soils. The various methods through which this can be done include:

- surface and subgrade crowning and crossfall suited to surface material for e.g. asphalt may only require 2% crossfall whereas gravel should be up around 5% if possible
- storm sewer with curb, gutter and catch basing (very rare)
- ditch and culverts with adequate depth to drain subgrade and ample grade to allow for flow
- tile in subgrade
- french drains in subgrade

WATER CROSSINGS

The main function of a water crossing is to efficiently and without erosion or major failure pass the water course flows for large watersheds. This requires a thorough analysis to determine peak flows, eg. design flood flows.

The type of water crossings include:

- culverts
  - small diameter
  - multiple
  - large diameter

- bridges
  - timber crib
  - steel stringers
  - log stringers
  - bailey bridges

- erosion control
  - rip-rap
  - filter cloth
  - gabion walls

Fishery concerns should be addressed at the design stage with the calculation of acceptable fish flow velocities and depths as identified in the MTO Drainage Manual and the possibility of modifying culverts with fishways to achieve the desired results.

SWAMP CROSSINGS

Swamp crossings should be avoided where ever possible due to their instablity and they tend to be very costly. In swamps where the organic material is over a meter in depth, a reinforcing medium is required otherwise road fill can be placed directly on the root mat. The two most common reinforcement methods are log corduroy or a geotextile
fabric. Both are illustrated in the following cross-sectional drawings. Note that proper construction tecniques are a must to avoid any unnecessary costs(no disrubtion to the natural root mat).

RAILWAY CROSSINGS

Railway crossing design is governed by safety factors. The designer should consider aspects such as perpendicular approaches, long sight distances, additional clearing around crossing location and adequate signage before and at the crossing. Transportation Agency

SAFETY FEATURES

Once the road design has been completed it is good practice to identify the required safety measures, these include:

- signage (speed, warning signs, load restrictions) to conform to standards identified in the pertinent sections of the manual
- guide rails
- line painting (park roads)

COST ESTIMATES

Upon completion of design the total project cost estimate should be done to provide an accurate construction cost for budgeting purposes.

GOOD DESIGN PRACTICES

1) Keep on hand previous year's tenders for good representation of construction costs.

2) Incorporate into your design all mitigation techniques to ensure the proper components are, in fact, constructed.

3) Start a library of available construction materials and new technology (i.e. geotextiles, agromat, Big "O" pipe, etc.)

4) Consult other road building agencies within the same area (local MTO Office, area Municipalities, adjacent MNR Districts, Forest Operators, local road building contractors).

LAYOUT

Preliminary and final layout techniques and accuracy will vary according to project requirements but would contain the following:

- Compass Flag and paint
- Theodolite (Transit) and level to layout line and offset with grade stakes
- Total station line and grade stakes can be laid out with coordinates obtained from design software

CONTROL POINTS

Survey control points may include the following:

- Brass cap in concrete
- Concrete monuments
- Cut cross in bed rock
- Nails in trees
- Woodstakes
- Paint on trees

AVAILABLE METHODS OF ENGINEERING AND DESIGN

Engineering and Design work may be carried out by:

- district engineering staff
- regional engineering office staff
- consulting engineer

- standard consulting engineering agreements are available in the Supply Management Manuals and policy and Procedure directives
- refer also to Administration, Operation and Liability sections of this Manual
- combination of above

LEGISLATION

MNR employees, timber company employees and contractors working on forest access roads are responsible for complying with all Federal and Provincial Statutes and Regulations and Municipal By-Laws. In addition to the Environmental Assessment Act, legislation affecting the design and construction of access roads includes:

* the Fisheries Act - Federal Department of Fisheries and Oceans - Ministry of Natural Resources

* the Navigable Waters Protection Act - Ministry of Transport, Canadian Coast Guard

* the Railway Act - National Transportation Agency of Canada (formerly Canadian Transport Commission)

* the Crown Timber Act - Ministry of Natural Resources

* the Environmental Protection Act - Ministry of the Environment

* the Forest Fire Prevention Act - Ministry of Natural Resources

* the Lakes and Rivers Improvement Act - Ministry of Natural Resources

* the Mining Act - Ministry of Northern Development & Mines

* the Occupational Health and Safety Act - Ministry of Labour

* the Ontario Heritage Act - Ministry of Culture and Communications

* the Ontario Water Resources Act - Ministry of the Environment

* the Pesticides Act - Ministry of the Environment

* the Aggregate Resources Act - Ministry of Natural Resources

* the Construction Lien Act - Ministry of Labour

LIST OF REFERENCE MATERIAL

The following is a list of reference material which provide an excellent source of information:

* ONTARIO PROVINCIAL STANDARD SPECIFICATIONS - MTO

* ONTARIO PROVINCIAL STANDARD DRAWINGS - MTO

* MINISTRY OF TRANSPORTATION DESIGN & ESTIMATING MANUALS, 2 VOLUMES

* MINISTRY OF TRANSPORTATION CONSTRUCTION MANUALS, 2 VOLUMES

* MINISTRY OF TRANSPORTATION DRAINAGE MANUALS, 3 VOLUMES

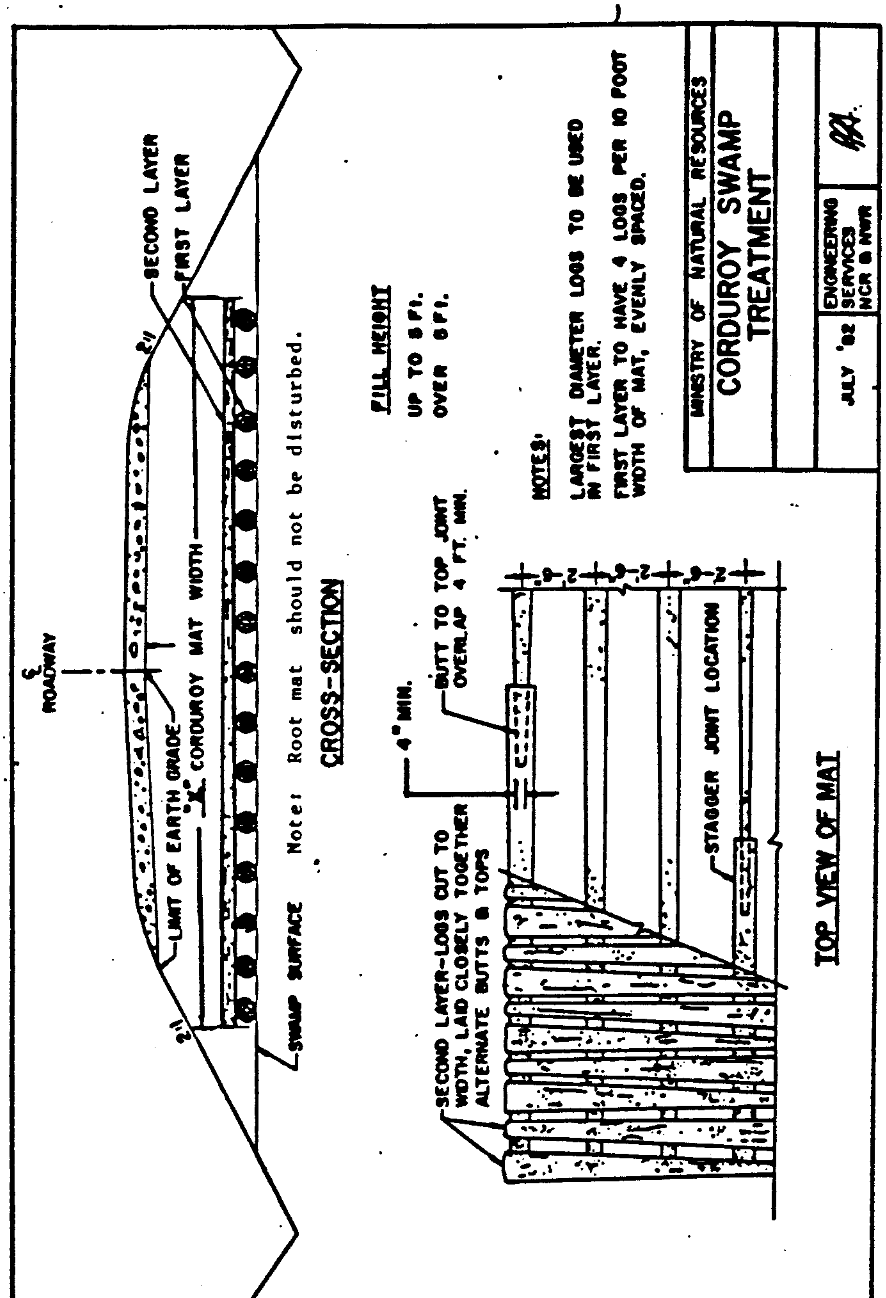
* ENVIRONMENTAL GUIDELINES FOR ACCESS ROADS AND WATER CROSSINGS - MNR

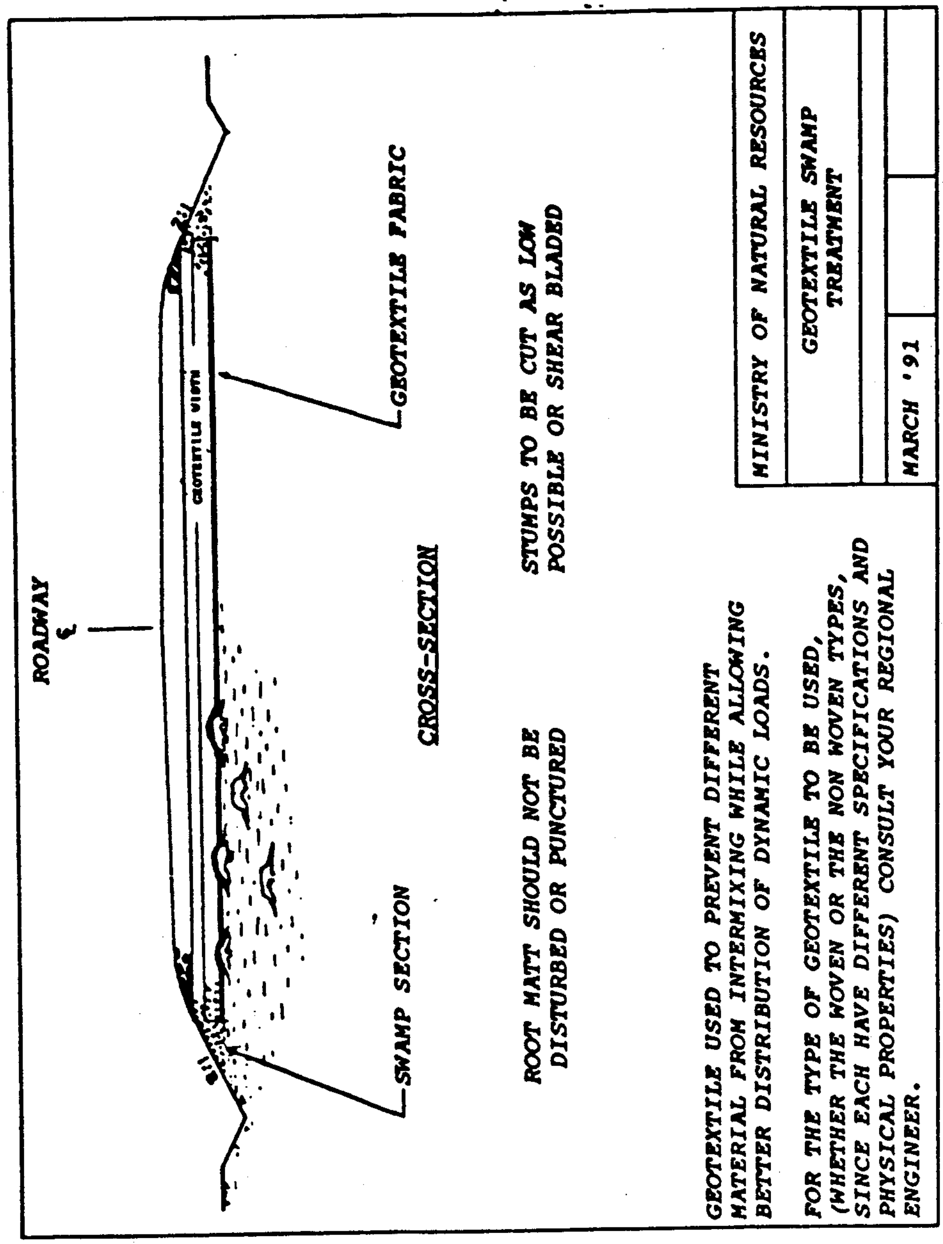
* A DESCRIPTION OF ROAD ACCESS FOR TIMBER MANAGEMENT - MNR

* MNR CONSTRUCTION AND MITIGATION HANDBOOK

* FINAL REPORT ON CROWN LAND BRIDGE MANAGEMENT POLICY - MNR

* FERIC LOG BRIDGE MANUAL (WITH ONTARIO SUPPLEMENT)


℄ ROADWAY
SECOND LAYER
FIRST LAYER
2:1
2:1
LIMIT OF EARTH GRADE
"X" CORDUROY MAT WIDTH
SWAMP SURFACE
Note: Root mat should not be disturbed.
CROSS-SECTION
FILL HEIGHT
UP TO 5 Ft.
OVER 5 Ft.
NOTES:
LARGEST DIAMETER LOGS TO BE USED IN FIRST LAYER.
FIRST LAYER TO HAVE 4 LOGS PER 10 FOOT WIDTH OF MAT, EVENLY SPACED.
4" MIN.
BUTT TO TOP JOINT OVERLAP 4 FT. MIN.
2'-6"
2'-6"
2'-6"
STAGGER JOINT LOCATION
SECOND LAYER-LOGS CUT TO WIDTH, LAID CLOSELY TOGETHER ALTERNATE BUTTS & TOPS
TOP VIEW OF MAT
MINISTRY OF NATURAL RESOURCES
CORDUROY SWAMP TREATMENT
JULY '82
ENGINEERING SERVICES NCR & NWR

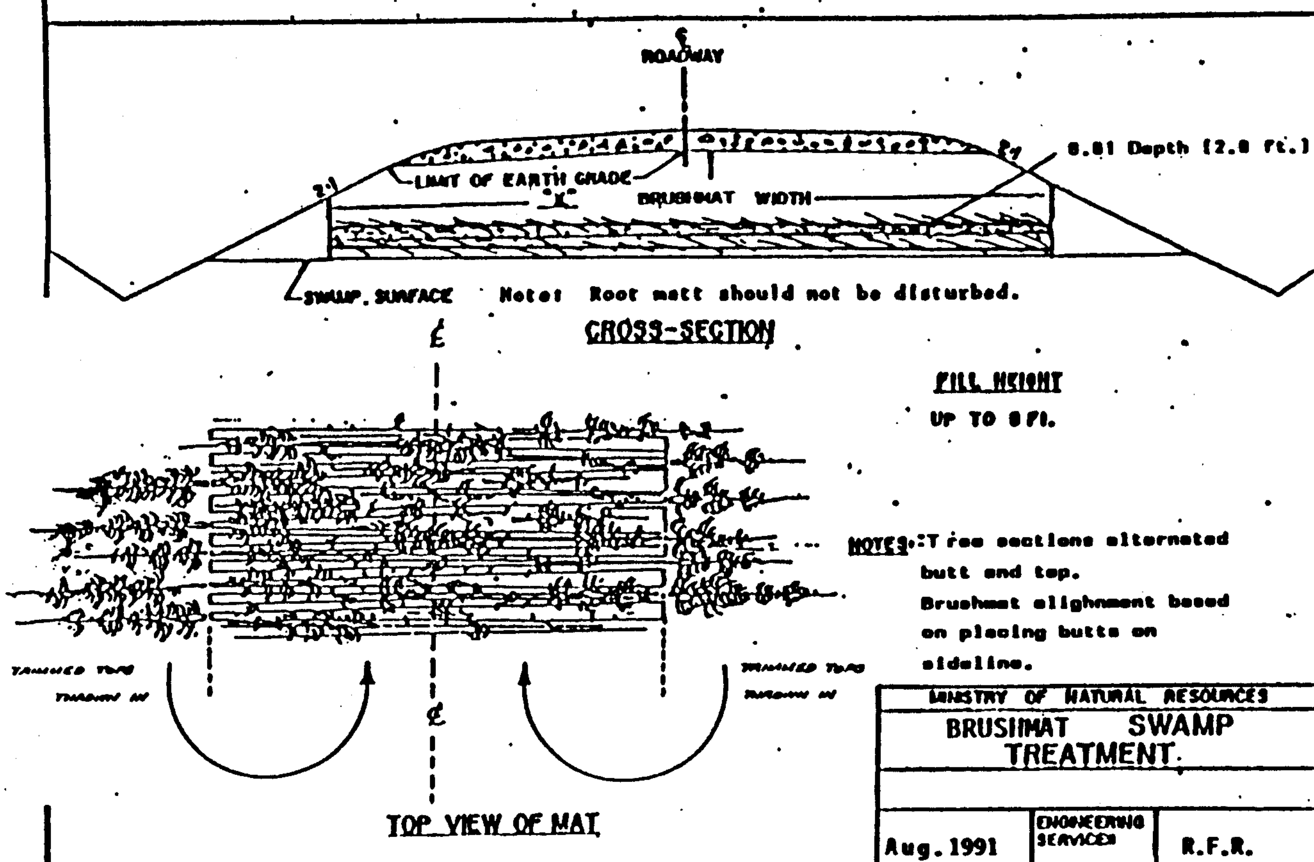


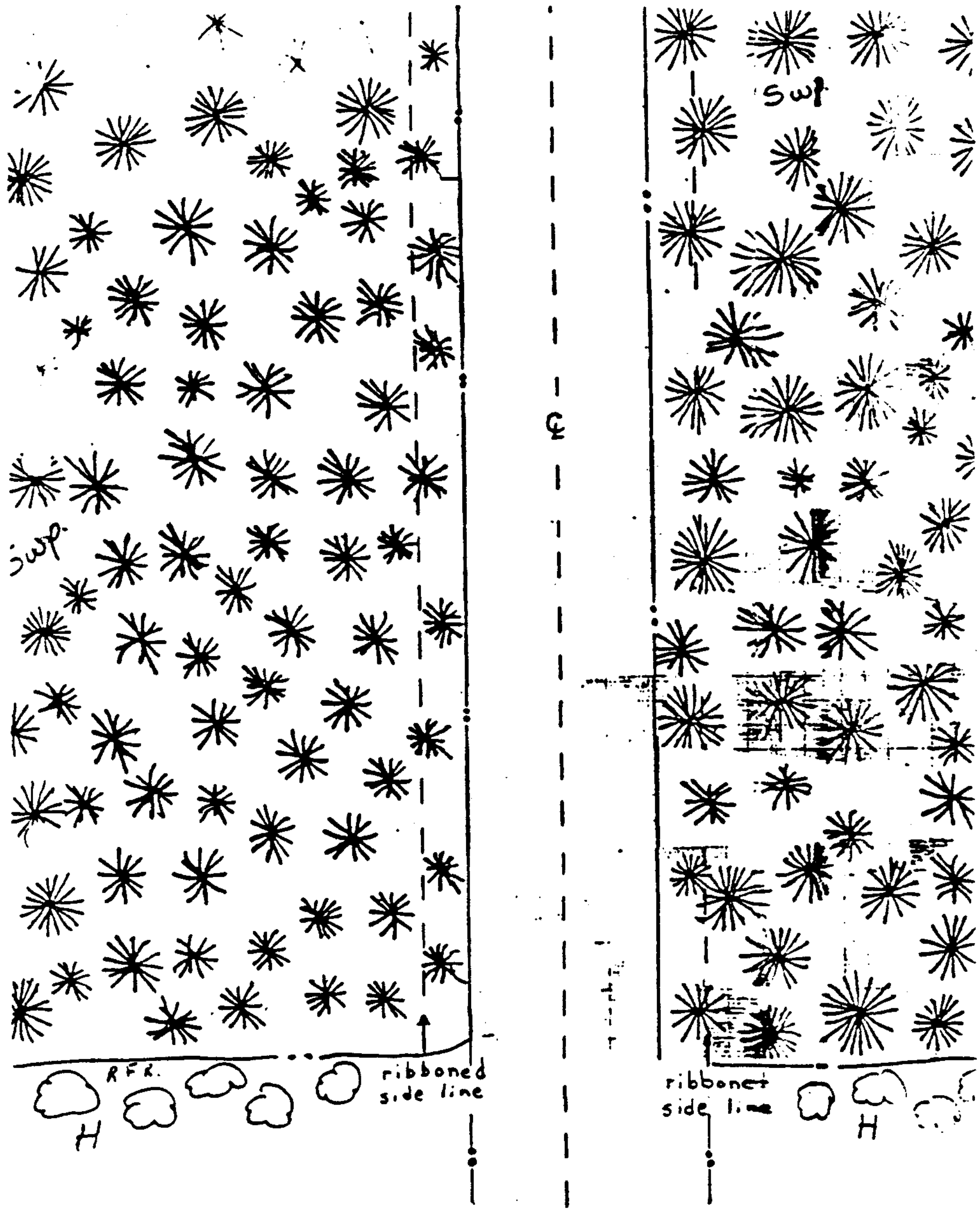
ROADWAY ℄
GEOTEXTILE WIDTH
2:1
GEOTEXTILE FABRIC
SWAMP SECTION
CROSS-SECTION
ROOT MATT SHOULD NOT BE DISTURBED OR PUNCTURED
STUMPS TO BE CUT AS LOW POSSIBLE OR SHEAR BLADED
GEOTEXTILE USED TO PREVENT DIFFERENT MATERIAL FROM INTERMIXING WHILE ALLOWING BETTER DISTRIBUTION OF DYNAMIC LOADS.
FOR THE TYPE OF GEOTEXTILE TO BE USED, (WHETHER THE WOVEN OR THE NON WOVEN TYPES, SINCE EACH HAVE DIFFERENT SPECIFICATIONS AND PHYSICAL PROPERTIES) CONSULT YOUR REGIONAL ENGINEER.
MINISTRY OF NATURAL RESOURCES
GEOTEXTILE SWAMP TREATMENT
MARCH '91

Definition: BRUSHMAT

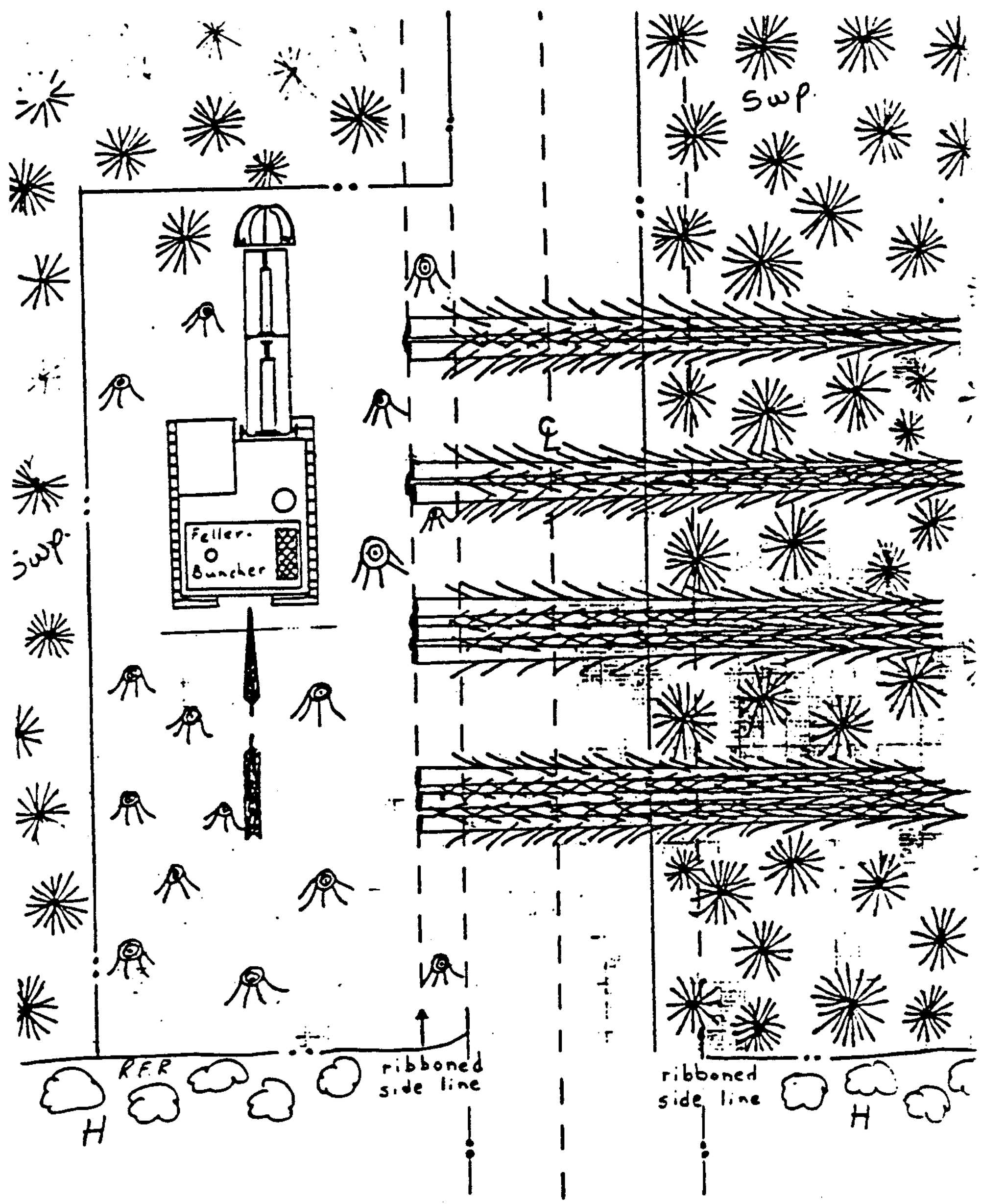
Is very similar to corduroy swamp treatment but incorporates the use of the branches and tops to retain the roadbed fill. It is preferably made from brushy conifers with the exception of larch.

The trees are laid down perpendicularly to the road's direction of travel in a compressed layer of 0.61 meters(2.0 ft) thick. The root mat must remain undamaged from equipment travel in order to help the brushmat prevent the underlying organic matter from mixing with the road subgrade materials.This method of swamp treatment is beneficial when heavy surface water cross-drainage is encountered in swamps of greater than 45 cm (18 in.) organic soil depth.

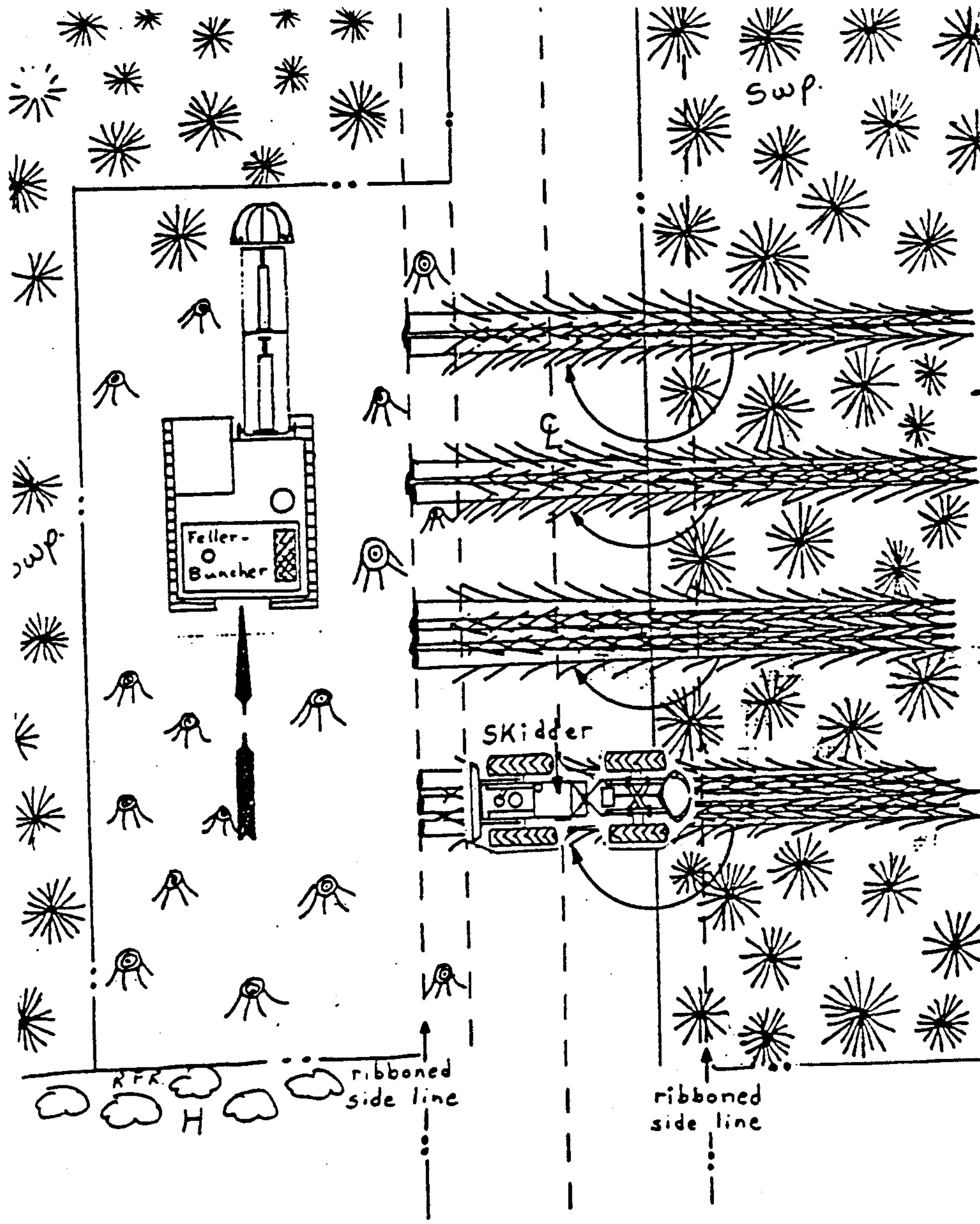




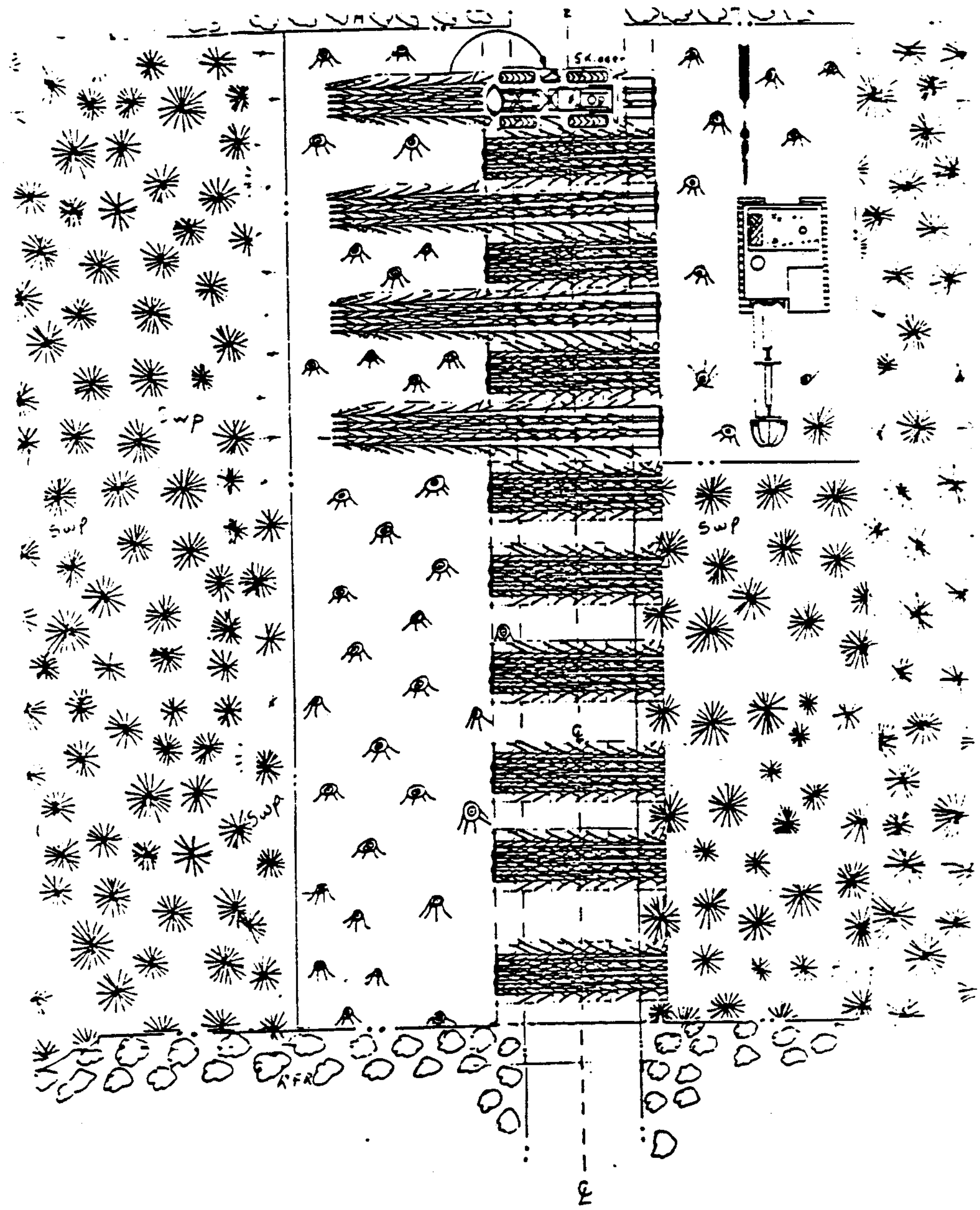
STEP 1: Place brushmat sideline ribbons on both sides of the centerline trail.
NOTE: Right of way sidelines are not required when using Feller-Buncher. The machine operator simply has to measure this distance once to adjust his boom reach and proceed.



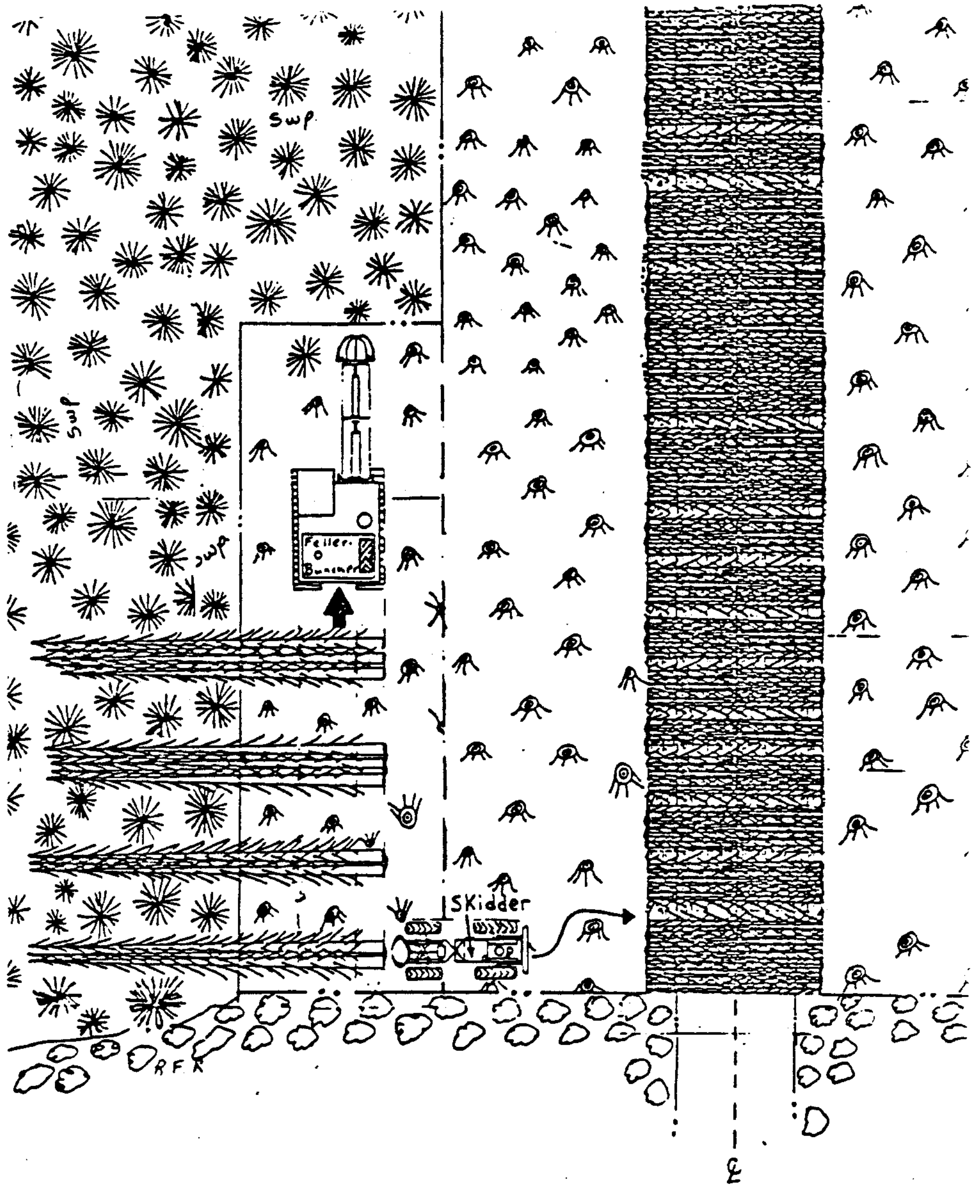
STEP 2: Feller-Buncher cuts one side of centerline and places bunches on ribboned sideline ensuring that butts are in alignment.



STEP 3: Skidder follows in behind and operator cuts off tops with chainsaw on the opposite sideline. The grapple skidder then picks up the tops and skids them forward over the original bunched stems.



STEP 4: THE Feller-Buncher returns down the opposite side of the road centerline. His cut bunches are placed with their butts in alignment to the adjacent sideline. The grapple skidder operator continues to cutt the tops of the bunches and skids them forward.



STEP 5: When the brushmat requires additional trees due to holes or lack of tree volume in the Right of Way passes, then additional swaths may be cut with prior written permission from the crown. A grapple skidder that is also mounted with a blade grapple is ideal in placing cut bunches in the holes. A compressed depth of 0.61 m. (2.0 ft.) is required for ideal brushmat strength. A skidder must be able to travel over the brushmat evenly(level) in order to meet proper brushmat quality standards.