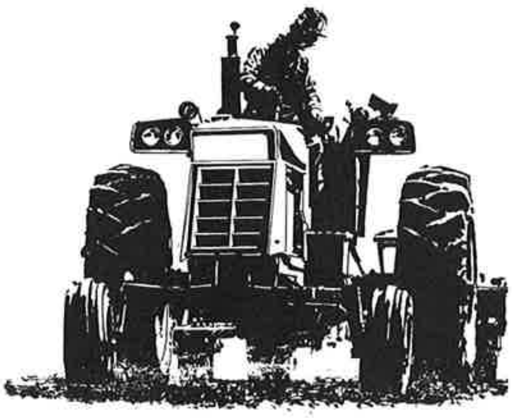
Pipeline construction: prevention of impacts to agricultural lands



by J.F. Ramsey and S.A. Burgess

The views, judgements, opinions and recommendations expressed in this paper do not necessarily reflect those of the National Energy Board, its Chairman or members, nor is the Board obligated to adopt any of them.

A variety of methods are available to minimize the adverse effects of pipeline constructions on agricultural lands

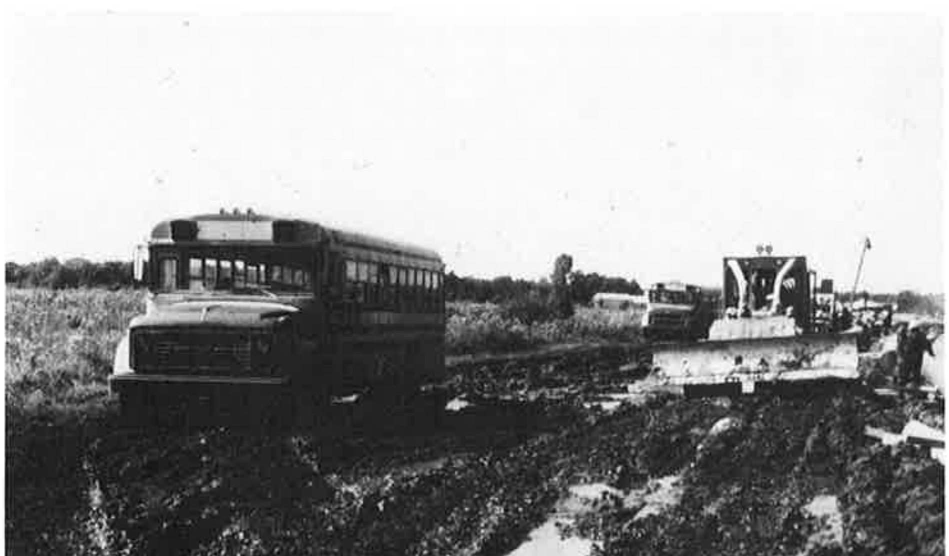
The construction of pipelines on agricultural lands has the potential for causing many adverse impacts. Most of those effects can be traced to improper soil storage and handling, and ground disturbance caused by ditching and vehicular traffic. Organic matter content and, hence, soil fertility are often reduced, while surface and subsurface soil compaction may occur. Those and other impacts often make restoration of the affected lands very difficult.

Potential impacts of construction

Soil compaction and mixing of topsoil with subsoil are the most commonly occurring impacts to agricultural soils (Culley *et al*, 1981) resulting from pipeline construction. The physical characteristics of the soil, its moisture content, and the construction and mitigation methods employed, all contribute to the degree to which a soil will be impacted from construction. Of those factors, soil moisture has the greatest influence on soil compactibility. Research into the relationship between soil moisture and compactibility indicates that the optimum conditions for compaction exist when soil moisture is at or near field capacity[1].

In general, sandy soils are most compactible when their moisture content is about 10%. Loamy and clayey soils tend to compact the most when their moisture contents are between 15-20% and 25-30%, respectively. Studies carried out by Raghaven *et al* (1977) in Québec concluded that clay soils were most heavily compacted when soil moistures ranged from 28-35%.

Although sandy soils are more com-



The right-of-way in this photograph was too wet to withstand the load-bearing pressures exerted by typical pipelining equipment and crew buses. As a result, the right-of-way became severely rutted. Rutting is known to lead to such problems as soil compaction and loss of topsoil.

pactible than clayey soils, it is the latter which under field conditions exhibit the most severe effects of a compacted condition. Those effects can include increased soil density and reduced permeability, which can lead to such problems as ponding of water, decreased root penetration and reduced aeration of the soil. Sandy soils are usually better drained and, therefore, are less apt to display moisture conditions which contribute to compaction.

Soil compaction is known to affect the heat budget of a soil by changing its bulk density, soil/water relationships and soil surface reflectivity (Willis and Raney, 1971). Compacted soils that retain excess water, warm more slowly in the spring, so plant growth can be either retarded or prevented altogether.

Whenever topsoil is lost or mixed with subsoil, concentrations of nitrogen (a valuable plant nutrient) are usually reduced. Phosphorus and potassium ions can also be depleted when topsoil and subsoil are mixed or when excessive soil moisture leaches those ions below a plant's normal rooting depth. Since most of the soil nutrients available to plants occur in the topsoil layer, every effort must be made to conserve or restore topsoil to its pre-construction condition.

Pipeline construction on agricultural lands can cause a decline in the structural stability of a soil. For example, when topsoil and its associated organic matter are stripped from prescribed sections of a right-of-way prior to pipe installation, the exposed subsoil often becomes susceptible to erosion by water and wind. Those forces, combined with the load-bearing pressures of pipelining equipment and operations such as pipe stringing, trenching and backfilling can lead to the destruction of soil structure and aggregate[2] stability in the surface and subsurface layers. Research by Coote *et al* (1981) has shown that almost any decline in the organic matter content of a mineral soil weakens it structurally, which can later lead to such problems as erosion and compaction. Specific studies carried out on Interprovincial Pipe Lines' Sarnia to Montreal Extension indicated that an average 33% reduction in crop yield was attributable to significant decreases in organic matter content of soils subjected to pipeline construction.

In the prairie regions of Canada, where soil salinity has increasingly become a concern, removal of the topsoil layer during clearing and grading can accelerate the migration of subsoil salts (primarily sodium) to the surface due to increased rates of evaporation, especially during the construction period. High levels of those salts can lead to the formation of dense subsurface soil horizons which can impede water infiltration and percolation, as well as root penetration.

Impact prevention and mitigation

The process of minimizing impacts to agricultural lands begins with pipeline routing and construction scheduling. Wherever possible, pipelines should be located on soils which are resistant to the effects of construction. In general, coarse-textured, well-drained soils with the topsoil having a high organic matter content are preferred. Fine-textured, poorly drained soils are highly susceptible to impacts resulting from construction. In addition, the high-quality soils tend to be more easily restored than poor-quality soils.

Construction scheduling is an important component in minimizing soil impacts resulting from construction. Preferably, where the ground normally freezes to a depth capable of supporting construction equipment, pipe installation should be carried out during the winter. Alternatively, work can be undertaken during the summer period when dry soil conditions can usually be expected.

In addition to proper pipeline routing and construction scheduling, a number of methods to be implemented during construction are available to prevent or mitigate adverse impacts. For example, standard practice where grading of the right-of-way is required, is that topsoil should be stripped from the entire area that is to be graded or used for spoil storage. That material is then carefully stockpiled for replacement after construction.

During construction, three separate areas can be identified on the right-of-way. The ditch in which the pipeline is installed is usually located in the central portion of the right-of-way. On one side of the ditch is the work area, to which all construction equipment is restricted. On the other side is the storage area, where subsoil and topsoil from the ditch are stored. Topsoil is generally removed from the ditch and spoil storage areas prior to clitching in agricultural areas. Ditch spoil is piled in such a way as to avoid mixing with the topsoil. Topsoil may be left on the work area because it helps to protect the subsoil from compaction caused by the passage of construction vehicles.

Regardless of when construction occurs, wet soil conditions may be encountered. Where the soil will be wet only temporarily such as after a heavy rainfall, construction may be stopped or activity restricted until the soil is dry enough for damage to be avoided. Restriction or shut-down of construction activities must be done quickly, however, before any soil damage has occurred. Where the soil is expected to be wet on a long-term basis, special techniques may be required to protect the topsoil, particularly on the work area. Swamp mats are intended to protect patchy or localized wet areas, while large sections of wet soil may be protected by using corduroy or sand padding over geotextile material. Care must be given when using those load-spreading devices, however, to avoid contamination of the soil with excessive quantities of sand, wood chips or other materials. In situations where extensive sections of the right-of-way may be susceptible to compaction and load-spreading devices would be impractical, special attention should be given to minimizing the amount of vehicle activity on the right-of-way. Reliance on the use of tracked vehicles to minimize impacts is not encouraged unless the treads are specially designed (uncleated and extra-wide pads) for low contact pressures.

In many cases, post-construction restoration is the most practical means of ensuring that topsoil in disturbed areas is rehabilitated and compacted subsoil is restored.

Many soil restoration methods are available to pipeline companies. Seeding to a cover crop and constructing drainage control devices such as diversion berms helps control surface erosion while promoting rapid recovery of the affected portions of right-of-way. Standard techniques of restoring soil fertility include replacement of topsoil, followed by the application of fertilizers or manure to improve fertility and to replace any organic matter lost as a result of construction. To improve soil structure, the right-of-way is generally cultivated and then seeded to a cover crop such as alfalfa or a clover/grass mixture. Where excessive stones are present after construction, stone picking is carried out. A crown can also be left over the ditchline to allow for the settlement of the backfill.

Proper drainage has not been maintained at this site. Note the rutted condition of the right-of-way and the ponded water.

These clay soils were traversed when the right-of-way was excessively wet. As a result, the soil was unable to support the construction equipment without becoming severely rutted. Research has shown that rutting can cause a reduction in a soil's structural stability and other problems which can affect plant growth and development.

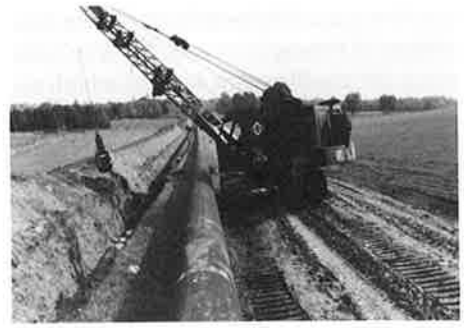
Mechanical decompactors, or subsoilders as they are more commonly known, are often used to relieve compaction that has occurred in deeper soil layers (up to 60 cm from the surface). For the subsoiler to be effective though, two prerequisites are necessary. First, the soil must be dry enough to allow shattering of the soil aggregates, and second, the soil must be relatively free of stones. Those requirements are not often met, however, so subsoiling may not be entirely effective in alleviating subsoil compaction. An alternative to subsoiling compacted sections of right-of-way is to plant deep-rooting legumes such as alfalfa. The disadvantage of that method, however, is that several growing seasons may be needed to achieve effective decompaction, and landowners may be reluctant to leave their land out of production for that length of time.

Construction inspection and monitoring is essential in identifying areas where impacts to soils have occurred and where special restoration procedures will likely be required. An effective monitoring program will provide information on the extent and severity of the damage and will help to define the restoration program required both on the permanent right-of-way and the temporary work areas.

Where appropriate measures are taken to avoid long-term impacts, full recovery of agricultural lands usually takes place within two growing seasons following completion of construction. Where impacts are severe, full recovery may take much longer (Culley *et al*, 1981), and special restoration measures such as trucking-in of topsoil or the use of site-specific crop rotations may be required.

Summary

The process of minimizing impacts to agricultural lands begins with pipeline routing and construction scheduling. Whenever possible, pipelines should be located on soils which are resistant to the effects of construction. In general, the preferred soils are coarse-textured (sandy), well drained, with the topsoil having a high organic matter content.



This is an example of pipeline construction under ideal conditions. Topsoil has not been stripped from the work area to protect the subsoil from compaction and erosion.

Fine-textured (clayey), poorly-drained soils tend to be very susceptible to impacts resulting from construction, and are often difficult to restore to previous levels of productivity.

In situations where work on sensitive soils cannot be avoided, appropriate mitigative measures should be implemented. If it is determined through inspection and monitoring that soils have been impacted, a restoration program designed to remedy the specific problems encountered at various locations along the right-of-way should be carried out.

Notes:

1) field capacity — The percentage of water remaining in the soil 2 or 3 days after the soil has been saturated and free drainage has practically ceased. The percentage may be expressed in terms of weight or volume.

2) aggregate — A group of soil particles cohering in such a way that they behave mechanically as a unit.

References

Culley, J.L.B., D.K. Dow, E.W. President and A.J. Maclean. 1981 Impacts of Installation of an Oil Pipeline on the Productivity of Ontario Cropland. *Contr. 66. Land Resource Research Institute. Agriculture Canada. 88 pages*

Raghavan, G.S.V., E. McKyes and B. Beaulieu. 1977. Prediction of Clay Soil Compaction. *J. Terramechanics 14, 31-38.*

Coote, D.R. J. Dumanski and J.F. Ramsey. 1981 An Assessment of the Degradation of Agricultural Lands in Canada. LRRI Contr. #118.

Willis, W.O. and W.A. Raney. 1971. Effects of Compaction on Content and Transmission of Heat in Soils. Pages 165-177 in *K.K. Barnes et al. (eds.). Compaction of Agricultural Soils. Am. Soc. Agric. Eng. Monogr., St. Joseph, Mo.*

Anonymous. 1976 Revised. Glossary of Terms in Soil Science. Research Branch, Canada Department of Agriculture. Publication #1459. Ottawa, Ontario.