ENVIRONMENTAL HANDBOOK
FOR PIPELINE CONSTRUCTION

Alberta Environment
Land Reclamation Division
Edmonton, Alberta
1988

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FOREWORD

The conservation of Alberta's land resources and the protection of the environment are of concern to all citizens of Alberta. This handbook recognizes the potential adverse impact of pipeline construction on the environment and the public and identifies environmental protection measures to minimize those impacts.

This handbook is intended for use as a technical reference manual by pipeline owners and contractors and is not designed to provide a rigid set of step by step instructions on construction procedures. Therefore, the environmental protection measures contained herein are not to be construed as enforceable standards or immutable requirements. Design and procedures are provided as suggestions for the pipeline company or contractor to develop effective environmental protection measures for use during pipeline construction. Furthermore, the owner or pipeline contractor should in no case be reproved for using alternate measures. However, owners and contractors are responsible for the development of other sound environmental practices in addition to those described in this handbook.

The Department of Environment looks forward to the continued cooperation and support of the pipeline industry, landowners and government agencies to make the best use of this document in order that we can collectively contribute to the protection of our environment.

ACKNOWLEDGEMENTS

Alberta Environment wishes to thank Mutrie-Wishart Environmental Consultants for preparation of the initial draft of this handbook. Owner companies, pipeline contractors and government agencies (for list see appendix) who provided input to this handbook are also gratefully acknowledged. Their comments on the effectiveness of environmental protection measures and their permission to allow Alberta Environment to reproduce selected drawings as part of this handbook are much appreciated.

Alberta Environment would also like to thank the numerous public and industrial organizations, as well as government departments for their constructive review of the initial draft document.

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this handbook is to encourage effective environmental protection during the construction of pipelines in Alberta. The handbook is intended to be used as a helpful reference rather than as a regulatory requirement. Owner companies are encouraged to incorporate appropriate environmental protection measures into their construction specifications to form part of the contract between the owner company and the pipeline contractor. Experience has shown that incorporation of such measures into the contract helps to ensure effective implementation.

1.2 METHOD

This handbook has been prepared by reviewing and adapting selected descriptions and drawings of preferred environmental protection measures contained in existing industry manuals, government guidelines and published literature. The handbook represents a compendium of environmental protection measures currently utilized by the pipeline industry.

1.3 SCOPE

This handbook addresses pipeline construction activities from project scheduling, through testing to final clean-up. Ancillary facilities such as compressor stations, access roads, construction camps, equipment yards, powerlines, and borrow pits are not covered in this document although they are an integral part of pipeline development. Similarly, the operation and abandonment stages of a pipeline project are not dealt with in the handbook. However, the user should be aware that ancillary facilities and post construction activities are normally considered a part of pipeline development.

Only those pipeline construction activities that have potential environmental impact are addressed. Although exclusive engineering or construction concerns and activities are not discussed, the implimentation of sound environmental practices can ensure that the primary goal of the

owner company for an efficient and economical construction of the pipeline is achieved.

Finally, the handbook provides protection measures for environmental conditions normally encountered in Alberta. Large scale projects or projects which affect particularly sensitive environments may require additional measures beyond the scope of this handbook.

1.4 ORGANIZATION AND UPDATING

This handbook is organized under standard pipeline construction activity headings to facilitate the incorporation of environmental protection measures into construction specifications. The organization reflects the chronological order of activities for most pipeline construction projects. The format used for each activity is:

Description
- a general description of the construction activity.

Potential Impacts
- an identification of potential environmental impacts or concerns related to the construction activity.

Protection Measures
- a discussion of appropriate environmental protection measures to minimize the impact.

Although the document is written primarily for those involved in the planning and construction of pipelines, the Description sections are purposefully simplistic to facilitate understanding by readers not familiar with pipeline construction.

Most of the environmental protection measures are illustrated by drawings with detailed explanation in the "Notes".

The format of the handbook is designed to facilitate the addition and deletion of environmental protection measures as existing construction procedures are improved and new ones are developed. The handbook design also facilitates the reproduction of environmental protection measures for handout use, or for environmental planning, if appropriate.

Alberta Environment will periodically update the handbook based upon information received from the public, industry and government. Comments, suggestions, and requests for revised updates are welcome and should be directed to:

Head, Regulated Operations Branch
Land Reclamation Division
Alberta Environment
3rd Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta T5K 2J6
Telephone: 427-6322.

2.0 GENERAL ENVIRONMENTAL PROTECTION MEASURES

Several environmental protection measures apply to all pipeline construction activities. These general measures are described below:

1. The environmental protection measures within the construction specifications should be carried out by the contractor and sub contractor under the inspection of the owner company. An environmental inspector can be assigned if necessary, to help with interpretation and execution of environmental protection measures in the field.

2. All construction personnel should be made aware of environmental concerns, laws, rules, and regulations applicable to the construction area.

3. Firearms and dogs should be prohibited on the right of way. Wildlife and livestock should not be harassed or fed. All workers should follow provincial hunting and fishing regulations.

4. Waste materials such as pipe coating, spent welding rods, containers, cans, lunch wrappings, used engine oil, and other garbage arising from normal pipeline activities should be collected daily by each crew and disposed of in an approved manner.

5. Continuous efforts should be made to prevent and control forest fires; soil erosion; and air, noise, and water pollution.

6. All vehicular traffic associated with pipeline construction should be confined to the right of way as defined by the surface lease agreement.

3.0 CONSTRUCTION SCHEDULE

3.1 DESCRIPTION

The construction schedule refers to the proposed start and finish of construction, including the timing of individual construction activities. Right of way survey and final clean-up do not always occur in the same season as mainline construction.

3.2 POTENTIAL IMPACTS

Poor scheduling of construction activities can result in adverse impacts on soil, fish, and wildlife resources as well as on agricultural, forestry, recreational, and other land uses, or land users. Therefore, one construction goal is to avoid or minimize impacts by scheduling activities according to the relative sensitivity of the environmental concerns. On some projects, major environmental concerns will require a construction schedule which conflicts with lesser environmental concerns. These conflicts can be resolved, either by using alternative construction techniques having less environmental impact, or by separating the area of secondary concern from the main construction schedule. An example of the first case is fluming a watercourse instead of employing the conventional wet crossing method. An example of the second case is pre-building the watercourse crossing to avoid instream construction during critical fish spawning periods.

3.3 PROTECTION MEASURES

1. Schedule construction to proceed quickly with a tight spread and a minimum of open trench. Initial clean-up should follow immediately after backfill.

2. To ensure that traffic on the right of way is not impeded and environmental impact remains minimal, schedule construction during winter where the pipeline route traverses extensive muskeg. A minimum of 45 cm of frost penetration in muskeg is necessary. Recommended frost depths for other materials are:

Loam Soils	15 cm
Saturated Silts or Clays	30 cm
Swamp, Sloughs or Shallow Water	90 cm

Ensure that the schedule allows for completion of construction prior to normal spring break-up.

3. Schedule construction during low fire hazard season in forested areas.

4. Schedule construction to avoid spring break-up to minimize surface disturbance and major impacts on aquatic habitats and agricultural land.

5. Schedule construction across watercourses during periods of low flow unless an alternate timing window is requested for fisheries protection by Forestry, Lands and Wildlife, Fish and Wildlife Division.

6. Schedule construction across, or in proximity to, important wildlife habitats during periods of low sensitivity as defined by Forestry, Lands and Wildlife, Fish and Wildlife Division.

7. Schedule construction to minimize interference with agricultural activities, including seeding and harvest.

8. Schedule construction to avoid working in irrigation districts during the irrigation season.

9. Schedule construction to avoid open-cutting roads during log-hauling in forested areas and grain-hauling in agricultural areas.

10. Schedule construction to avoid high-use periods across, or in proximity to, recreation areas.

11. Schedule construction to occur only between 0700 hours and 2000 hours near residential or other occupied lands such as campgrounds or parks.

12. Schedule construction to avoid transportation of equipment and material while road load restrictions and road bans are in effect during spring break-up.

4.0 CONTINGENCY PLANNING

4.1 DESCRIPTION

Contingency planning is the preparation of emergency plans and procedures that can be put into action quickly if unexpected events occur.

4.2 POTENTIAL IMPACTS

Poor contingency planning can result in delayed or ineffective response to unexpected events. In turn, this delay could result in short and long term environmental impact and threats to public safety and convenience. Working on unstable ground can cause serious surface disturbance; working during wet weather can reduce soil capability for agriculture and may result in the unacceptable sedimentation of aquatic habitats. The spreading of fires from the right of way and the accidental release of toxic substances to the air, water, and soil can have serious environmental and public safety implications. Although every project may not encounter these problems, the owner company and pipeline contractor should be prepared to take appropriate action quickly if the worst case develops.

4.3 PROTECTION MEASURES

1. Prepare contingency plans prior to construction. Make construction personnel aware of their required response to potential problems. Act quickly as required.

2. If a winter thaw causes insufficient frost depth, skip over localized low frost areas or use alternative construction procedures such as swamp mats, log corduroy, rip-rap or filter fabric. When the problem becomes widespread, postpone construction until soils refreeze or dry to avoid significant surface disturbance on the right of way and damage to local roads. Employ temporary erosion control measures as required to protect the right of way during break-up. Respect all road bans.

3. In the event of accidental fire, activate the fire contingency plan. The risk of accidental fire can be reduced by making all personnel aware of proper disposal of cigarette butts and by forbidding any fires on the right of way when the fire hazard is extreme. In addition, install spark arresters on construction equipment and vehicles. Maintain exhaust and engine systems in good repair and free of dried grass and

other combustibles. The fire contingency plan should provide for an effective fire detection system and should ensure that construction crews have fire fighting equipment on hand capable of controlling any fire that may occur as a result of their activities. In addition, train a core fire fighting crew with authority to organize construction crews into fire fighting squads. Report any fires immediately to the Alberta Forest Service or landowner and, upon request, make all equipment and personnel available to control the fire.

4. During the onset of wet weather and saturated soils, suspend equipment travel on the right of way to minimize topsoil and subsoil compaction and mixing, rutting and loss of organic matter. Indication of excessively wet soils include: wheelslip, build-up of mud on tires and cleats, formation of ruts, and ponding. Equipment travel should resume only after soils are sufficiently dry or frozen.

5. If soil drifting causes loss of topsoil, take control measures. These measures may include watering down the working side and suspending topsoil stripping and backfill operations during high winds.

6. On agricultural land, construction equipment brought in from outside the project area should be cleaned prior to its arrival on site to minimize the introduction of new weeds to the area.

7. Should excessive flows in watercourses occur due to winter thaw or wet weather, postpone the water crossing until flows drop to acceptable levels. Flumes or dams placed in watercourses should be removed until flows drop.

8. When spills of construction fluids occur, a contingency plan should be quickly put into action to contain and clean up the spill. All fuel and service vehicles should carry a minimum of 10 kg of suitable commercial absorbent material for use on small fuel or oil spills. Mobile construction equipment should not be serviced or refuelled within 100 m of watercourses to prevent water pollution. Assistance with larger spills can be provided by the appropriate oil spill co-operative. Report all spills to the local Energy Resources Conservation Board and Alberta Forest Service authorities.

9. If H_2S or other toxic substances are accidentally released during construction or operations, the appropriate emergency response plan should be activated and appropriate authorities should be informed immediately.

5.0 NOTIFICATION OF CONCERNED PARTIES

5.1 DESCRIPTION

Landowners, tenants,* government agencies and other concerned parties are kept notified of the progress of construction as required. These parties are generally approached on route selection and environmental and reclamation issues for their views on minimizing potential adverse environmental impact. Special requests by landowners for construction and clean-up are normally compiled in the line list.

5.2 POTENTIAL IMPACTS

Failure to properly notify concerned parties will violate regulatory conditions and may interfere with other land uses. As well, landowners can be inconvenienced by poor timing, inappropriate construction methods, and by not discussing reclamation procedures with them.

5.3 PROTECTION MEASURES

1. Obtain all necessary approvals, permits, licences, and right of way agreements prior to construction and post at the construction site.

2. Notify all appropriate provincial and local government representatives as stipulated in conditions of approval, or as required by legislation. Maintain contacts until project is completed.

3. Notify landowners of right of way location and construction schedules well in advance of entering their lands. Notify landowners of any revisions to the proposed schedule. Maintain these contacts until project is completed.

4. Provide landowners with appropriate company contacts, along with their titles and telephone numbers.

5. At least five days prior to entering their trapping areas, notify registered trappers by registered mail, normal mail, or in person. Inform trappers of right of way location and construction schedules.

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*Any subsequent reference to landowners in this handbook includes tenants where appropriate.

6. Notify the local Fish and Wildlife officer and registered trapper if pipeline construction will damage beaver ponds, dams and lodges, muskrat push-ups or other aquatic furbearer habitats.

7. Notify Forest Management Agreement holders and quota holders prior to timber clearing and salvage operations.

8. Notify road, rail, and foreign pipeline owners as required by crossing and road use agreements.

9. Stop construction in the immediate area and notify the Archaeological Survey of Alberta if any previously unidentified archaeological or heritage sites are discovered during construction.

6.0 RIGHT OF WAY SURVEY

6.1 DESCRIPTION

Surveying the right of way is normally the first construction activity. The work is usually done by a survey company prior to hiring a pipeline contractor. The boundaries of the pipeline right of way are surveyed and clearly marked prior to other construction activities. In certain circumstances, the surveyors will make minor routing adjustments to avoid problem areas such as small but steep sidehills.

6.2 POTENTIAL IMPACTS

Although surveyors generally cause minimal environmental impact, the primary concern is that they be given appropriate direction by the owner company regarding standard right of way width, location of additional right of way, and minor adjustments to skirt around problem areas.

A restricted right of way slows construction progress and can lead to a mixing of topsoil and subsoil in agricultural areas and a loss of merchantable timber in forested areas. As well, too narrow a right of way generally makes reclamation more difficult. With water injection or supply pipelines, the depth of cover is often 2 m or more. In these instances, the normal right of way width may be insufficient to accommodate the amount of accumulated spoil, resulting in highly restricted working conditions or off right of way damages.

Excessive right of way width results in unnecessary surface disturbance. Poor right of way location can result in unnecessary disturbance of sensitive soils, aquatic habitats, and heritage resource sites; slight shifts in alignment may avoid these problems. A straight-line alignment may affect aesthetics or wildlife in some forested areas.

6.3 PROTECTION MEASURES

1. Notify landowners and public land managers of intent to conduct a survey.

2. Instruct surveyors to carry out their duties in an environmentally responsible manner. Make them aware of particularly sensitive areas.

3. Encourage surveyors to exercise good environmental judgement by making minor route adjustments to minimize impact on environmentally sensitive areas such as steep sidehills. Walk sensitive areas and adjust right of way if possible to avoid sidehills, poor water crossing approaches, shelterbelts, granaries, and other structures.

4. Determine standard right of way width considering factors described on Drawing No. 6-1. Identify specific locations requiring additional right of way. Mark off areas where special procedures are to be used.

5. Flag right of way boundaries and limits of clearing with stakes and flagging. Maintain stakes and flagging throughout construction period.

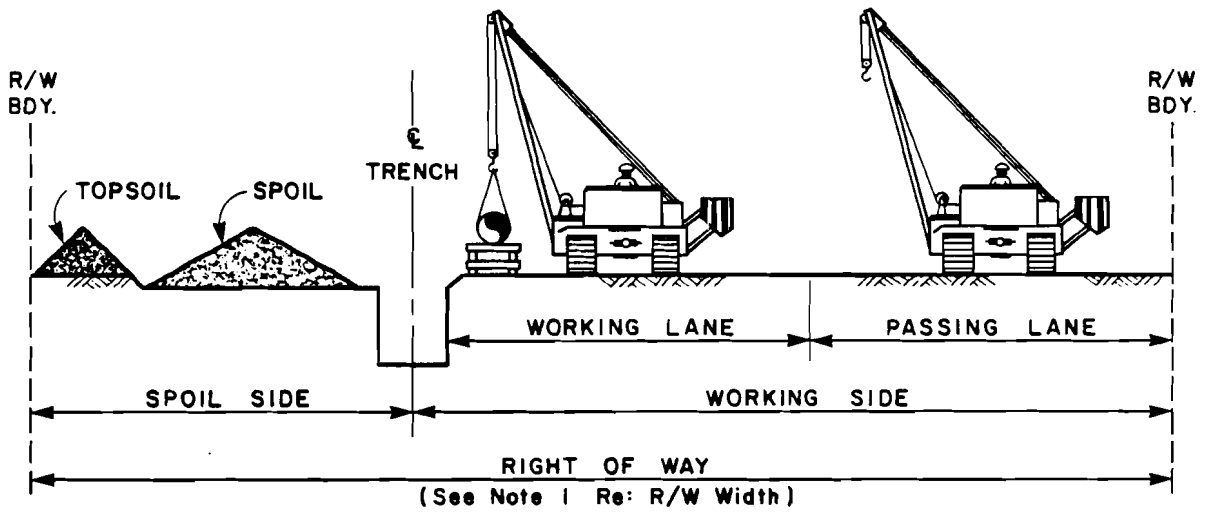
6. Confine construction activities to the right of way, designated access roads (shoo-flies), and ancillary sites. If additional right of way is required during construction, obtain prior written agreement from the landowner or approvals from authorities having jurisdiction.

7. Fence archaeological or heritage resource sites adjacent to, or in proximity to, the right of way. Avoid inadvertent damage during construction (Drawing No. 6-2). Install fences to preserve shelterbelts, shade trees, dugouts, and other significant features.

8. In consultation with government agencies, instruct the surveyor to dogleg the right of way at selected road and trail crossings to limit line of sight along the right of way in forested areas of high aesthetic or wildlife value. (Drawing No.6-3).

9. In consultation with government agencies, instruct the surveyor to snake the right of way at selected locations to limit line of sight along the right of way in heavily forested areas of high aesthetic or wildlife value. (Drawing No. 6-4).

10. Instruct the surveyor to note any traplines that may be traversed by the pipeline right of way to avoid inadvertent blockage during pipeline construction.



PROFILE

N.T.S.

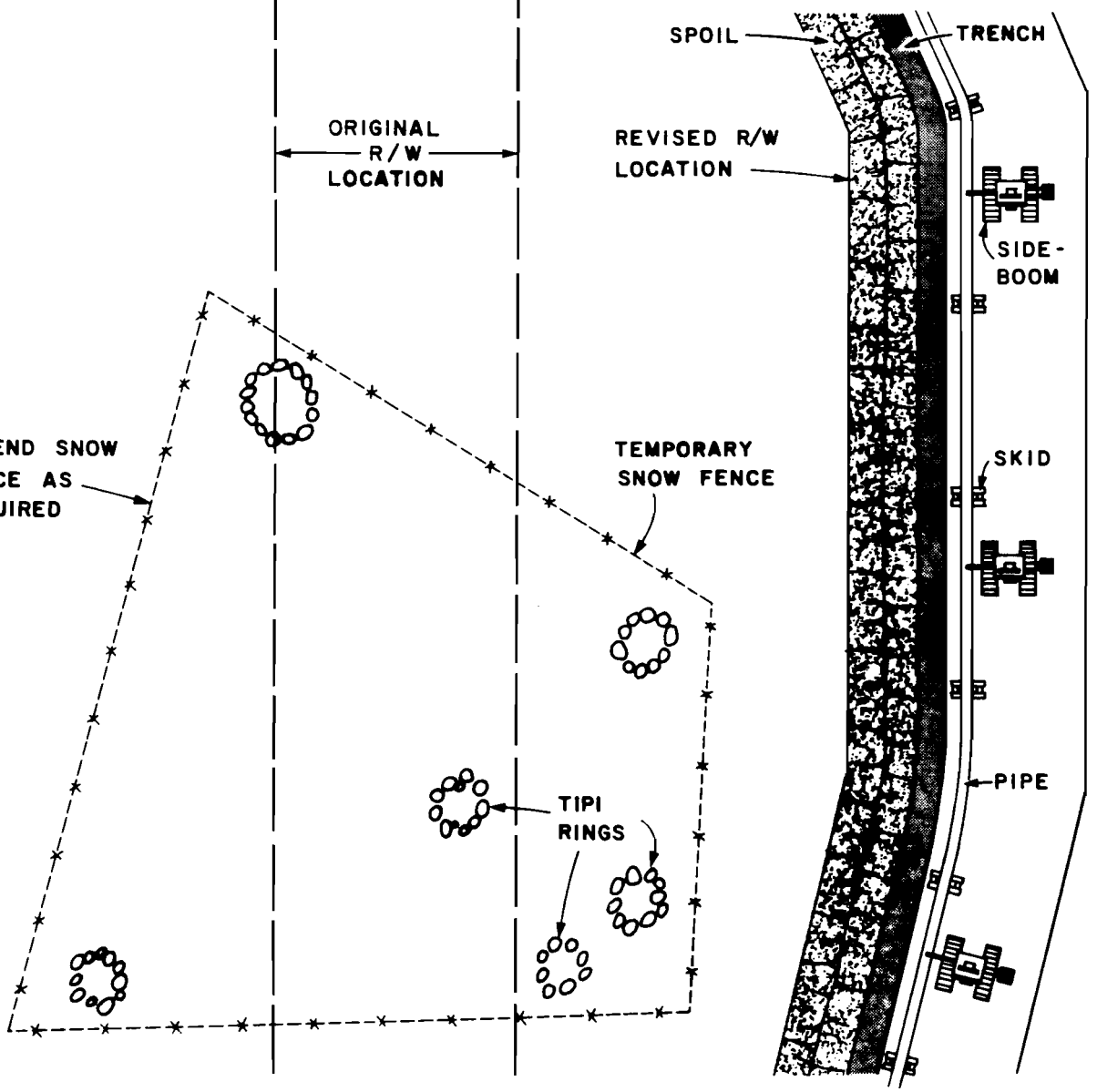
Notes

1. Prior to construction, determine standard right of way width and locations requiring additional right of way. Merchantable timber can then be cleared and salvaged, and topsoil can be stripped and stockpiled separately from spoil.

Right of Way Width Considerations

	Less R/W	More R/W		Less R/W	More R/W
a) No. of Pipelines			f) Grading		
— Single	x		— None	x	
— Multiple		x	— Extensive		x
b) Pipe Diameter			g) Trench Material		
— Small Inch	x		— Clay	x	
— Big Inch		x	— Sand		x
c) Working Space			— Rock (Blasting)		x
— Crossings		x	h) Depth Of Cover		
— Expansion Loops		x	— 1 m	x	
— Passing Lane		x	— 3 m		x
d) Slash Disposal			i) Water Table		
— Burning	x		— Low	x	
— Total Rollback		x	— High		x
e) Topsoil Stripping			j) Trenching Equipment		
— Width — None	x		— Wheel	x	
— Full R/W		x	— Hoe		x
— Depth — 6 cm	x				
— Depth — 30 cm		x			

DRAWING No. 6-1 PIPELINE RIGHT OF WAY



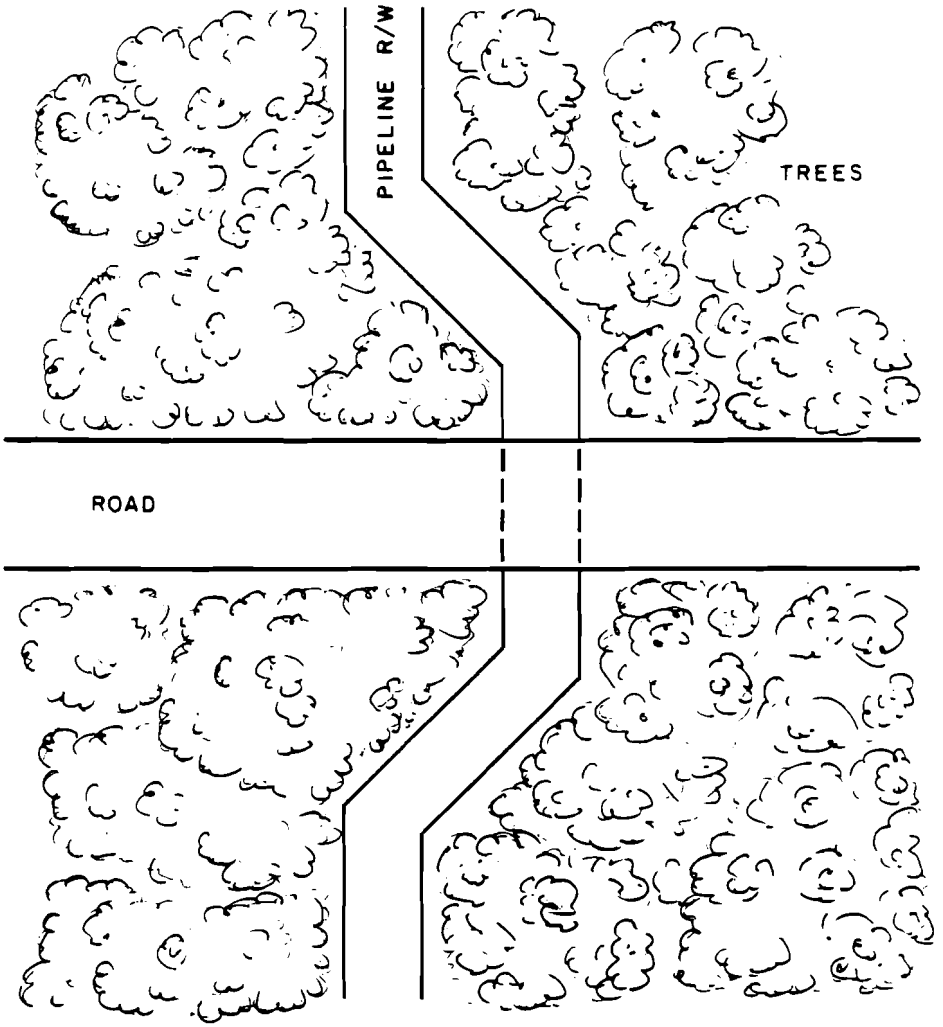
PLAN VIEW
N.T.S.

Notes

1. Fence known archaeological or heritage resource sites adjacent to or in proximity to the right of way to protect them from inadvertent off right of way damage. Erect fence during survey and take down after final clean-up.
2. Use fencing procedure for preservation of shelterbelts, shade trees, dugouts, and other significant features.

Source: Adapted from Fedirchuk McCullough & Associates Ltd., 1982.

DRAWING No. 6-2 **PROTECTION OF ARCHAEOLOGICAL SITE ADJACENT TO RIGHT OF WAY**



PLAN VIEW

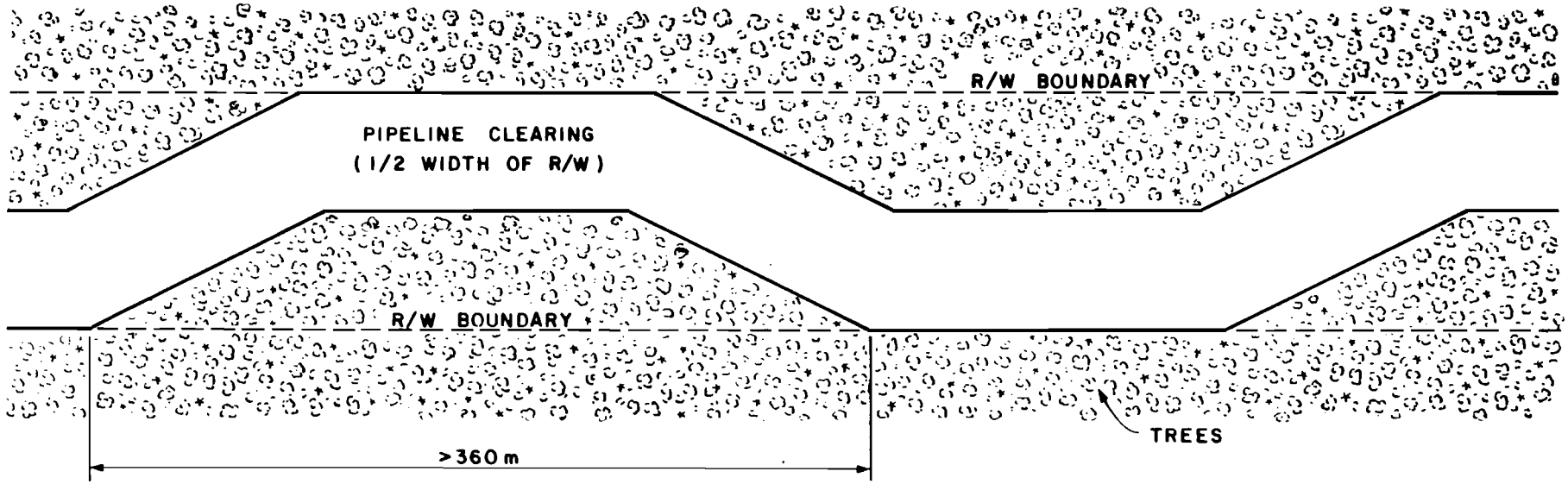
N.T.S.

Notes

1. Deflect the right of way at a sufficient angle to block line of sight at road and trail crossings in forested areas of high aesthetic or wildlife value.
2. Take additional right of way as required.
3. See Drawings No. 10-1 and 14-2 for alternatives.

Source: Adapted from Mutrie-Wishart Environmental Consultants, 1983.

DRAWING No. 6-3 DOGLEGGED ROAD CROSSING



N.T.S.

Notes

1. Use snaking procedure in flat forested areas where clearing would otherwise permit a long line of sight. This procedure requires extra right of way and will increase line, pipe, surveying, clearing, and bending costs. Use in highly sensitive areas such as provincial parks or in areas of high aesthetic or wildlife value.
2. See Drawing No. 14-3 for alternative.

Source: Adapted from Shell Canada Resources Limited (1980) and Stubbs and Markham (1979).

DRAWING No. 6 - 4

SNAKING THE RIGHT OF WAY

7.0 FENCES AND GATES

7.1 DESCRIPTION

Fences crossed by the right of way are dismantled to allow passage of construction equipment. Temporary gates and fences are installed where required to control livestock movements. Following construction, temporary fences and gates are removed and permanent fences replaced.

7.2 POTENTIAL IMPACTS

Improper cutting of fences can cause slackening for some distance along the fence-line, possibly leading to escape of livestock and inconvenience to landowners. Similar problems may occur if gates are left open or if temporary fencing is not supplied where required. Poor landowner relationships will develop if fences are not properly repaired following construction.

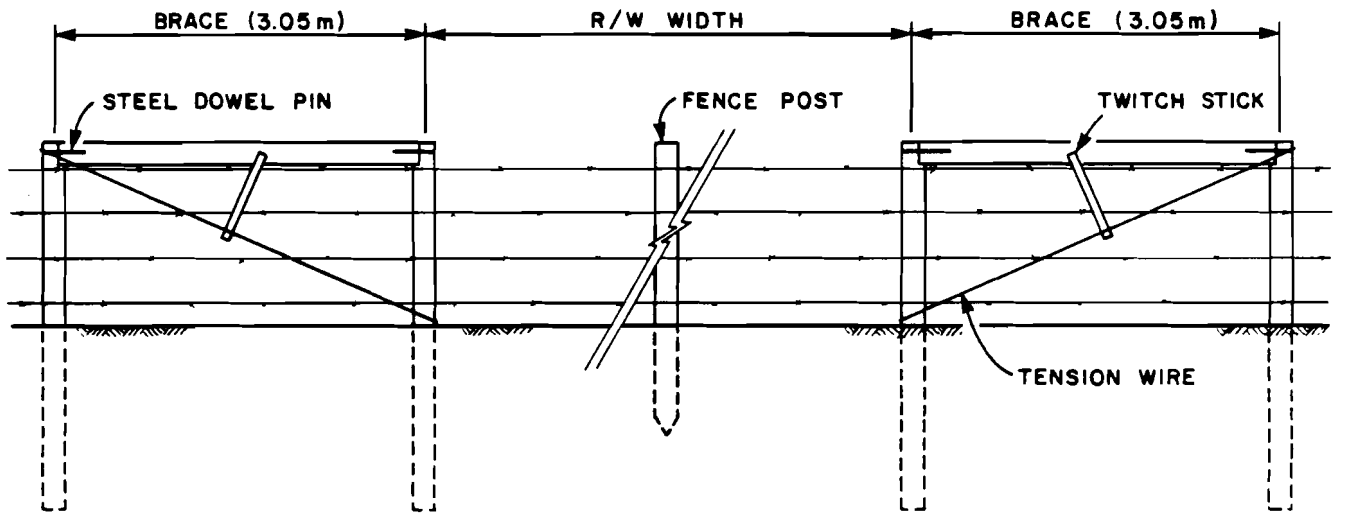
7.3 PROTECTION MEASURES

1. Make arrangements with landowner, if possible, to keep livestock in fields not traversed by the right of way. First, obtain consent prior to dismantling fences. Then, prior to construction, dismantle fences and install temporary gates, if required, to prevent livestock from entering or leaving the property. See Drawing No. 7-1 for a description of a post and wire fence. See Drawing No. 7-2 for a description of a temporary wire gate.

2. It is important that end braces be installed and the tension taken off the fence wire prior to cutting the fence. This is especially true for high tension suspension fences where double end braces will be required to resist the fence tension.

3. Where requested, all antique fences of stump, stone or rail should be carefully dismantled and the materials conserved for later reassembly.

4. Install temporary fences as requested by landowner.



PROFILE

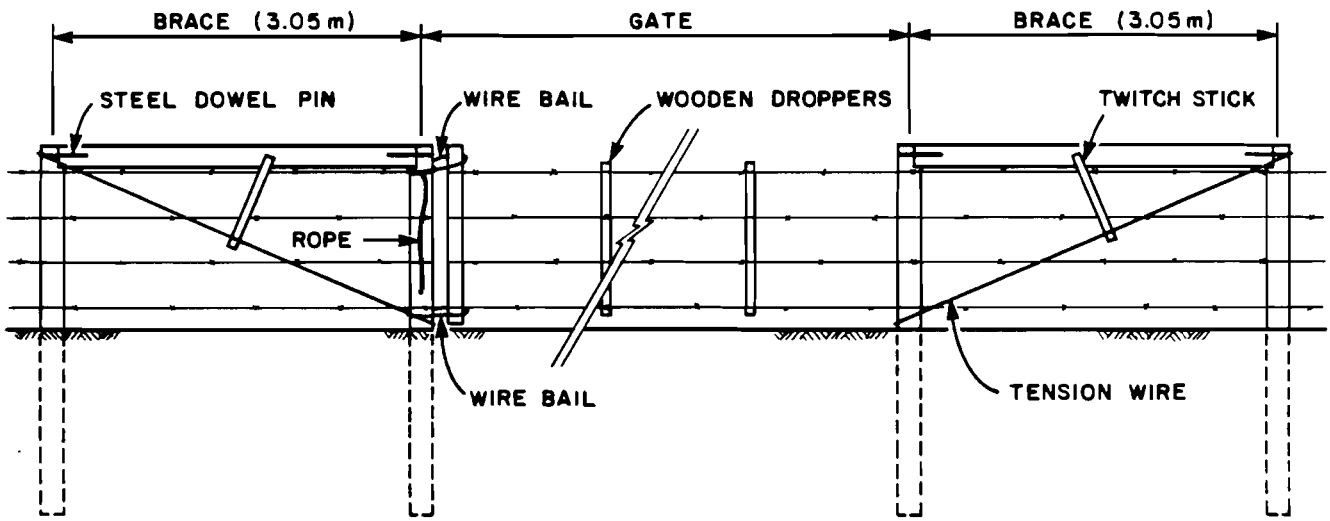
N.T.S.

Notes

1. Where the right of way crosses existing fences, obtain consent of landowner and tenant prior to cutting the fence. Cut fence prior to any subsequent construction activity.
2. Brace fence on each side of the right of way and tension each wire before cutting fence. Use material of equal or better quality for the brace. Salvage posts and wire if in good condition.
3. Install temporary gate if required (Dwg. No. 7-2).
4. Following construction, remove temporary gate and replace with new fence of equal or better quality. Retain braces as permanent part of fence structure. If ground is frozen, use metal posts and replace with wood posts when soil conditions permit. Where appropriate, maintain a minimum bottom wire elevation of 40 cm to accommodate passage of antelope under the fence.
5. Inspect fence for 100 m in both directions for slack when tensioning the wires.
6. Remove all excess wood, wire, staples, and other waste.

Source: Drawing adapted from Union Gas Limited, 1982.

DRAWING No. 7-1 POST AND WIRE FENCE



PROFILE
N.T.S.

Notes

1. Install temporary gate where required, using equal or better quality material than original fence.
2. Keep gate closed at all times except during passage of men and equipment to prevent livestock from entering or leaving the property. If necessary, assign a watchman to ensure gate closure.
3. Remove temporary gate and replace fence following construction unless otherwise requested by landowner.

Source: Drawing adapted from Transcanada Pipelines, 1979.

DRAWING No. 7-2 TEMPORARY WIRE GATE

8.0 CLEARING

8.1 DESCRIPTION

Clearing involves the removal of trees, brush, crops, and other objects from the right of way. Merchantable timber is salvaged and slash is disposed.

8.2 POTENTIAL IMPACTS

Clearing is the first major surface disturbance associated with pipeline construction and is often done by a sub-contractor. Poor clearing practices can slow construction progress and complicate right of way reclamation. The removal of vegetation can lead to erosion on steep slopes and sensitive soils. Merchantable timber can be wasted by poor clearing techniques, inaccessible timber decks, or by poor communication with logging companies. The beds and banks of watercourses can be damaged if heavy equipment walks across before appropriate vehicular crossing structures are installed, or if logs are skidded across. Indiscriminate or extra-wide clearing can cause off right of way damage and diminish landscape aesthetics in scenic areas. Careless slash disposal can create unnecessary fire hazards.

8.3 PROTECTION MEASURES

The following protection measures require the approval of: the Alberta Forest Service for public lands in the Green Area and the Public Lands Division for public lands in the White Area; the landowner; and the local municipal authority having jurisdiction over burning on patented lands. For convenience, the text assumes public land in the Green Area unless otherwise noted.

1. In sensitive areas, utilize construction equipment which will minimize surface disturbance, soil compaction, and loss of topsoil. Such equipment includes low ground pressure tracks or tires, blade shoes, and brush rake attachments.

2. Install suitable water crossing structures such as temporary

bridges and culverts or utilize roads (see Section 15.3).

3. Clear area only between marked right of way boundaries. Fell trees on the right of way and away from watercourses to prevent damage to adjacent trees and aquatic habitat.

4. Do not pre-clear steep, erodible slopes unless construction is scheduled to commence immediately following clearing, or clear as approved by the appropriate agency or landowner. Leave a temporary uncleared buffer zone extending back from the crest of a hill. The length of buffer zone should be equal to the height of slope. If access is required where pre-clearing is prohibited, construct a shoo-fly one blade in width (3.5 m) on the right of way or through less sensitive areas.

5. Hand clear erodible slopes which do not require grading. Remove trees, debris or soil inadvertently deposited within the high water mark of watercourses in a manner that minimizes disturbance of the bed and banks. Do not stand or yard trees across a watercourse. Do not drive logs into a watercourse.

6. Salvage merchantable timber as specified by the Alberta Forest Service (see Drawing No. 8-1). It is important that salvage requirements be specified and agreed to in advance of construction by the owner company, clearing contractor, Alberta Forest Service, and the commercial logging operator. The Alberta Forest Service may waive the salvage requirement in special circumstances.

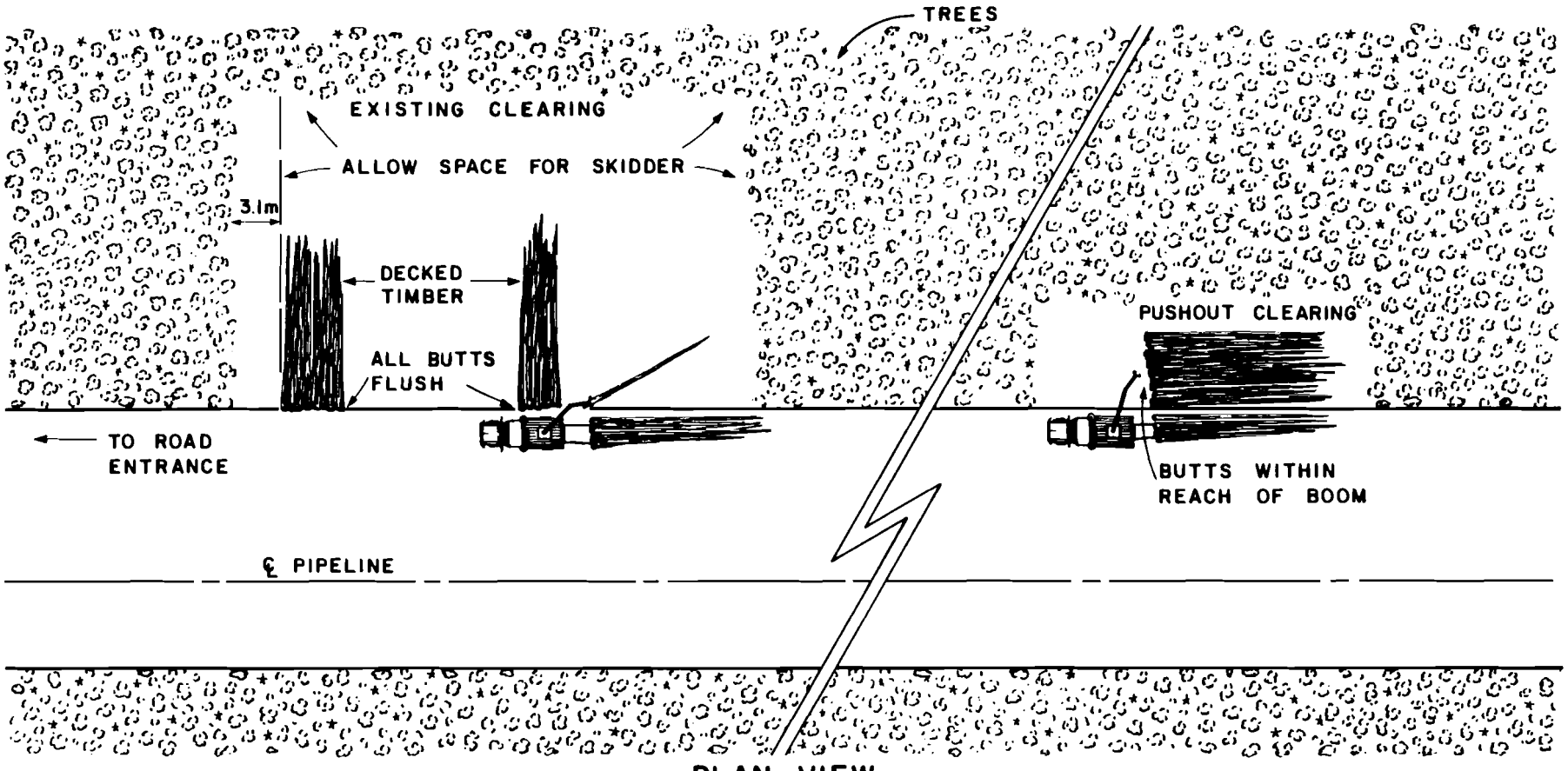
7. Unless the area is to be grubbed, clear non-merchantable timber and treed muskegs (maximum stump height less than 10 cm) in a manner that breaks the tree cleanly without pulling up the roots. Acceptable methods include using a KG blade on the bulldozer and bulldozing trees during extremely cold weather.

8. Dispose of slash as specified by the Alberta Forest Service. Slash is defined as stumps, tops, and limbs from merchantable timber, and the whole tree if non-merchantable. Alternative slash disposal methods include burning, rollback for access or erosion control, chipping, and mulching. Burying is not recommended. The burning and rollback methods are shown on Drawings No. 8-2A and 8-2B. A combination of partial burning and rollback is useful where there is a large volume of slash. In addition to the rollback method, retain non-merchantable timber for use as corduroy on muskeg (see Section 13.2), for logfill water crossings, or for restoration of banks of watercourses (see Drawings No. 15-1B and 15-3B).

9. Minimize the width of the right of way at shelterbelts and windbreaks. Salvage wood and dispose of slash as the landowner requests. Where no request is made, treat as public land.

10. Harvest mature crops along the right of way. Retain stubble in order to control dust and reduce soil compaction on the working side. Through scheduling, accommodate the landowner in his ability to harvest mature crops.

11. On patented land, obtain approval from the landowner and store salvaged timber off right of way.



PLAN VIEW
N.T.S.

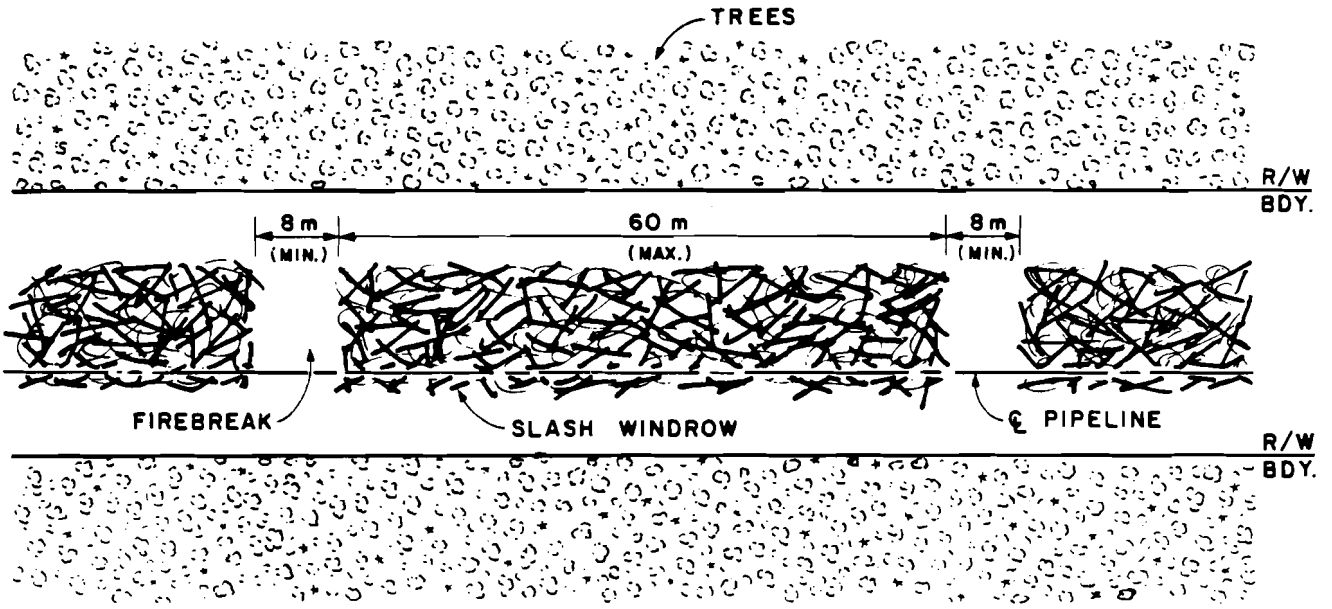
Notes

1. Salvage merchantable timber as specified by Alberta Forest Service.
2. Cut trees clean; do not bulldoze merchantable timber. Remove limbs and tops. Logs should not be skidded across or driven into watercourses.
3. Deck merchantable timber at existing clearings if possible. Obtain approval for pushout clearings. Place decks on high ground; avoid low spots or wet ground. Allow adequate space for loading logs.
4. Request logging operators to begin hauling timber, preferably after grading but before trenching and pipe stringing.

Source: Adapted from St. Regis (Alberta) Ltd. (N.D.).

DRAWING No. 8 - 1

SALVAGE OF MERCHANTABLE TIMBER



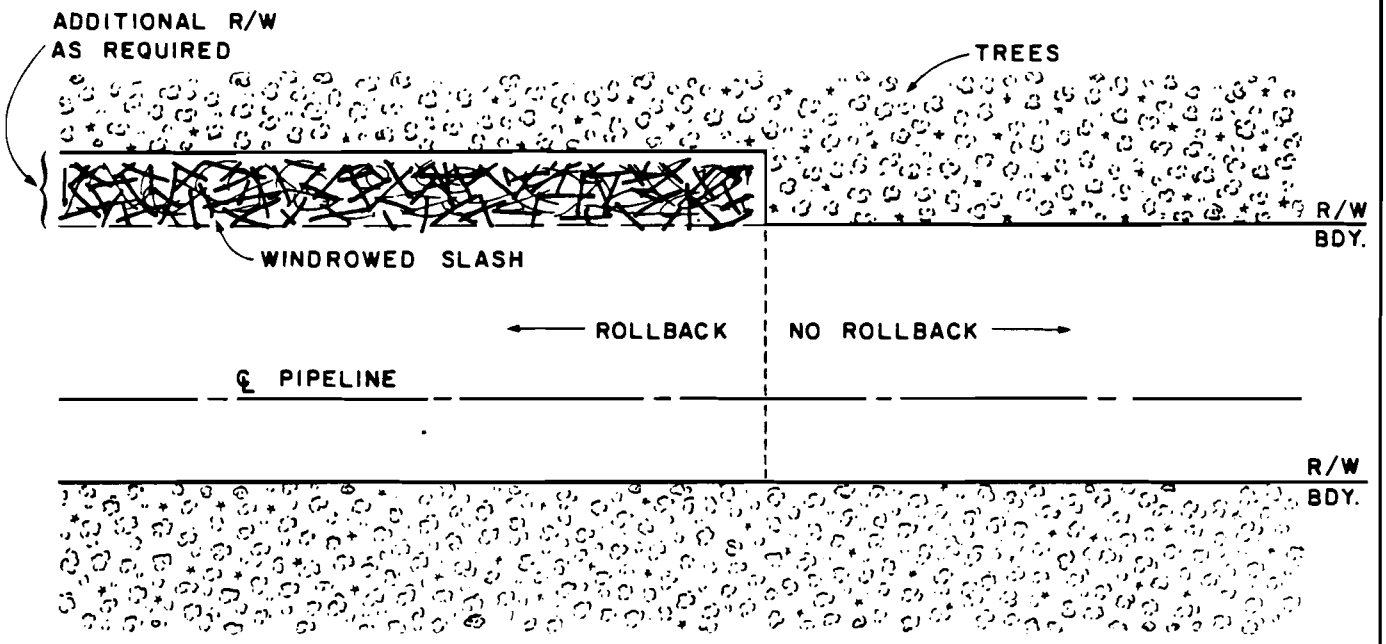
PLAN VIEW

N.T.S.

Notes

1. Obtain burning permit.
2. Maintain fire fighting equipment on site.
3. Push slash into windrows or piles along centre of right of way and separate by firebreaks. Locate burn areas more than 100 m from waterbodies.
4. Attend fires and prevent from spreading off right of way. Extinguish burning embers before leaving site.
5. Spread ashes over right of way. Windrow any remaining stumps along edge of working side.

DRAWING No. 8-2A SLASH DISPOSAL BY BURNING



PLAN VIEW
N.T.S.

Notes

1. Rollback method is used on erodible terrain or where access control is desired. Additional right of way is required.
2. Windrow slash on edge of working side.
3. Rollback slash during clean-up. Do not damage adjacent trees.
4. Walk slash down with bulldozer to minimize fire hazard.

DRAWING No. 8-2B SLASH DISPOSAL BY ROLLBACK

9.0 GRADING

9.1 DESCRIPTION

The right of way is graded to reduce steep slopes, allowing efficient movement of construction machinery and rubber-tired traffic. On winter projects, snow is usually roached over the trench line. On muskeg, however, snow is windrowed to the edge of the right of way to allow frost to penetrate into the ground. Grading is also done to avoid bending the pipe in excess of pipe specifications. Tree stumps are removed over the trench line and other portions of the right of way, as required, to facilitate trenching, backfill, and equipment movement. On agricultural lands, topsoil is stripped and stockpiled separate from the spoil pile.

9.2 POTENTIAL IMPACTS

Grading can cause the greatest surface disturbance of any pipeline activity. Cutting and replacing steep slopes may lead to long term instability and erosion, which may threaten the integrity of the pipeline. Grubbing stumps on steep slopes or near watercourses can cause erosion and disturbance to aquatic habitats. Aquatic habitats may also be damaged by changes in surface drainage patterns. Berming of snow or organic matter over the trench line during winter construction can temporarily block the movement of wildlife and livestock. On agricultural lands, poor topsoil stripping can lead to mixing of topsoil and subsoil, reducing soil capability for agriculture.

9.3 PROTECTION MEASURES

9.3.1 General

1. Minimize grade changes requiring excessive cuts and fills. Grade only as necessary to provide an adequate surface for construction equipment and to allow overbends and sags to be made within permissible bending limits (see Drawing No. 9-1). Do not store or push graded materials into treed areas.

2. Two-tone the right of way to limit the need for deep cuts and additional right of way on steep sidehills (see Drawing No. 9-2).

3. Minimize disturbance of natural drainage channels during grading; avoid blocking channels with graded material.

4. Grade away from watercourses to reduce the risk of material entering a watercourse. Do not place fill material in a watercourse during grading. If potential bank restoration problems exist, the Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife may request that special bank restoration techniques be used (see Drawings No. 15-2D, 15-3A, 15-3B and 15-3C).

5. Do not grade the entire right of way in proximity to a watercourse. When a ford is approved, grade only the trench line and the area immediately adjacent to the trench line for use as a work pad and travel surface (see Section 15.3).

6. For snow windrows that are greater than 1 m in height, leave 3 m gaps at regular intervals to allow for wildlife movement. For spacing of gaps contact the Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife. Generally, gaps should be placed at 400 m intervals.

7. If archaeological or historical sites are discovered, suspend grading until permission to continue is granted by the Archaeological Survey of Alberta (see Sections 4.3.9 and 5.3.8).

9.3.2 Forest

1. Restrict root grubbing to trench line on erodible slopes to maintain soil cohesion and to minimize erosion. Use blade shoes (skid shoe, brush rake) to reduce surface disturbance and loss of topsoil when grubbing. Restrict grubbing in muskeg to avoid creation of bogholes. Restrict grubbing to within 2 m of the right of way edge to prevent damaging adjacent trees. On winter projects, use snow to smooth out the working side if possible.

2. Delay grubbing slopes leading to watercourses or within 10 m of watercourse banks until construction of crossing is imminent. Leave an undisturbed organic mat within buffer zone to limit potential for introduction of sediment to the watercourse.

3. Stumps which remain after burning should be windrowed to the edge of the right of way (see Section 9.3.8).

4. Prior to grading and where slope conditions permit, salvage root zone material on potential agricultural lands or on erodible slope and store separately for replacement at final cleanup. Where possible, leave erodible slopes intact.

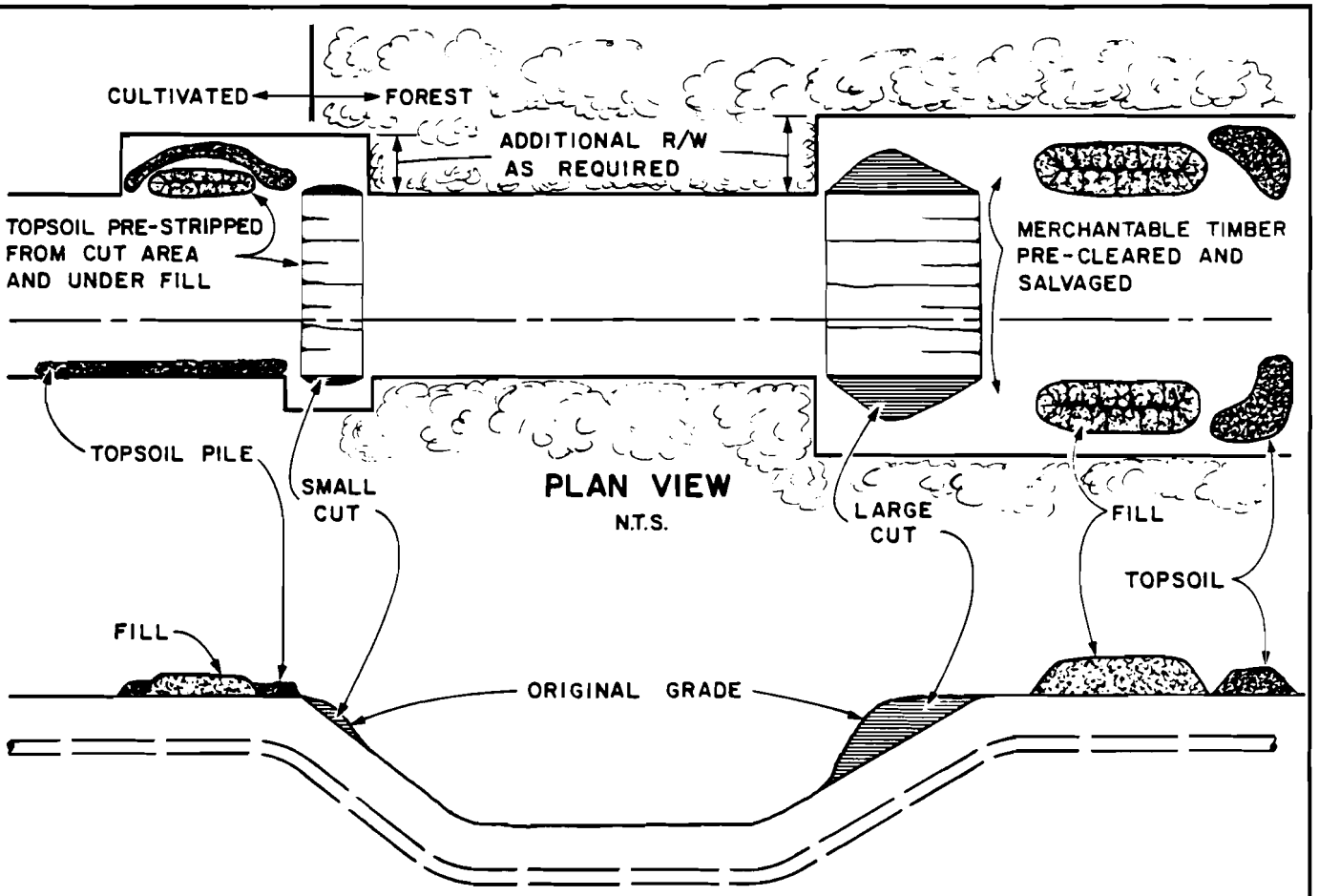
9.3.3 Agriculture

1. Salvage topsoil on agricultural lands** according to procedures illustrated on Drawings No. 9-4A, B, C, D, or E. The sequence of topsoil handling is shown on Drawing No. 9-3. Prior to the use of these procedures for planning and construction purposes, the reader should refer to the manual entitled "Manual on Soil Conservation And Pipeline Construction" for the procedures.

2. Do not use topsoil to ramp bar ditches on agricultural lands. Strip topsoil and ramp bar ditches with subsoil.

3. Suspend topsoil stripping during high wind or wet conditions.

**Please note that agricultural land pertains to arable or pasture land, patented or public lands.



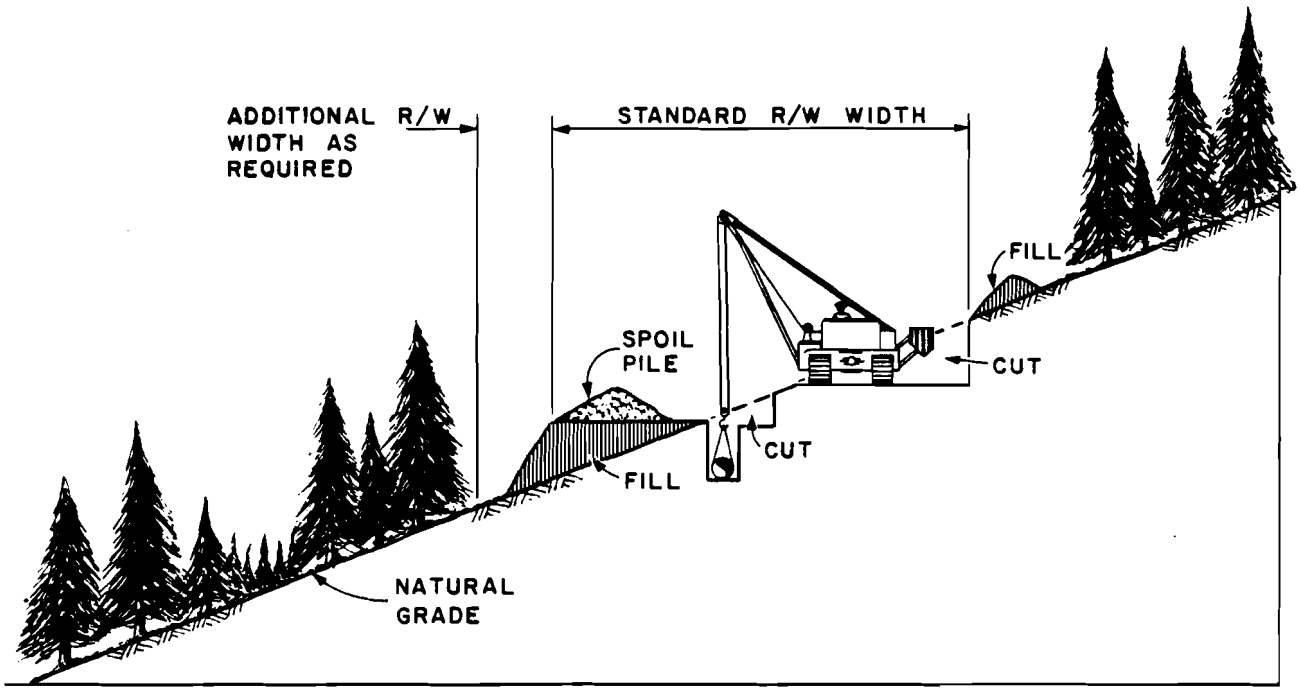
PROFILE

N.T.S.

Notes

1. Grade only as necessary to provide adequate surface for construction equipment and to allow overbends and sagbends to be made within permissible bending limits. On winter projects, use snow to smooth out the working side if possible.
2. Identify areas where additional right of way is required to accommodate cuts and fills. Salvage merchantable timber and topsoil. Maintain a minimum 1 m separation between topsoil and spoil piles.
3. Slope cuts sufficiently to minimize instability and resultant erosion and pipe integrity problems.
4. Stockpile fill in areas where it can be easily recovered (usually uphill) and where natural drainage is not blocked.
5. Do not stockpile fill in a manner which overloads slopes causing slope failure. Obtain advice from a geotechnical engineer.
6. Replace cuts and recontour slopes to maximum 1:3 grade unless otherwise directed by geotechnical engineer.
7. Employ erosion control measures such as breakers, cross ditches and berms, and revegetation (see Sections 12.0 and 14.0).

DRAWING No. 9-1 GRADING THE RIGHT OF WAY



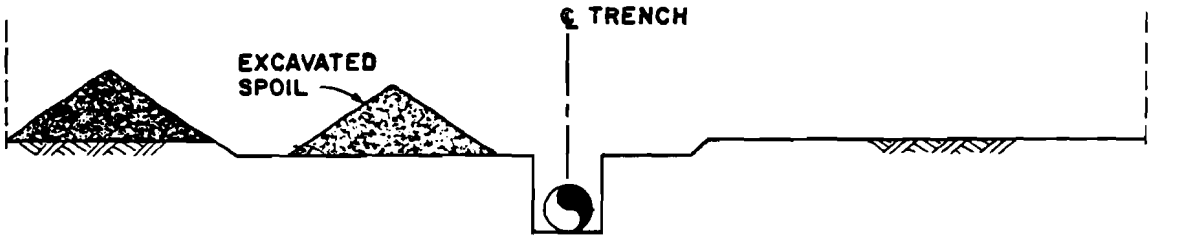
N.T.S.

Notes

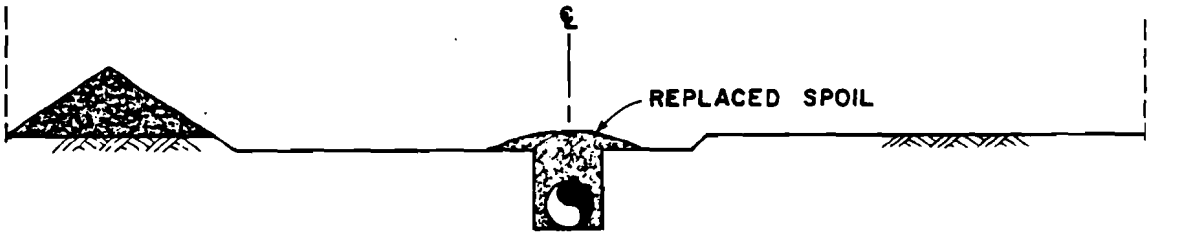
1. Two-tone the right of way to limit the need for deep cuts and additional right of way on steep sidehills.
2. Clear and stake additional right of way to allow for extra spoil.
3. Ensure side boom tractors are equipped with boom extenders and counterweights if required.
4. Use backhoe to assist bulldozers with replacing cuts. Recontour to maximum 1:3 grade unless otherwise directed by geotechnical engineer.
5. Employ erosion control measures such as breakers, cross ditches and berms, and revegetation (see Sections 12.0 and 13.0).

DRAWING No. 9-2 TWO-TONING THE RIGHT OF WAY

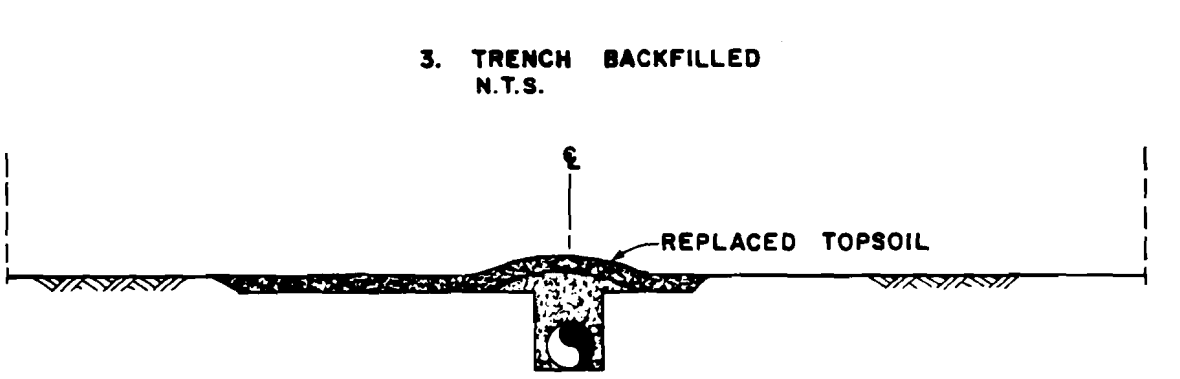
1. TOPSOIL STRIPPED
N.T.S.



2. TRENCH EXCAVATED
N.T.S.

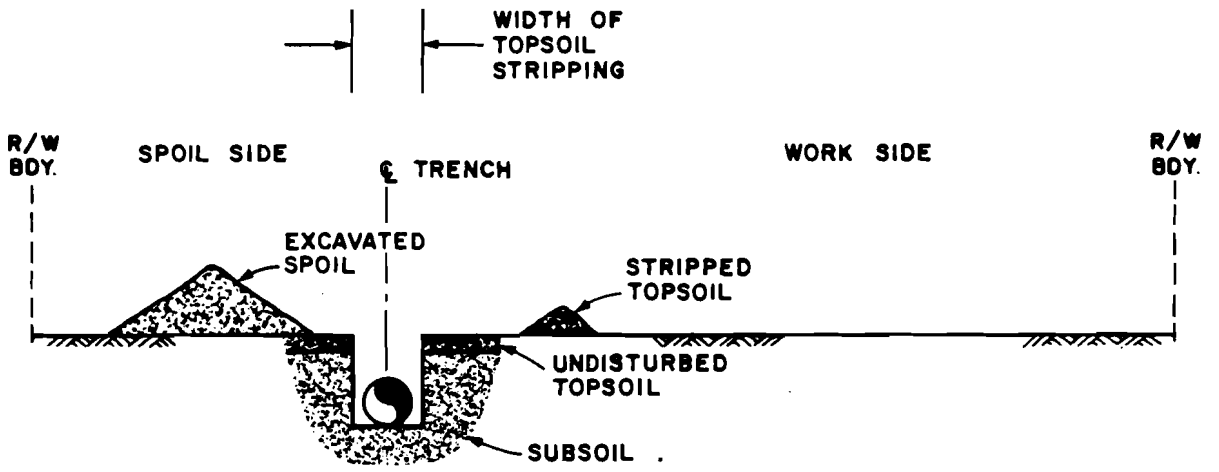


3. TRENCH BACKFILLED
N.T.S.



4. TOPSOIL REPLACED
N.T.S.

DRAWING No. 9-3 SEQUENCE OF TOPSOIL HANDLING

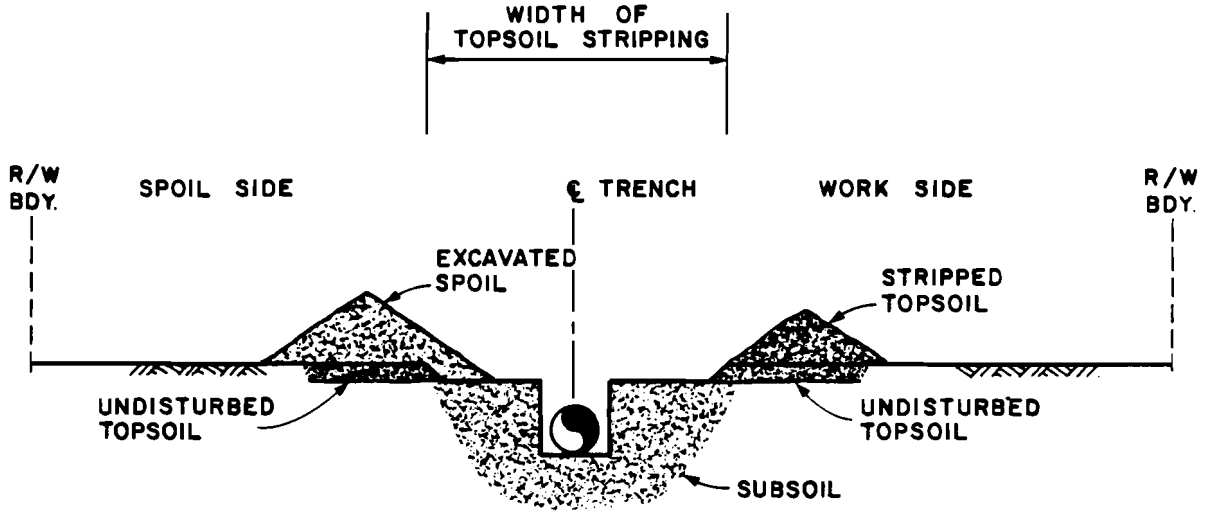


N.T.S.

Notes

1. Remove topsoil from the trench line and store on work side adjacent to the trench. Stripped width will be approximately 0.8-1.2 m. Stored topsoil should be approximately 1.3 m from the trench to allow for subsequent pass or trencher to excavate subsoil material.
2. Excavate trench subsoil and store on spoil side adjacent to the trench.
3. Return trench spoil to trench and compact. On grassed lands, minimize scalping of sod layer.
4. Return topsoil evenly over the trench line after trench has sufficiently settled or has been compacted.
5. On cultivated lands, alleviate compaction of topsoil over entire right of way. Do not rip on grassed lands; reseed with a compatible seed mix and fertilize.

DRAWING No. 9-4A TRENCH WIDTH TOPSOIL STRIPPING

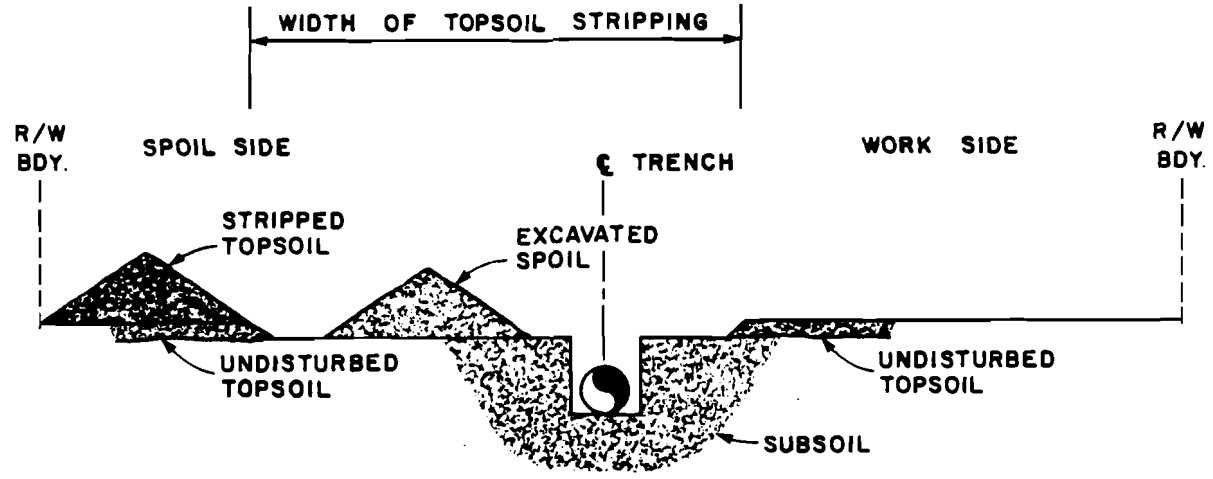


N.T.S.

Notes

1. Remove topsoil from an area centered over the trench line. Stripped width will be approximately 3.0-3.5 m. Store topsoil on work side adjacent to stripped area. Topsoil can be stored in a pile or spread out over the work side.
2. Excavate trench subsoil and store on spoil side adjacent to trench.
3. Return trench spoil to trench and compact. Feather out excess spoil over stripped area leaving a low roach centered over the trench.
4. Return topsoil evenly over the stripped area after trench has sufficiently settled or has been compacted.
5. On cultivated lands, alleviate compaction of topsoil over entire right of way. On grassed lands, reseed with a compatible seed mix and fertilize.

DRAWING No. 9-4B BLADE WIDTH TOPSOIL STRIPPING



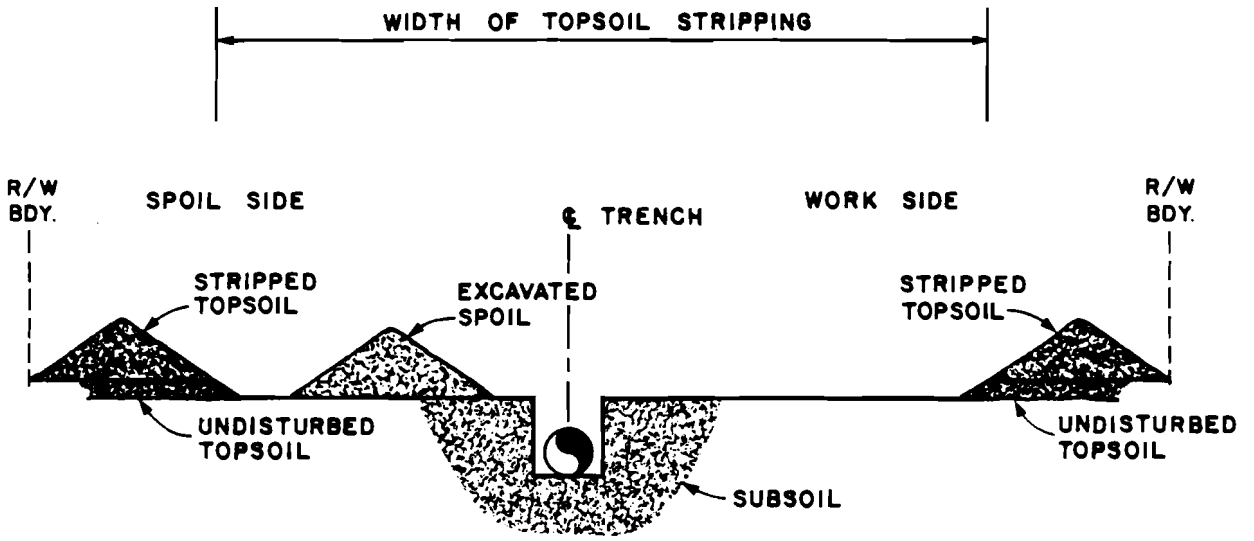
PROFILE

N.T.S.

Notes

1. Remove topsoil from over the trench and under the spoil pile. Stripped width will be approximately 6-8 m. Store topsoil on spoil side adjacent to stripped area.
2. Excavate trench subsoil and store on spoil side adjacent to the trench. Allow for a 1 m separation between the topsoil pile and the trench spoil.
3. Return trench spoil to trench and compact. Feather out excess spoil over stripped area leaving a low roach centered over the trench. Alleviate compaction of clay rich subsoils over the stripped area.
4. Return topsoil evenly over the stripped area after trench has sufficiently settled or has been compacted.
5. Alleviate compaction of topsoil over entire right of way.

DRAWING No. 9-4C **TRENCH AND SPOIL AREA TOPSOIL STRIPPING**



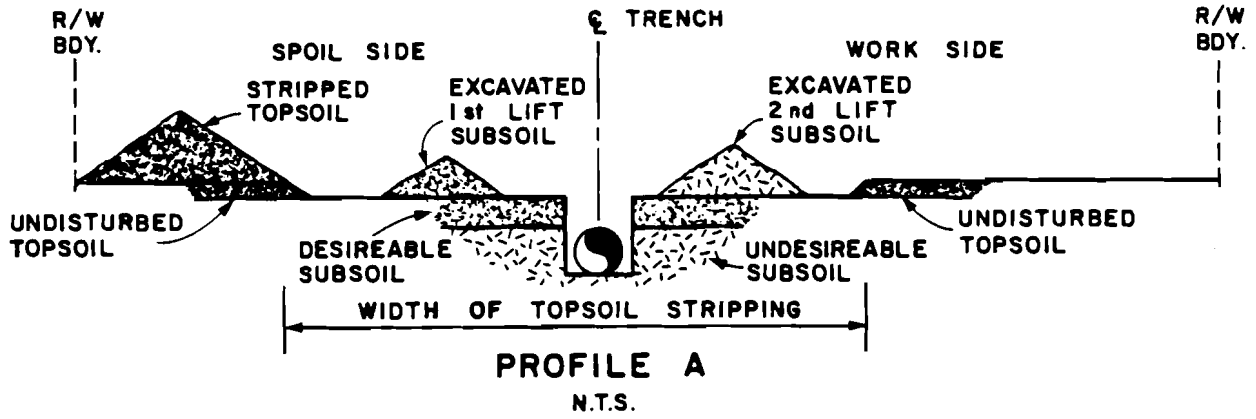
PROFILE

N.T.S.

Notes

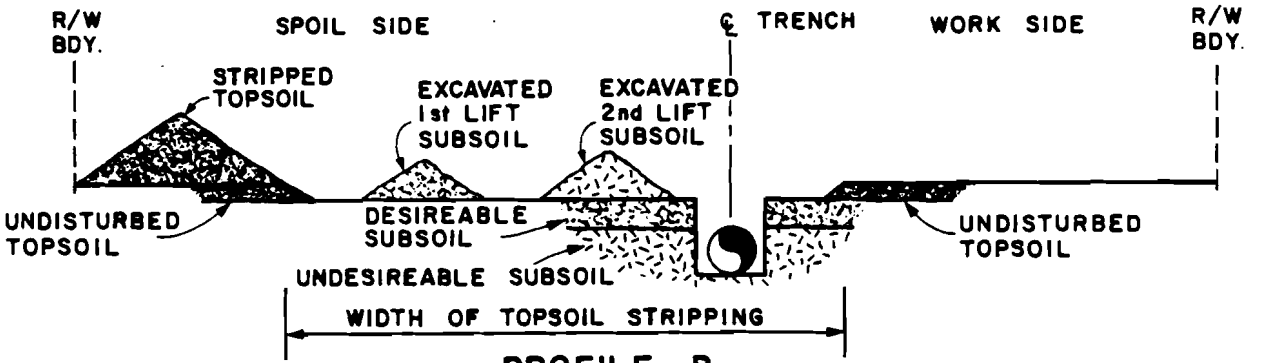
1. Remove topsoil from the trench, spoil storage, and work areas. Store topsoil on both sides of the right of way adjacent to the stripped area.
2. Excavate trench subsoil and store on spoil side adjacent to the trench. Allow for a 1 m separation between the topsoil pile and the trench spoil.
3. Return trench spoil to trench and compact. Feather out excess spoil over stripped area leaving a low roach centered over the trench. Rip or cultivate to reduce compaction and restore soil permeability capacity of clay rich subsoils.
4. Return topsoil evenly over the stripped area after trench has sufficiently settled or has been compacted.
5. Restore topsoil to seedbed condition, over entire right of way.

DRAWING No. 9-4D TRENCH, SPOIL, AND WORK AREA TOPSOIL STRIPPING



PROFILE A

N.T.S.



PROFILE B

N.T.S.

Notes

1. Remove topsoil from over the trench and under the spoil piles. Stripped width will be approximately 7-9 m. Store topsoil on spoil side adjacent to stripped area.
2. Excavate first lift of desireable trench subsoil and store on spoil side either adjacent to the trench (a) or back far enough to accommodate storage of second subsoil lift (b). Allow for a 1 m separation between the topsoil pile and the trench spoil.
3. Excavate second lift of undesireable trench subsoil and store adjacent to the trench either on the work side (a) or the spoil side (b). Allow for a 1 m separation between the two trench spoil piles (b) or the second lift spoil pile and the undisturbed topsoil on the work side (a).
4. Return second lift trench spoil to the trench and compact.
5. Return first lift trench spoil to the trench and compact. Feather out excess first lift spoil over the stripped area. Alleviate compaction of clay rich subsoils over the stripped area.
6. Return topsoil evenly over the stripped area after trench has sufficiently settled or has been compacted.
7. On cultivated lands, alleviate compaction of topsoil over entire right of way.

DRAWING No. 9-4E THREE PHASE SOIL HANDLING

10.0 TRENCHING

10.1 DESCRIPTION

The pipe trench is excavated by open cutting with wheel trenchers, backhoes, draglines or clams. At road and rail line crossings or at other locations where trenching is impractical, boring, directional drilling, or punching methods are used. Spoil (subsoil) from the pipe trench is typically piled near the trench opposite the working side. Ripping or blasting is sometimes required at locations where rock is encountered. Trenching may occur after grading, stringing or welding. For example, trenching on winter projects is generally conducted after welding to minimize freezing of the backfill (see Section 11.0).

10.2 POTENTIAL IMPACTS

Trenching can block movements of livestock and wildlife as well as restrict vehicle traffic across the right of way. Open-cut crossings of roads can inconvenience the travelling public. Trenching too far in advance of lowering-in and backfill operations can prolong the inconvenience and also cause adverse impact on aquatic systems by draining sloughs, allowing sediment to enter watercourses or blocking watercourses with spoil (see Section 15.0). Improper placement of spoil, or insufficient right of way can adversely affect soil capability by mixing subsoil with salvaged topsoil. In forested areas, pushing the spoil pile into trees will make it difficult to backfill without damaging the trees. Blasting of rock may result in adverse impacts on the public, livestock, wildlife, and fish.

10.3 PROTECTION MEASURES

1. Use alternative trenching equipment such as the plough or ditch witch where feasible. These procedures may be applicable on small diameter lines. Their advantage over conventional equipment and methods is that they cause less disturbance and require less right of way. Due to inherent greater disturbances associated with backhoes, use backhoes only where trenchers will not work.

2. To accomodate a wider or deeper trench, obtain permission and mark additional right of way at locations where extra space will be required. The extra space is necessary to store excess spoil. These locations commonly occur at crossings of roads, watercourses, railways, foreign lines, and at areas where rock will be encountered (see Drawing No. 6-1). Extra cover is also necessary for future farm and logging equipment crossings, tile drainage, deep tillage and land levelling for irrigation. Ensure that topsoil is stripped and stockpiled where it will not be buried by the spoil pile. In forested areas, maintain a minimum 1.0 m separation between topsoil and spoil piles and standing forest cover. Also ensure that merchantable timber has been salvaged prior to trenching.

3. If soil conditions permit, bore major road crossings to minimize interference with road users and risk of road settlement (see Drawing No. 10-1). Boring is also useful in preserving roadside trees and blocking line of sight down the right of way. This procedure can also be used for crossing railways, foreign lines, irrigation canals, selected watercourses, (see Section 15.0) and important shelterbelts. Road crossing requires the approval of Alberta Transportation and Utilities or the local government authority.

4. If subsurface materials such as rock, gravel or organic material preclude boring, open cut the road. Notify road owners and users and construct detours as required. Minimize duration of open cut crossing. Install safety barricades, fences, signs, and flashers around open road crossings. If possible, complete trenching, lowering-in, and backfill within one working day.

5. Minimize the time between trenching and backfill. This interval is typically no more than three days and less than one day on winter jobs. When crossing critical wildlife habitat, the amount of continuous open trench allowable may be specified by the Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife.

6. Delay trenching in areas with a high water table until just prior to lowering-in to prevent the trench from sloughing.

7. Stop trenching activities short of watercourse banks to prevent silty trench water from entering watercourses. Leave hard trench plugs in place until the watercourse crossing has been initiated. The recommended minimum plug width is 3 m. Protection measures for watercourse crossings are presented in Section 15.3.

8. Avoid draining sloughs and waterholes with the trench unless permission has been granted by the landowner or government agency having jurisdiction. Leave hard plugs or install soft plugs as required.

9. De-water the trench onto stable surfaces in a manner that does not cause erosion of soils or sedimentation of watercourses.

10. Leave gaps in the spoil pile at natural drainage channels to accommodate surface run-off. Leave plugs and corresponding gaps in the spoil pile at intervals requested by landowner to permit vehicular access or movement of livestock to watering and feeding areas. Recommended minimum width of the plug and gap is 3 m. Within wildlife habitat areas, leave plugs and gaps at intervals requested by the Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife.

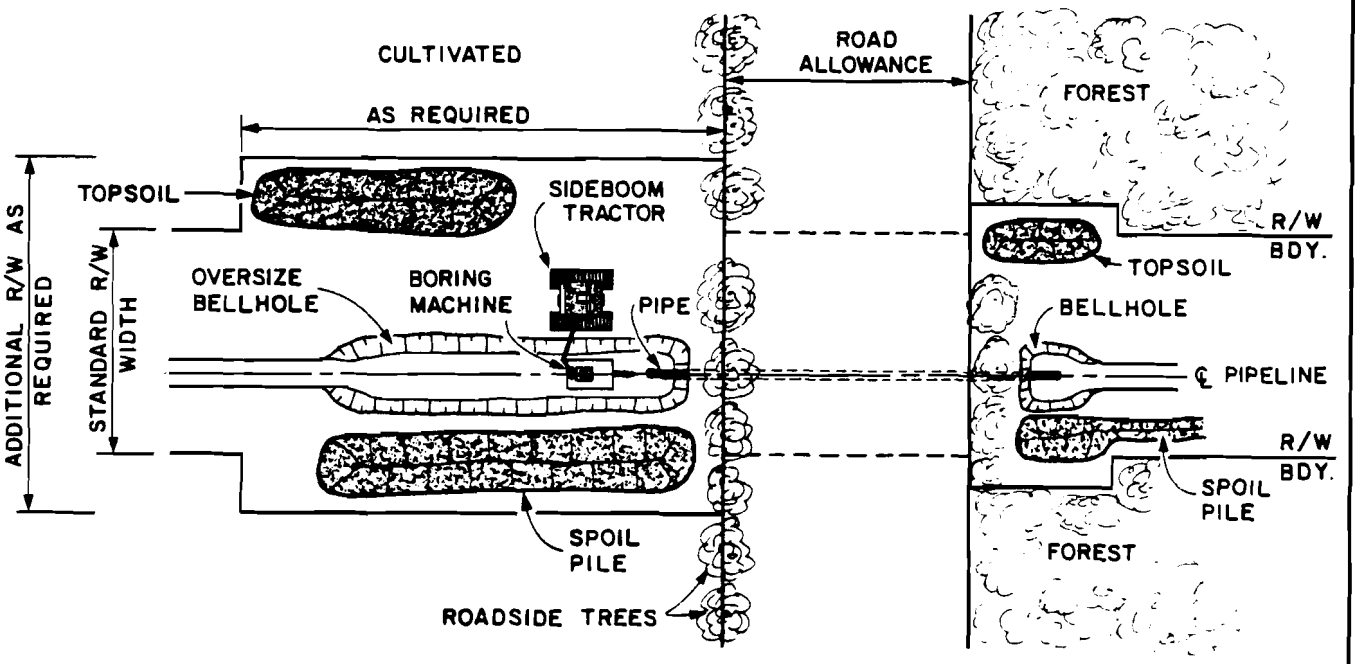
11. Suspend trenching if archaeological or historical sites are identified until permission to proceed is granted by Archaeological Survey of Alberta.

12. Where blasting is necessary, conduct operations in accordance with Explosives Safety Regulations to protect workers and the local public. Obtain a blasting permit and forewarn the local public prior to initiation of blasting activities. Utilize blasting mats to prevent damage from fly-rock. Immediately collect and dispose of fly-rock from the vicinity of residences, highways, utilities, structures, and from cultivated and improved lands. Dispose of blasting refuse such as dynamite containers, cartridges, and caps at locations and in a manner approved by local authorities having jurisdiction. If blasting within 50 m of fish bearing watercourses is necessary, see Section 15.3 for protection measures.

13. All explosives should be carefully handled, transported and stored in a secure and safe manner, strictly in accordance with the Explosives Act. Storage places, temporary or otherwise, should be clearly marked and be in the charge of a responsible party.

14. If drain tiles are cut, mark the location, cap ends to prevent clogging drains with dirt or debris, and install temporary flume if necessary to maintain drainage. Additional information on drain tile repair is provide in Section 12.3 and Drawing No. 12-5.

15. The trench width topsoil stripping procedure necessitates involvement of the trenching crew. If this procedure is used, see Section 9.3 and Drawing No. 9-4A for the recommended protection measure.



PLAN VIEW

N.T.S.

Notes

1. If subsoil conditions permit, major road crossings should be bored to avoid interference with road users. Continue boring under roadside trees to preserve the trees and to block line of sight down the right of way in treed areas of high aesthetic value. This procedure can also be used for crossing railways, foreign lines, irrigation canals, selected watercourses, and shelterbelts (Dwg. No. 15-2d).
2. Obtain permission and mark additional right of way as required to accommodate bellholes and spoil piles. Ensure that topsoil is stripped and stockpiled at edge of additional right of way so that it will not be buried by the spoil pile. Ensure that merchantable timber has been salvaged.

DRAWING No. 10-1 BORED ROAD CROSSING

11.0 HAULING, STRINGING, BENDING, WELDING, COATING AND LOWERING-IN

11.1 DESCRIPTION

Pipe handling begins when the pipe is unloaded from stringing trucks and placed beside the trench line on wooden skids. The pipe is bent to conform to grade and points of inflection; then skidded higher and welded together into continuous sections. As required, the welds are inspected and tested according to CSA standards and the Pipeline Regulations pursuant to the Pipeline Act. An outer coating or tape is applied. If pre-coated pipe is used, only the joints are coated. The pipeline is weighted, insulated as required, and lowered into the trench.

11.2 POTENTIAL IMPACTS

Activities from hauling to lowering-in can interfere with farming activities and movement of livestock and wildlife. Long, continuous lengths of open trench and welded pipe can be a barrier to wildlife, landowner vehicles, and livestock. Spent welding rods can become a potential fire hazard as well as a risk to livestock.

11.3 PROTECTION MEASURES

1. At locations requested by landowner, leave a minimum 3 m wide gap in pipe joints to permit vehicular access or movement of livestock to watering and feeding areas. Within wildlife habitat areas, leave gaps for wildlife movement as requested by the Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife. The gaps in strung pipe should coincide with gaps left in topsoil and spoil piles, snow windrows, trench plugs, and continuous welded sections (see Drawing No. 11-1).

2. Bend pipe to maximum permissable limits in erodible areas where bending is preferable to grading of the right of way.

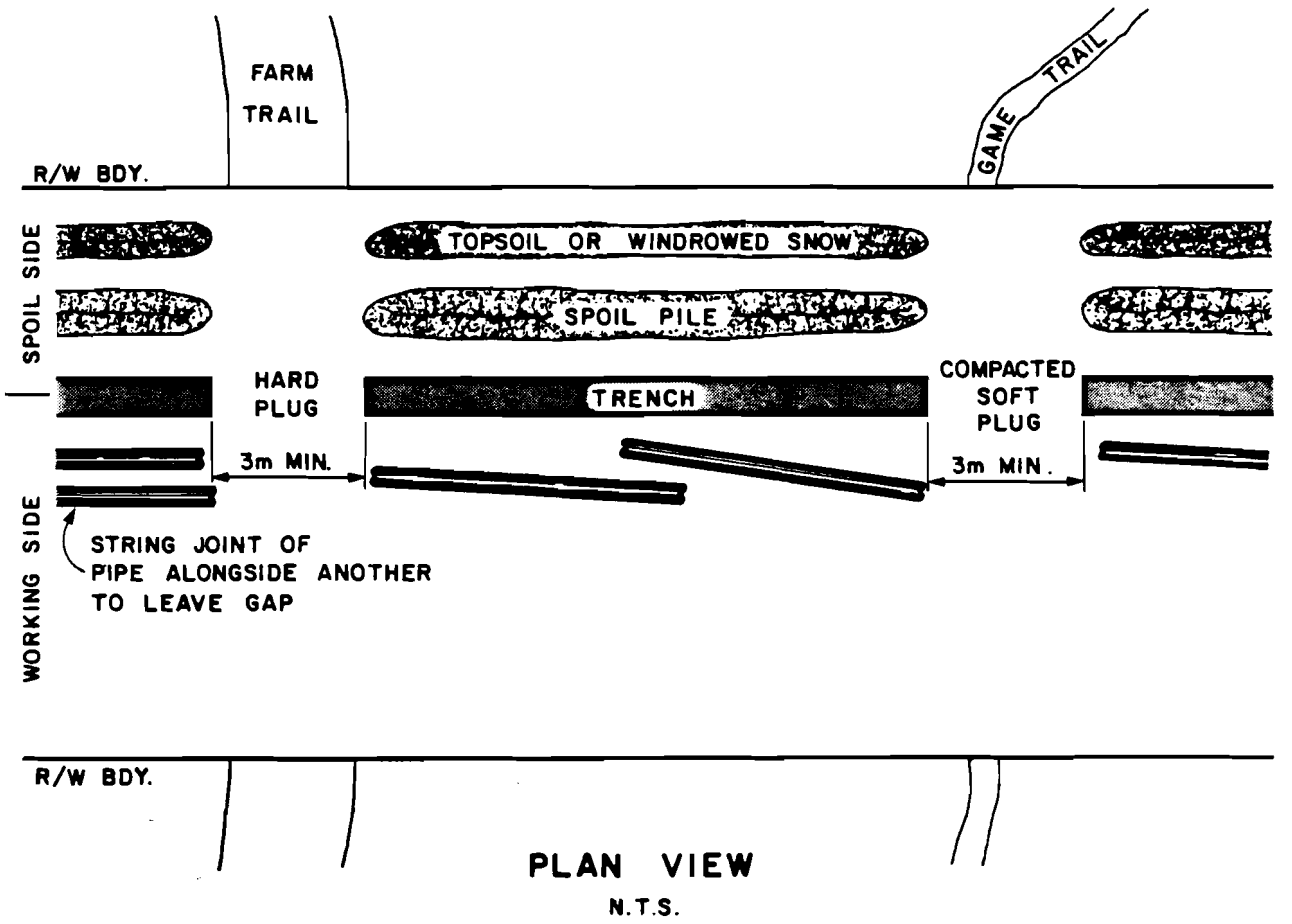
3. On agricultural land and where possible, haul equipment and materials in over the trench line after topsoil stripping and prior to trenching to localize and minimize soil compaction.

4. Provide receptacles for proper disposal of welding rods. Spent welding rods should not be left on the ground or in the trench. In high fire hazard areas, shut down welding during high winds.

5. Leave gaps in continuous welded sections every 1.6 km, or as requested by the landowner or the Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife to permit passage of livestock and wildlife.

6. Minimize the length of open trench by lowering-in as soon as possible after welding and coating to reduce interference with landowners, livestock and wildlife.

7. De-water the trench onto stable surfaces in a manner that does not cause erosion of soils or sedimentation of water-courses.



PLAN VIEW

N.T.S.

Notes

1. Leave gaps in pipe stringing to permit vehicular access or movement of livestock and wildlife across the right of way. Consult with landowner or the Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife.
2. Gaps in strung pipe should coincide with gaps left in snow berms, topsoil, and spoil piles, and with hard and soft plugs in trench.

DRAWING No. 11 - 1 GAPS IN PIPE STRINGING

12.0 BACKFILLING

12.1 DESCRIPTION

Excavated spoil or select backfill is placed in the trench over the pipe. The spoil may be compacted and is roached or crowned over the trench to allow for subsidence. Trench breakers and subdrains are installed to prevent the movement of water down the trench. When appropriate, repairs are made to drainage tiles. Finally, the right of way is recontoured and topsoil replaced.

12.2 POTENTIAL IMPACTS

Backfilling is the first stage in reclaiming the right of way. Improper procedure at this stage can affect the quality of final reclamation on the project. Poorly compacted backfill material or an excessive roach can cause drainage problems as well as inconvenience for landowners, livestock, and wildlife. Follow-up reclamation may be necessary to reduce the height of the roach or to fill in sunken trench. The type of trenching equipment used for excavation can be a significant factor in a poorly compacted trench. For example, a backhoe will generally excavate spoil in lumps, resulting in a "looser" filled trench than a wheel trencher, particularly in frozen soil conditions. In some instances, proper trenching equipment can reduce this compaction problem.

Erosion of trench spoil and failure of recontoured slopes can pose an environmental hazard and risk to pipe integrity, particularly after working with frozen soils during winter construction. Mixing of topsoil with subsoil may occur during backfilling and reduce soil capability.

12.3 PROTECTION MEASURES

1. Minimize the length of open trench by backfilling immediately after lowering-in.

2. Backfill subsoil prior to replacing topsoil. Do not use topsoil for padding the pipe. Keep the backfill free of wood, skids, garbage and other construction debris.

3. Confine backfill activities to the construction right of way. To prevent off right of way damage, use Mormon board, backhoe or Gradall where bulldozers do not have sufficient working space. An auger or similar machine is useful to break heavy clods or semi-frozen soils.

4. On cultivated lands leave the top 0.3 m of trench free of rocks to prevent interference with farm implements. The average density and average size of rocks left on the right of way should be no more than that on adjacent lands.

5. Compact the backfilled subsoil, if feasible, as described on Drawing No. 12-1.

6. Roach the trench sufficiently to compensate for settlement and to minimize changes in natural drainage patterns as described on Drawing No. 12-2.

7. Install trench breakers constructed of sandbags (Drawing No. 12-3A), bentonite (Drawing No. 12-3B), urethane foam, or other compacted impervious materials. Breakers force ground water seepage along the pipeline trench to the surface and are useful on steep slopes, adjacent to watercourses, edges of muskegs, and on other similar sites. Determine the location of trench breakers by on-site investigation considering potential for subsurface flow and degree of slope. Mark location of trench breaker prior to backfilling to facilitate correct placement of diversion berm immediately downslope of breaker (see Drawing No. 14-1A).

8. Install subdrains to divert shallow groundwater flow from the right of way and to improve slope stability (see Drawing No. 12-4).

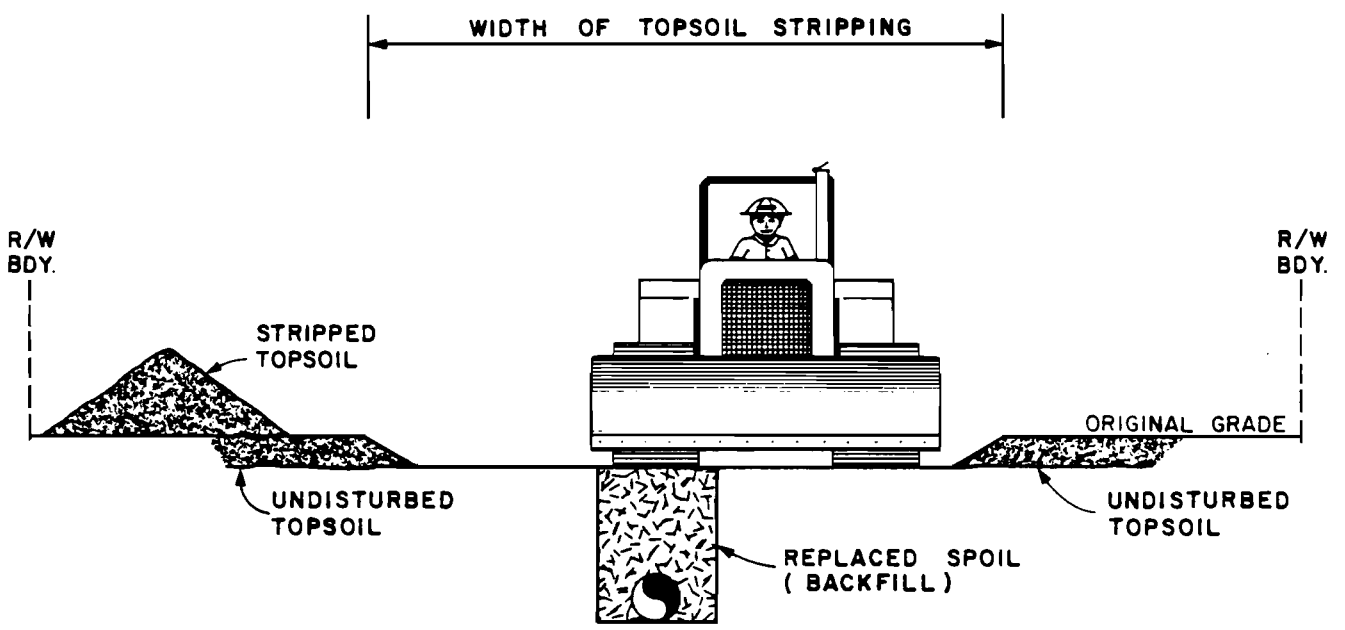
9. In irrigated or dryland areas, repair any drainage tile cut during trenching or crushed by heavy equipment (see Drawing No. 12-5).

10. Recontour the right of way to approximate preconstruction profile and replace sidehills or other areas which have been graded. Where this is not technically feasible due to risk of ovalling the pipe or failure of fill on slopes, recontour to grades not exceeding 1:3 or as advised by a geotechnical engineer.

11. Restore all drainage courses and watercourses to original location and to a stable condition (Section 15.3).

12. Pick rocks prior to topsoil replacement where cultivated topsoils overlay subsoils containing gravel lenses. The average density and size of rocks left on the right of way should be no more than that on adjacent lands.

13. Spread topsoil evenly over stripped portions of the right of way. Do not grade the right of way to obtain replacement topsoil; utilize only topsoil previously salvaged. Frozen topsoil is difficult to spread evenly and should not be replaced until thawed. Topsoil replacement should cease during wet weather or high winds (see Section 4.3) to prevent loss of topsoil. Also see Drawings No. 9-4A to E for notes on topsoil replacement.



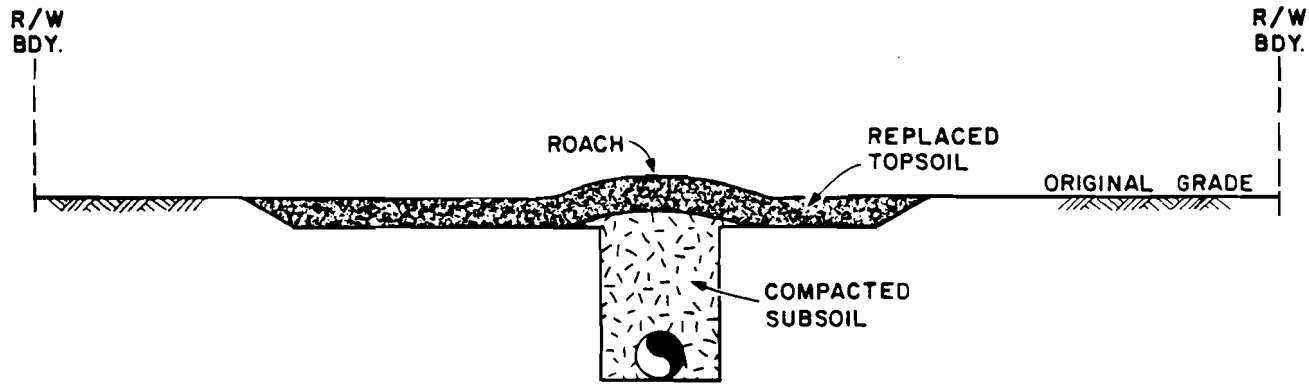
PROFILE

N.T.S.

Notes

1. Except in rocky or muskeg areas, compact the backfilled subsoil to minimize settlement. The degree of compaction which can be achieved is limited by soil type, frost and moisture content, depth of cover, pipe strength and insulation, and other factors. Typically, compaction is achieved by a few passes with a crawler tractor. In special cases such as irrigated fields and open cut road crossings, 100% compaction is desirable and requires special equipment and compaction in multiple lifts.
2. Dispose of excess subsoil in locations satisfactory to the landowner and in a manner which will prevent mixing with topsoil.

DRAWING No. 12-1 COMPACTION OF BACKFILL



PROFILE

N.T.S.

Notes

1. Roach the trench to compensate for settlement and changes in natural drainage patterns. The height of the roach depends upon land use, the degree of compaction achieved, and soil frost. Frozen soils require higher roaches than non-frozen soils. In agricultural lands, including forested lands in the yellow area, the roach should be low and wide (unfrozen case) to facilitate topsoil replacement. A higher roach is acceptable on forested land provided drainage and wildlife are unaffected. Typical values for roaching of representative soil types are presented below. The higher numbers in the range represent the worst case (frozen or clods).

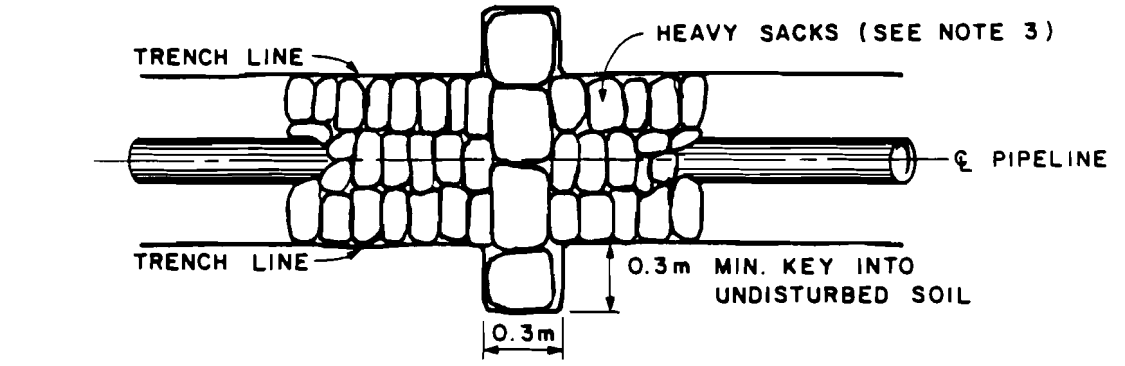
Type of Backfill	Swell Coefficient (r)
blasted rock	.00 - .05
sand & gravel	.05 - .10
sand	.08 - .15
silty sand	.10 - .15
silt	.10 - .20
clay	.10 - .25
organic (muskeg)	.50 - 1.00

$R = r \times D$ where R = height of roach
r = swell coefficient
D = depth of trench

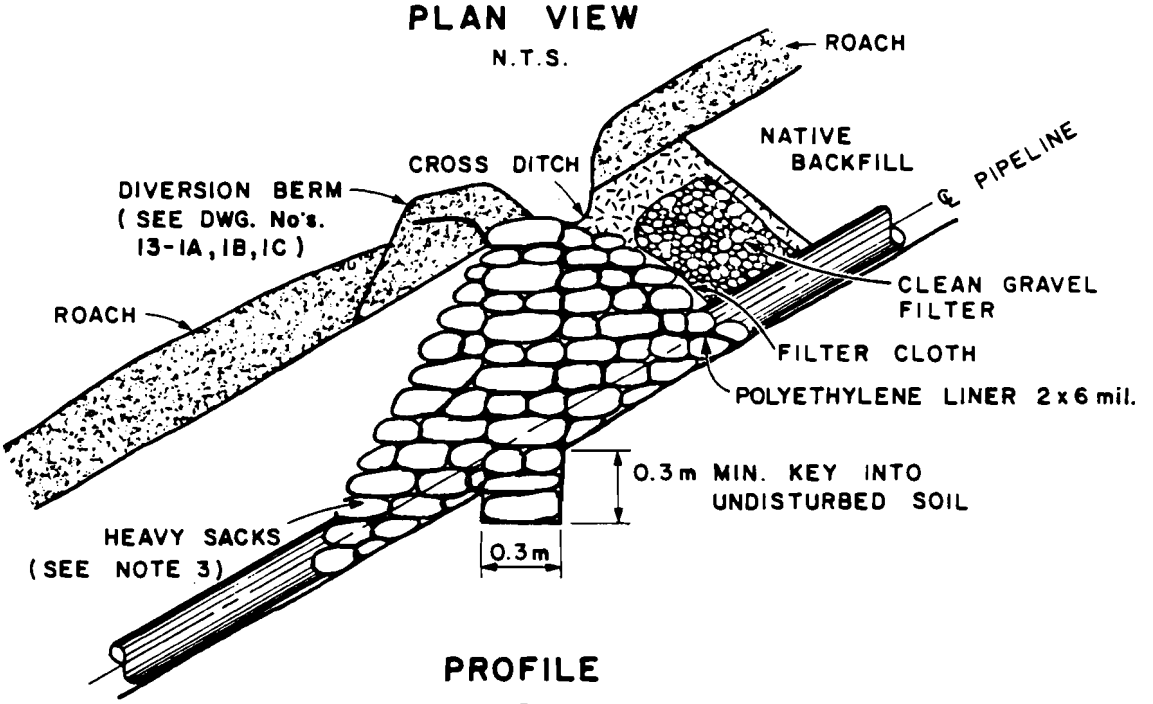
2. Leave periodic gaps in roach (e.g., 250 m), at all obvious drainage courses and at trench breakers (Dwgs. No. 12-3a and 3b) to allow for surface run-off. These gaps may require maintenance the following year to fill in settled areas.
3. Replace topsoil evenly after trench has settled or has been compacted.

Source: Formula adapted from Transcanada Pipelines, 1979.

DRAWING No. 12-2 ROACHING THE TRENCH



PLAN VIEW
N.T.S.

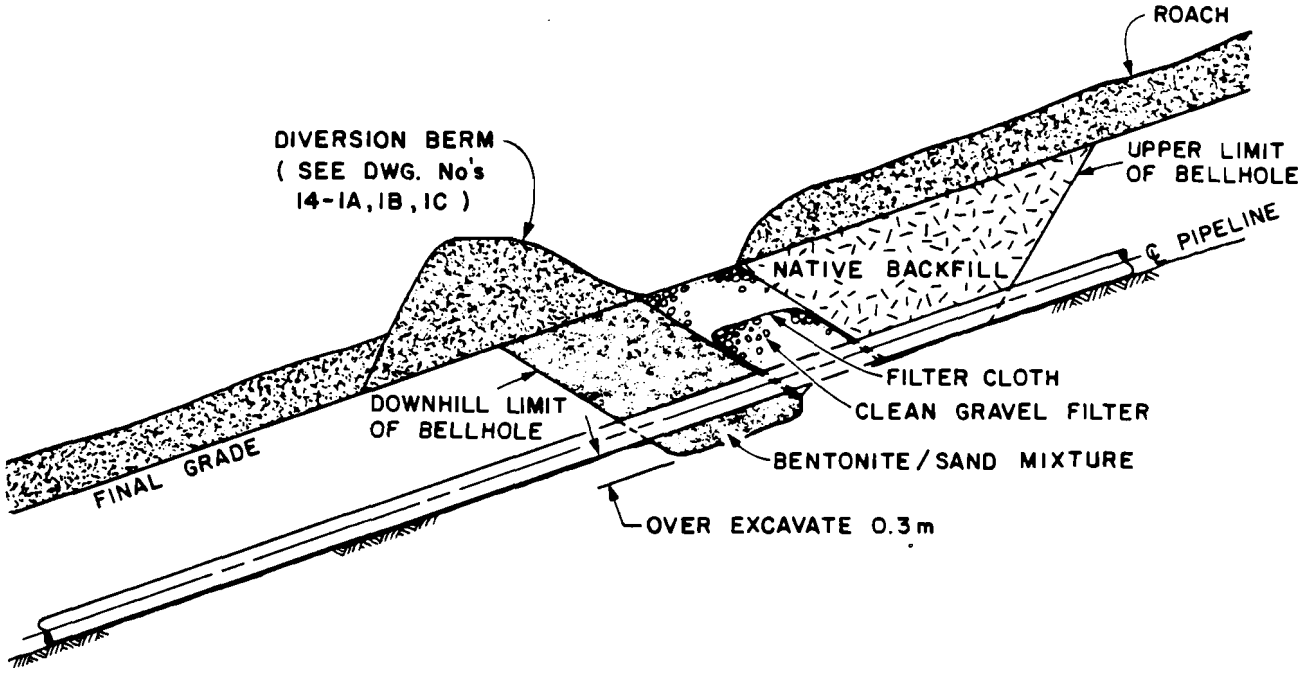


PROFILE
N.T.S.

Notes

1. Install sack breaker on steep slopes, adjacent to watercourses, edges of muskegs and other similar sites to force seepage to the surface and prevent erosion of padding and backfill material.
2. Fill sacks with earth, clay, sand or a cement and sand mixture.
3. Interlock sacks by hand to provide a watertight barrier. Install a polyethylene liner, a bentonite layer or other impermeable material. Key the structure into trench walls and bottom for added stability. Install a clean gravel filter upslope to permit controlled seepage to the surface. Wrap in filter cloth to prevent infiltration of fines into the filter material. Alternatives to gravel filters include wicking materials or equivalent.

DRAWING No. 12-3A SACK BREAKER



PROFILE

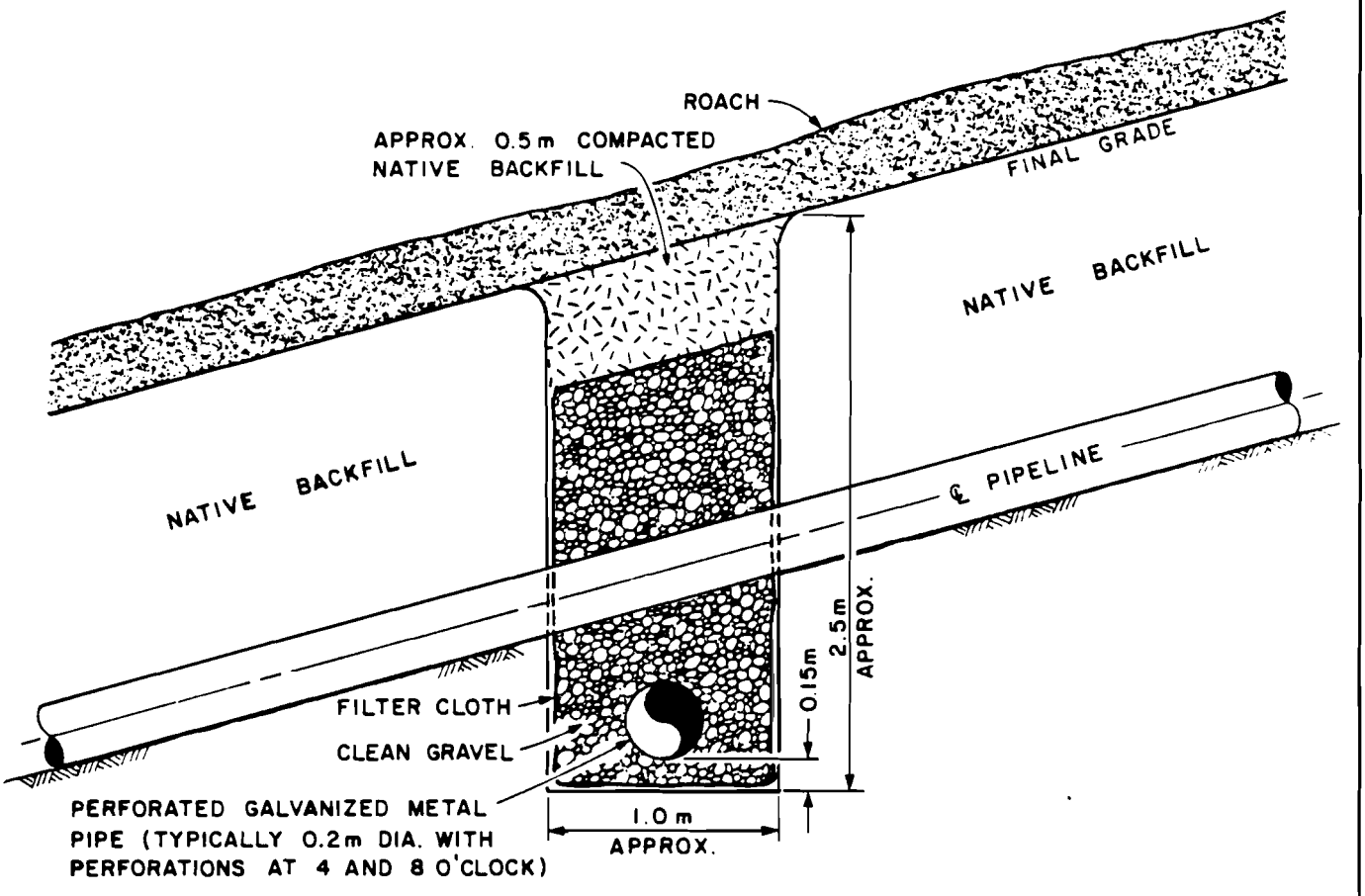
N.T.S.

Notes

1. Install bentonite (or gel) and sand breaker on steep slopes, adjacent to watercourses, edges of muskegs, and other similar sites to force seepage to the surface and prevent erosion of padding and backfill materials.
2. Use a 15-20% mixture by weight of bentonite with sand. This mixture can be prepared using a truck-mounted concrete mixer.
3. Install a clean gravel filter upslope to permit controlled seepage to the surface. To prevent infiltration of fines into the filter material, wrap in filter cloth. Alternatives to the gravel filter include a wicking material or equivalent.

Source: Adapted from Marshall and Ruban (1983).

DRAWING No. 12-3B BENTONITE / SAND TRENCH BREAKER



PROFILE

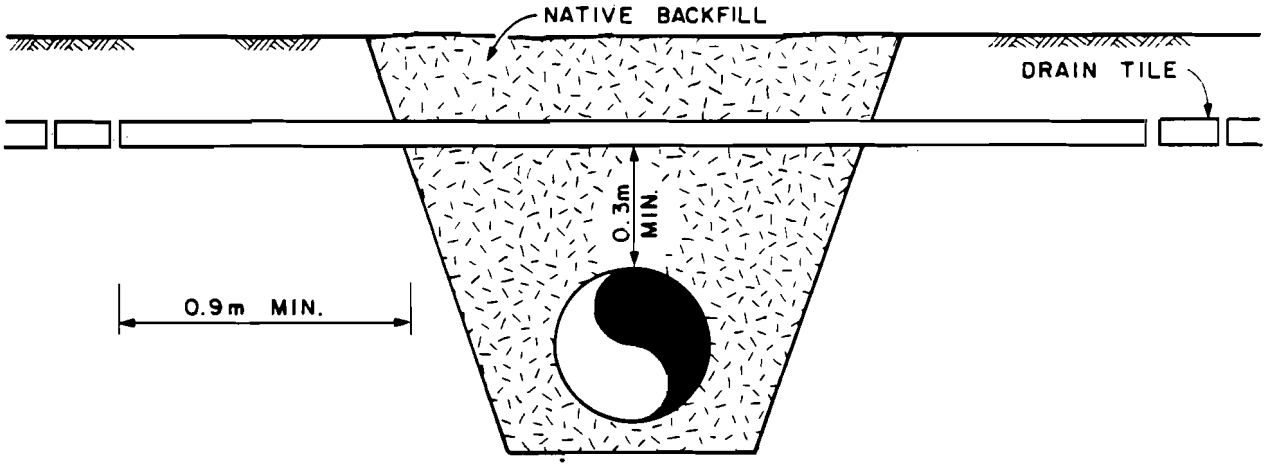
N.T.S.

Notes

1. Improve slope stability by installing subdrains to divert shallow groundwater flow from the right of way. Clean gravel, wrapped in filter cloth, permits drainage and aids in retention of backfill. Note that this drawing depicts a cross-drain. In certain circumstances, the sub-drain may be installed lengthwise down the slope underneath the pipeline. A geotechnical engineer can advise on which method is most appropriate.
2. Determine the location of subdrain by on-site investigation considering such factors as groundwater conditions in trench, soil types, local topography, and drainage patterns.
3. Skew subdrain across the right of way 5° to ensure sufficient drainage. (Dwg. No. 14-1a).
4. Where drains cross pipeline trench, install trench breaker and diversion berm downslope of drain to prevent drain water flowing down pipe trench. (Dwgs. No. 12-3a, 12-3b, 14-1a, 14-1b and 14-1c).

Source: Adapted from Marshall and Ruban (1983).

DRAWING No. 12-4 SUBDRAIN DETAIL



PROFILE

N.T.S.

Notes

1. If tile or tube drains are cut during trenching, mark locations, cap drains to prevent clogging with dirt or debris, and install a temporary flume to maintain drainage.
2. Prior to topsoil replacement, replace drains with a length of solid pipe to prevent settling. If disturbance is extensive, replace with new drain tubing, or perforated solid pipe on a compacted bed.
3. Insert a rod into open drain ends far enough to ensure that right of way traffic has not damaged or displaced drains.
4. Remove and replace broken drain. Replace with solid pipe to prevent settling.
5. Replace drain to its former gradient and alignment.
6. Carefully place backfill and tamp in lifts beneath and around pipe.

Source: Adapted from Transcanada Pipelines (1984) and Union Gas Ltd. (1982).

DRAWING No. 12-5 DRAIN TILE RESTORATION

13.0 TESTING

13.1 DESCRIPTION

Construction and sizing pigs are propelled through the pipeline by compressed air to clean the pipe and check for internal damage. Damaged pipe is exposed or "daylighted" and repairs made. The pipeline is then pressurized for a specified time in excess of the designed operating pressure. Typical test media include water, methanol, air, and inert gases. During winter, the water is heated or antifreeze is added. Any failures are daylighted and repairs made. Following a successful test, a slug of methanol may be injected to dry the pipe prior to putting the line into service.

13.2 POTENTIAL IMPACTS

While testing is crucial to public safety during the operation of the pipeline, it is often of minor concern with respect to potential environmental impacts during construction. However, significant environmental impacts can occur, particularly if pipe failures and repairs are frequent or if they occur at sensitive locations such as water crossings. Daylighting the pipe to make repairs can involve the same potential impacts as normal excavation, and even more in some instances. The withdrawal and discharge (dewatering) of test water into natural waterbodies can adversely impact downstream users and fisheries habitat. Impact can result from excessive water withdrawal or discharge rates to waterbodies; introduction of foreign aquatic organisms to a drainage basin, or from the introduction of hazardous materials to soils or waterbodies. Due to high pressures involved in testing, line failure can endanger the public or construction personnel along the right of way.

13.3 PROTECTION MEASURES

1 Use proper procedure for safe testing operations. Post warning signs and advise the public of danger.

2. In the event of a test failure, have sufficient men and equipment available on site to repair any rupture, leak or erosion.

3. Prior to lowering-in, pre-test pipe sections to be installed at watercourses and other sensitive environmental locations. This will avoid major impact involved with daylighting and making repairs.

4. If feasible, utilize alternatives to natural waterbodies as a source of hydrostatic test water. If air testing is not feasible, preferred sources and disposal locations for hydrostatic testing are industrial water supplies (i.e., gas plant or refinery) and tankage trucked to the site. See points 6 to 11 if hydrostatic test medium from natural waterbodies (streams, lakes or sloughs) is required.

5. On agricultural soils, prior to testing or daylighting, strip topsoil from areas to be disturbed.

6. Select withdrawal sources which have sufficient quantity and quality of water required for testing purposes. Damming of small watercourses or linking sloughs together via new drainage ditches should only be done as a last resort. Avoid locating test sites on steep slopes or muskeg. Follow the conditions, including proper notification of concerned parties, on the license to divert water obtained from Alberta Environment.

7. Isolate test pumps and water heaters from waterbodies with an impermeable lined dyke or depression to prevent spills of fuel or lubricants from entering any waterbody. To minimize erosion, ensure that both the fill and the discharge lines are free of leaks. Activate the contingency plan when spills occur (see Section 5.3). Screen intakes in accordance with guidelines prepared by the Fish and Wildlife Division, Alberta Forestry, Lands and Wildlife (1980).

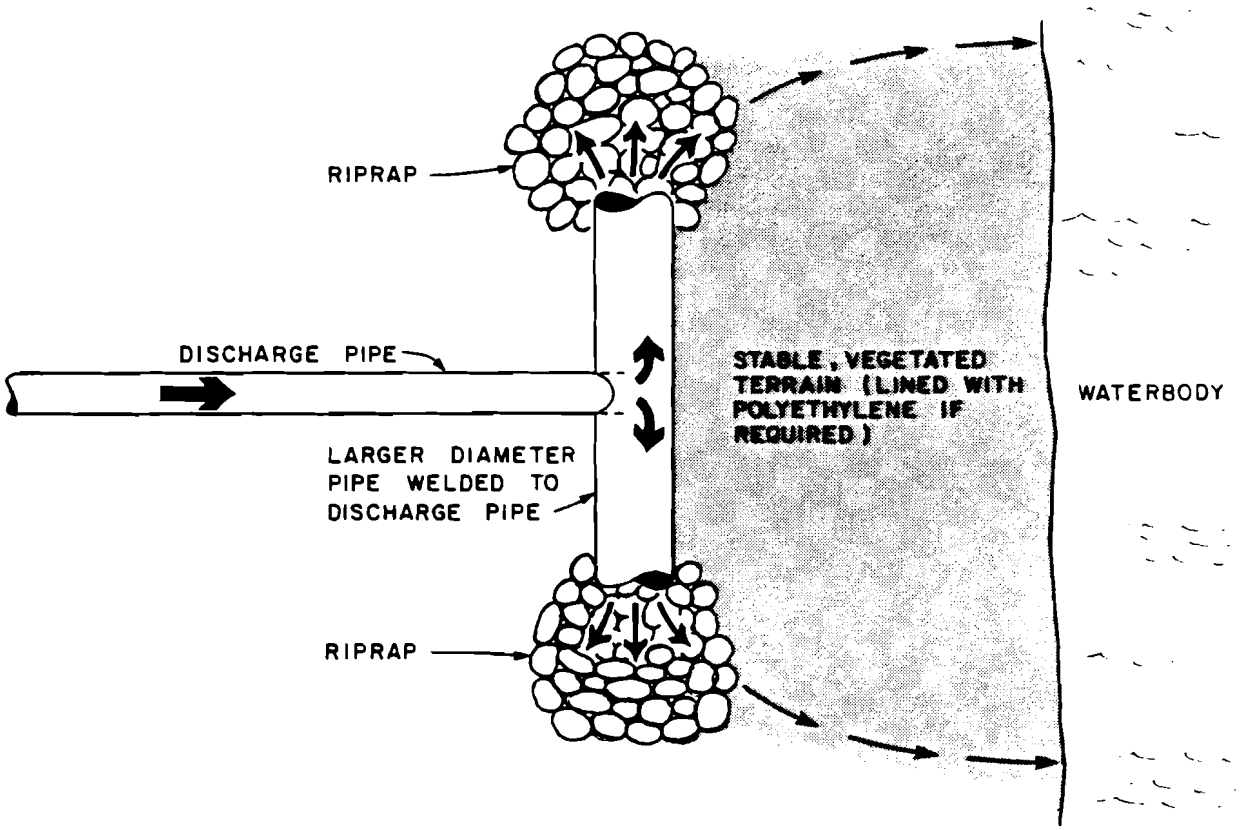
8. Do not exceed permitted withdrawal rates, nor 10% of the flow or volume of the water source.

9. Select dewatering sites which are more than 2 km upstream of public water intakes. If possible, de-water back into the original source. Do not discharge water taken from one major drainage basin such as the Athabasca (which drains to the Arctic Ocean) into another basin such as the North Saskatchewan (which drains to Hudson's Bay). This will prevent the introduction of foreign aquatic organisms.

10. Water returned to natural waterbodies should be of sufficient quality to avoid serious pollution problems. Discharged water should be no more than $20^{o}C$ warmer or colder than the receiving waterbody. Contact the Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife and the Water Resources Administration Division of Alberta Environment for procedures when handling discharge water containing bactericides, oxygen scavengers or corrosion inhibitors. The test water may require a 24 hour bioassay or other quality tests prior to discharge.

11. De-water the pipeline in a manner which will prevent soil erosion and damage to the beds and banks of waterbodies. On large waterbodies, arch the discharge pipe to oxygenate the water and dissipate erosive energy. On smaller waterbodies, dissipate the erosive energy as described on Drawing No. 13-1, and de-water onto stable, well vegetated land.

12. Recover in tankage all methanol, ethylene glycol, and water contaminated by freezing depressants. Do not allow contaminants to enter natural waterbodies.



PROFILE

N.T.S.

Notes

1. Dissipate the energy of water discharge during dewatering to prevent soil erosion and damage to the beds and banks of waterbodies. Erosive energy can be dissipated as shown above or by other methods including: arcing pipe into the air; using a muffler-style energy dissipator; directing the flow at swamp mats, plywood or rock riprap. Choice of the most appropriate method depends upon volume and pressure of discharge water. Many kilometres of large diameter pipe will necessitate a more robust method than a short length of small diameter pipe. If surging is anticipated, utilize a robust method.
2. Ensure that discharge pipe is free of leaks.
3. Dewater at rate used to withdraw water. If erosion control measures are found to be inadequate, lower the dewatering rate or stop operations until satisfactory measures are in place.
4. Anchor the discharge pipe to prevent bouncing or snaking during surging.

DRAWING No. 13-1 ENERGY DISSIPATOR

14.0 CLEAN-UP

14.1 DESCRIPTION

Clean-up is normally the final stage of reclamation. Garbage and debris are removed from the right of way and final erosion control structures installed. At this time, watercourse crossing structures and survey stakes are removed, fences and gates repaired or replaced, topsoil prepared for seeding, and the right of way reseeded. When mainline construction occurs in the winter or late fall, final clean-up is delayed until spring, or as soon as possible thereafter.

14.2 POTENTIAL IMPACTS

A good clean-up effort is essential to repair construction damage as much as possible and to eliminate long-term reclamation problems. A proper clean-up is essential to good relations with the landowner. Poor clean-up can result in a littered, erodible right of way adversely affecting agricultural, recreational, and other land uses, as well as fish and wildlife habitat. Reduced agricultural capability may result from: trench settlement and ponding, litter, soil compaction, rocks left on or near the surface, poorly restored drainage channels, and improper seed bed preparation. Poorly stabilized banks and slopes leading to watercourses may increase stream silt loads and create long-term impact on fish populations and habitat. Wildlife can be adversely affected by long line of sight or reduced food sources if the right of way is not revegetated following completion of construction.

14.3 PROTECTION MEASURES

During winter construction, some clean-up activities are not feasible due to frozen soil conditions. Points 1-16 apply to clean-up operations irrespective of construction season. Clean-up activities 17-29 should be delayed until the following spring prior to working of the land and when soils are dry enough to allow travel. However, if mainline construction is conducted in late fall or winter, all clean-up activities on lands

inaccessible in the spring or summer, such as muskeg, should be completed during the winter. Approval of clean-up by the landowner, or appropriate government agency when specified in approval documents, is required.

14.3.1 General (All Construction Seasons)

1. Remove all garbage and debris associated with pipeline construction from the right of way on a daily basis and dispose at an approved landfill site.

2. Commence clean-up immediately following backfill operations.

3. Conduct all clean-up, restoration, and revegetation activities during first pass of clean-up, if conditions permit. Complete all clean-up activities related to summer or early fall construction prior to freeze-up. When this is not feasible, complete all final grading and install erosion control devices prior to freeze-up.

4. Restore stream banks and approaches immediately following construction of water crossing (see Section 15.3).

5. Restore all drainage and watercourses to original location and to a stable condition. Restore beds and banks with clean granular material if erodible materials are exposed.

6. Restore all damaged property such as bridges, culverts and access roads to meet or exceed preconstruction condition.

7. Collect and dispose of all waste fuels, lubricating fluids, insecticides, herbicides and other chemicals in a manner which will not result in adverse environmental impact and in accordance with manufacturer specifications and government requirements.

8. Where required for erosion control on steep slopes, spread slash over right of way and walk down (see Drawing No. 8-2B).

9. Fell and dispose of leaning or damaged trees along the edge of the right of way.

10. Remove and dispose of slash used as corduroy in muskeg and swampy areas on private lands unless otherwise requested by landowner. Remove corduroy from public lands if obstruction of natural drainage occurs.

11. Install diversion berms and cross ditches on steep slopes to divert surface water off the right of way (see Drawings No. 14-1A, B and C).

12. Determine location, type, and direction of diversion berms

in the field based on local topography and drainage patterns. Ensure berms terminate in natural vegetation off the right of way.

13. When final clean-up is delayed until after spring break-up, install temporary erosion control devices to minimize erosion until permanent measures can be implemented.

14. Create microsites for revegetation on slopes by running cleat tracks perpendicular to slope or by other means such as rippers or brush rakes.

15. During winter clean-up operations, manually revegetate erodible slopes and watercourse banks with a nurse crop such as annual rye grass to promote early growth and slope stability. If muskeg or other wet soil conditions prohibit summer access, seed and fertilize the right of way by broadcasting on top of snow cover (see 14.3.2.21).

16. Erect warning signs to alert the public to the presence of a buried pipeline and to identify the contact person in the event of an emergency.

14.3.2 Non-Frozen Soil Conditions

1. Pick rocks prior to topsoil replacement where cultivated topsoils overlay subsoils containing gravel lenses, unless otherwise specified by the landowner. The average density and size of rocks picked should be no less than that existing on adjacent lands.

2. Replace topsoil evenly over stripped portions of the right of way if topsoil was not replaced during backfilling due to frozen conditions. Cease topsoil replacement during wet weather or high winds to prevent loss of topsoil (see Section 4.3). See Drawings No. 9-4A to E for notes on topsoil replacement.

3. Chisel plough in areas where stone is present and pick rocks from the plow layer. Dispose of rock in a manner acceptable to landowner. The average density and size of rock left on the right of way should be no less than that on adjacent lands.

4. In cultivated lands, cultivate the entire right of way to a depth adequate to alleviate compaction and in a manner acceptable to the landowner. Limit cultivation in areas of light soil to prevent powdering of the soil.

5. Seed and fertilize the right of way as requested by landowner. Use seed mix, fertilizer, and respective application rates approved by landowner. The Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife may require the addition of palatable species to the seed

for specific wildlife areas. Use only certified seed from a local source and keep the certificates to present to the landowner at his request. Schedule seeding for periods when potential for seed germination is high.

6. Drill, rather than broadcast, seed where terrain and soil conditions permit. Seed and fertilize slopes greater than 20%, and wet soils manually or aerially to minimize surface disturbance. Manually seed and fertilize berms and other erosion control necessary to ensure immediate revegetation or soil stability. Utilize hydroseeders, mulches, tackifiers, netting or other suitable methods.

7. If necessary, install temporary fences to restrict grazing of seeded right of way until plantings become established. Install snow fence or other suitable wind break to allow plants to establish on soils susceptible to wind erosion. Utilize straw crimping or mechanically create microsites to promote germination of seeds on dry areas susceptible to wind erosion.

8. Plant shrubs on right of way at road intersections or in staggered blocks to limit the line of sight in forested areas of high aesthetic value or to encourage use of habitat by wildlife (see Drawings No. 14-2 and 14-3). Refer to Drawings No. 6-3, 6-4, and 10-1 for other methods of restricting line of sight.

9. Consult with landowner prior to commencement of final clean-up program.

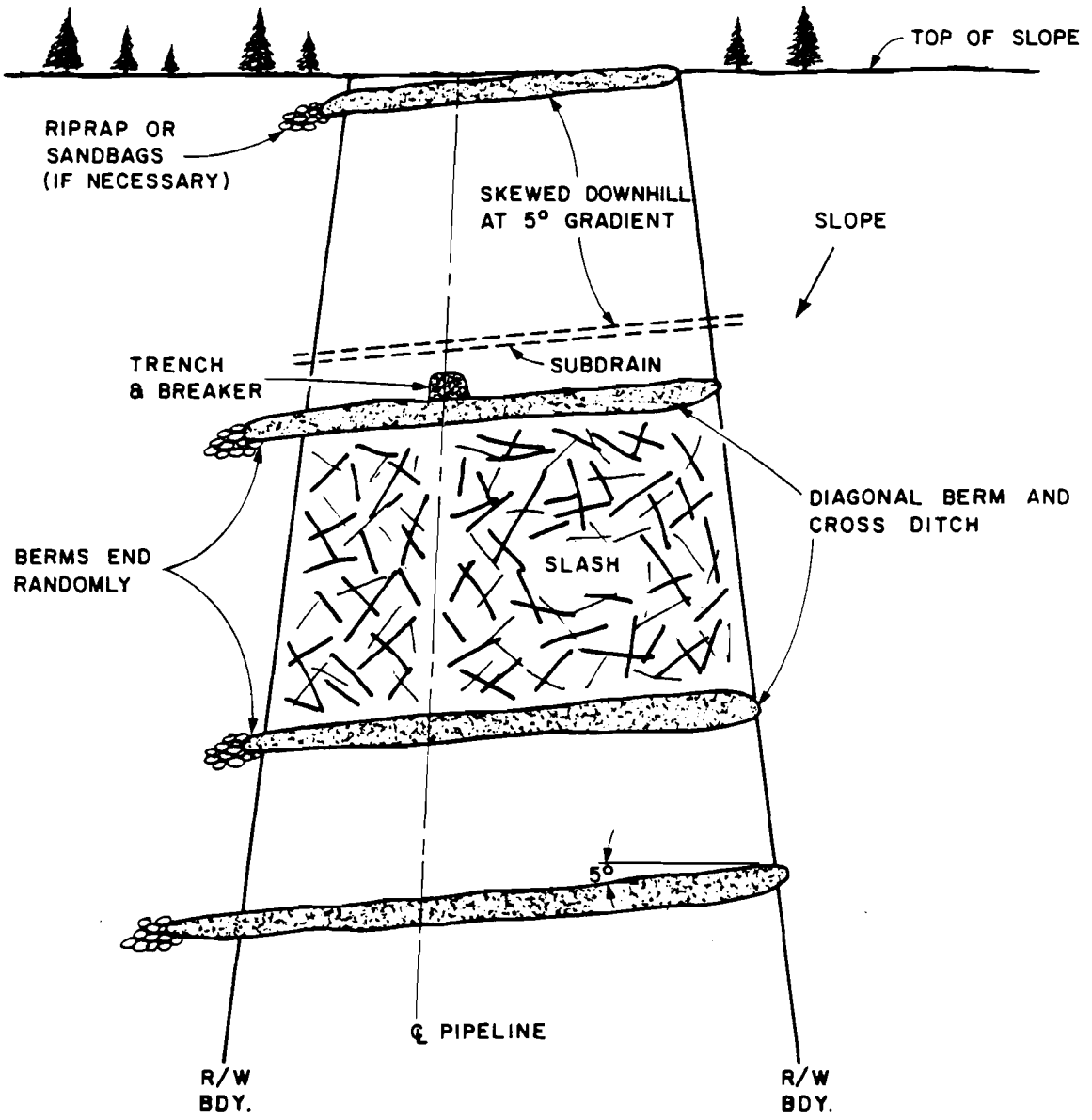
10. Allow for natural encroachment of shrubs by minimizing vegetation control practices.

11. Identify and immediately restore areas with erosion problems. Regrade areas with vehicle ruts and erosion gullies. Regrade trench depressions and excessive roaches which may interfere with natural drainage or land use. Inspect stream banks and approaches to water crossings to assess erosion control measures. If erosion is evident, conduct remedial work immediately. Reseed areas which have not revegetated within one growing season.

12. Utilize weed control measures in conjunction with the landowner.

13. Replace temporary gates with permanent fences unless otherwise requested by the landowner (see Section 7.3 and Drawing 7-1).

14. Avoid using a restored right of way for construction traffic.



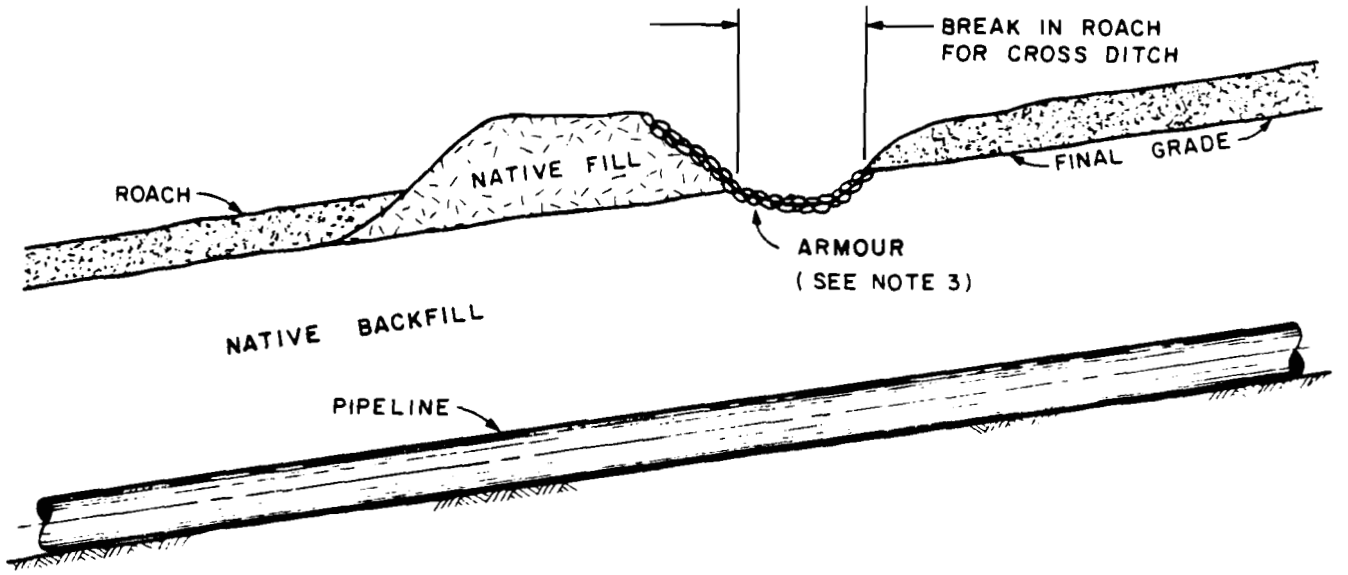
PERSPECTIVE

N.T.S.

Notes

1. Install subdrains and trench breakers to collect and remove groundwater flow from right of way (Dwgs. No. 12-3a, 12-3b and 12-4).
2. Install berms and cross ditches immediately downslope of trench breakers to collect seepage forced to the surface and divert off the right of way (Dwgs. No. 14-1b and 14-1c). Berms should extend at least 2 m off the right of way to minimize the potential for berms to erode at their ends and runoff flowing down the right of way.
3. Rollback slash and walk down with bulldozer on erodible slopes (Dwg. No. 8-2b).

DRAWING No. 14-1A LAYOUT OF SLOPE EROSION CONTROL STRUCTURES

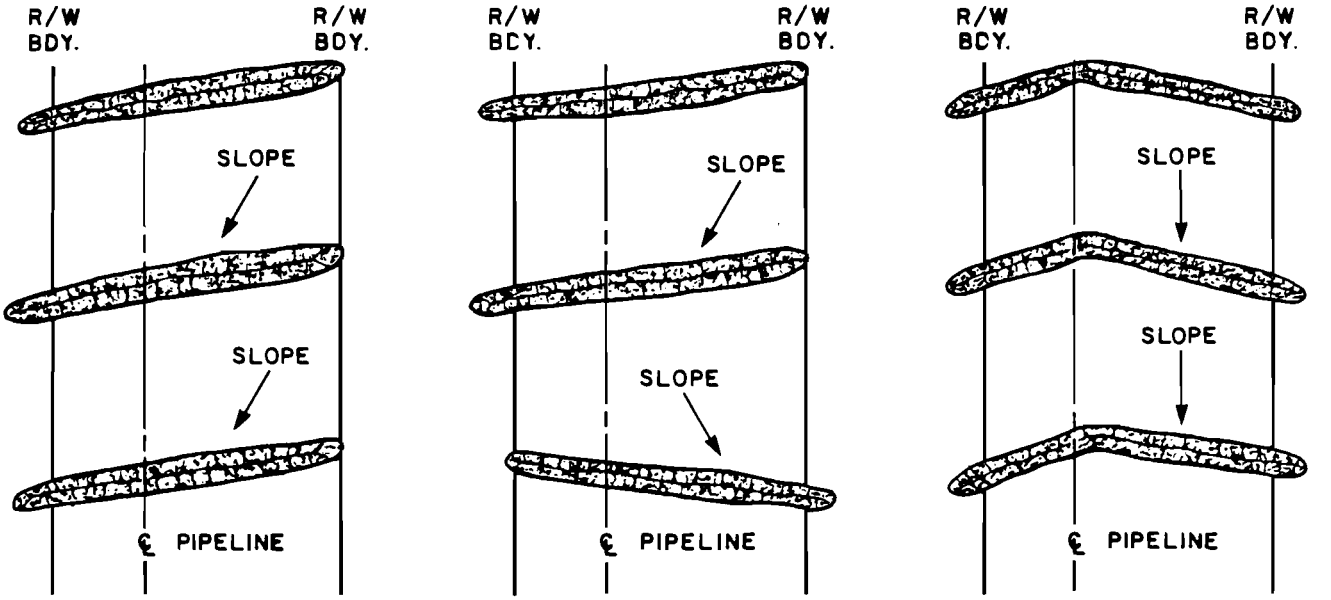


PROFILE
N.T.S.

Notes

1. Install diversion berm and cross ditch on steep slopes to divert surface water off the right of way. Also install berms immediately downslope of trench breakers to collect seepage forced to the surface.
2. Skew berm across the right of way 5° to prevent water pounding behind berms.
3. Construct diversion berm of compacted native soils. Avoid use of snow, ice, or organic material. Where native material is highly erodible, protect upslope of berm and base of cross ditch with riprap or armour. Armour upslope face of berm with earth filled sand bags. Diversion berms may also be constructed of logs or sandbags.
4. Typical diversion berm heights and widths are approximately 1 m each for winter construction and 0.75 m for summer construction. Berms constructed in winter should be inspected during the following spring; replace or restore berms as required.
5. Leave a break in roach immediately upslope of diversion berm and cross ditch.

DRAWING No. 14-1B DIVERSION BERM AND CROSS DITCH



DIAGONAL BERMS ONE-WAY SURFACE FLOW

DIAGONAL BERMS TWO-WAY SURFACE FLOW

HERRINGBONE BERMS ONE-WAY SURFACE FLOW

N.T.S.

Notes

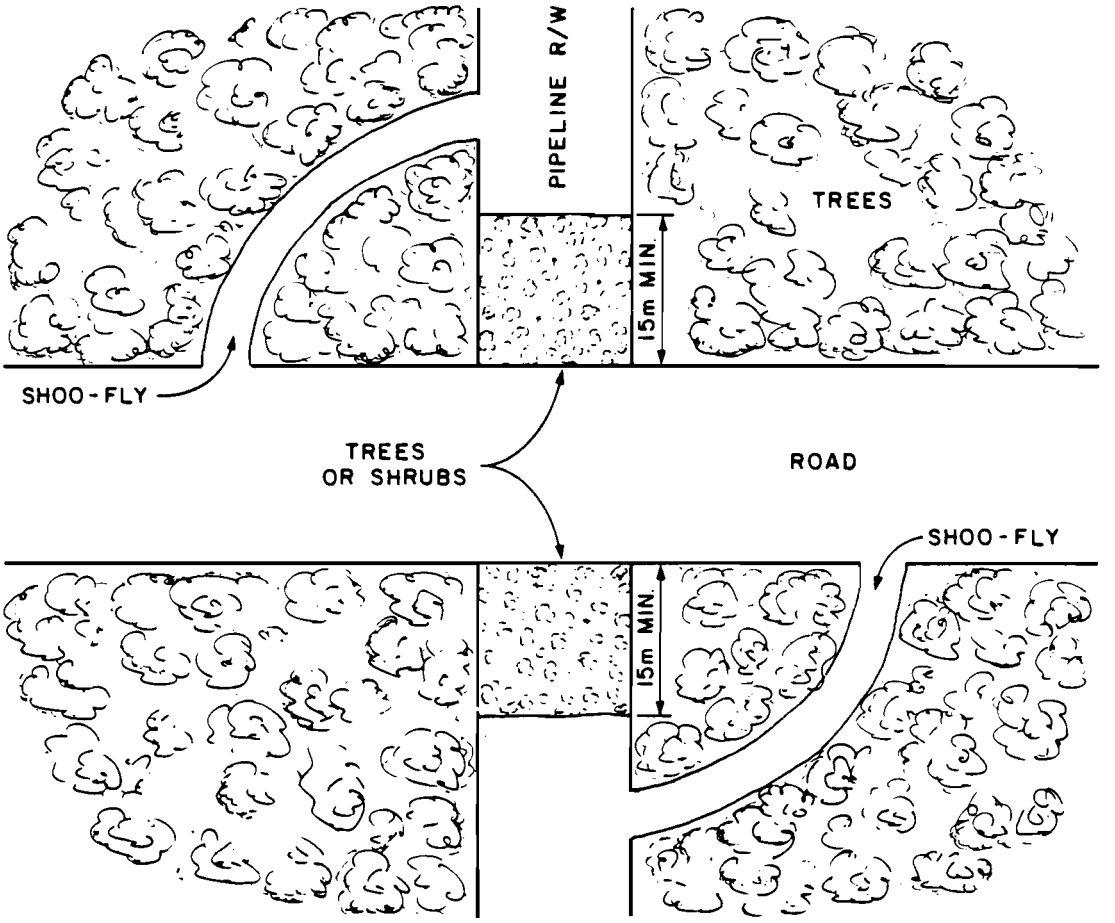
1. Use diagonal berms where direction of slope and surface water movement is oblique to pipeline right of way.
2. Use herringbone berm and cross ditch where direction of slope and surface water movement is parallel to right of way.
3. Determine location and direction of berm based on local topography and drainage patterns. Also, install berms immediately downslope of trench breakers. Skew berms 5° to prevent water ponding behind berms. Extend berms a minimum of 2 m off the right of way.
4. Typical diversion berm spacing:*

Slope Gradient (%)	Typical Spacing (m)**
less than 15	as required
15 - 20	60
20 - 25	45
25 - 30	35
greater than 30	20 - 30

* From Marshall and Ruban, 1983.

** Rely on field judgement to determine appropriate spacing. For example, highly erodible materials, such as glacial-lacustrine parent materials, install berms approximately 50% closer than indicated above.

DRAWING No. 14-IC DIVERSION BERM CONFIGURATIONS AND SPACING

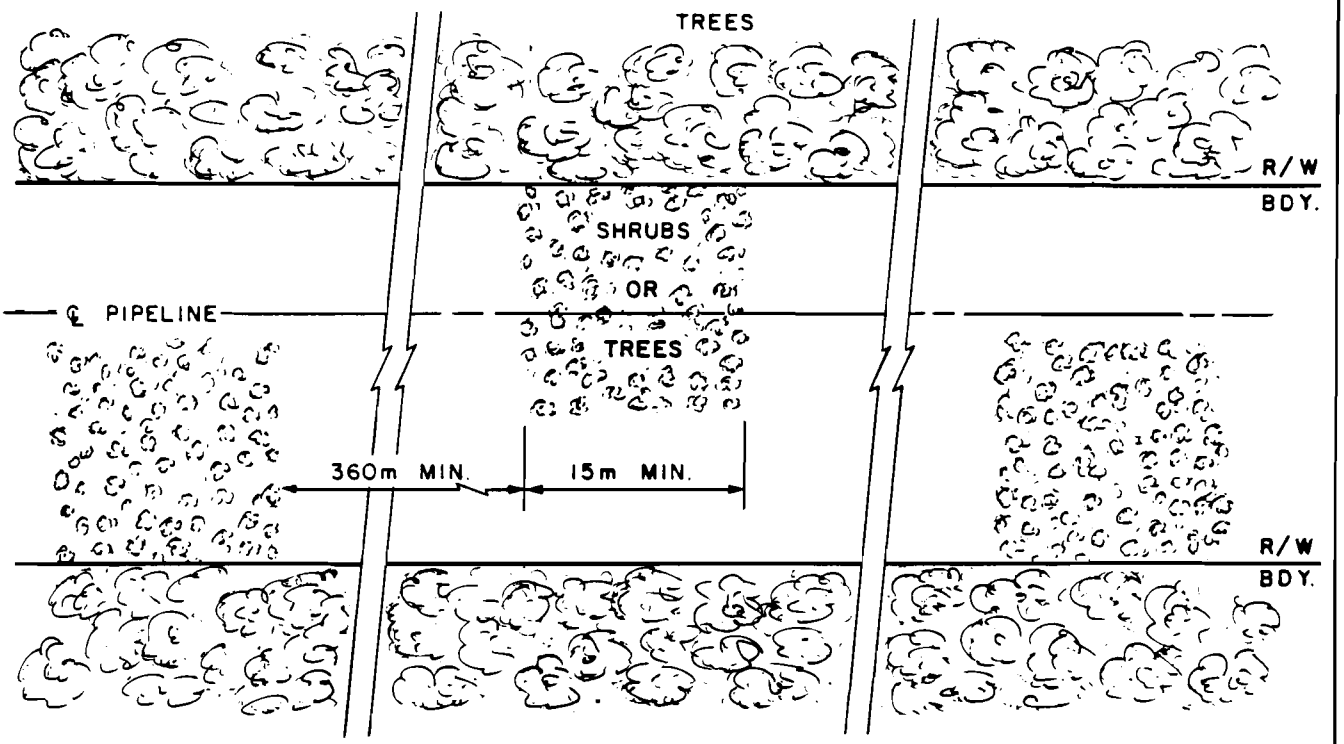


PLAN VIEW
N.T.S.

Notes

1. Plant trees or shrubs on right of way at road intersections to limit line of sight in forested areas of high aesthetic value. Use native species which will attain heights of over 2 m.
2. If post construction access is required from road to pipeline right of way, construct a curved shoo-fly.

DRAWING No. 14-2 RIGHT OF WAY OR ROAD INTERSECTION REVEGETATION SCREEN



PLAN VIEW

N.T.S.

Notes

1. Plant blocks of trees or shrubs to limit line of sight along right of way in forested areas of high aesthetic value and to encourage wildlife habitat utilization in key wildlife areas. Use native species which will attain heights of over 2 m. Natural enroachment of shrubs may be encouraged by minimizing vegetation control practices.
2. Extend revegetation blocks over centre line of right of way.

Source: After Stubbs and Markham, 1979.

DRAWING No. 14-3 REVEGETATION BLOCKS

15.0 WATER CROSSINGS

15.1 DESCRIPTION

Water crossings involve three activities. First, construction equipment must cross the watercourse via fords, bridges or other structures. Second, the pipe is installed under the bed of the watercourse with sufficient cover to protect it from scouring. Normally, the trench is excavated through the flowing watercourse with a backhoe, clam or dragline and the trench spoil is piled on the banks or in the watercourse. The pipe is then weighted and lowered-in or pulled into the trench. Third, the trench is backfilled and the banks restored. In some cases, alternative methods are used to install the pipe without excavating a trench in the watercourse. These alternatives are known as dry crossing methods.

15.2 POTENTIAL IMPACTS

Water crossings, particularly wet crossing methods, are one of the major environmental concerns associated with pipeline construction. Poor construction schedules or inadequate protection measures can damage fish habitat and harm aquatic life, as well as interfere with downstream water users. Pipeline construction may cause: alteration of stream substrates, physical or chemical changes in water quality such as sediment loading, interruption of stream flow, or blockage of fish movements. Many of these impacts are relatively short term in that the impact ceases soon after completion of the crossing. However, long term impacts may occur if the adjacent right of way is not revegetated or if the banks are not properly restored.

15.3 PROTECTION MEASURES

The following points cover the most commonly accepted methods of constructing water crossings. Due to the number of alternative methods available, it is not possible to cover all aspects of pipeline water crossings in the handbook. Hence, only selected methods are described. The documents listed in the References offer a more comprehensive treatment of pipeline water crossings.

15.3.1 Vehicle Crossings

1. Use Table 1 as a general guide for selection of vehicle crossing methods. Alternative vehicle crossing methods are shown on Drawings No. 15-1A to 1E.

2. Obtain the permission of Fish and Wildlife Division, Alberta Forestry, Lands and Wildlife, prior to installing crossing structure.

3. Install vehicle crossing structure as part of clearing operation so that no construction equipment need ford the watercourse, unless use of a ford is approved (see 8.3).

4. Remove crossing structures, restore and stabilize stream beds, banks, and other disturbed areas when the vehicle crossing is no longer required.

15.3.2 Pipe Installation

1. Obtain approvals from the appropriate authority prior to construction of any pipeline watercourse crossing.

2. If extra right of way is required, obtain permission and mark it prior to initiation of watercourse crossing.

3. Hand-clear slopes leading to watercourses. Fell trees away from watercourses to reduce damage to aquatic habitat. Trees, debris, or soil inadvertently deposited within the high water mark of watercourses should be immediately removed in a manner that minimizes disturbance of the bed and banks.

4. Do not skid or yard trees across a watercourse. Do not push logs into a watercourse.

5. Save non-merchantable timber in the proximity to the watercourse for possible use in vehicle crossing structures or bank restoration (see Drawing No. 14-1B and 14-3B).

6. Do not place fill material in a watercourse during grading. However, if potential bank restoration problems exist, the Fish and Wildlife Division of Albert Forestry, Lands and Wildlife may request that special bank restoration techniques be used (see Drawings No. 15-2D, 15-3A, 15-3B and 15-3C).

7. Do not grade the entire width of the right of way in proximity to a watercourse.

8. Delay grubbing slopes next to a watercourse or within 10 m of the watercourse banks until construction of crossing is imminent. Leave an undisturbed organic mat within buffer zone to limit potential for sediment to enter the watercourse.

Table 1
Watercourse Vehicle Crossing Methods

CROSSING METHOD	<6 m WIDE <0.6 m DEEP			6 - 15 m WIDE 0.6 - 1.0 m DEEP			>15 m WIDE >1.0 m DEEP		
Ford	X								
Logfill or Swamp Mat	X	X							
Culvert	(X)	X		X	X				
Ice Bridge	(X)	X	X	X	X	X	X	X	X
Temporary Bridge	(X)	(X)	X	(X)	(X)	X	X	X	X
Existing Bridge	(X)	(X)	X	(X)	(X)	X	X	X	X
	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
	Environmental Sensitivity								

Notes

1. This table is intended as a general guide to environmentally acceptable crossing methods in the absence of specified conditions on Water Crossing Permits. Other factors to be considered include: bed and bank composition and stability, bank height, water velocity, cost, and engineering requirements (such as type and weight of equipment, anticipated number of trips, and availability of materials).

2. X the method is environmentally acceptable.
   (X) the method is environmentally acceptable, however, it is not practical in most cases, considering lower environmental sensitivity and higher construction cost.

3. Environmental Sensitivity levels are defined below. Note that Alberta Forestry, Lands and Wildlife or Alberta Environment may define sensitivity of a particular crossing.

Low

— no downstream water users, and
— sport fish absent or present in low numbers during non-sensitive time period

Moderate

— downstream water users, or
— warm water sport fish sensitive habitat within zone of potential crossing-related sedimentation

High

— downstream water users cannot tolerate increased sediment load, or
— cold water sport fish sensitive habitat within zone of potential crossing-related sedimentation

9. Stop trenching activities short of watercourse banks so that silt-laden water is prevented from entering the watercourse by hard trench plugs. The recommended minimum plug width is 3 m.

10. Do not allow trenching operations to drain sloughs and other standing waterbodies unless permission has been granted by the landowner or government agency having jurisdiction. Leave hard plugs or install soft plugs as required.

11. Ensure that all necessary equipment and materials are on site and ready for installation prior to commencing water-crossing construction.

12. Do not wash equipment or machinery in waterbodies.

13. Inspect hydraulic, fuel, and lubrication systems of equipment used in water crossing to ensure that systems are in good condition and free of leaks. Prevent the discharge of materials toxic to fish or other aquatic life into watercourses. To prevent water pollution, mobile construction equipment should not be serviced or refuelled within 100 m of a watercourse.

14. In watercourses where control of sedimentation is not a major concern, use the wet crossing method (Drawing No. 15-2A). Conduct all in-stream activity quickly during the timing window approved by the Fish and Wildlife Division, Alberta Forestry, Lands and Wildlife, to minimize the duration and severity of disturbance. If it is not feasible to construct the crossing during the approved timing window, use an alternative crossing method approved by the Fish and Wildlife Division and Alberta Environment, Water Resources Administration Division to minimize construction impacts on fish, fish habitat, and downstream water users. Selected alternative crossing methods are presented on Drawings No. 15-2B to 15-2E. Use Table 2 as a general guide for selection of an appropriate water crossing construction method.

15. Leave hard plugs in trench at watercourse banks as long as possible. When removing hard plugs, install soft plugs where necessary to prevent silt-laden water within trench from entering watercourse. De-water trench onto stable surfaces in a manner that does not cause erosion of soils or sediment to run into watercourses.

16. On watercourses less than 20 m in width, pile trench spoil on the banks and not in the water. For larger watercourses, place spoil in discrete instream piles away from areas of highest water velocity. Do not windrow spoil across channel or block more than one third of the stream channel.

17. If necessary, construct a berm or filter consisting of saddle weights, boulders or staked straw bales to prevent spoil pile on banks from flowing back into the watercourse.

Table 2
Selected Water Crossing Construction Methods

WATER CROSSING CONSTRUCTION METHOD	< 10 m WIDE Flow Condition 3A			10 - 20 m WIDE Flow Condition 3B			> 20 m WIDE Flow Condition 3B		
Backhoe	X			X			X	X (5)	X (5)
Dragline or Clam	(X)			(X)			X	X (5)	X (5)
Dam and Pump	(X)	X	X	(X)					
Flume	(X)	X	X	(X)					
Boring or Punching	(X)	(X)	(X)	(X)	X	X			
Directional Drilling	(X)	(X)	(X)	(X)	(X)	(X)	X	X	X
	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
				Environmental Sensitivity					

Notes

1. This table is intended as a general guide to environmentally acceptable crossing methods to be used in the absence of specified conditions on Water Crossing Permits. Additional factors which should be considered include: bed and bank composition and stability, bank height, water depth and velocity, cost, and engineering requirements (such as availability of equipment).

2. X the method is environmentally acceptable.
   (X) the method is environmentally acceptable, however, is not practical in most cases, considering lower environmental sensitivity and higher construction cost.

3. Flow Condition A — flow can readily be handled by portable pump(s) or flume pipe(s).
   Flow Condition B — flow exceeds level which can be handled by portable pump(s) or flume pipe(s).

4. Environmental Sensitivity levels are defined below. Note that Alberta Forestry, Lands and Wildlife, or Alberta Environment, may define sensitivity of a particular crossing. Crossing of watercourses with Moderate or High Environmental Sensitivity within approved timing windows will generally permit use of construction method recommended for Low Sensitivity.

   Low
   - — no downstream water users, and
   - — sport fish absent or present in low numbers during non-sensitive time period

   Moderate
   - — downstream water users, or
   - — warm water sport fish sensitive habitat within zone of potential crossing-related sedimentation

   High
   - — downstream water users cannot tolerate increased sediment load, or
   - — cold water sport fish sensitive habitat within zone of potential crossing-related sedimentation

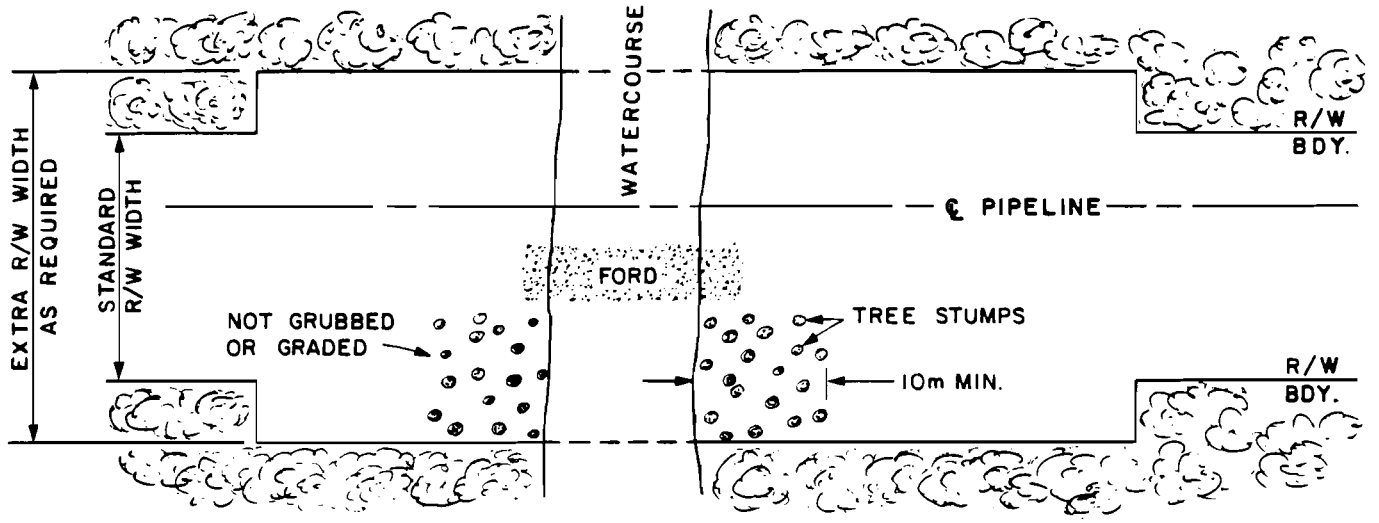
5. Although use of this method may result in high sediment loads, alternate construction methods are limited. The use of a backhoe or clam may not be feasible for watercourses with depths > 1.2 m or with soft stream bed conditions; alternatives include mounting the equipment on a submerged sled or floating barge.

18. Permission is required from the Regional Habitat Biologist when explosives are to be used in watercourses frequented by fish. When sport fish are concentrated in a crossing area requiring blasting, use blast deflectors or absorbers and smallest charges feasible, to minimize blasting impacts. Remove fish and block their access to the crossing area, if feasible.

15.3.3 Restoration

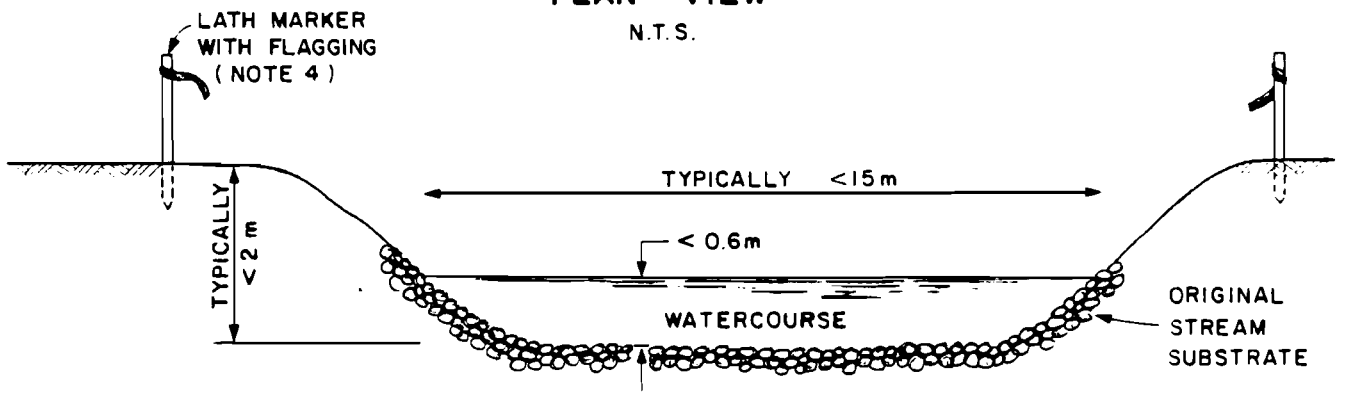
1. Backfill with original stream bed material to original contour. At water crossing sites where sport fish spawn, backfill upper layer of trench with material of a composition equal to, or better than, original bed material.

2. Immediately following backfill operations, restore and stabilize stream banks to original contour and revegetate with herbaceous species, and where necessary, with shrub cuttings to provide shade and cover. If slopes are less or equal to 1.5:1, armour stream banks to ensure that bank erosion does not occur (Drawing No. 15-3A). Where preconstruction stream bank provided significant fish habitat, construct overhanging banks or abrupt banks (see Drawings No. 15-3B and 15-3C).



PLAN VIEW

N.T.S.



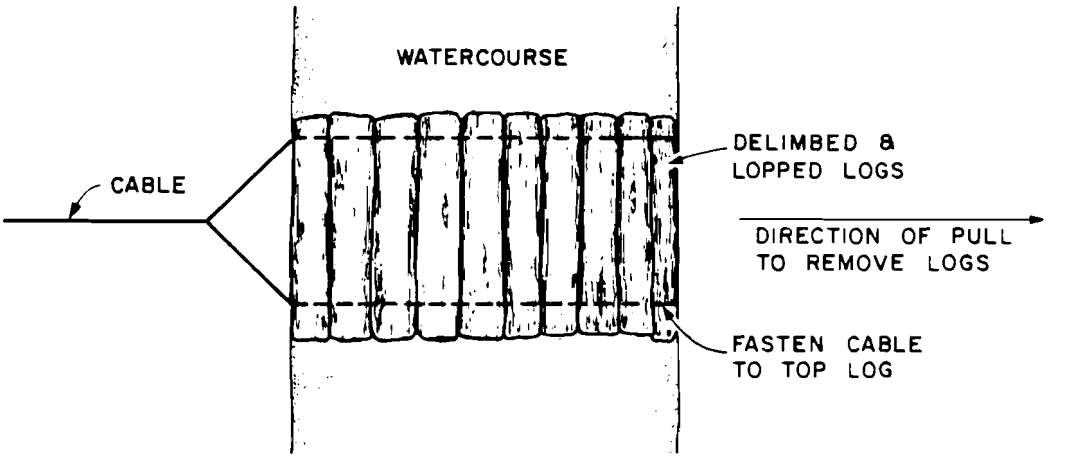
PROFILE ENLARGEMENT

N.T.S.

Notes

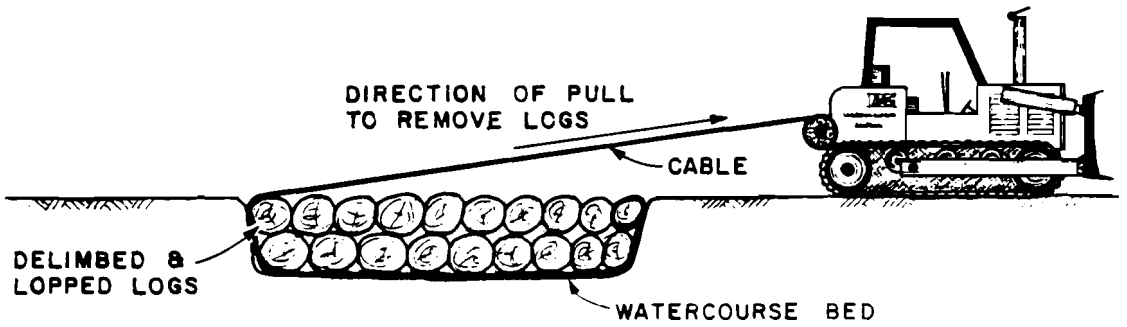
1. Utilize fords to provide vehicular access across relatively shallow and narrow watercourses with granular beds and stable banks.
2. Minimize grading in proximity to watercourse. Grade and grub only along the trench line and an area immediately adjacent to the trench line. Pull dirt and debris away from watercourse if banks require sloping.
3. Stabilize banks and approaches with granular blanket.
4. Mark boundaries of ford on both sides of crossing to confine all vehicle traffic to ford.
5. Restore and stabilize beds and banks when ford is no longer required. Granular blanket need not be removed if it is not a barrier to fish during low flow conditions.

DRAWING No. 15-1A VEHICLE CROSSING - FORD



PLAN VIEW

N.T.S.



PROFILE

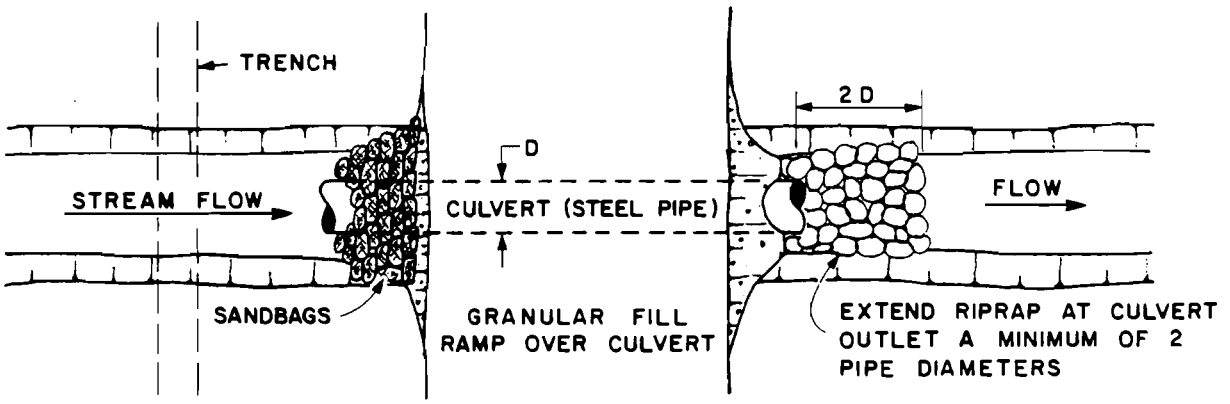
N.T.S

Notes

1. Utilize logfill to provide vehicular access across small watercourses with square or v-shaped channels to minimize sedimentation and stream bed disturbance. Logfills are not appropriate where fish passage is required. Logfill should not impede flow or cause flooding. A variation of the logfill method use is of a pre-fabricated swamp mat.
2. Install cable under the logs or cable logs together to facilitate removal.
3. Add compacted snow if necessary to bring up to grade. If soil is used, install a filter fabric or equivalent to prevent soil from entering watercourse.
4. Remove crossing at completion of construction and prior to spring break-up.

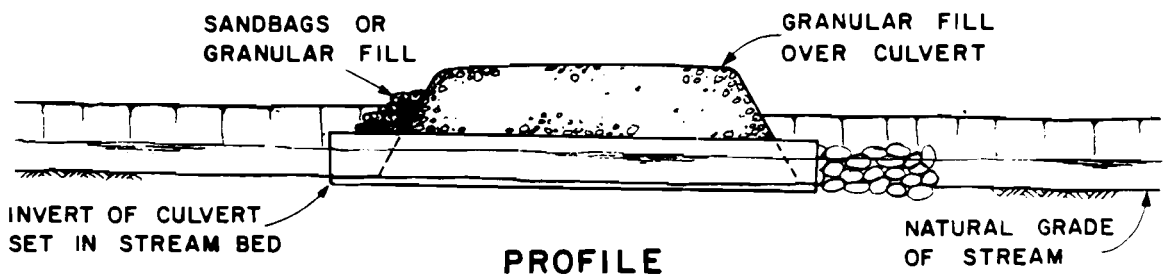
Source: Adapted from Peace Pipe Line Ltd., 1983.

DRAWING No. 15-1B VEHICLE CROSSING - LOGFILL



PLAN VIEW

N.T.S.



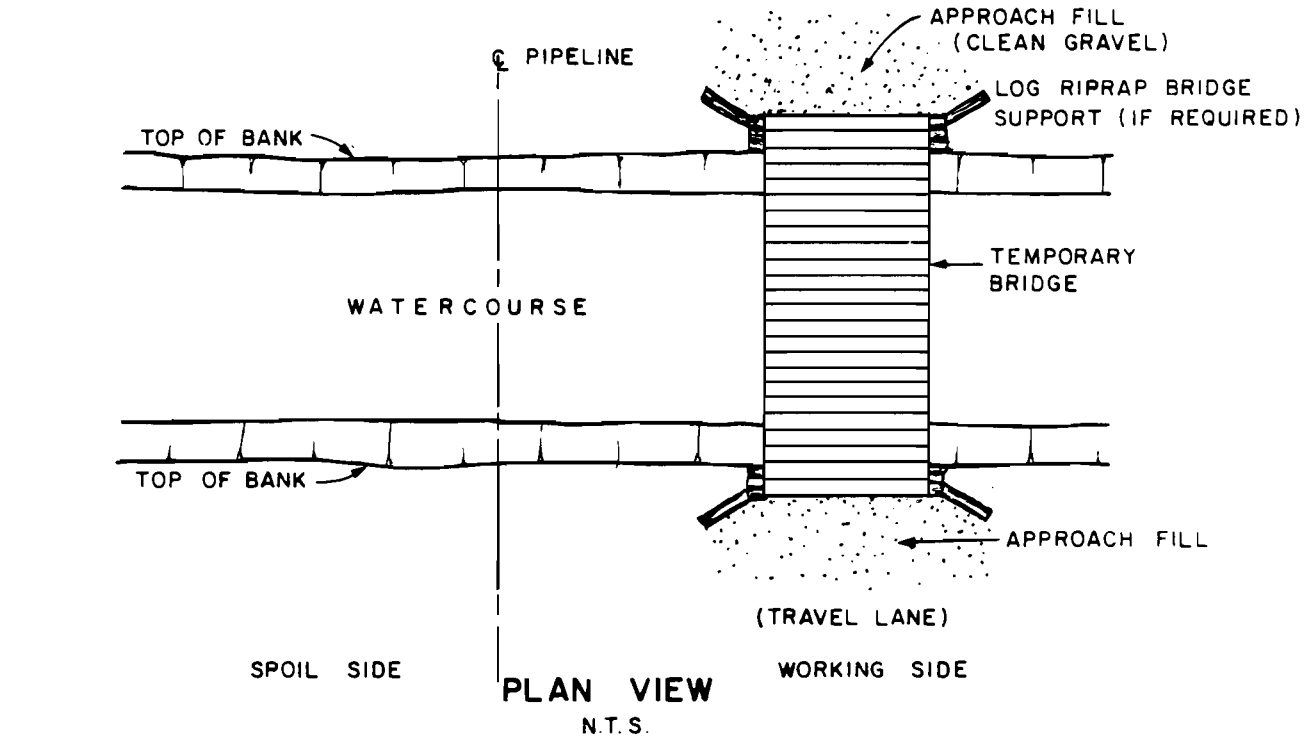
PROFILE

N.T.S.

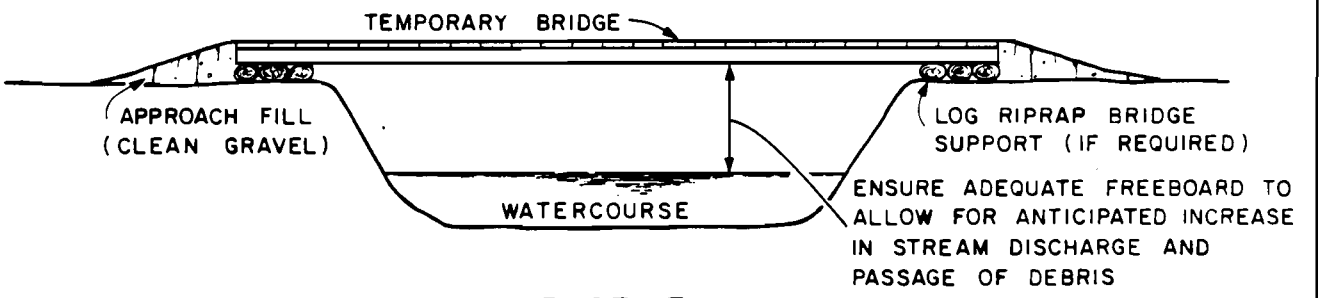
Notes

1. Use culverts to allow vehicles to cross relatively narrow watercourses where sedimentation must be minimized or fish passage allowed. See Drawing No. 14-2c if culvert is to be extended across trench.
2. The following guidelines apply to culverts where fish passage (i.e., spawning migration) is required while culverts are in place: minimum water depth of 0.2 m; maximum average water velocity of 0.5 m/s for warm water species and 0.9 m/s for cold water species; culvert sized to handle 1:25 year peak flow and to ensure that maximum allowable water velocities are not exceeded for more than 3 days during 1:10 year design flood; and minimum culvert diameter is 1 m.
3. Place culvert inverts below the natural grade line of stream at an angle which does not exceed normal stream gradient. Depth of placement is dependent upon bed type, culvert size and expected flow conditions.
4. Remove temporary culverts and ramp material as soon as no longer required; remove culvert and ramp prior to spring break-up.
5. Restore and stabilize stream bed and banks.

DRAWING No. 15-1C VEHICLE CROSSING – CULVERT



PLAN VIEW
N.T.S.

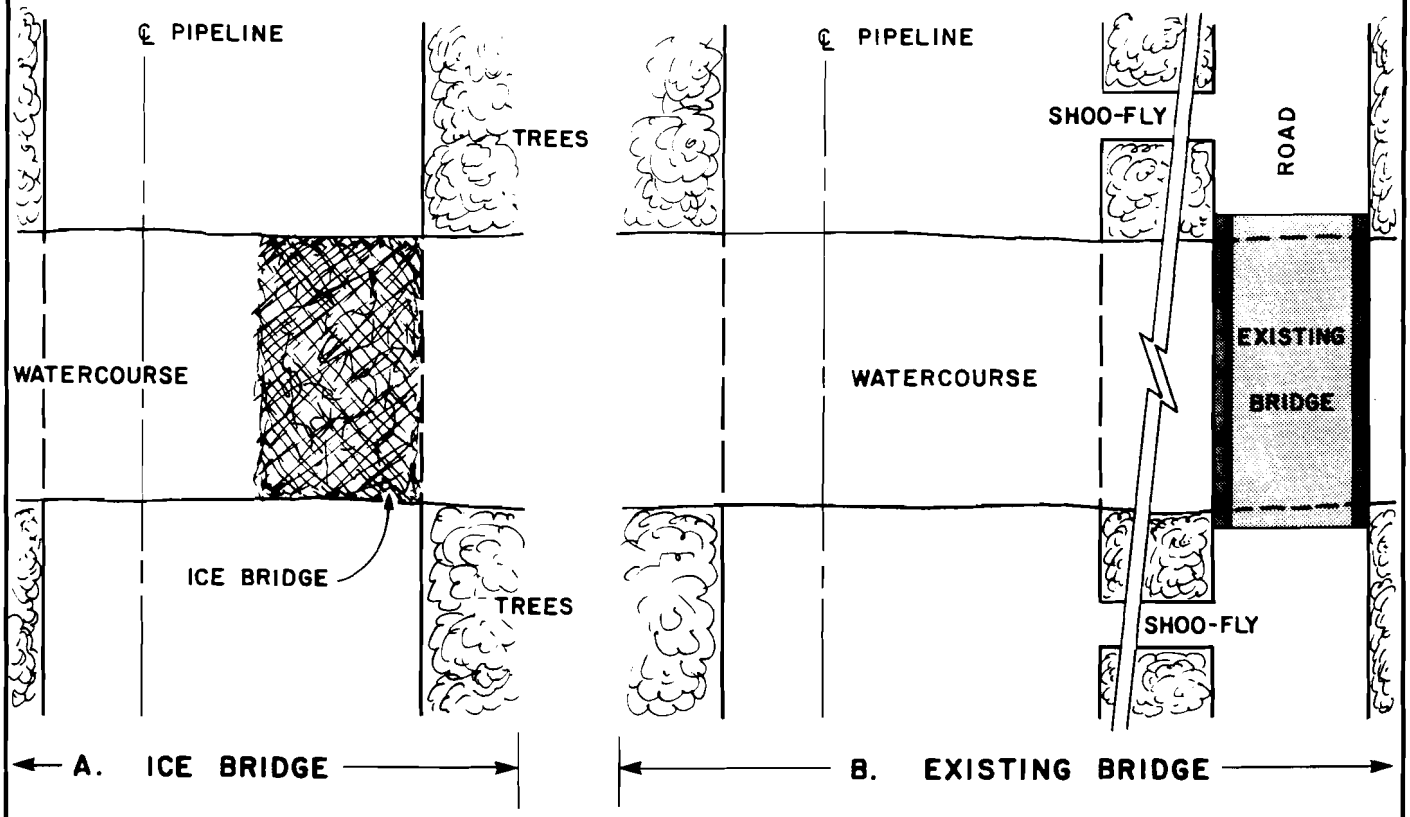


PROFILE
N.T.S.

Notes

1. Use a temporary bridge to allow vehicles to cross a watercourse which is highly sensitive or which has unstable bed and banks. Bridges are also used where watercourses are too deep, wide or fast to permit an alternate crossing structure. This method minimizes sedimentation of the watercourse, and stream bank and bed restoration work. It is generally limited to watercourses less than 30 m in width.
2. Utilize approach fills of clean granular material rather than cuts in stream banks to minimize erosion potential. Do not constrict flow with approach fill or support structures.
3. Remove bridge as soon as possible after use. Remove support structures and approach fills. Restore and stabilize banks.
4. Where required install apron of logs or plywood to ensure that fill material does not spill into the watercourse.

DRAWING No. 15-1D VEHICLE CROSSING – TEMPORARY BRIDGE



PLAN VIEW
N.T.S.

Notes

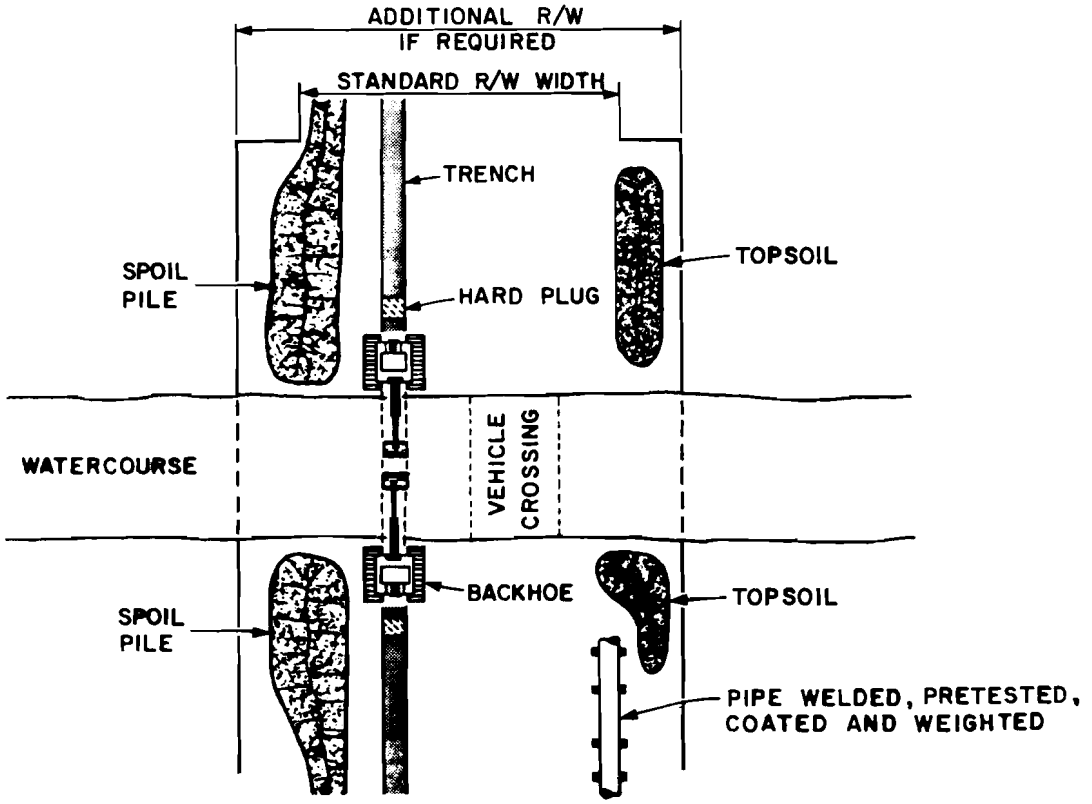
a. Ice Bridge

1. Use ice bridges on winter projects when a safe ice thickness can be maintained.
2. Locate ice bridges at sites with gently sloping banks to minimize cuts in watercourse banks. Use snow and ice to slope approaches, rather than cut banks.
3. Flood ice surface with water and cover with snow to increase load bearing capacity. Logs may be used as a base to strengthen the bridge. Ice bridge should not impede flow. Remove logs and breach ice bridge by physical means prior to spring break-up.
4. Restore and stabilize stream banks and approaches.

b. Existing Bridge

1. Use existing bridge to prevent sedimentation of watercourse, bank disturbance, and alteration of stream beds caused by vehicles crossing the watercourse.
2. Locate shoo-flies as far from watercourse as practical to minimize clearing and grading in proximity to watercourse.
3. Restore shoo-flies as part of the main right of way clean up.

DRAWING No. 15-1E ICE BRIDGE AND EXISTING BRIDGE



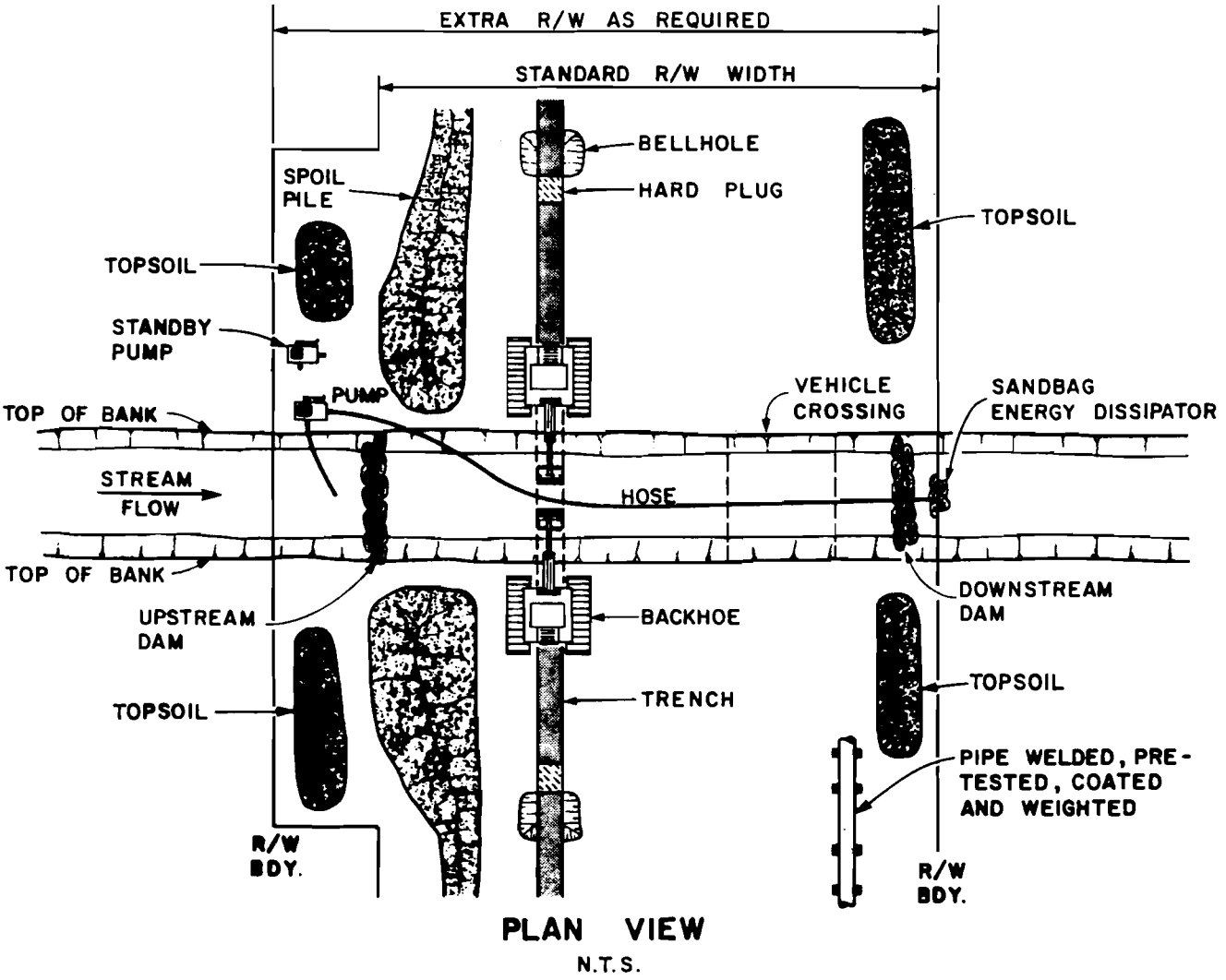
PLAN VIEW

N.T.S.

Notes

1. Use a wet crossing when control of sedimentation is not a major concern.
2. Schedule construction during low flow period and the appropriate timing window to minimize fisheries impacts. Check the weather forecast and postpone construction if it is probable that heavy rains or run-off will occur over the proposed crossing period.
3. Obtain permission and stake extra right of way if required. Keep vehicles within stakes.
4. Install vehicle crossing if required during clearing so that no vehicles need ford the watercourse. (See Drawings No. 15-1a to 1e).
5. Stop trenching activities short of watercourse banks. Retain hard plugs as long as possible.
6. Pipe should be welded, pre-tested, coated and weighted prior to initiating pipe installation.
7. Trench through watercourse, maintaining hard plugs at each bank until just prior to pipe installation. If necessary to control water flow and trench sloughing, install temporary soft plugs and dewater trench onto stable vegetated land, not directly to watercourse. Work from both banks and pile spoil on land if possible. Lower in pipe and backfill immediately. Trenching and backfilling should be completed in the same day if possible. Utilize two backhoes if necessary to expedite the crossing.
8. Remove vehicular crossing, restore banks to original condition, and stabilize as required.

DRAWING No. 15-2A WET CROSSING



PLAN VIEW

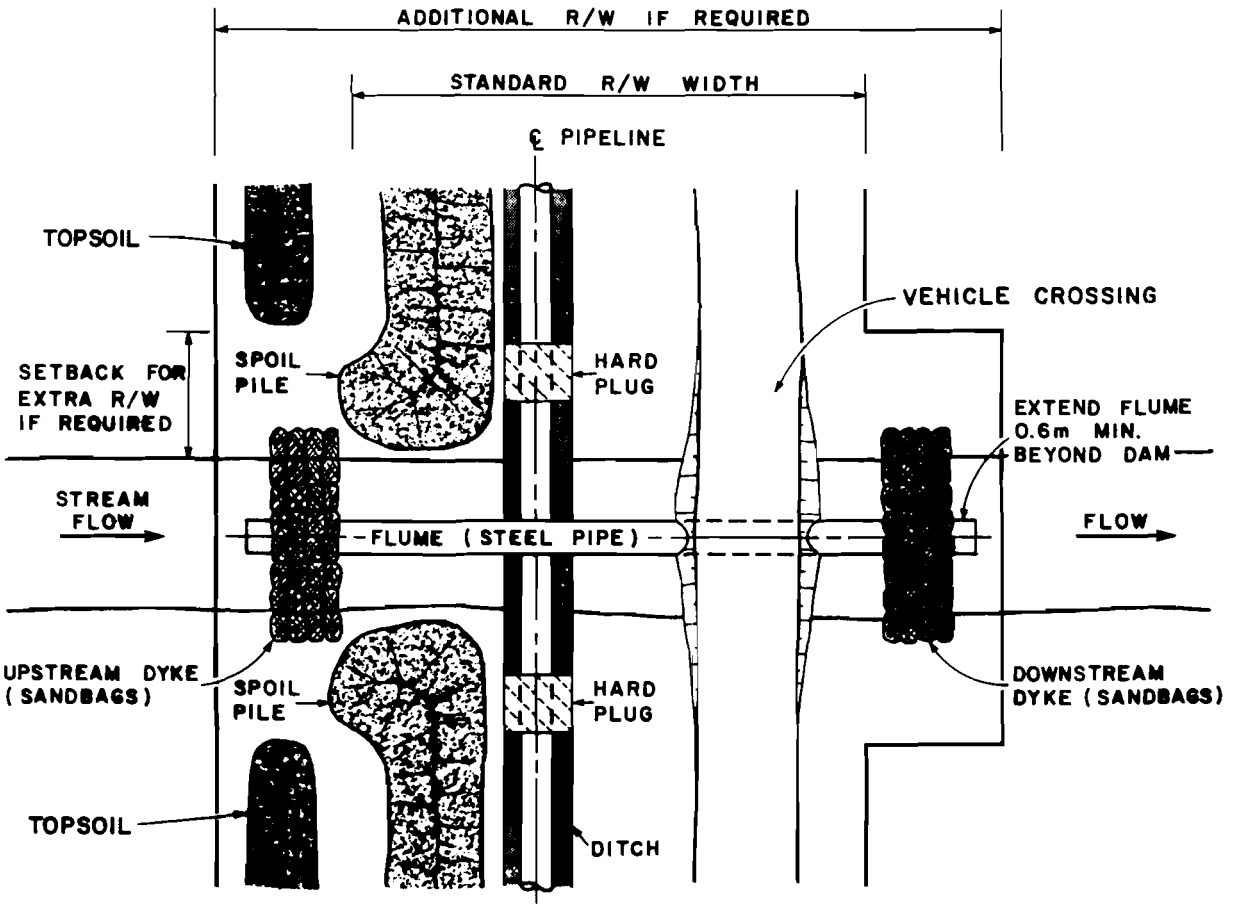
N.T.S.

Notes

1. Use dam and pump method on narrow watercourses with limited stream flow to prevent sedimentation and interruption of stream flow during crossing construction. If fish passage is a concern, this method is not appropriate.
2. Schedule construction during low flow period. Follow Notes 2-8 on Drawing No. 15-2a.
3. Set up pump and hose as shown, or use other practical alternatives. Pump should have twice the pumping capacity of anticipated flow. Have standby pump on site.
4. Install upstream dam composed of sandbags or clean gravel with plastic liner. Install downstream dam if required to keep stream bed dry.
5. Excavate trench and lower in pipe under hose. Move hose as required or disconnect if temporary flow blockage is acceptable. Backfill trench.
6. Dismantle downstream dam, then upstream dam. Keep pump running to maintain stream flow.

Source: Adapted from Mutrie-Wishart Environmental Consultants, 1983; Tera Environmental Consultants (Alta) Ltd. 1983.

DRAWING No. 15-2B DAM AND PUMP METHOD



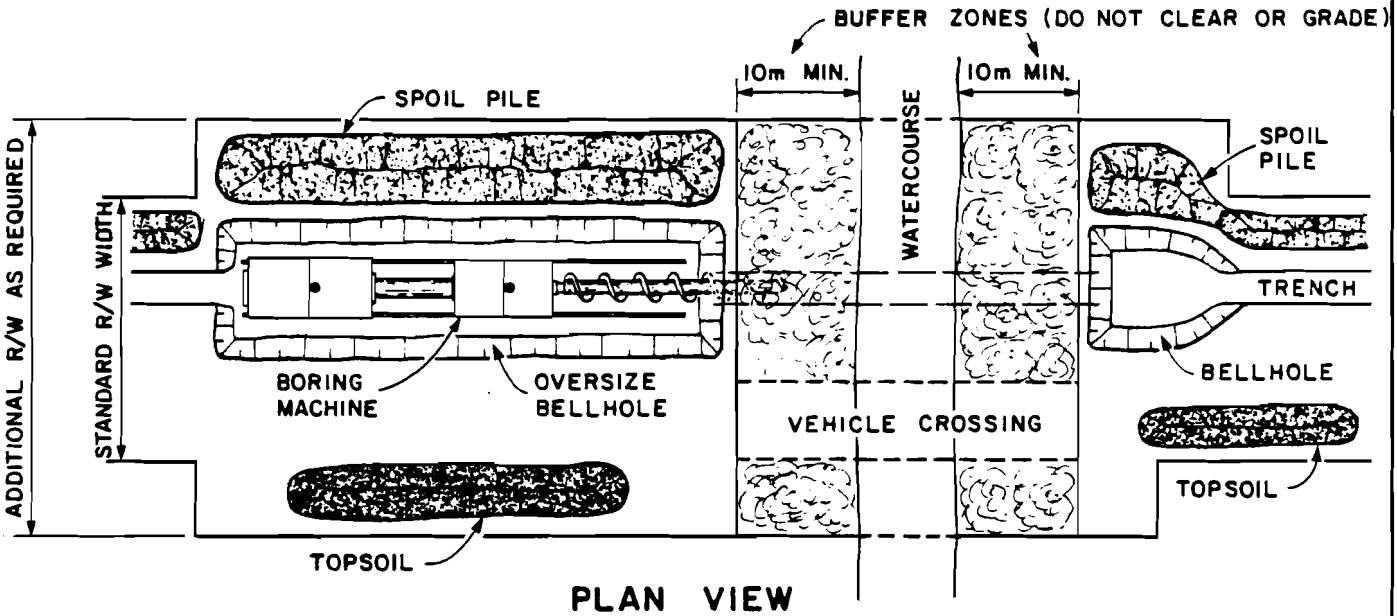
PLAN VIEW

N.T.S.

Notes

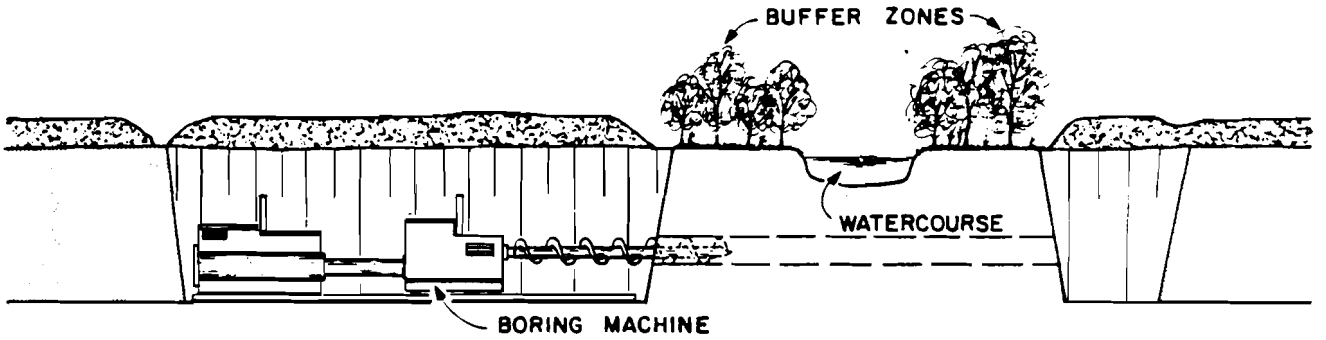
1. Install a flume on small watercourses when downstream siltation is to be avoided. Flumes are generally not recommended for use on a watercourse with: a broad unconfined channel, a very low gradient, a permeable substrate, excessive discharge, or where a significant amount of bed or bank alteration is required to install flume or dykes.
2. Schedule construction during low flow period. Follow Note 2 on Drawing No. 15-2a.
3. Size flume to handle anticipated flows. Install flume in watercourse. See Drawing No. 15-1c for culvert vehicular crossing.
4. Construct upstream dyke and then downstream dyke. Where necessary to ensure a watertight barrier, install flange on upstream end of flume and seal to substrate with sand bags and polyethylene liner. Key dykes into banks or construct secondary dyke if necessary.
5. Pump stream channel dry between dykes. Discharge water onto stable surface to prevent erosion.
6. Excavate through hard plugs, across stream channel, and under flume.
7. Lower in pipe by passing under flume. Backfill immediately.
8. Remove in the following order: vehicle crossing ramp, downstream dam, upstream dam, and flume.
9. Restore stream banks to approximate original condition and stabilize as required.

DRAWING No. 15-2C FLUMED WATERCOURSE CROSSING



PLAN VIEW

N.T.S.



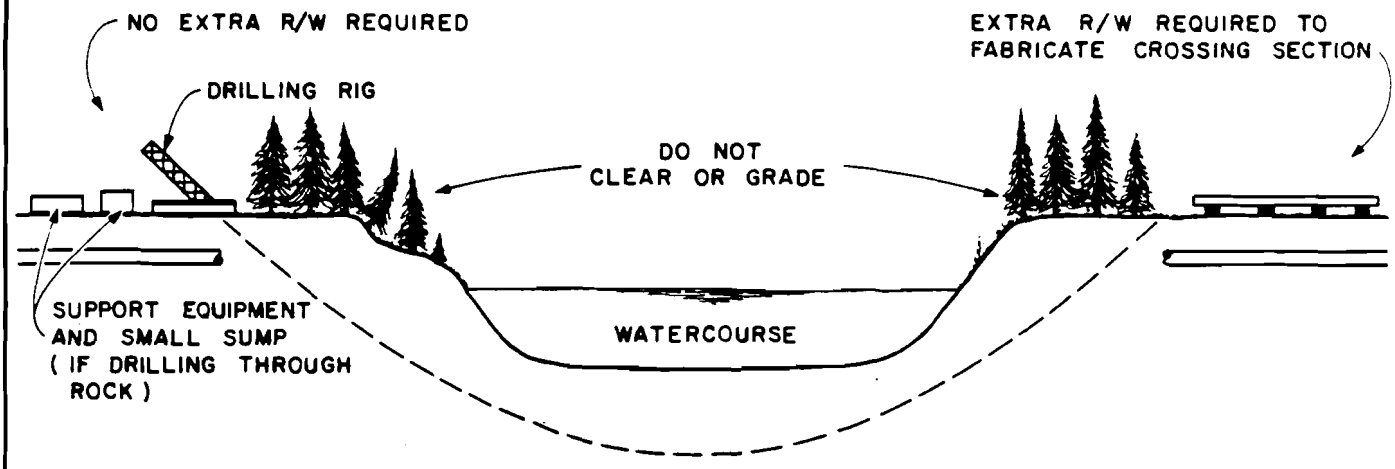
PROFILE

N.T.S.

Notes

1. Bore (or punch) watercourse crossing to prevent sedimentation of watercourse, interruption of stream flow, and alteration of stream substrate. This method is appropriate for crossing irrigation canals and occasionally, for crossing natural watercourses. The advantage is that in-stream work is eliminated and timing of the crossing is not restricted. However, this method may not be possible if excessive groundwater is present or if the substrate consists of large boulders or bedrock. Obtain geotechnical data prior to commencing boring (or punching).
2. Follow Notes 2-8 on Drawing No. 15-2a. Particularly, ensure that a buffer is maintained adjacent to the watercourse and that the trench is dewatered onto stable, vegetated land, not directly to watercourse.

DRAWING No. 15-2D WATERCOURSE BORING METHOD



PROFILE

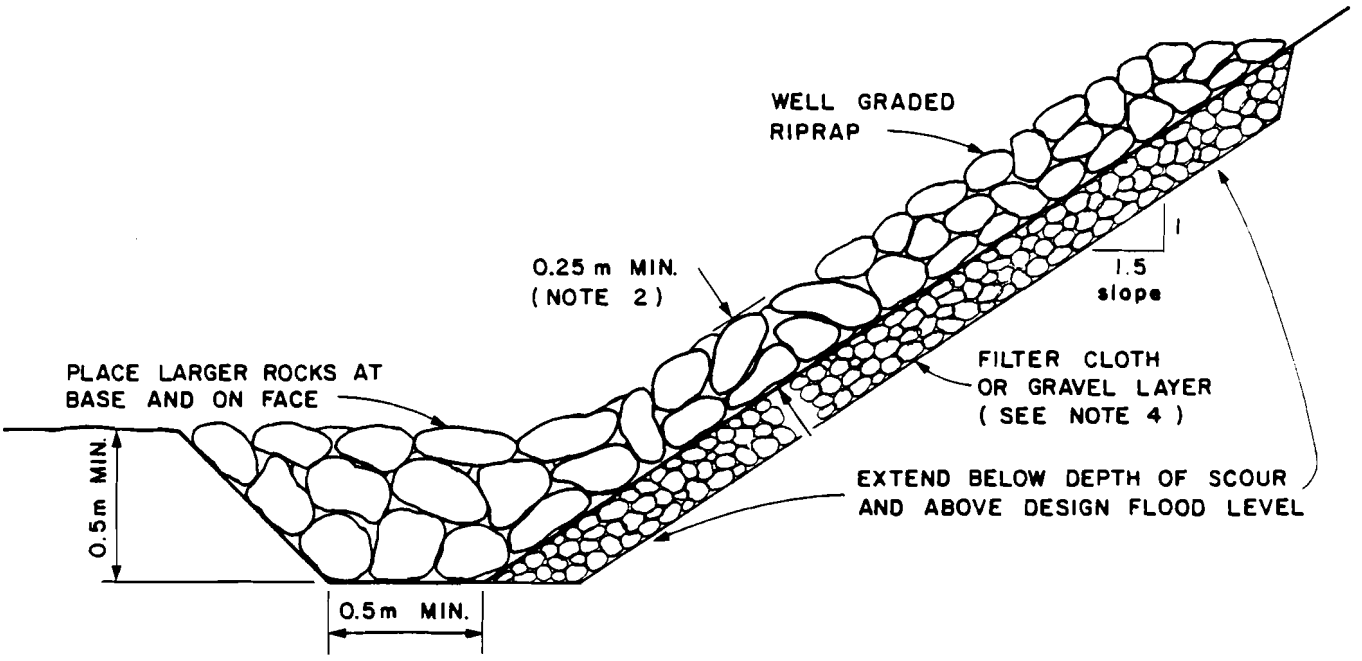
N.T.S.

Notes

1. Use directional drilling method to cross large watercourses which are environmentally sensitive to instream activity or where conventional methods are not feasible due to engineering or navigational constraints. Directional drilling could be useful on large deep rivers requiring considerable extra cover and expensive reclamation work.
2. Obtain geotechnical data prior to initiating drilling. Drilling is not feasible in some materials such as unconsolidated gravels.
3. Set up drilling equipment a minimum of 10 m from the edge of the watercourse; do not clear or grade within 10 m zone.
4. Utilize existing bridge for vehicle crossing (Dwg. No. 15-1e).

Source: Adapted from Slant Drilling Systems Ltd. and other sources.

DRAWING No. 15-2E DIRECTIONAL DRILLING A WATERCOURSE



PROFILE

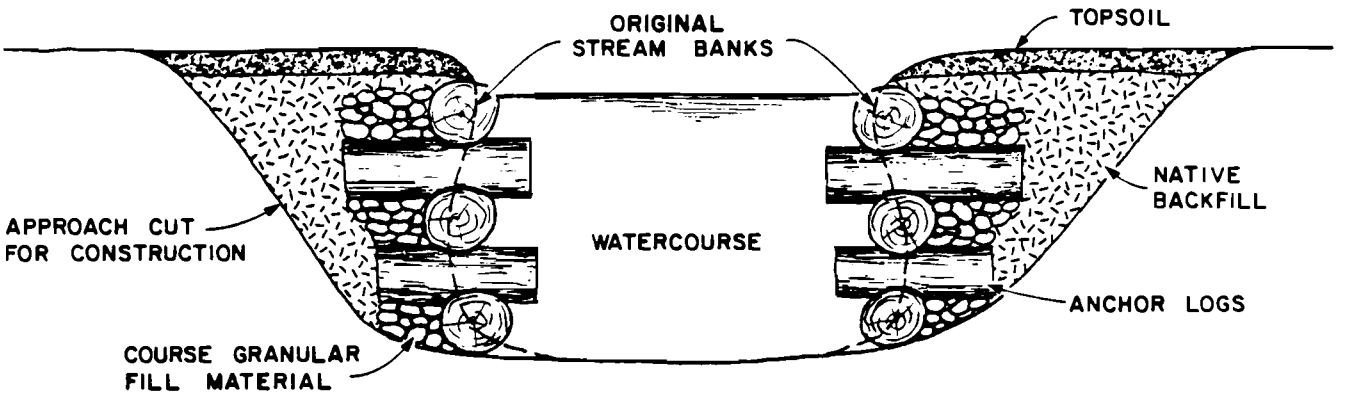
N.T.S.

Notes

1. Use riprap to stabilize erosion-sensitive stream banks at locations where original banks did not provide significant fish habitat.
2. Install riprap to a depth approximately 1.5 to 2 times the diameter of the riprap.
3. Size of riprap used is dependent upon slope of bank and water velocity. Flat rocks are more effective than round rocks because they resist movement by water and ice.
4. Install filter cloth or gravel layer if water turbulence could result in erosion of bank material between large rocks.
5. Construct riprap boundaries in a manner such that it will not be undermined from the side.

Source: Adapted from USFS, 1968.

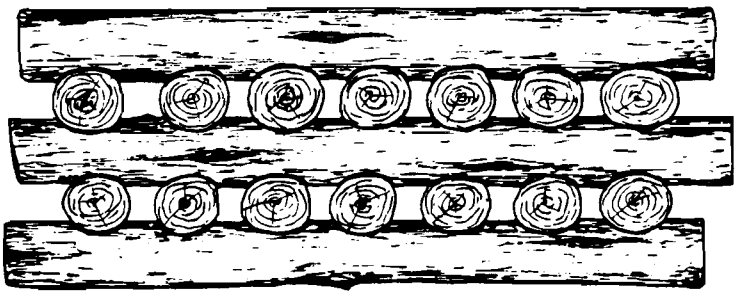
DRAWING No. 15-3A RIPRAP INSTALLATION FOR STREAMS



PROFILE

N.T.S.

NOTCH AND
SPIKE LOGS



FRONT VIEW

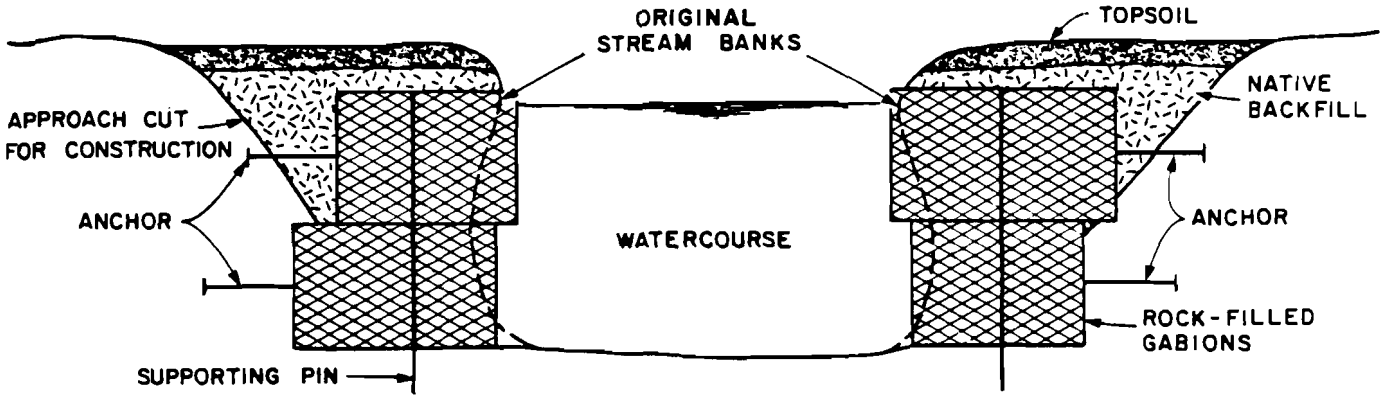
N.T.S.

Notes

1. Install overhanging log bank wall to restore fish habitat at sites where original stream banks provided significant fish habitat.
2. Bury anchor logs with coarse granular materials.

Source: Allan, 1983.

DRAWING No. 15-3B OVERHANGING STREAM BANK - LOG WALL



PROFILE

N.T.S.

Notes

1. Install overhanging gabions to restore fish habitat at sites where original stream banks provided significant fish habitat.
2. Determine size of basket and diameter of rock fill basket based on water velocity, substrate type and degree of bank protection required.
3. Attach gabions securely to each other and anchor firmly into surrounding substrate.
4. Close basket lids in a downstream direction or towards shore to avoid snagging debris.
5. Do not use where stream bed is incapable of supporting gabion weight.

Source: Allan, 1983.

DRAWING No. 15-3C OVERHANGING STREAM BANK – GABIONS

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APPENDIX

LIST OF ASSISTING ORGANIZATIONS

1. Owner Companies

Canadian Western Natural Gas Co. Ltd., Calgary
Dome Petroleum Limited, Calgary
Gulf Canada Resources Inc., Calgary
Manitoba Hydro, Winnipeg
Northwestern Utilities Limited, Edmonton
Nova Corporation of Alberta, Calgary
Pacific Gas and Electric Company, San Ramon, California
PanCanadian Petroleum Limited, Calgary
Peace Pipe Line Ltd., Calgary
Petro-Canada Inc., Calgary
TransCanada PipeLines, Toronto
Saskatchewan Power Corporation, Regina
Union Gas Limited, Chatham
Westcoast Transmission Company Limited, Vancouver

2. Pipeline Contractors

Gooding & Matt Construction Ltd., Nisku
Ledcor Industries Limited, Edmonton
Marine Pipeline Construction of Canada Limited, Calgary
O.J Pipelines, Edmonton
Petro-Line Construction Canada Ltd., Edmonton
SRB Construction Ltd., Winterburn

3. Associations

Alberta Cattle Commission
Alberta Surface Rights Federation
Bear Lake Farm Rights Group
Canadian Petroleum Association
Farmers Advocate
Independent Petroleum Association of Canada
Oilfield Contractors Association
Reclamation Research Technical Advisory Committee
Unifarm

4. Government Agencies

Alberta Agriculture

Alberta Culture

Alberta Forestry, Lands and Wildlife

- Fish and Wildlife Division
- Alberta Forest Service
- Public Lands Division

Alberta Environment

- Land Reclamation Division
- Land Conservation and Reclamation Council
- Drafting Pool, Design & Construction Division

Alberta Municipal Affairs

Alberta Recreation and Parks

Energy Resources Conservation Board

- Pipeline Department
- Environmental Protection Department

B.C. Energy, Mines and Petroleum Resources, Victoria

B.C. Environment, Victoria

Manitoba Environment Management Services, Winnipeg

Michigan Department of Natural Resources, Lansing

National Energy Board, Environment Group Pipelines Branch, Ottawa

Ontario Energy Board, Toronto

Saskatchewan Environment, Regina