GUIDELINES

FOR

ALTERNATIVE SOIL HANDLING PROCEDURES

DURING PIPELINE CONSTRUCTION

Prepared for
Soil handling Sub-committee of the Alberta
Pipeline Environmental Steering Committee

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PREFACE

The Soil Handling Sub-committee of the Alberta Pipeline Environmental Steering Committee requested an independent review to finalize guidlelines for soil handling procedures during pipeline construction. A Soil Handling Review Committee was drawn from the independent soil community and included specialties in salinity, mapping, agronomy, revegetation and reclamation. The members were: Dr. Wayne Pettapiece, P. Ag. (Agriculture and Agri-Food Canada - Chairman), Dr. Colin McKenzie, P. Ag. (Alberta Agriculture, Food and Rural Development), Dr. M. Anne Naeth, P. Ag. (University of Alberta), Mr. Al Twardy, P.Ag. (Pedocan Land Evaluation), and Mr. Mark Dell (Research Associate).

The terms of reference for the review committee were: to review and amend as appropriate the Interim Guidelines for Soil Handling Procedures for Problem Soils During Pipeline Construction. The emphasis was on saline/sodic soils and three-lift procedures but the reviewers were given the latitude to consider all problem soils and all handling procedures. The reviewers were instructed to consider all relevant recent research and practical expereience.

EXECUTIVE SUMMARY

The Soil Handling Sub-committee of the Alberta Pipeline Environmental Steering Committee (APESC) commissioned a Review Committee to finalize the guidelines for handling problem soils during pipeline construction. The present guidelines are interim and have been in use since 1991 (amended 1992). Activities related to handling problem soils during pipeline construction have been ongoing for more than a decade. Concerns of Industry, private Consultants and Government have been well documented and it was the opinion of the Soil Handling Sub-Committee of APESC that sufficient literature and experience should now be present to finalize the interim guidelines.

The terms of reference did not restrict the review to any previous decisions. All procedures and relevant information of current handling methods could be considered and evaluated. Current literature, pertaining specifically to pipeline construction in Alberta (1990 to the present) was reviewed. A questionnaire was prepared and sent out to field personnel specializing in different facets of pipeline construction to collect further experience and knowledge that was not found in the literature. The questionnaire raised several concepts which helped direct the review. These included the need to define "environments", to minimize disturbance, to handle variability, for greater flexibility and easy-to-follow guidelines.

The Interim Guidelines (1992) were considered basically sound and were used extensively. The changes mainly reflect an orientation on how the information should be used. These are not prescriptions for every situation. Rather, they are general guidelines to support professional on-site decisions. First, it was felt that soil handling should not be considered in isolation from the land reclamation principles of equivalent capability. Also, the recent literature indicated that surface salinity will decrease under normal climatic conditions. These two considerations, in particular, allowed for recognition of greater flexibility in soil handling options. However, it must be emphasized that with greater flexibility comes increased industry responsibility and accountability for planning, construction and reclamation performance.

Technical changes from the Interim Guidelines (1992) include: the deletion of sodium adsorption ratio (SAR) and contrasting textures from problem soil definitions; the deletion of Solonetzic soil considerations; the recognition of the soil map unit as the basic management unit and the use of averaging within that context; and the recognition of four basic "environments".

With the inclusion of minimum disturbance as a primary objective, it is recommended that a task force be struck to consider the issue of trench width and soil handling options for all soils.

1.0 INTRODUCTION

This report is the result of Government and Industry's desire to finalize guidelines for Alternative Soil Handling Procedures for Problem Soils in Pipeline Construction. Issues related to handling problem soils during pipeline construction have been ongoing for more than a decade. Concerns of Industry, private Consultants and Government have been well documented (Deloitte and Touche 1990; APESC 1992). It was the opinion of the Soil Handling Sub-Committee of the Alberta Pipeline Environmental Steering Committee (APESC) that sufficient literature and experience should now be present to finalize the interim guidelines.

The focus of the review committee throughout the review process was to meet the goals and objectives of "conservation" and "reclamation" by minimizing the extent of disturbance; salvaging soil resources; controlling wind erosion; and enhancing the potential for disturbed land to be reclaimed to an equivalent land capability, pursuant to the Environmental Protection and Enhancement Act (AEP 1994).

1.1 History

Prior to 1963 there was no legislated requirement for the reclamation of disturbed lands in Alberta. The increase in both resource development and public concern led to the development of Surface Reclamation Act in 1963. The Act dealt specifically with disturbed land and soil conservation was not required. Continual public concern in the 1960s and 1970s led to the passing of the Land Surface Conservation and Reclamation Act in 1973. This Act required that environmental protection and reclamation be part of the development planning. The concept of equivalent capability was introduced and review and approval processes such as Environmental Impact Assessments (EIA) and Development and Reclamation Approvals (D and R Plan) were implemented in the late1970s (Brocke 1988). The Act of 1973 was replaced by the current Environmental Protection and Enhancement Act (EPEA) in 1993.

The Alberta Pipeline Environmental Steering Committee (APESC) was formed to address environmental issues in pipeline development and operation outside of formal review processes (APESC 1992). The Soil Handling Sub-committee (formerly the 3-Lift Task Force) of APESC was set-up to oversee development and implementation of soil handling guidelines for problem soils. Interim guidelines for handling problem soils during pipeline construction were developed in 1991 and amended in 1992.

The Soil Handling Review Committee was struck in early January 1996, at the request of the Soil Handling Sub-Committee of APESC, to review current research literature and opinion in an attempt to finalize soil handling guidelines for pipeline construction. The resultant report would replace the current interim guidelines set-up by APESC for Alternative Soil Handling Procedures for Problem Soils, otherwise known as the Three-Lift Guidelines.

1.2 Philosophy

The intent of this report is to provide a simple guideline to follow when dealing or confronted with problem soils that require alternative soil handling procedures, while meeting the main criteria of achieving equivalent land capability as expressed in the Environmental Protection and Enhancement Act. It is the belief of the Soil Handling Review Committee that meeting the equivalent land capability objective may be achieved in more than one way. The procedures chosen should be based on a survey of the biophysical conditions along the pipeline route and the recommendations of a qualified professional with pedological expertise. The should also include recognition of physical construction constraints. The final accountability rests with the pipeline owner. The role of government is to review applications to ensure that reasonable plans are in place and to audit the final results for achievement of objectives.

Emphasis must be placed on the fact that guidelines are <u>guidelines</u>. They are a set of principles or instructions set forth as a guide (Avis et al. 1979). Based on present knowledge and experience, they provide the best assessment about what will achieve the desired results. They are not a precise method, they do not ensure ideal results under all conditions and they are not in themselves a substitute for accountability.

Although these guidelines were approached from a perspective which included all ecological areas and landuses, the main concern, and, therefore primary focus, is directed toward agricultural landuse.

1.3 Objective

The objective of the Soil Handling Review Committee was to review and amend, as appropriate, the guidelines for handling problem soils during pipeline construction. While the emphasis was on saline/sodic situations, and the use of three-lift procedures, the review considered all problem soils and all alternatives for handling them.

A secondary objective was to provide easy-to-use guidelines.

1.4 Application

Class 1 pipelines require a Conservation and Reclamation Approval (C and R Approval) prior to any surface disturbance. Class 1 lines are those with an index of 2690 or greater unless excluded (see Activities Designation Regulation: Section 1(5)(h))(AEP 1994). The index is determined by multiplying length of the pipeline (km) by outside diameter (OD) (mm) [length (km) x diameter (mm) =

Index] (AEP 1994). Class 2 pipelines do not require a C and R Approval. However, the objectives, to conserve and reclaim, are still applicable.

2.0 PROCEDURE

Responsibility to review soil handling procedures for problem soils was accepted in December 1995. A review committee was struck with member expertise in areas of soil mapping, salinity, vegetation and environmental issues. The members were not directly involved in the pipeline regulatory or construction roles.

The review committee first met January 29, 1996 to discuss the issues related to handling of problem soils in pipelines and to formalize objectives. Research collected to date was summarized and presented to further familiarize committee members on current research in dealing specifically with problem soils during pipeline construction. A questionnaire was drafted to augment the information in the literature. A list of interviewees was compiled and finalized by the Soil Handling Sub-committee of APESC. Results from the questionnaire were compiled and, along with pertinent literature, reviewed by the committee at the second meeting held March 18, 1996. General report content and format were also determined at that meeting.

2.1 Literature Review

A comprehensive literature review was conducted on material pertaining primarily with soil issues and pipeline construction in Alberta. While all general scientific literature was searched, the majority of pertinent literature was obtained from the Alberta Government and NOVA Gas Transmission Ltd (NGTL). The focus of the literature review was on material dated from 1990 to the present. A literature review of salt movement in disturbed soils was previously undertaken by Finlayson (1993) who thoroughly summarized material prior to 1993. Several research studies have been undertaken since concerns were raised about the gaps of knowledge that exist in pipeline soils handling. Major concerns were the extent and movement of salts out of disturbed soils and the length of time required for soils to return to chemical values similar to those of pre-disturbed profiles. The focus of the literature reviewed is primarily in this area. The literature covers a range of alternative soil handling procedures, landscapes, soil zones and vegetation types.

2.2 Review of Interim Guidelines

A comprehensive review of the 1992 Interim Guidelines was undertaken by the committee. In general, the committee agreed the information contained within the report was sound and that the report should be used as a base for any new guidelines.

2.3 Questionnaire

During Phase I of the review, the committee discussed issues involved in handling problem soils. They decided that a questionnaire was needed to access the experience of those persons actively involved in the pipeline construction process, which is not otherwise documented in the literature. A set of questions was finalized by the committee (Appendix 1), along with a list of groups and areas of specialization, to ensure that all aspects of pipeline construction and soils handling were represented. The Soil Handling Sub-committee provided a list of names of potential interviewees for the questionnaire. A list of groups and specializations and questionnaire procedure is located in Appendix 1.

3.0 BACKGROUND ISSUES AND RECOMMENDATIONS

A number of issues or terms which required clarification were identified in the questionnaire and literature review. Discussion of the review committee and recent literature were used to develop the following statements. Some are simply confirmation of usage while others recognize recent research and new approaches.

3.1 Land Reclamation Success

The ultimate objective of the soil handling procedures is to achieve successful land reclamation and, as indicated earlier, there may be several ways to achieve this objective. The purpose of this report is not to provide methods to assess success of the reclamation process as defined by equivalent capability (see also section 3.3). Rather, it is to present guidelines which will help make decisions relative to the handling of problem soils such that equivalent capability is achieved. The two are closely linked and the distinction may be moot when proper soil handling techniques ensure success of land reclamation . However, one is a concept while the other is a procedure, and there is not a one-to-one relationship between the two. This report will be confined to soil handling considerations.

3.2 Role of Vegetation

From the literature, the role of vegetation is clear in identifying problems in success of post-construction soil replacement and conversely, in supporting claims of land reclamation success. Revegetation success in past studies can also be used to provide some interpretation of the success of various soil handling procedures and the potential for future use under similar ecological, soil and landuse conditions. This research material must be interpreted from two perspectives: long-term ability of disturbed soil to return to pre-disturbance conditions as identified by vegetation and the ability for vegetation to be immediately established on post-construction soils. The use of vegetation in the monitoring or establishment of land reclamation success is recognized. Also, correlation of revegetation success with various soil handling procedures is very useful. However, it must be stressed that vegetation per se is not part of the soil handling guidelines.

3.3 Equivalent Capability

Under current Provincial Legislation (EPEA), the objective of land reclamationis to achieve a land capability equivalent to that of pre-disturbed land. To provide consistency in assessing and comparing pre- and post-construction soils in pipelines, it is essential that a specific rating system be designated as a standard for each end use. This does not preclude the use of one system for more than one end use, or the adoption of a new standard, as warranted by advances in knowledge or requirements. If the end use(s) involve only soil considerations (e.g. plant growth) then a soil rating would be appropriate. If the end use involves landscape considerations (e.g. wetlands or habitat) then systems which include those features should be used.

To get around the problem of a single unit (at a class boundary) changing the rating by a whole class, it is further recommended that the system chosen be one which uses a continuous scale rather than classes. Using a continuous scale rating, a post-disturbance rating can be specified within *x* % or *y* points of the pre-disturbance rating - irrespective of class boundaries. This recognizes that all soil attributes are continuous and allows an improvement in one to compensate for a decrease in another - a feature not recognized at present. For example, in the case of Solonetzic soils, a decrease in quality due to increased surface salinity might be offset by the improvement of subsoil structure.

There are several rating systems which meet the above criteria including: the Land Capability Classification of Arable Land in Alberta (ASAC 1987); The Agricultural Capability Classification for Reclamation - working document (Leskiw 1993); and the Land Suitability Rating System (LSRS) for Agricultural Crops (AIIWG 1995). The Leskiw and LSRS are modifications of the LCC. Since climate will be a constant, and the focus of the issue is on the changes in soil properties, it is further recommended that only the soil (or soil plus landscape) component of the above rating system be used for the determination of equivalent capability.

As linear disturbances such as pipelines are concerned with the establishment of plant growth and as the focus is directed to agricultural uses, it is suggested the soil component of the LSRS be used for assessment of capability. It is further proposed that equivalent capability be defined as being within 15% of the base (pre-disturbance) rating.

3.4 Variable Soil Conditions

Some soil characteristics can be quite variable over short distances. Depth of surface horizons, surface pH and features associated with soluble salts fall into this category. How this variability is managed depends on the scale of landuse and the relative importance of the features to the objectives of the land management activities. For example, site specific horticulture plantings might deal with pH on a scale of less than one metre while the preparation of an industrial site might ignore all surface variation over an area of several hectares. Pipelines are somewhere between those extremes, with a nominal minimum length of disturbance of 100 m and vegetation considerations mainly restricted to grasses (and grains).

Given the parameters of 100 m and grasses, and with an additional consideration of a 5 yr time frame, average conditions should be considered for "map units" (i.e. designated management units or soil handling units down to 100 m in length as defined in the pre-disturbance survey). That is, if 2/3 of the unit had a surface EC of 6.0 and 1/3 had an EC of 3.0, the "average" would be (2 x 6.0) + (1 x 3.0)/3 = 5.0. Assessments of "capability" would also be made on average conditions.

3.5 Salt Movement

As determined in recent research, there is considerable natural leaching of soluble salts from the upper 15 to 20 cm of pipeline spoil. The rate varies with water movement through the soil, being higher in areas of higher precipitation and coarser soil texture. The results vary, but in general, in five years surface decrease in salinity might be as high as 10 dS/m in the parkland area with the drier grasslands decreasing 3 to 5 dS/m. Thus assessment of post-disturbance capability could assume a five year decrease in surface salinity.

3.6 Sodium Adsorption Ratio (SAR)

There is a high correlation (approximately 0.90) between SAR and salinity level as measured by EC (McKenzie 1996 per comm.). It is therefore recommended that SAR be removed from the guidelines . An exception is the occurrence of sodic bedrock but this can be identified by physical characteristics.

3.7 Contrasting Texture

The concept of contrasting texture is mainly covered by the consideration of gravel and stone content. The presence of coarse fragments with sand is common and having both brought to the surface would be detrimental to the reclamation process. Exceptions should be considered where a very unsuitable subsoil material is encountered below 50 cm.

3.8 Environmental Framework

As determined through evaluation of questionnaire results, soil handling procedures for pipelines are site specific. Each ecological area is unique and handling procedures should probably be modified to ensure the objective of attaining equivalent capability. The present land use "environment" was also considered important. However, for practical purposes and to meet the objective of keeping the guidelines simple, the environmental framework might be reduced to four situations. These include: two ecological areas; parkland and boreal forest (black and grey soil zones), and native grasslands (both fescue and mixed grass prairie - brown and dark brown soil zones); and two landuse types, cultivated and native vegetation (see section 6.0).

3.9 Problem Soils

A "problem soil requiring alternate soil handling procedures" is defined as a soil having strongly contrasting differences in quality of upper and lower soil profile to a degree that soil capability would be compromised if standard pipeline soil handling procedures were utilized.

Geomorphic, geologic and soil characteristics that present pipeline reclamation problems are located in most areas of the province. These features can be very limited in linear extent, often less than 100 to 200 m along a proposed pipeline. Problem soils and landscape features can include near-surface sand and gravel layers or lenses, consolidated bedrock and salt-affected soils. These features may cause a loss of agricultural capability if trench spoil is not handled properly. Common locations for sand and gravel layer are active floodplains, terraces above active floodplains, glacial meltwater channels and upland kame deposits. Consolidated bedrock with a veneer of soil is common in the foothills region but may also be found in localized areas on the plains. Salt-affected soils tend to be regionalized in the plains area (Appendix 5) in association with a dry climate and saline-sodic bedrock or glacial tills derived from sodic bedrock. The occurrence of salt affected problem soils may be higher in groundwater discharge areas.

The conditions identified in the interim guidelines, namely saline, gravel or bedrock in the subsoil, were confirmed as problems requiring special attention by the questionnaire participants. Also identified were other conditions such as the surface of forested Luvisolic soils, organic soils and poorly-drained soils. Forested soils may not require special consideration beyond minimum disturbance and equivalent capability. However, in instances of poor subsoil , surface stripping may be beneficial for seedbed considerations. The poorly-drained (including organic) situations are problems but are dealt with on a project/site specific basis relating to construction procedures more than to soil handling considerations.

3.10 Minimum Disturbance

The theme of minimum disturbance occurred in both the literature and questionnaire, thus must be addressed. The least possible disturbance, while meeting other requirements, should be a basic objective. This makes sense from both an environmental and construction perspective. It is recognized that the “minimum” will change with such considerations as size of pipe, trench width, the need to strip topsoil , the number of machinery passes and general equipment access. That is, there are trade-offs which need to be evaluated. However, the concept should be given more weight than in the recent past. For example, if smaller machinery, combined with no-strip, can reduce the functional right-of-way (RoW) from 15 m to 10 m, then this should be considered.

3.11 Trench Width / Pipe Diameter

The role of trench width / pipe diameter was not considered in the Interim guidelines. However, the questionnaire participants indicated that soil handling procedures would vary depending on pipe diameter.

The concern with minimum disturbance as outlined in section 3.8, is the disturbance of a stable sod layer several metres wide to install a pipe of 15 cm in diameter into a trench of less than 1m. The effect of soil disturbance in a confined trench area was less than the potential loss of soil quality over an expanded RoW.

3.12 Critical Depth (Soil Layer Thickness)

Although the majority of roots of most forb and grass species are located within a 50 cm depth of the soil profile, the root zone is highly variable both between species and within species given variations in climate and edaphic factors. It is, therefore, somewhat misleading to call the upper 50 cm the maximum root zone depth. However, it is reasonable, from a practical perspective, to consider 50 cm as a nominal root zone and to use 50 cm as a standard depth for separating lower subsoil from upper subsoil.

4.0 BASIC CONSIDERATIONS

Based on the Interim Guidelines and considering the previous discussions, the following assumptions are given as a basis for decisions for handling problem soils.

4.1 Equivalent or Better Capability

The requirement of achieving equivalent land capability under the EPEA is a given. However, there may be more than one way to achieve this end result. Trade-offs in some soil properties may be made to enhance others thereby achieving the necessary equivalent land capability.

4.2 Responsibility for Results

As there may be more than one procedure (or combination) which can satisfy the minimum objectives and as there may also be local variations which should be recognized, there needs to be a clear line of responsibility for decisions and accountability. This should include the environmental (soils) consultant, the on-site manager and the pipeline owner. Government plays a role when C and R approvals are required and takes on some responsibility upon acceptance of plans.

4.3 Soil Variability

Inherent variability is recognized and should be managed by averaging within the "map units" as established by the professional pedologist.

4.4 Two-Lift is the Standard Procedure

Two-Lift remains the standard for cultivated lands. The objective is to preserve the organic rich surface layer. The depth of the first lift can be modified as appropriate for local conditions from a minimum of 10 cm to a maximum to 35 cm. If there are no clear indications of critical depth then a default of 20 cm is suggested. Special overstrip situations might increase the surface lift to 50 cm.

Other procedures might be considered as standard for particular situations. For example:

- I All native vegetation: no-strip Right of Way
- ii Narrow trench width (< 60 cm): no-strip (topsoil saving should still be considered on cultivated lands)
- iii Problem soils: alternative soil handling procedures as appropriate.

4.5 Surface (Ap) Horizons of Cultivated Lands Should be Preserved

Cultivated lands include both those fields currently under cereal and oilseed production as well as those fields that are under short-term and long-term rotation forage crops. The minimum practical depth of topsoil salvage is 10 cm but thinner layers might be considered for special sets of conditions such as very poor subsoil.

4.6 Minimum Disturbance is an Objective

This is tempered (balanced) with other objectives. See section 3.8 for discussion.

4.7 Seedbed

A reasonable seedbed is required to ensure rapid establishment of vegetation to reduce erosion potential.

4.8 Extreme Site Conditions

Extreme site specific problems such as wet areas, water crossings and very steep slopes are land related issues involving more than soil considerations and will be evaluated separately and on a site by site basis.

4.9 Guidelines

These are guidelines. Based on present knowledge and experience, they provide the best assessment about what will achieve the desired results. They are not a precise method, they do not ensure ideal results under all conditions and are not in themselves a substitute for accountability.

5.0 CRITERIA FOR ALTERNATIVE SOIL HANDLING PROCEDURES

The criteria in this section are not presented in any order of priority. Definitions and additional technical information are included in the Appendices. Also, there is a soil handling procedure decision flow chart at the end of this section which may be helpful in applying the criteria.

5.1 Soil Handling Unit

The soil handling unit is the soil map unit. All units identified on a map with a particular symbol (soil map unit delineation) should be handled in the same manner.

5.2 Soil Handling Unit Length

A soil handling unit length is equivalent to one soil map unit delineation at a map scale of 1:10,000. Except for situations where there are strongly contrasting soils or topographic features (e.g., bedrock ridge, stream channels, pot holes) the soil handling length would normally be a minimum of

100 m. The minimum soil handling length and the minimum soil map unit size are assumed to be equal.

5.3 Soil Sampling Criteria for Problem Soil Management

Sufficient soil sampling (based on professional judgement) should be completed to determine if the map unit delineation should be considered for alternative soil handling. If problem soils are anticipated, there should be at least one sample every 400 m.

Additional soil investigation or sampling may be required at a later time to better define a problem soil area identified by the pedologist in the initial survey. If an alternative soil handling candidate map unit delineation is less than or equal to 400 m in length and there are no soil chemistry data for that unit, the entire map unit delineation should be considered for alternative soil handling.

Further soil investigation or sampling is suggested as necessary to reduce the length of alternative handling procedures as requested or suggested by the field pedologist.

5.4 Topsoil Thickness Criteria

For topsoil stripping, the average topsoil thickness in a map unit delineation should be between 10 cm and 35 cm, and must be of "better quality" than the upper subsoil. Actual stripping depths can be modified during construction by on-site inspection. Again, special situations might suggest consideration of < 10 cm.

5.5 Upper Subsoil Thickness Criteria

The average thickness of the upper subsoil of the soil map must be greater than 15 cm before separate subsoil lift handling is considered.

Maximum aggregate thickness of topsoil and upper subsoil to be separately handled is 50 cm. Therefore, the maximum amount of upper subsoil to be separately salvaged is 40 cm. This limit is set for better planning of RoW width requirements.

Actual stripping depths can be modified during construction by on-site inspection.

5.6 Stone or Gravel Content

Alternate soil handling procedures should be considered when the upper subsoil is of non-gravelly or non-stony material and:

i) the lower subsoil (50 cm to trench depth) has a coarse fragment (> 2 mm in diameter) content of > 35 % if gravelly and > 20 % if cobbly (See Agriculture Canada 1987 for details),

ii) consolidated bedrock is encountered that would break into hard fragments with trenching.

5.7 Sodic Bedrock Criteria

Alternate soil handling procedures should be considered when the upper subsoil has an electrical conductivity (EC) of less than 8 dS/m and the lower subsoil includes sodic bedrock which, by definition, has an SAR greater than 15.

5.8 Subsoil Salinity

As a general guide for identifying problem areas and to avoid those areas with a minor amount of lower subsoil that meets the chemistry criteria identified in Section 5.9, alternative soil handling procedures should be considered when: lower subsoil with an EC of greater than 10 dS/m occupies 50% or more by depth of the material below 50 cm to trench depth. These numbers should not be taken as definitive but rather to alert the assessor of potential problems. Also, this criterion should not be dealt with in isolation from other soil characteristics such as the presence of Bn or Bnt horizons.

5.9 Salinity Criteria for Three-Lift

Three-lift procedures should be considered when the upper subsoil has an EC of less than 8 dS/m and the following conditions for salinity are met:

i) pre-construction EC of the upper subsoil must be less than 8 dS/m

ii) threshold EC of lower subsoil must be exceeded (see table), and

iii) critical difference EC (lower subsoil minus upper subsoil) must be greater than or equal to 4 dS/m.

Table 1. Salt affected soil criteria for different soil zones

Soil Zone	Upper Subsoil EC (dS/m)	Lower Subsoil Threshold EC (dS/m)	Critical Difference EC (dS/m)
Brown	<8	>5	≥4
Dark Brown	<8	>6	≥4
Others	<8	>8	≥4

6.0 RECOMMENDED ALTERNATIVE SOIL HANDLING PROCEDURES FOR PROBLEM SOILS

The standard soil handling procedure in pipeline construction may not always be the most appropriate procedure for maintaining equivalent soil capability, especially when there are marked differences in the quality of the upper and lower subsoils. The Soil Handling Sub-committee recognizes soil handling procedures could, in some cases, have detrimental effects on soil capability that are serious enough to warrant alternative procedures.

Tables 2 and 3 include acceptable procedures for different ecological and landuse environments. Those listed as number 1 are recommended (if followed, and documented in the "as built" report, the amount of audit (checking) for reclamation certification will be minimized). Others listed can be considered as alternatives if local conditions warrant (as assessed by on site soil experts). Increased auditing may be required for certification.

7.0 RECOMMENDATIONS

The terms of reference for the Review Committee limited the review to problem soils. However, in the process of the review there were a number of issues identified which impact on the more general approach to all pipeline procedures. Two in particular were the ideas of minimum disturbance and pipe or trench diamenter. While two- lift is recognized as the standard for non-problem soils (see sec. 4.4), the Committee feels that it may not always be the best option when assessed against an objective of minimum disturbance. The consideration of pipe size or trench width also needs to be considered in this context (see Appendix 7 for an example).

Therefore, the Review Committee recommends the APESC strike a task force to develop soil handling options for all soils. These options should include overstripping and no-strip where appropriate. In the meantime, it seems reasonable that operators should be allowed the option of discussing alternative procedures with the regulators on a case-by-case basis.

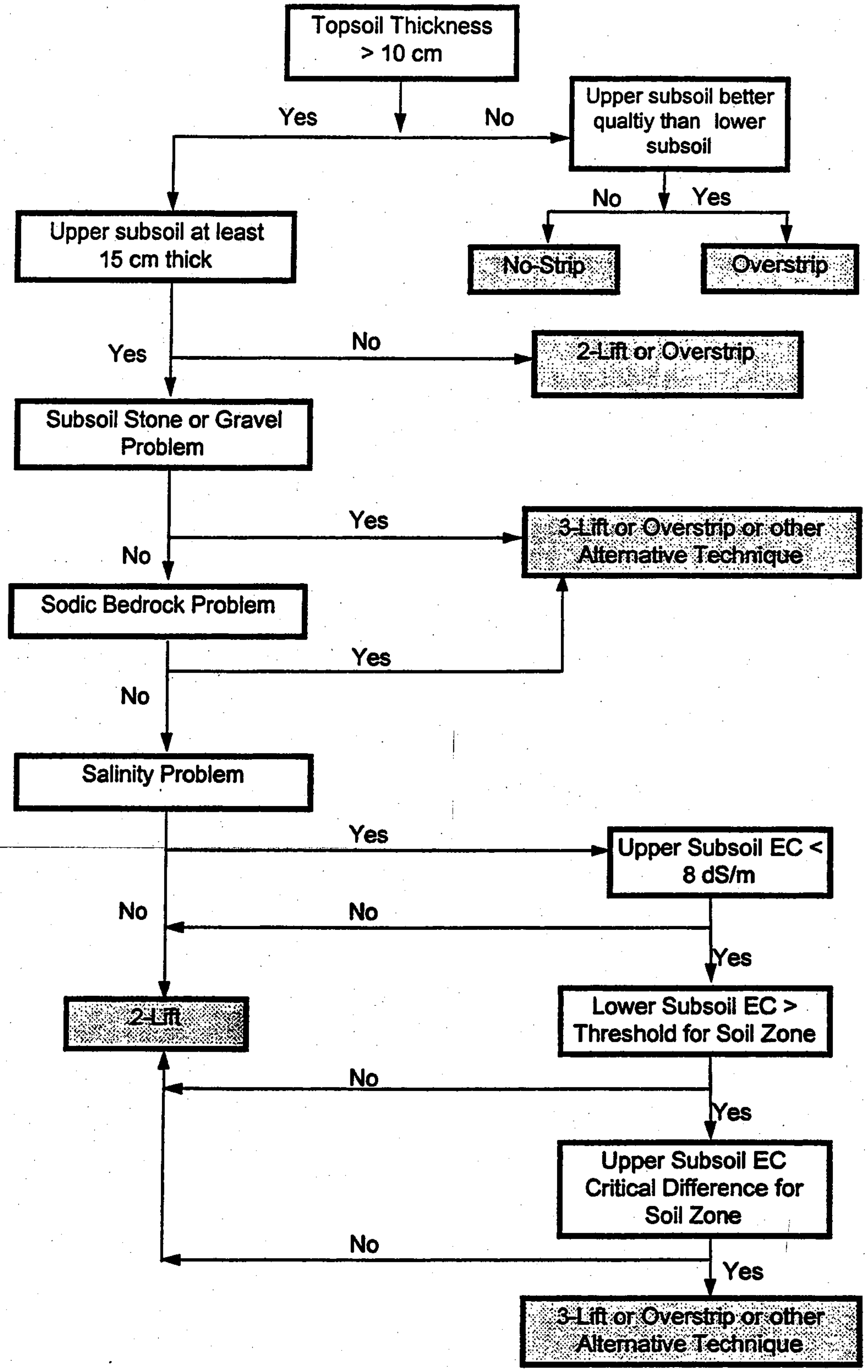

FIGURE 1. PROBLEM SOIL HANDLING PROCEDURE DECISION CHART

Table 2. Recommended soil handling procedures for problem soils in prairie environments[1] (Brown and Dark Brown Soil Zones)

Problem Soils	Native[2]	Cultivated[2]
Saline Subsoil	1) 2-Lift[3] 2) No-Strip	1) 3-Lift 2) 2-Lift 3) Overstrip[3]
Gravel Subsoil	1) 2-Lift or Overstrip 2) No-Strip concern is quick revegetation (sands)	1) 2-Lift or Overstrip 2) 3-Lift
Bedrock Subsoil	1) 2-Lift or Overstrip 2) No-Strip concern is for revegetation (seedbed)	1) 2-lift or Overstrip 2) 3-Lift

[1]The following table indicates the acceptable procedures for different ecological and landuse environments. Those listed as number 1 are recommended (if followed, and documented in the "as built" report, the amount of audit (checking) for reclamation certification will be minimized). Others listed can be considered as alternatives if local conditions warrant. Local conditions will be assessed by the on site soil experts.

[2]Soils that are currently under forage crops (pasture or hay lands) may fit into either category depending on the formation of an adequate sod layer. If the sod layer, in the opinion of the pedologist's report is sufficient, stripping may not be necessary since spoil material may be satisfactorily removed from the sod layer post-construction. If the pasture is newly seeded, the field should be treated as if it was under cultivation.

[3]Common depths for the surface lift are about 20 cm for normal 2-Lift and about 40 cm for overstripping.

Table 3. Recommended soil handling procedures for problem soils in parkland/boreal environments[1] (Black and Grey Soil Zones)

Problem Soils	Native[2]	Cultivated[2]
Saline Subsoil	1) 2-Lift[3] 2) No-Strip	1) 3-Lift 2) 2-Lift (20 cm)
Gravel Subsoil	1) 2-Lift or Overstrip 2) No-Strip concern is quick revegetation (sands)	1) 2-Lift or Overstrip[3] 2) 3-Lift
Bedrock Subsoil	1) 2-Lift or Overstrip 2) No-Strip concern is for revegetation (seedbed)	1) Overstrip 2) 3-Lift

[1]The following table indicates the acceptable procedures for different ecological and landuse environments. Those listed as number 1 are recommended (if followed, and documented in the "as built" report, the amount of audit (checking) for reclamation certification will be minimized). Others listed can be considered as alternatives if local conditions warrant. Local conditions will be assessed by the on site soil experts.

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APPENDIX 1 EXAMPLES

1. Example of 3-Lift Situation

The upper subsoil of a Black Zone soil has an EC of 1 dS/m and the lower subsoil has an EC of 10 dS/m. Trench depth is 1.4 m, topsoil depth is 0.2 m and the lower subsoil starts at a depth of 0.6 m.

Recommended Soil Handling Procedure

- Salvage topsoil (upper 20 cm as first lift)
- Salvage 30 cm of upper subsoil material (second lift)
- The third lift will constitute the remaining 90-cm of material

2. Example of Overstrip Situation

The upper subsoil of a Brown Zone soil has an EC of 1 dS/m and the lower subsoil has an EC of 8 dS/m. Trench depth is 1.4 m, topsoil depth is 0.1 m and the lower subsoil starts at a depth of 0.2 m.

Recommended Soil Handling Procedure

- Since topsoil and upper subsoil depths are rather thin, the first lift should be to a depth of 20 cm (topsoil plus upper subsoil).
- The second lift will consist of the remaining material to a depth of 1.4 m.

APPENDIX 2 DEFINITIONS

Definitions (APESC 1992)

For those requiring definitions for terms not found on the following pages, please refer to "Glossary of Terms in Soil Science", Publication 1459 (Revised 1976), published by the Research Branch, Canada Department of Agriculture or "Glossary of Reclamation Terms - 4th Edition, published by the Reclamation Research Technical Advisory Committee (C. Powter- Compiler, 1995).

Bnt Horizon
A solonetzic B horizon with a columnar or prismatic structure, that is hard to extremely hard when dry and has a ratio of exchangeable Ca to Na of 10 or less. Solonetzic B horizon - The term includes both Bn and Bnt horizons. These horizons have prismatic or columnar primary structure that breaks to blocky secondary structure; both structural units have hard to extremely hard consistence when dry. The ratio of exchangeable Ca to Na is 10 or less.

Coarse Fragments
Rock or mineral particles greater than 2.0 mm in diameter. Rounded and sub-rounded rock fragments up to 7.5 cm (3 in.) in diameter are referred to as gravelly, 7.5 to 25 cm (3 to 10 in.) in diameter are called cobbly and over 25 cm (10 in.) in diameter are called stony or bouldery.

Equivalent Capability
After reclamation, the ability of the land to support various land uses is similar to that which existed prior to disturbance.

Lower Subsoil
The soil material lying below the upper subsoil.

Overstripping
The intentional stripping of the upper subsoil with the topsoil. This would only be done where incorporation of the upper subsoil would not significantly degrade topsoil quality. This procedure may be suitable for areas with a shallow topsoil layer and good quality upper subsoil.

Saline Soil
A soil containing sufficient soluble salts to impair its productivity. Specifically, a soil providing a saturation-paste extract having an electrical conductivity >4 dS/m (at 25°C). The term saline, when used alone, implies a low Sodium Adsorption Ratio (<15).

Saline-Sodic Soil
A soil containing sufficient exchangeable sodium to interfere with the growth of most crop plants and containing appreciable quantities of soluble salts. The Sodium Adsorption Ratio is >15, the conductivity of the saturation extract is >4 dS/m (at 25°C) and the pH is usually 8.5 or less in the saturated soil.

Sodic Bedrock
Sodic bedrock is defined as unconsolidated sedimentary rock (bentonitic shales, clayey sandstones) also referred to as soft rock or residual materials, of marine origin containing sufficient exchangeable sodium to interfere with the growth of most crop plants and also containing appreciable quantities of soluble salts. The SAR is greater than 15. Sodic bedrock also has high saturation percent values and water supply problems and poor structural (aggregation) properties.

Salinization
The process of accumulation of salts in soil.

Salt-affected Soil — Soil that has been adversely modified for the growth of most crop plants by the presence of certain types of exchangeable ions or of soluble salts. It includes soils having an excess of salts or an excess of exchangeable sodium or both. See also saline-sodic soil, saline soil, and sodic soil.

Seepage

(i) The slow flow of water into or from a soil. Seepage usually involves the lateral flow of water.

(ii) The emergence of water from the soil along an extensive line of surface in contrast to a spring where the water emerges from a local spot.

Sodic Soil — A soil that contains sufficient exchangeable sodium to interfere with the growth of most crop plants; the Sodium Adsorption Ratio of the saturated-paste extract is 15 or more.

Soil Complex — A mapping unit used in detailed and reconnaissance soil surveys where two or more defined soil units are so intimately intermixed geographically that it is impractical, because of the scale used, to separate them.

Soil Formation Factors — The variable, usually interrelated, natural agencies that are responsible for the formation of soil. The factors are parent material, climate, vegetation, topography and time.

Soil Map Unit — A defined and named repetitive grouping of soil bodies occurring together in an individual and natural characteristic pattern over the soil landscape. The attributes of a map unit vary within more or less narrow limits that are determined by the intensity of the survey. A map unit comprises all the map delineations that have the same name. A map unit is conceptual; a map delineation is real.

Soil Map Unit Delineation — A single soil area or polygon on a soil map which is differentiated from other areas on the basis of soil and landscape features.

Soil Productivity — The capacity of a soil, in its normal environment, to produce a specified crop or sequence of crops under a specified system of management. The "specified" limitations are needed because no soil can produce all crops with equal success and a single system of management cannot produce the same effect on all soils. Productivity means the capacity of soil to produce crops and is expressed in terms of yields.

Soil Salinity — The amount of soluble salts in a soil, expressed as electrical conductivity (EC) in units of dS/m or in terms of percentage or parts per million.

Soil Series — The basic unit of soil classification in the Canadian System of Soil Classification and consists of soils that are essentially alike in all major profile characteristics except the texture of the surface.

Soil Sodicity — A measure of the amount of sodium on the exchange complex (often expressed as the Sodium Adsorption Ratio - SAR).

Soil Survey	The systematic examination, description, classification and mapping of soils in an area.
Soil Texture	The relative proportions of the various soil separates (sand, silt, clay) in a soil; often labelled by class names found in a soil texture triangle.
Soil Type	A unit in the natural system of soil classification: a subdivision of a soil series consisting of or describing soils that are alike in all characteristics including the texture of the A horizon.
Solod	A great group of soils in the Solonetzic order occurring most commonly in the grassland and parkland regions. The soils have a dark-coloured surface (Ah) horizon, a prominent eluvial (Ahe or Ae) horizon at least 5 cm (2 in.) thick, a prominent transitional (AB) horizon that breaks readily into blocky aggregates, and a darkly stained B (Bnt) horizon over a C horizon that is saline and usually calcareous.
Solodized Solonetz	A great group of soils in the Solonetzic order, occurring most commonly in the grassland and parkland regions and consisting of soils with a variable surface (Ah, Ahe, or Ae) horizon that is underlain by a well developed Ae horizon, a compact prismatic or columnar Bnt horizon, and a C horizon that is saline and usually calcareous.
Solonetz	A great group of soils in the Solonetzic order, occurring most commonly in the grassland and parkland regions and consisting of soils with a variable surface (Ah, Ahe, or Ae) horizon that breaks abruptly into a hard, compact prismatic or columnar B (Bnt, rarely a Bn) horizon underlain by one or more saline and usually calcareous (Bs, Cs, Csa, Csk, Cca) horizons. They lack a continuous Ae horizon 2.5 cm (1 in.) or more thick.
Solonetzic	An order of soils developed mainly under grass or grass-forest vegetative cover in semiarid to sub-humid climates. The soils have a stained brownish solonetzic B (Bnt or Bn) horizon and a saline C horizon. The surface may be one or more of Ap, Ah or Ae horizons. The order includes the Solonetz, Solodized Solonetz, and Solod great groups.
Standard Soil Handling Procedure	Topsoil is selectively removed in one lift and spoil material is removed in a second lift. Following pipe installation the topsoil and subsoil materials are replaced in their preconstruction order and depth. See also two-lift.
Stones	Rock fragments greater than 25 cm (10 in.) in diameter if rounded and greater than 38 cm (15 in.) along the greater axis. See also coarse fragments. In engineering practice these fragments are included with boulders, which are considered to be greater than 20 cm (8 in.) in diameter.
Stoniness	The relative proportion of stones in or on the soil. This term is used in the classification of soils. See also coarse fragments.
Subsoil	The soil material found beneath the topsoil but above the bedrock.

Surface Soil The uppermost part of the soil that is ordinarily moved in tillage, or its equivalent in uncultivated soils. It ranges in depth from 7.5 cm to 25 cm (3 in. to 10 in.) and is frequently designated as the "plow layer", the "Ap layer", or the "Ap horizon".

Sustained Yield A continual yield of crops from an area; this implies management practices that maintain the productive capacity of the land.

Three-Lift A soil handling procedure whereby the soil is selectively removed, stored and replaced in three layers; topsoil, upper subsoil, and lower subsoil.

Till Unstratified glacial drift, deposited directly by ice and consisting of clay, sand, gravel, and boulders intermingled in any proportion.

Tilth The physical condition of soil as related to its ease of tillage, fitness as a seedbed, and impedance to seedling emergence and root penetration.

Topography The physical features of a district or region, such as those represented on a map, taken collectively, especially, the relief and contours of the land.

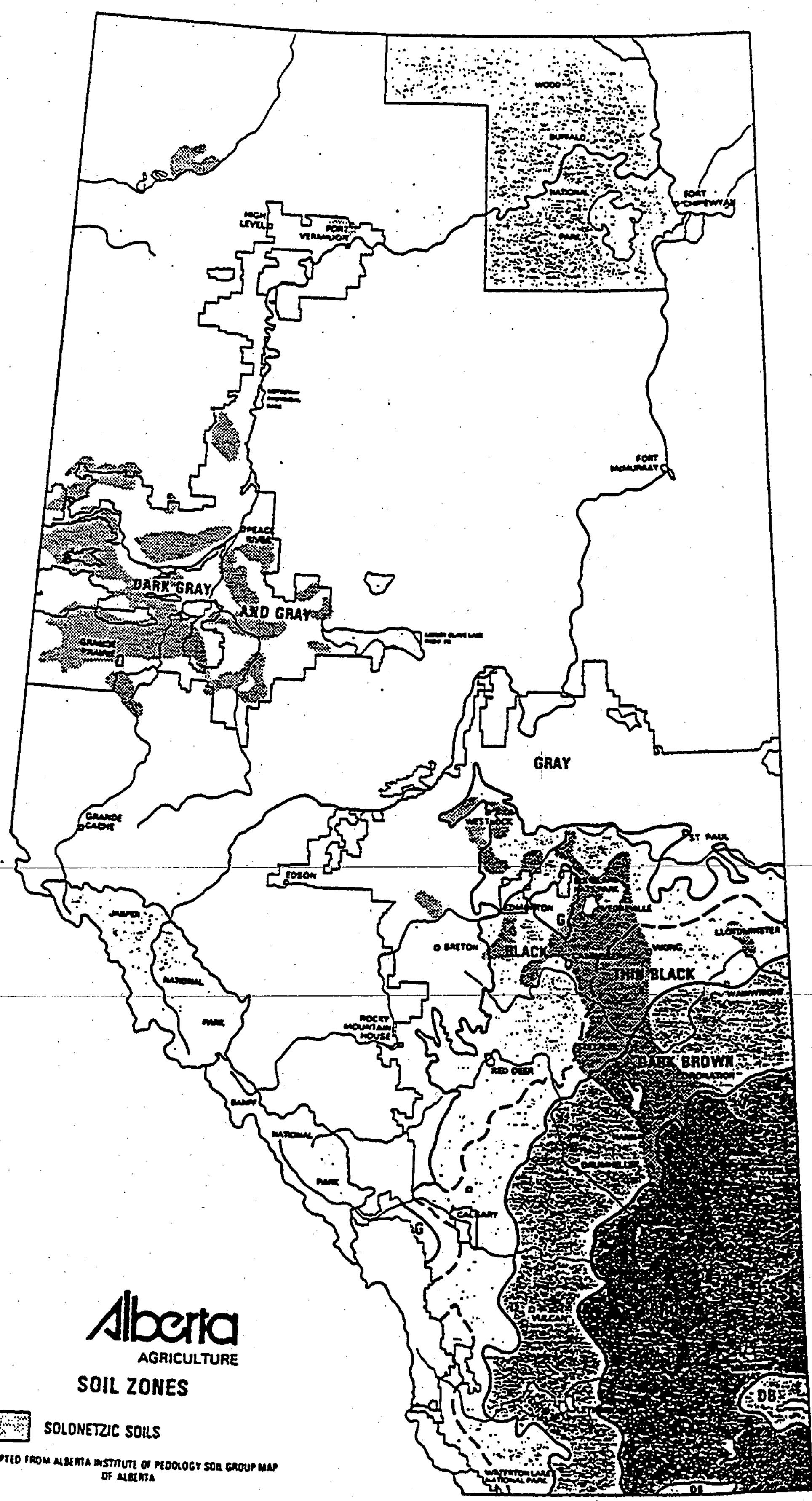
Topsoil

(I) The layer of soil moved in cultivation (Ap horizon). See also surface soil.
(ii) The A Horizon.
(iii) The Ah (Ahe, Ahg) horizon.
(iv) Presumably fertile soil material used to topdress road banks, gardens, and lawns.

Two-Lift A soil handling procedure whereby the soil is selectively removed, stored and replaced in two layers; topsoil and subsoil. See also standard soil handling procedure.

Upper Subsoil The soil material found immediately below the topsoil. For the purposes of soil handling procedures as outlined in these Interim Guidelines, the upper subsoil stops at a depth of 50 cm from the surface of the soil.

APPENDIX 3 SOIL ZONE MAP (APESC 1992)



PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA ENERGY AND NATURAL RESOURCES, 1986

APPENDIX 4 SOIL MAP OF POTENTIAL AREAS OF SODIC BEDROCK IN ALBERTA (APESC 1992)

APPENDIX 5. QUESTIONNAIRE AND INTERVIEW LIST

Procedure

During Phase I of the review, the Committee discussed issues involved in handling problem soils. The Committee decided a questionnaire was needed to access the experience of persons actively involved in the pipeline construction process, who are not otherwise documented in the literature such as contractors, landowners and land managers. The questionnaire would also provide some assessment on current procedures used with problem soils.

Due to the short timeline, a limited number of questionnaires were mailed to individuals in specific disciplines of pipeline construction. A list of individuals was obtained from the Soil Handling Sub-Committee of APESC and then shortened further by the Soil Handling Review Committee.

The persons short-listed for the questionnaire were initially contacted by phone and a commitment to complete the questionnaire was obtained. The questionnaire was then mailed or faxed to them for completion. A total of 22 questionnaires were mailed or faxed out.

Questionnaire Content

The questionnaire consisted of 8 questions that provided further opportunity for experts in the field to identify problem soils (Q1) and construction procedures (Q2) currently undertaken to deal with the problem soils. Additional questions were asked concerning problems associated with current handling procedures both in mapping problem soils, directly handling the soil during construction (Q3) and special ecological or cultural situations (Q4). Concerns over post-construction landuse (Q5) were also addressed along with importance of specific environments and soil handling procedures for them (Q6).

To provide a basis under which all questions were answered and obtain answers that would be comparable from all relevant parties, assumptions were provided. These assumptions were obtained from the revised Interim Guidelines for Handling Problem Soils in Pipeline Construction (APESC 1992) and are currently in use for dealing with problem soils. Question 7 deals specifically with the issue of whether the assumptions under which the questionnaire was issued are reasonable. Other recommendations and concerns pertaining to the issue of soil handling in pipeline construction were also solicited (Q8).

Alternative Soil Handling Review Committee (Pipelines) Questionnaire

Dear participant:

The Soil Handling Subcommittee of APESC (Alberta Pipeline Environmental Steering Committee) is interested in establishing guidelines to replace the existing Revised Interim Guidelines 'Soil Handling Procedures for Problem Soils During Pipeline Construction' (July 1992) prepared by the APESC Three-Lift Task Force. We would like to take this opportunity to thank-you for your participation in this questionnaire. The objective of this questionnaire is to obtain the expertise and opinions that may not be present in the literature in formulating final guidelines pertaining to handling problem soil in pipelines. A timely response is being requested and will be appreciated. We will be following up this questionnaire with a phone call to answer any questions or concerns. The questionnaire may be returned by **fax (403) 495-5344**, or by mail to:

c/o Mark Dell
Agriculture and Agri-Food Canada
Land Resources Unit
Suite 1295, Royal LePage Building
10130 - 103 Street
Edmonton, Alberta
T5J 3N9

We appreciate that all mail-in questionnaires be returned by February 23, 1996 to the Review Committee. If you have any questions or concerns please contact **Wayne Pettapiece or Mark Dell at (403) 495-5539 or (403) 492-0100 (Mark Dell only).** If additional space is needed to answer questions, please attach additional pages to your questionnaire.

Name of Participant: ______________________________

Affiliation(Gov't/Industry/Consultant/Other): ______________________________

Assumptions: Root zone is 50 cm
Time Frame -5 years or less is short-term
2-lift is standard
Alternative soil handling procedures include - overstripping, plowing -in, boring, chemical treatment, rerouting, 3-lift, trenching.

1) What are problem soils (Check appropriate box(s) if present)?

Salt-affected soil (salinity/sodicity)	☐
Stone or gravel content (coarse fragment)	☐
Strongly contrasting differences in texture	☐
Sodic bedrock	☐

Are there Others?

____

2) What are your present soil handling procedures for each of the problem soils listed above?

3) What are your problems associated with present soil handling procedures?

Machinery limitations for small distances (what limits)

Consistent definition of a problem soil (limit of criteria)
-chemical/physical
-depth of topsoil

Consistent definition of aerial extent (mapping)

Are there others? Clarify choices, if necessary.

4) Are there concerns related to special ecological or cultural situations (other special situations that may require alternative soil handling techniques) (check appropriate box(s))?

Archeological digs (sites) ☐
Riparian zones ☐
Endangered species (flora or fauna ☐
Cultural considerations (road crossings, cemeteries, golf course) ☐

Are there others? Clarify choices, if necessary.

____

____

____

5) Are there any concerns over post-construction landuse and land management beyond the contractors control (which would make the extra cost/care unwarranted)?

____

____

____

6) What particular situations (environments) do you think are important? Would you handle soils differently in these environments (check appropriate box(s))?

Ecological (Primary)		Landuse (Secondary)	
Forest	☐	Native	☐
Parkland	☐	Cultivated	☐
Prairie	☐	Improved pasture	☐
Tundra	☐	Hay (Good sod/bad sod)	☐
Organic Soils	☐		
Others	☐	Others	☐

Are there other environments not listed? Are there other levels? Are some combinations more important than others?

____

____

____

7) Are the basic assumptions reasonable?

Root zone is 50 cm
Time Frame -5 years or less is short-term
2-lift is standard
Alternative soil handling procedures include - overstripping, plowing -in, boring, chemical treatment, rerouting, 3-lift.

If no, please comment.

8) Do you have any other specific recommendations or concerns?

Interview List

Soil Handling Subcommittee of APESC
- Chris Powter (Environment/Chair)*
- Adolph Bruneski (Forestry)*
- Travis Ferguson (Environment)*
- Wayne Tedder (Lands)*
- Hank Vander Pluym (Agriculture)*
- Jim Burke (NOVA)*
- Rob McNeill (Renaissance)*
- Rob Staniland (Talisman)*
- Nancy Finlayson (Land Resources Network)*
- Katherine Bessie (EBA Engineering)*

CAPP/APESC Members
- Ian Scott*
- Fred Kuipers*

Soil Consultants/Mapping
- Len Leskiw (Can-Ag)*
- Murray Riddell (Genesis Environmental)*

Environmental Inspectors (Industry)
- Darwin McNeely (NOVA)*
- Al Lootin*

Environmental Inspectors (Government)
- Mike Smith (Environment/Wainwright)
- Barry Cole (Public Lands/Red Deer)*
- Steve Demkiw (Environment/Lethbridge)
- Barry Adams (Public Lands)*

Pipeline Contractors
- John Rypien (OJ Pipelines)*
- Mike Houser (EEE)*
- Larry Harborenko (NOVA)*

Land Owners
- Paul Vasseur (Farmers Advocate)
- Carl Zajes (Surface Rights Consultant)?*
- Unifarm (contact)*

Environmental Lobbyists**
- Mike Sawyer (Rocky Mountain Ecosystem Coalition)*
- Don Styles (Federation of Alberta Naturalists)*
- Ian Dyson (Prairie Conservation Coordinating Committee)

* - indicates initial sources contacted
** - Several attempts were made to interview members but all contacts attempted, including several suggested by the initial contacts, declined to complete the questionnaire due to lack of knowledge in soils and pipeline issues.

APPENDIX 6 QUESTIONNAIRE RESULTS

Several individual groups that were initially on the list of contacts, specifically the environmental lobby groups, did not complete the questionnaire. Several different groups were contacted and replies indicated a lack of knowledge to sufficiently provide any useful comments. Additional lobby groups with more exposure to pipelines disturbance were contacted at the request of the initial lobby groups but contact and comments from them were similar. Only one group (Farmer's Advocate) was successfully contacted to represent the individual landowners.

Results (17 questionnaires were returned and tallied)

The assumptions under which the questionnaire were asked were:

Root zone is 50 cm
Time Frame -5 years or less is short-term
2-lift is standard
Alternative soil handling procedures include - overstripping, plowing -in, boring, chemical treatment, rerouting, 3-lift, trenching (APESC 1992).

1) What are problem soils (Check appropriate box(s) if present)?
- Salt-affected soil (salinity/sodicity) n=12
- Stone or gravel content (coarse fragment) n=14
- Strongly contrasting differences in texture n=12
- Sodic bedrock n=14

Are there Others?
- excessively wet soils (excavation and replacement of soil may not impact vegetation but special procedures needed - back hoe) n=1
- hard bedrock/shallow bedrock/consolidated bedrock (currently included with stones and gravel) n=4
- Luvisols may be a problem in distinguishing horizon changes (A from B) n=1
- organic veneers on arable lands and possible on grazing lands (concerns are unsuitable soil brought up in the profile and loss of organic resources due to oxidation (insufficient TS salvage)) n=1
- peat soils n=1
- permafrost n=1
- to qualify, the above soils are only problematic if sufficient concentration and volume are present and within the depth of the trench/amount of coarse fragment n=2
- the above may or may not be problems depending on the procedure chosen and horizon depth variability as well as eco-climatic conditions and dominant plant-limiting factors
- salinity and sodicity problems are only short-term due to leaching potential n=2
- depends on definition of saline and sodic and the situation

Summary: Confirmation of what constitutes problem soils. The physical issues (gravel and bedrock) seem to get the most attention. Luvisols, peat soils and permafrost might be added to the list (more of a surface problem).

2) What are your present soil handling procedures for each of the problem soils listed above? ***(this one will need some editing)***

- salt affected - 2-lift
- excessive stone or gravel - usually 2-lift due to limited extent
- texture - 2 or 3-lift
- Sodic bedrock 3-lift if sufficient depth
- minimum disturbance on RoW overall is being done (ditch witching small diameter pipe 8 inches or less)
- 3-lift, overstripping, no strip and 2-strip, all have modifications, limit width of construction, winter conditions, etc.
- whatever is needed (depends on contract and what the owner wants)
- 3-lift for Sodic bedrock and gravel layers
- salt affected, depends 2 and or 3-lift; for gravel depending on location 3-lift; texture, 2-lift or overstrip; Sodic bedrock, likely 3-lift; shallow bedrock, likely 3- lift
- either overstripping or 3-lift (minimize disturbance on native prairie by overstripping; on veneers also encourage overstripping
- respond to industry proposals
- have 3-lift guidelines as a 'standard alternative' that industry may opt for
- salt-affected soils are overstripped into non-saline B or strip surface soil
- coarse fragments - as above (non-gravel B)
- texture - as above (maximize volume of same texture) or improve texture with lower material
- Sodic bedrock - as with salt-affected soil
- following practices used are 3-lift, re-routing and plowing-in
- as per APESC guidelines for most problem soils
- 3-lift sodic bedrock or other bedrock of poor structure n=2
- overstripping for texture
- gravel is 2 or 3-lift
- salt-affected is 2 or 3 lifted or overstripping

Summary: Highly variable and many standard and modified procedures have been used to deal with specific problems in soil handling. One apparent consensus is the use of 3-lift procedures for sodic bedrock. Another is minimum disturbance of a RoW. Gravel and texture appear more of a concern when considering alternative soil handling procedures than are salt-affected soils.

3) What are your problems associated with present soil handling procedures?

Machinery limitations for small distances (what limits)

- 100 m sufficient for procedure change in sporadic problem soils n=3
- in complex soils/terrain, minimize need to change procedure by basing procedure on the limiting soil
- if strongly contrasting areas then distance may be small (blasting of bedrock or wet areas of 20 m) different equipment is required anyway
- use of large equipment for stripping jobs on small diameter pipe (large disturbance for small diameter); perception of what is required (bid process in hiring a contractor)
- equipment availability (some pieces are better for large pipes than small and vice versa/large equipment has difficulty for small deviations in soil
- handling less than 10 cm over a very narrow width, or 15 to 20 cm over a wider strip is very problematic n=2, under most situations depth is chosen and stuck with for stripping n=3 (cannot chase variable depth) used for narrow disturbance (fixed step-blade)
- recognize the extra cost of handling short distances but cost is minor in view of maintaining land capability
- require readily identifiable landmarks to separate different handling procedures

Consistent definition of a problem soil (limit of criteria)

-chemical/physical
-depth of topsoil

- differences in EC (difference of 4 dS/m), SAR and texture are not contrasting enough/leaching potential n=2
- consider both the chemical/physical through profile and the local critical growth or quality factors n=2
- sodicity and conductivity can be hard to predict and identify in the field (laboratory analysis collected to supplement soil survey)/hard to target plow layer n=2
- SAR, critical difference for medium and fine textured soils is OK but keep value consistent
-depth of topsoil/soil layers satisfactory n=2
- variability in topsoil layer is hard to target n=2
- winter construction vs. summer (inconsistent stripping due to frost variability) and type of equipment used in stripping (back hoe vs. wheel ditcher) n=2
- salvage topsoil only then look at the impact of spoil - consider risks/merits of overstripping on surface and profile; consider impacts of wider disturbances vs. narrower, more vs. less traffic/problem is not defining soil but what to do with them n=2
- should be defined by predicted, net result
- haven't seen possible 3-lift jobs except in recent fluvial deposits for textural reasons
- definition is elaborate but necessary to cover the various parameters and conditions
- should consider soil associations and not soil series (example is Solonetzic landscape there may be more salts under Solods or Solonetz but these are not 3-lifted while Solonetzic Chernozem is)
- weeds are more prevalent on wider RoW

Consistent definition of aerial extent (mapping)
- mapping is unable to deal with the very typical horizon depth variability encountered - more detailed mapping won't help even if stripping lengths could be shorter - still have to limit other types of disturbance n=2(3)
- increased sampling density required if the depth to the gravel layer or Sodic material is highly variable/inadequate inspections in problem areas n=2
- pedologist must be able to see the problem in the field
- most difficult problem because a soil survey does not provide traditional material handling recommendations (as above)
- map units and soil suites should be used to determine soil handling procedures
- change salt criteria/increase criteria differences n=2
- inclusions of gravel at depth are more important than salts at depth
-hard to reference problem areas for construction workers when landforms are absent n=2

Summary: How to address and handle variability is the main concern. Pipe size may be a criteria to consider.

Are there others? Clarify choices, if necessary.

- summarize in a table format that is easily used and only a guideline that is based on recommendation of pedologist n=2
- there are other concerns or priorities that may negate 3-lift
- ability to write clear, effective and fair guidelines for industry to follow
- do not take sampling as gospel since point sampling is done/may want to consider composite sampling

Summary: Need easy-to-follow guideline.

4) Are there concerns related to special ecological or cultural situations (other special situations that may require alternative soil handling techniques) (check appropriate box(s))?
-Archeological digs (sites) n=9
-Riparian zones n=7
-Endangered species (flora or fauna n=7
-Cultural considerations (road crossings, cemeteries, golf course) n=5

Are there others? Clarify choices, if necessary.
- usually pipeline is re-aligned to address issue n=2(3)
- archeological sites narrow zone of disturbance is required, riparian a minimal disturbance to retain habitat/minimum traffic n=2
- in riparian zones must consider large coulees and river breaks and aesthetic value of typical badlands topography
- riparian, endangered species and cultural are not considered in Alberta n=2
- riparian zones avoid or replant
- riparian zones are very susceptible to erosion and water quality therefore need special consideration
- standardized treatment for Gleysols
- Native prairie and erodible soils (for texture and slope reasons) require minimum disturbance and limited traffic
-native prairie and irrigation
- endangered species to include native prairie/parkland
- there are many special conditions that may occur together and competing interests must be weighed.

Summary: There are a number of special situations but they are generally already recognized and are being addressed.

5) Are there any concerns over post-construction landuse and land management beyond the contractors control (which would make the extra cost/care unwarranted)?
- operator has initial responsibility to ensure job is done correctly during construction and reclamation n=3 (where reclamation is hindered from landowner management the government will discuss resolution with the operator)
- extra RoW in forestry and native prairie (not what we were really after) n=2 (the larger the area disturbed the greater the exposure to inappropriate land management (erosion and stability))
- grazing is a big factor in post-construction (determine success or failure of reclamation or delay results) *n=2*
- not really a problem since regulations state equal capability and not productivity
- government prefers to review soil handling practices during and immediately after construction (cannot predict future landuse)
- non-arable lands do not require 3-lift (native prairie use minimal disturbance)

Summary: Not a clear cut question. In general it appears that the best answer is minimum disturbance and keep the options as broad as possible.

6) What particular situations (environments) do you think are important? Would you handle soils differently in these environments (check appropriate box(s))?

Ecological (Primary)		Landuse (Secondary)	
Forest	n=12	Native	n=14
Parkland	n=12	Cultivated	n=12
Prairie	n=13	Improved pasture	n=13
Tundra	n=10	Hay (Good sod/bad sod)	n=13
Organic Soils	n=11		
Others	n=1	Others	n=3

Are there other environments not listed? Are there other levels? Are some combinations more important than others?
- permafrost
- foothills grassland/porcupine hills - montane; may want to overstrip if insufficient replacement topsoil
- native range not a landuse but rather an ecological environment with grazing and recreation as landuses
- disturbed lands are not included (looping existed lines)
- distinguish between arable and non-arable forest land
- woodlots and saline areas
- irrigated lands
- wetlands should be differentiated
- organic soils require separation into arable and non-arable n=2
- at times there are other higher priorities than replacing soil layers
- practice proper techniques in each situation (all are important)/soil salvage needed n=2
- native prairie soil irreplaceable; cultivated is permanently disturbed so not that sensitive; pasture and hay moderately sensitive but replaceable n=3
- land management objectives are important (minimal disturbance)
- note forest soils important but land managers prefer own soils handling approach
- handle all forest soils the same whether arable or not

Summary: There appears to be a strong recommendation that soil handling procedures be tailored to the prevailing environmental/landuse conditions.

7) Are the basic assumptions reasonable?

Root zone is 50 cm
Time Frame -5 years or less is short-term
2-lift is standard
Alternative soil handling procedures include - overstripping, plowing -in, boring, chemical treatment, rerouting, 3-lift.

If no, please comment.
- yes n=8(10)
- addition of other alternative procedures (selective handling)/other modified 2-lift procedures n=2
- yes except for root zone - not in all areas - depth should vary depending on location n=2 /crop based
- yes except for root zone (consider as a series of zones with different critical factors)
- 2-lift may not be the standard on native prairie (good sod) n=2
- small diameter line can be no-strip or plowed in; 2-lift is too broad as the stripping width can vary from trench line to full RoW
- time frame is to return to equivalent capability (depends on definition of capability) is varies depending on where you are (Black and Dark Brown less than Brown soil zone)

Summary: Basic assumptions are OK but maybe should add to the alternatives - modified 2-lift, and no-strip. Again, reference is made to pipe size as a consideration.

8) Do you have any other specific recommendations or concerns?
- need to accept the premise that during construction disturbance is going to occur but it must be minimized within acceptable economic operations n=3
- greatest area of disturbance is not the trench but the spoil side area that is stripped of TS (1 m vs. 7 to 9 m) n=2
- width of trench can vary, this may influence choice of procedure (i.e.: with a wider trench (2-3 m) a 3-lift may be more appropriate, a narrow trench, 2-lift)
- objective for the work is clear and simple guidelines that protect soil and sustainable vegetation *n=3*
- ensure consideration of all impacts not just a look at soil profile - consider reasonable expectations of economic construction procedures consider cost/benefit of extraordinary measures *n=2*
- Topsoil handling practices are good
- subsoil much less of a concern, only a few areas require the second lift on a linear disturbance - versus minimal area disturbance
- criteria generally good but do not base on chemistry alone, new research may indicate that this is not appropriate
- continue to be innovative but industry must be flexible in their construction to accommodate the variables of soil, ecoregions and landuse
- Landuse is very important as is the land management objective
- land capability must be maintained or improved because of the need for future landuse diversification
- differences in critical values for different areas
- use a sliding scale
- define strongly contrasting
- post-construction evaluation to determine success
- present limits are not mappable in many cases (one profile mapped and lines are drawn)

Summary: Keep it simple and practical (particularly to identifying and handling 'contrasting' and 'variability'). Use a landuse (environment) framework.

APPENDIX 6 AN EXAMPLE OF MINIMUM DISTURBANCE CONSIDERATIONS FOR ALTERNATIVE SOIL HANDLING PROCEDURES.

Table 5. Recommended soil handling procedures for soils in prairie environments[1] (Brown and Dark Brown Soil Zones)

	Native[2]	Cultivated[2]
Trench Width ≤ 60 cm (24 in)/Pipe Diameter generally ≤ 20 cm (8 in)		
All Soils	No-Strip	1) No-Strip 2) Overstrip
Trench Width> 60 cm (24 in)/Pipe Diameter generally > 20 cm (8 in)		
Standard for non-problem Soils	No-Strip	2-Lift
Problem Soils		
Saline Subsoil	1) 2-Lift[3] 2) No-Strip	1) 3-Lift 2) 2-Lift 3) Overstrip[3]
Gravel Subsoil	1) 2-Lift or Overstrip 2) No-Strip concern is quick revegetation (sands)	1) 2-Lift or Overstrip 2) 3-Lift
Bedrock Subsoil	1) 2-Lift or Overstrip 2) No-Strip concern is for revegetation (seedbed)	1) 2-lift or Overstrip 2) 3-Lift

[1]The following table indicates the acceptable procedures for different ecological and landuse environments. Those listed as number 1 are recommended (if followed, and documented in the "as built" report, the amount of audit (checking) for reclamation certification will be minimized). Others listed can be considered as alternatives if local conditions warrant. Local conditions will be assessed by the on site soil experts.

[2]Soils that are currently under forage crops (pasture or hay lands) may fit into either category depending on the formation of an adequate sod layer. If the sod layer, in the opinion of the pedologist's report is sufficient, stripping may not be necessary since spoil material may be satisfactorily removed from the sod layer post-construction. If the pasture is newly seeded, the field should be treated as if it was under cultivation.

[3]Common depths for the surface lift are about 20 cm for normal 2-Lift and about 40 cm for overstripping.