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August 29, 2022

VIA ELECTRONIC FILING

Attention: Nancy Marconi, Registrar of the OEB
Ontario Energy Board
27th Floor, 2300 Yonge Street
Toronto, ON M4P 1E4

Dear Registrar:

RE: EB-2022-0086 – Enbridge Gas Inc. – Dawn to Corunna Replacement Project
CAEPLA-DCLC Responses to Pollution Probe Interrogatories

In accordance with the OEB's Procedural Direction No. 4, please find enclosed for filing in the above noted proceeding the responses of CAEPLA-DCLC to Pollution Probe's interrogatories.

Yours truly,
SCOTT PETRIE LLP
LAW FIRM

John D. Goudy

Encl.

c.c.: Parties to EB-2022-0086, *via email*

EB-2022-0086

ONTARIO ENERGY BOARD

IN THE MATTER OF the *Ontario Energy Board Act, 1998*, S.O. 1998, c. 15, Schedule B, and in particular, sections 90(1) and 97 thereof;

AND IN THE MATTER OF an Application by Enbridge Gas Inc. for an Order or Orders granting leave to construct natural gas pipelines and ancillary facilities from the Township of Dawn Euphemia to St. Clair Township;

AND IN THE MATTER OF an Application by Enbridge Gas Inc. for an Order or Orders approving the proposed forms of agreements for Pipeline Easement and Options for Temporary Land Use.

CAEPLA-DCLC RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

August 29, 2022

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1. **References:**

Preamble:

Request: Is CAEPLA aware of any cases for Enbridge (i.e. legacy Enbridge and Union Gas or affiliates) pipeline projects where Enbridge did not comply with the conditions in the MOU, Environmental Mitigation Plans (e.g. project specific or Construction Manual recommendations), OEB requirements (including project conditions of approval), or recognized best practices? If yes, please provide some contextual examples to illustrate the issue and related impacts.

Responses: The Final Reports of the Independent Construction Monitors appointed for the Union Gas Limited Panhandle Reinforcement Project (EB-2016-0186), the Union Gas Limited Dawn Parkway 2016 Expansion Project (EB-2014-0261) and the Union Gas Limited NPS 48 Strathroy-Lobo Project (EB-2005-0550) all identify instances of non-compliance with LOU requirements (see highlighted excerpts at **Attachment 1**). These examples of non-compliance related primarily to soils handling, SCN mitigation and wet soils shutdown. The main impact of these instances of non-compliance would have been damage to soils.

Union Gas Limited Panhandle Reinforcement Dawn to Dover Station NPS 36 Pipeline Project

Independent Construction Monitor Final Report

Attention:

George Adams
Project Manager
Union Gas Limited
PO Box 2001, 50 Keil Drive North
Chatham, ON

December 2018

Submitted by:

The Soil Resource Group
50 Crimea Street
Guelph, ON
N1H 2Y6

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Sec.3. Continued Supply of Services

Compliant: Maintenance of services was undertaken by the contractor and Union Gas.

Sec.4. Water Wells

Compliant: Monitoring the quality of well water was undertaken by the project's environmental personnel. One landowner complaint of well water quality determined not to be related to construction remained unresolved at the time of the Post Construction Report.

Sec.5. Staking of Work Space

Compliant: The outside boundary of the easement and temporary land use area of the project workspace was marked using red painted wooden stakes with chainage marked at intervals of 30m or less prior to construction and remained until after topsoil was stripped. Work activities did not exceed the easement boundary though small areas of topsoil piling extended beyond the boundary. Occasionally, topsoil needed to be pulled back with excavators from off easement back onto the pile.

Sec.6. Topsoil Stripping

Partially Compliant: Prior to installing the pipeline in agricultural areas, topsoil was stripped across the entire width of the easement of all agricultural properties as well as across wider temporary land use areas. Topsoil stripping occurred under generally favourable conditions. Topsoil was stripped in two directions from the centre area of the easement to each side separating previously disturbed soils and undisturbed topsoil into two piles, as requested by CAEPLA. The basis of determination of this separation designation was unclear. Topsoil was piled in Temporary Land Use storage areas along the length of the easement and along the wider TLU areas. An additional shallow mixed layer from the topsoil subsoil interface was graded in a pile up to the foot of the topsoil pile. Foreman and operator differences occasionally did not comply in separating the mixed interface layer into separate disturbed and undisturbed piles. Due diligence was implemented to ensure that subsoil piles removed during trenching maintained separation from the topsoil pile. Maintaining 1m of separation was not always done along the easement due to space constraints where trench stability was a concern and greater subsoil was removed to create a more sloping trench face. There was rarely a physical barrier or other mediation practice employed. Determining topsoil depth was occasionally misread by individual operators adding subsoil when stripping. The Soil Inspector was typically present when a new property or soil condition was stripped to establish proper topsoil depth though often inspectors were not present while operators stripped topsoil. Experienced operators were relied upon to identify colour change indicators and maintain consistent separation of soil horizons.

Sec.7. Depth of Cover

Compliant: The pipeline was installed with a minimum of 1.2m of cover that was ensured with the continuous monitoring of the trench depth manually as it was being dug to allow for adequate soil cover of the pipeline and subsequently by GPS measurement of the returned and graded soil cover.

Sec.8. Leveling of Pipe Trench

Compliant: During trench backfilling, the excess subsoil material was piled on the easement until removal during the year of construction. Landowners indicated in the preconstruction interview and were granted excess soil. It is unknown whether landowners were always given the right of first refusal of any excess material before it was removed as one landowner did not receive material before it was trucked away. Properties with exposed subsoil the year after construction were graded level though isolated areas near the south end and at tie-ins had excess extraneous subsoil removed. For the 40 properties with topsoil returned the year of construction, several had uneven grade differences the year after sometimes related to trench subsidence. The settlement and uneven easement was sometimes repaired by filling in with imported topsoil before grading level. Mounding of topsoil over the trench line that persisted the year following construction was graded level with the second year clean-up activities. A few landowners signed-off and waived further topsoil restoration after the fall of construction waiving additional second year decompaction and grading.

Sec.9. Topsoil Replacement, Compaction Removal and Stone Picking

Partially Compliant: Prior to topsoil spreading, subsoil decompaction was completed under variable conditions. During the year of construction, decompaction was less effective on clayey soils that remained moist but was largely effective on sandy soils and properties worked the year after construction. After subsoil had been graded level with a bulldozer, decompaction was typically done using a deep ripper mounted on a D6 bulldozer or on a grader, followed by a chisel plow disc and harrows that was sometimes followed by a bulldozer pass to level. Deep tillage was done on clayey areas of a few properties when conditions remained unsuitably wet though ponded water was pumped off. Decompaction of the subsoil was incomplete on 78 agricultural properties by late fall when conditions were too wet to be effective. Many landowners were not made aware or presumably uninterested in the type of decompaction implements used. Stones were not an issue in these soils but any were picked from the subsoil by hand to a size not less than 50mm in diameter. Topsoil was returned to 40 properties starting in the north end in the year of construction matching the easement lands with the surrounding grade. All but two landowners requested topsoil be returned the year of construction if conditions were suitable. However, weather and construction decisions did not permit further topsoil return. Topsoil was returned the year of construction and the year after construction under generally favourable conditions using backhoes to pull back and bulldozers to grade level. Initially, a D8 bulldozer with narrow tracks was used to push topsoil but was removed after the compaction risk was recognized. Decompaction of the topsoil used a paratill, followed by a disc ripper tillage implement, and then fine leveling was done with disc and cultivator implements. The soil inspector tested the decompaction of each property for subsoil and then the topsoil on and off easement using a digital penetrometer though the results were not requested by the landowners or provided to the ICM. The depth of topsoil was not checked or adjusted based on final grading.

Sec.10. Drainage Tiling

Partially Compliant: Field drainage systems were considered with the pre-construction activities of installing header tiles in the fall and winter prior to construction, maintaining main tile drainage the year of construction and repairing and adding easement tile to the system the year after construction. A

Union Gas drainage inspector acted as the liaison between landowners and a qualified independent drainage consultant for the majority of properties. A small number of landowners had another preferred contractor directly involved for their property. A tile plan for each landowner was developed prior to and modified after construction with their consultation. Tile crossings that were intercepted during construction were staked and capped and georeferenced. Main tiles were temporarily repaired across the trench line but not always by a drainage consultant as in the LOU. Some repairs by drainage consultants were not done effectively eg. collapsed tile, as uncovered during the final tile installation the year after construction. Other areas of drainage needs such as a temporary tile plan to receive accumulated surface water, or tile for newly cleared agricultural land were not required. Existing tile lines were not used to directly pump accumulated water into as a result of the construction though a few situations used a filter bag or French drain to drain water from a trench or easement subsoil. Conditions and the clean-up progress did not allow any tile installation work to be initiated by the project tiler the year of construction. Four landowners that had signed-off installed tile the same year. The year after construction, tiling was completed on the large majority of properties with approximately 10 properties not done by end of season.

Sec.11 Water Accumulation during Construction

Compliant: Water accumulated on the easement after rainfall was pumped to suitable areas, primarily road ditches, as directed by the environmental inspectors into filter bags to reduce the release of sediment. A significant amount of resources was dedicated to the removal of accumulated water from the easement during wet soil shutdown periods. Small ponded areas mid road concession were occasionally sprayed onto topsoil piles with minimal erosion and minimal overspray onto agricultural lands. Significant water ponding off easement seldom occurred as a result of piled topsoil blocking runoff though crop damage was addressed through compensation.

Sec.12 Access Across the Trench

Compliant: Access across the easement was maintained for each property field with breaks in the topsoil piles by property. Following pipe installation and backfill, site conditions and landowner situations did not require creating a gravel base on filter fabric across the trench line as outlined in the LOU. Following construction, a wood construction mat laneway on topsoil was provided in one case to allow specialty crop harvest. The restored and reconfigured soils after construction often becomes unsuitable when wet up in the late fall the year of construction until soils dry out the year following construction. Landowners that required access onto the easement during this time experienced severe rutting in spots.

Sec.13 Restoration of Woodlots

Compliant: tree clearing was undertaken prior to construction (February to March) to remove all trees, stumps and brush from the easement. No land was known to be converted from woodlot to agricultural land after construction.

Sec.14 Tree Replacement

Compliant: arrangements to replace trees that were cleared from the easement were made in consultation with the landowners.

Sec.15. Covenants

Covenants of Union Gas listed in the LOU were or will be presumably Compliant with the exception of the following covenants that were Partially Compliant:

i) Survey techniques (GPS) to establish pre-construction and post-construction soil grades were not generally utilized as soils were restored from visual reliance of experienced contractor operators and personnel.

ii) Proper clean-up practices were completed throughout the affected area; however, a small number of properties did not receive the benefit of the full soil restoration practices of the project. Conditions and resource dedication were not sufficient to complete restoration the year of construction prompting some landowners to sign-off on the commitments and accept compensation to restore their own land, with mixed results.

iii) Travel on the easement was primarily done in the work area and driving lane for practical reasons, not on the trench line, for much of the construction period from delivering and welding of the pipe prior to trenching until after backfilling was completed. Traffic areas on subsoil before and after this period were inconsistent and not confined to the trench line.

xi) Landowner Complaint Tracking system was not made available to landowners or the ICM.

xvi) The Soil Inspector on the project carried out comparative compaction testing on and off easement after construction; however, independent Consultant testing of compaction, fertility and GPS recording of testing after construction was not known to be done.

xvii) Weed control along the pipeline easement was not fully recognized as a concern by Union Gas the year of construction though sandy topsoil piles that were hydromulched to reduce wind erosion benefited in also controlling some weeds. Attempts were made by some landowners to spray topsoil piles or cut weeds on gored land that grew to maturity. Attempts were made the year after construction to mow weed growth and seeded cover crops though weed regrowth was allowed to become well established prior to drainage tiling as well as after drainage tiling without a cover crop being seeded.

xx) Imported topsoil was required on the easement the year after construction during clean-up to repair subsidence and low areas. Sources of topsoil were evaluated by the soil specialist with Stantec to have attributes suitable for adjacent agricultural soil, and be free of SCN. Reasonable considerations were used except for one clay loam site that received loamy topsoil that was unscreened from off easement. Information of whether each landowner had input or knowledge of the quality or the source of imported topsoil was not provided but indications were this did not occur.

The wet soils shutdown practice for pipeline construction on agricultural lands (LOU Schedule 6) was addressed in a separate section of the report.

The remaining sections in the LOU cover dispute resolution, landowner rights and compensation that were not in the scope of activity for the monitor.

5.2 Biosecurity

Biosecurity was considered with the potential movement of topsoil bound Soybean Cyst Nematode (SCN) between properties. The extent of the SCN insect pest was identified with soil sampling of agricultural properties preconstruction in the fall of 2016 by soil specialists from Stantec that determined 99 of the 118 properties tested positive. Negative test properties were resampled to confirm. Only one landowner had properties that tested negative south of the Sydenham River, who later waived the need for protective measures for SCN. A SCN protocol was slow to be established with signs indicating SCN positive fields being erected 3 weeks after the onset of construction and insufficient restriction initially of vehicle and personnel movement prior to stripping topsoil. Adoption of a protocol for personnel became better enforced over the first month that included disposable booties over footwear that were replaced with more durable rubber boots dedicated for use only on SCN fields and the use of boot washing stations at roadsides and impacted properties. Equipment wash stations were established at the boundary between SCN and non SCN properties that were well managed in removing topsoil during the topsoil stripping operation.

With the proliferation of SCN in the area, the risk of a breach in biosecurity was considerable. Movement of subcontractors such as mechanics and project vehicles off and back onto roads was an issue that could be improved. However, roads may also be an area of transmission between farm vehicles with impacted fields and project vehicles. The risk of topsoil transmission is reduced when working in dry conditions, emphasizing the importance of a soil shut down when conditions are not suitable. The level of due diligence by the contractor and the inspector team was good in designing a SCN protocol though there was an initial delay in full implementation.

In the clean-up phase, the completion of topsoil return of the clayey soils north of the Sydenham River appeared to maintain SCN protocols. However, properties that were SCN negative that were required to have the SCN protocol maintained throughout the second year activities were not signed that would alert all traffic to comply. Topsoil imported in the clean-up phase was reportedly negative for SCN. An important consideration of biosecurity for farmers is not only for SCN but other pests including chemical resistant weed seeds in minimizing the transport of topsoil eg. truck, boots, machines, between any property. The risk of topsoil movement between properties on topsoil stripping or drainage tile equipment was often reduced with the knocking off soil from equipment tracks, etc. but should be rigorously and consistently managed to reduce the risk.

Based on the biosecurity observations, the following are recommended guidelines:

a. Soil sample analysis for SCN preconstruction that has confirmed SCN results, should be repeated ***post construction*** on all non SCN tested properties

b. Establish a thorough and rigorous SCN protocol for all equipment and all personnel to follow ***prior*** to the construction project through to the clean-up ***completion***

c. Familiarize all contractors before and after construction of an overall ***pest protocol*** that considers SCN and other pests including resistant weed seeds in minimizing the transport of topsoil between any property

May 19 - P105 SCN impacted property with posted SCN protocol warning

May 23 - P98 wash station cleaning infected SCN topsoil from machinery adjacent to non SCN field

May 30 - P97 (non SCN) and P96 (SCN) boundary topsoil stripped toward SCN impacted property

Oct 23 - P98 (SCN) and P97 (non SCN) boundary topsoil returned and separation maintained

5.3 Topsoil Stripping

Agricultural production relies on the preservation of topsoil, or the organic layer, as it is distinct in characteristic from the subsoil layers below. The project team displayed considerable effort in the careful removal and handling of topsoil from agricultural properties. Several pieces of heavy equipment were employed to strip topsoil after an initial tractor discing. The typical sequence began with a road grader for the first cut to cleanly separate the undisturbed soil from the previously disturbed soil on the easement and establish the topsoil depth. Bulldozers (D6) primarily completed the topsoil stripping to the edge of the topsoil storage TLU on either side of the easement in separate undisturbed and disturbed piles. Where requested by the landowner, a straw mulch layer was spread over the topsoil before piling as a visual indicator for topsoil return. Additional topsoil stripping was done at wider TLU areas at road and stream crossings and staging areas primarily using excavators and piled separately. The final stripping and leveling across the easement was to be by a grader. This A/B soil

horizon transition layer or 'seconds' containing much of the remaining topsoil was scraped shallow separating both sides into a small windrow positioned at the base of the topsoil pile. Individual foreman and operator would occasionally not separate these remaining undisturbed and disturbed soils or would use a bulldozer that is less accurate.
Conditions were assessed each day prior to topsoil stripping by the Soil Inspector at each location. Three separate field crews were supervised throughout the project involved in the topsoil stripping activity that each included several machines. This made it impossible for the qualified soil inspector to be present to monitor the removal of topsoil to the appropriate depth throughout the day. The contractor equipment operators and foremen appeared experienced in visually identifying the interface between the A and B soil horizons though the large contrast in soil type from the north to the south end of the easement required careful attention to the changing visual indicators. The involvement of several operators occasionally resulted in different results with the general tendency to remove more than what was required in causing mixing of the topsoil with some subsoil. Communication between the Soil Inspector, foremen and the ICM helped alleviate some operator uncertainties though any direction given was requested to be through the Soil Inspector.

Soils at the north end of the easement presented a distinct challenge as they were uniformly Brookston clay loam that was slow to dry. The decision to begin activities on these soils when lighter textured soils were more suitable resulted in delays in topsoil stripping as well as potentially damaging soils, particularly the Union Gas Dawn Station property that was stripped too wet. The Brookston soils also had a relatively shallow topsoil layer (<20cm) that was often mixed in with several cm of the underlying clayey B subsoil horizon of similar colour. In contrast, the silty loam highly productive soils of the south end of the easement had topsoil of 40-50cm depth. With consultation, it was decided to be stripped as much as could be stored with a minimum of 30cm.

Information of the measured topsoil depth for a field had not been collected ahead of stripping to assist the operators. Soil assessments conducted by the ICM confirmed the soils in the area of the new pipeline were undisturbed from construction and those in the area of previous construction were generally disturbed with C material subsoil, if not in the topsoil, in the underlying subsoil.
Based on topsoil stripping observations, the following are recommended guidelines:

a. Identify topsoil depth for a field during the ***preconstruction*** soil sampling and testing activities to inform operators at the time of topsoil stripping

b. Agricultural land topsoil stripping to be done with a qualified Soil Inspector or Independent Construction Monitor (ICM) ***present to provide guidance and record variances in depth by property***

c. Continue to ***separate*** topsoil into areas of previously disturbed soil (eg. mixing from previous construction) and undisturbed (native) soil piles off easement

d. Topsoil stripping equipment to be initially done by ***grader in undisturbed soil*** area, bulldozer (D6 or smaller) in disturbed soil area; ***backhoe in moist areas*** and crossings TLU's

e. After topsoil stripping, the ***transition layer*** of the remaining topsoil and intruded subsoil to be removed using ***grader only***

f. ***Record using GPS georeference*** the preconstruction grade of topsoil and the grade of subsoil after topsoil stripping; comparison can then be made to the reestablished subsoil and topsoil grade post construction, to help verify uniform topsoil depth and help ensure no restriction of the overland flow of water

Note: The OEB Environmental Guidelines suggest ‘The topsoil depth and method of stripping should be determined after consultation with the landowner prior to construction’.

May 29 - P121 topsoil stripping initially by grader to proper depth separating undisturbed topsoil

June 9 - P109 grader has made first cuts and bulldozer continues to strip topsoil

May 24 - P120 topsoil stripping depth exceeded for Brookston clay topsoil where 20cm adequate

July 3 - P3 topsoil depths taken approached a half metre as in many parts of Dover Township

June 2 - P110 topsoil stripping sequence of discing, grader centre cut, bulldozer pushing windrow

June 17 - P48 topsoil stripping piled onto straw mulch layer in TLU area along edge of easement

June 22 - P45 topsoil stripping with 12 heavy equipment machines and 3 tractor implements

May 23 - P54 completed topsoil stripping of RoW into two piles, each with seconds pile at base

5.4 Soil Piling

Topsoil was stored in piles in the storage TLU on either side of the easement within the designated easement boundary marked in regular 25-30m intervals with red painted wooden stakes. The storage area was not encroached by the discing prior to topsoil stripping so that the risk of an operator not distinguishing the loose material of the pile from loosened original topsoil surface underneath was minimized. A straw mulch layer was spread on the storage area surface before piling where the landowner requested it to provide a visual indicator when the topsoil pile was removed. However, experienced operators were adept at removing the piled topsoil from a firm undisturbed soil surface. The size of topsoil piles was somewhat dependent on the depth of stripping and width of the easement as where there was an additional TLU area. Occasionally, the larger sized piles would slightly exceed the easement boundary though clods of topsoil would be manually shoveled back or long armed excavators would be used to lift back the edge.

Protection of the topsoil piles was considered important during the initial period of construction. Wind erosion of the sandy materials in the year of construction was addressed with the spraying of a hydromulch over the entire topsoil pile that provided a thin mulch crust and opportunity for the applied annual ryegrass to get established before the weeds. Properties of medium textured soils and particularly with large storage piles in a TLU did pose additional risk of soil loss from water erosion off easement without any containment though there was little extent of this occurring. The A/B soil transition layer pile at the base of the topsoil piles acted as a containment to greatly reduce the movement and mixing of topsoil into the adjacent subsoil material on easement. However, large piles of extraneous subsoil containing heavy clay left overwinter next to topsoil piles did not have sufficient separation to prevent mixing. Topsoil piles were returned for the clayey soils of the north section in the year of construction negating the risk of loss overwinter. However, the majority of properties remained unprotected overwinter through the spring and much of the summer the year after construction. Topsoil piles were not protected from weed growth though some operators did spray herbicide to reduce the proliferation of weed seeds. Where they went unchecked, the weeds did provide an effective erosion protection measure.

During the wet conditions during the year of construction, water pumped off the easement would occasionally be sprayed onto topsoil piles. The amount of water and careful application caused minor erosion; however, the addition of sediment laden water from subsoil areas should be low.
Based on observations of soil piling, the following are recommended guidelines:

a. Maintain ***separation of topsoil by property*** during stripping and separation of topsoil piles by property using a break in the windrow at property boundary

b. Protect topsoil piles from wind and water erosion on prone soil textures with the application of a ***spray tackifier (hydromulch) in both the year of and year after construction***

c. Maintain ***weed control*** on topsoil piles using herbicide spray to avoid seed set, if requested by landowner

May 23 - P100 TLU topsoil stripping excessive with no separation of subsoil on topsoil pile

June 7 - P121 TLU area where topsoil from P122 woodlot stored on hay mulch layer

July 6 - P24 topsoil that spilled over the back of pile off easement being pulled back onto pile

June 29 - P72 hydroseed spraying of topsoil piles in TLU of annual ryegrass on sandy soils

June 21 - P1 TLU topsoil pile hydroseeding well established for erosion protection

Aug 24 - P63 trench water sprayed onto topsoil piles causing minor eroding of soil

5.5 Pipeline (NPS16) Removal

The Panhandle Reinforcement Dawn to Dover Station Project included a lift and lay process whereby the existing NPS16 pipeline of the easement was to be removed to make way and be replaced by the installation of the NPS36 pipeline. With the completion of topsoil stripping on properties in the north half of the easement, the locating, digging and lifting out of the old 16in. pipeline from under a relatively shallow layer of subsoil began. Trenching using an excavator on either side of the pipe intercepted any drainage tile that was present. Tiles were capped closed and recorded with a georeferenced location. Lifted pipe was sheared into lengths and transferred by the excavator to TLU areas of road crossings for disposal.

Removal of the old pipe required careful management for short lengths in the south half of the easement where the protective coating was known to contain asbestos. The concern of possible contamination of material or liquids from the remaining 16in. pipe was assessed by Stantec environmental personnel to be insignificant. However, petroleum based protective coating fragments would detach with pipe snippings and handling. Fragments were not thoroughly picked up before being

5.8 Wet Soil Shutdown

Wet soil shutdown protocols are required during pipeline construction to prevent an adverse effect on soils during wet soil conditions. Rain gauges were located in 5 locations along the easement to help assess the daily soil condition by the Union Gas soil inspector. Rainfall was provided to the ICM upon request at the daily construction meeting. After a rainfall, the assessment of the Soil Inspector helped determine the extent and location of work shutdown decided by the Construction Superintendent. The extent of a shutdown, ie. full or partial shutdown, considered a number of factors including the conditions, amount of rainfall, soil type and different construction requirements. The year of construction was wetter than normal with a reported total number of partial or full shut down days affecting construction plans on the agricultural lands of 73 days. Inspection of suitable conditions was the responsibility of the Soil Inspector that removed any interpretation by the contractor foremen to manage personnel and subcontractor traffic. Weather forecast information including radar that was available in real time was always consulted by inspectors and the contractor to be aware of pending significant rainfall.

A number of incidents, however, were observed by the ICM despite the general acceptance of the wet soil shutdown policy. Rubber tired vehicle traffic such as pickup trucks occasionally left tracks that were potentially damaging to agricultural soils. Damage could have been reduced in many cases by avoiding standing water, a protocol that was generally accepted by most. A rigorous and diligent program was followed in removing standing water from the easement when it readily accumulated after rainfall. Trash pumps and hoses were used to draw water down the easement to roadside ditches to empty water and sediment through filter bags. The effort to remove water from the easement undoubtedly helped to lessen the infiltration, increase the drying potential and reduce the risk of subsoil compaction from subsequent traffic needs. The use of light all-terrain vehicles were relied on in moving equipment to facilitate the removal of standing water that inevitably caused some rutting; however, the benefit of minimal ATV traffic for this purpose was reasonable.

Subcontractor traffic (eg. fuel truck, hydro-vac, pipe scrap truck) occasionally caused wet soil damage that could have been avoided in some cases with the earlier use of the mitigation measure of wood construction mats. Extensive use of wood construction mats was employed in staging areas of large pipe boring activities and the work area along the easement in the heavier textures soils (4km lane) near the north end to reduce compaction. However, heavy equipment work from the mats through an extended period of wet saturated conditions did not represent a sufficient mitigation measure in preventing an adverse effect on soils. Non-compliance with the wet soil shutdown policy occurred most often during construction priorities, eg. water crossings, and activities later in the fall leading up to the pipeline in-service deadline date.

Working in saturated subsoils by heavy equipment when conditions were wet was occasionally done. Scraping the thin layer of wet subsoil to mix with drier material below to hasten drying was not a common practice but did occur. In TLU areas where pipeline tie-in activities were required, tracked machinery mixed wet subsoil of different depths; as well bulldozers were used to remove wet layers of subsoil to permit various kinds of traffic to complete pipe work. Contractor personnel were made more aware by the ICM of the risk of subsoil damage and the limitation of decompaction steps to remediate compaction. By not allowing the soil to dry, the natural structure and drainage capability were likely affected by heavy destructive forces causing detachment and smearing of soil particles. These separated particles in turn seal pores, increase the future risk of the subsoil to compaction and reduced the soils ability to infiltrate water.

Based on observations of wet soil shutdown, the following are recommended guidelines:

a. Determining wet soil shutdown conditions prior to daily construction by the Construction Superintendent to consider input from a ***qualified Soil Inspector***

b. Traffic, including pickup traffic, on easement throughout wet soil conditions to be avoided and restricted to ***required*** construction areas

c. Prioritizing pipe work during wet soil shutdown conditions should ***implement management practices*** (eg. construction mats) to minimize the area and depth of soil damage

d. Raise awareness of wet soil shutdown and risk of damage of wet soils by Union Gas and Contractor ***to Subcontractors***

e. Pumping ponded water off easement should continue to be a ***high priority*** to avoid causing saturated soil conditions that may lead to lengthy dry down time and additional soil compaction risk

f. Drying of easement subsoils not to be aided by scraping or ***blading of wet soil*** layer, of which removing wet layer should only be done if there are ***required*** construction areas to access

g. Delay soil work until June, particularly on clayey soils, and under dry conditions

Note: The OEB Environmental Guidelines suggest that the wet weather shut down policy is to include 'During wet weather conditions, contact with topsoil should be avoided and a total restriction placed on all rubber tired vehicles and equipment traveling on the ROW. If, due to delays, construction must continue under wet soil conditions to meet an in-service date, terms and conditions must be discussed with the landowner.'

May 4 - P1 pipe work traffic and activities in TLU area in wet soil conditions

May 15 - P128 topsoil stripping using ten heavy machines done too early on moist clayey subsoils

June 23 - P111 ponded water and tracks made by an Argo ATV transporting pump equipment

June 27 - P125 wood mat 4km lane covered in mud lying on wet clay soils and ponded water

July 15 - P124 wood mats covered in mud and floating, ponded water and wet soil conditions

Aug 29 - P120 standing water on compacted subsoil after rain after wood mat lane removal

July 25 - P107 saturated subsoil pushed aside by bulldozer before rutted by fuel truck traffic

Aug 18 - P96 wet soils and ruts off the access ramp from hydrovac truck before mats installed

Sept 20 - P38 impact on subsoil from stream crossing activities under wet soil conditions

Oct 16 - P54 pipe work activity disturbance of drier subsoil after saturated subsoil pushed off

Aug 17 - P33 random pickup truck traffic in wet soil and through standing water

Sept 14 - P8 pickup truck tracks in wet saturated soil

Nov 14 - P27 wet soil tracks from gator vehicle traffic during final construction activities

Aug 1/18 - P56 pickup turnaround tracks on wet soil just beyond mat lane

Union Gas Limited Hamilton to Milton NPS 48 Loop Pipeline

Independent Construction Monitor Final Report

Prepared for:

The Construction Monitor Committee
Zora Crnojacki - Project Advisor, Ontario Energy Board
Rob Marson - Project Manager, Union Gas Limited
Ian Goudy - Chair, Gas Pipeline Landowners of Ontario

December 20 2017

Submitted by:

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SOIL RESOURCE GROUP

1. Executive Summary

Union Gas Limited and the Ontario Energy Board (OEB) arrived at a Settlement Agreement for the construction of approximately 20km of NPS 48 pipeline (48 inch diameter) in an existing pipeline corridor extending from the Hamilton Valve Site to the Milton Valve Site. The Agreement considered issues raised by stakeholders including the Gas Pipeline Landowners of Ontario (GAPLO) that Union Gas appoints an independent construction monitor for construction on the agricultural lands portion. The construction monitor was chosen by a Construction Monitor Committee with a representative from Union Gas, the OEB and GAPLO to report on issues related to a Letter of Understanding (LOU). The LOU negotiated between Union Gas and affected landowners outlines the obligations with respect to: i) the construction of the pipeline; ii) remediation of the landowner's property; and iii) compensation to the landowner for various damages as a result of the construction of the pipeline. The scope of work for the construction monitor did not include part iii) or any financial matters between Union Gas and landowners but were listed as:

1. To observe impacts of construction on the land, including right-of-way preparation, trenching, backfill and clean-up operations as well as wet soil shutdown events;
2. To review construction activities for compliance with the OEB Conditions of Approval, Letters of Understanding (LOU) agreed to between landowners and Union;
3. To review all specific construction commitments included in Union's construction contract;
4. To respond to specific requests by landowners and the committee within 24 hours while maintaining limited contact with landowners on a day-to-day basis; and
5. To prepare and deliver a series of activity reports in a timely manner to the appropriate persons.

The Independent Construction Monitor (ICM) role was completed by The Soil Resource Group using a team of three qualified soil science professionals, each with over 25 years of experience working with agricultural soils in Ontario. One of the Monitors was on-site each day throughout the construction period when activities included or may have included agricultural lands. The ICM in its stated role was limited in contact with landowners to situations where a specific request was made by a landowner or the Construction Monitor Committee. Communication with the Construction Monitor Committee was channeled through the Monitor Lead primarily through written weekly monitoring reports as well as conference call and email correspondence to discuss issues of concern and clarification. Daily communication with Union Gas staff was initiated with a 6am Construction Meeting with inspectors held at the Union Gas yard office that outlined the daily work activities and safety issues. Observations of daily activities, soil conditions and related comments or concerns were summarized by the daily ICM and forwarded by the Monitor Lead to the Construction Superintendent.

Communication with the Committee included the submission of weekly reports by the ICM Lead that summarized the monitors daily report observations and concerns for each week. The ICM did not exercise any authority to decide when Wet Soil Shutdown was required and were not requested by the Committee to render an opinion if construction work took place in wet soil conditions as in the LOU. Comments were not received by the OEB representative though points of clarification were discussed over the phone occasionally with the Union Gas and GAPLO committee members separately. Construction issues that were discussed included topsoil stripping method, wet soil shutdown criteria, construction monitor role, soil inspector role, stone picking sufficiency, site specific soil erosion protection. Communications between the ICM team and landowners were minimal as the Land Relations Agent (LRA) was designated as the point of contact for the project. The impact on the agricultural land made up of 30 properties was the focus of monitoring activities.

The attention committed overall by the construction team in following the LOU was recognized by all three members of the ICM team. It must also be recognized that observance of the LOU and Union Gas specified construction practices was dependent on a cooperative effort with the contractor and subcontractors that were capable and committed to fulfilling the project obligations. Compliance with sections of the LOU was observed with the correction of a number of issues associated with topsoil management, soil restoration, tile drainage and wet soil shutdown. In a number of situations, small variances in managing soil that risked damage were attributed to individual operator error or supervision and insufficient oversight of qualified specialists with soil and agricultural experience.

The required environmental completion dates and pipeline in-service deadline late in the fall increased the risk of soil damage when conditions were wet. Proper restoration of easement lands was therefore not possible with the length of the construction season well into the fall. The clean-up phase was incomplete the year of construction on 14 agricultural properties though rock picking of subsoil and topsoil replacement was completed for all properties. Proper decompaction of subsoil remained incomplete for several properties the year following construction though surface soils were restored for these properties. Management of drainage tiling activities was a concern throughout the project from how the plans were developed, the plans delay, the interception of tiles, the tile installation in wet soil conditions, the pipeline strike of June by the drainage consultant, the repair of missing tile mains the year after construction, the completion in October by a second drainage consultant and the subsequent working of soils over the tile trench soon after.

Wet soil shutdown was seldom declared as a full shut down, as activities off the soil easement were permitted. Declaring a partial shutdown often required on site interpretation and recognition of what constitutes an adverse effect that was inconsistent between field personnel and insufficient to stop potentially damaging activities. Upon occasion, work continued when environmental permit or in-service deadlines needed to be met when mitigation measures developed on a site specific basis were not always sufficient. Traffic by rubber tired vehicles was occasionally carried out on the easement throughout the project during wet weather conditions with or without required construction needs though the extent of rutting was typically low as soils became packed firm from heavy traffic and moisture infiltration was low. Avoiding standing water needed to be reinforced.

Monitoring the impact of pipeline construction on the land largely considered the impact to soil, the landowner’s most valuable resource. Significant disturbance of soil by the construction of a pipeline cannot be avoided. Disturbance should be minimized and the extent of construction practices that impact a soil's function to support plant growth will influence the length of time that soil can return to its previous state and productivity potential. Observations by the ICM of the pipeline construction practices and soil related activities were examined in the Discussion section that were the basis of a number of recommended practices to be introduced or reinforced. These identified observations recognize the needs of landowners and the Union Gas construction process.

Sec.9. Topsoil Replacement, Compaction Removal and Stone Picking

Partially Compliant: Prior to topsoil replacement, subsoil decompaction was undertaken in varied conditions and was not completed for all properties. Decompaction using a ripper, chisel plow and disc implements during dry summer conditions at times overworked and damaged the subsoil surface. Deep tillage was done on small areas of some properties when conditions remained unsuitably wet and where ponded water was not pumped off. Decompaction of the subsoil was incomplete on 14 agricultural properties by late fall when conditions were too wet or too stony to be effective. Many landowners were not made aware or presumably uninterested in the type of subsoiling implement used. Stones were picked from the subsoil by mechanical stone picker when dry and by hand to a size not less than 100mm in diameter. A small number of properties had very stony and bouldery subsoil that were not completely picked clean but were extensively picked and left with a level surface. Topsoil was returned for all properties the year of construction under generally favourable conditions using backhoes and bulldozers to grade. Decompaction and fine leveling of the topsoil used subsoiler, disc, cultivator and cultipacker implements favoured by the contractor though soil moisture conditions were not always suitably dry to use the cultipacker. Stones were picked from the topsoil by mechanical stone picker when dry and by hand to a size not less than 100mm in diameter, though two very stony easement fields were picked to a reasonable comparison to the adjacent fields. The clean-up inspector, not a soil specialist, tested for compaction and topsoil depths for each property. Compaction testing was done on and off easement before and after topsoil replacement though the results were not requested by the landowners or provided to the ICM. A penetrometer was used the year of construction and a hand auger the next year when conditions were dry and penetrometer results were inconclusive. Topsoil depth was nominally checked during replacement and was not adjusted based on any topsoil depth measurement. Those properties that did not have subsoil decompaction and topsoil decompaction completed the year of construction were partially addressed the following year. Some landowners accepted compensation instead due to crop production wishes or due to the inspectors concerns of stoniness though subsoil compaction remained unresolved. Topsoil damage or loss overwinter was exacerbated from incomplete subsoil and topsoil restoration, erosion protection measures or missing drainage tiling.

Sec.10. Drainage Tiling

Partially Compliant: Repairs and restoration of field drainage systems and municipal drains impacted by construction were completed by a qualified independent drainage consultant the year of construction (December) and the year after construction (October). The drainage consultant did not work directly with each landowner prior to or during construction to determine whether there was pre-construction, post construction and/or temporary tile construction required on their land. There was no pre-construction tile work. A tile plan for each landowner was developed during construction from consultation between the landowner and Union Gas who subcontracted an engineering drainage firm to document the drainage system information known prior to construction. Tile crossings that were intercepted during construction were staked, but not capped or always georeferenced by the contractor. Tile mains were therefore not temporarily repaired across the trench line by a drainage consultant as in the LOU. Other areas of drainage needs such as a temporary tile plan to receive accumulated surface water, or tile for new cleared land were not required. Existing tile lines were not used to pump accumulated water into as a result of the construction. Tiling work was initiated the year of construction growth became well established on the easement the year after construction prior to any restoration. Weeds were baled off from two large properties as requested by the landowner/operator.

xx) Imported topsoil was required on the easement the year after construction during clean-up to repair subsidence and topsoil erosion. Two sources of topsoil were evaluated by a soil specialist with Stantec and one source reportedly had attributes consistent with an agricultural soil and was free of SCN and met MOE Table 1 background soil standards. The moderately coarse texture of the topsoil matched well with some adjacent easement soils but was not consistent for the range of surface soil textures from clay loam to sandy loam found on other properties. Information of whether each landowner had input or knowledge of the quality or the source of imported topsoil was not provided but indications were this did not occur.

xxi) The wet soils shutdown practice for pipeline construction on agricultural lands (LOU Schedule 6) was implemented several times by the Construction Superintendent in consultation with Union Gas environmental inspectors in directing either a partial shutdown or complete shutdown. Construction restrictions were imposed on the contractor when an adverse effect on soils due to wet soil conditions was likely to occur; however, recognition of what constitutes an adverse effect was inconsistent between field personnel and insufficient to stop potentially damaging activities. Mitigation measures developed on a site specific basis were not always sufficient. Traffic by rubber tired vehicles was occasionally carried out on the easement throughout the project during wet weather conditions with or without required construction needs.

The remaining sections in the LOU cover dispute resolution, landowner rights and compensation that were not in the scope of activity for the monitor.

5. Discussion

Monitoring the impact of pipeline construction on the land largely considered the integrity of the soil in all its profile horizons as being of paramount importance to maintain proper soil function. Soil having formed over thousands of years once lifted, mixed, compacted and reconsolidated will be disturbed and damaged for a considerable amount of time. The nature of the construction process cannot prevent a degree of this change from happening in an agricultural soil. The soils ability to function as a favourable medium for plants with sufficient porosity to allow nutrient, water and air exchange throughout the rooting zone extends beyond the A horizon. Disturbance of soil by construction should be minimized firstly, and secondly construction practices that impact soil function in the subsoil and topsoil will influence the length of time that soil can return to its previous state and productivity potential.

Monitoring of the construction practices and related activities by the ICM are grouped for discussion as they presented themselves during the project. A number of related concerns and improvements were

5.8 Wet Soil Shutdown

The wet soil shutdown policy is required during construction to prevent an adverse effect on soils during wet soil conditions. In determining the daily condition of the easement, a network of 5 rain gauges was checked by the Union Gas environmental inspector. After a rainfall, the extent and location of work shutdown was a decision of the Construction Superintendent based in part on the assessment of the environmental inspector and the designated soil inspector during clean-up. Factors considered in determining the extent of a shutdown ie. full or partial shutdown, were the varied conditions throughout the easement (eg. rainfall, soil type) and different construction requirements. Few full wet soil shutdown days were declared over the construction phase for agricultural lands. Inspection and monitoring of easement conditions for partial shutdowns became a responsibility of the team of inspectors on site throughout the day for the large number of work locations. Suitable conditions were also an interpretation of experienced contractor foremen, which managed contractor staff and subcontractor traffic onto the easement.

A number of incidents were observed by the ICM, despite the general acceptance of the wet soil shutdown policy, where wet subsoils of the easement were trafficked and compaction was at risk. Pickup traffic was often seen in areas of wet soil though the extent of rutting was typically low as soils became packed firm from heavy traffic and moisture infiltration was low.

Avoiding standing water was generally accepted though isolated areas of ponding were encroached including when stream crossing activities were considered a priority. Subcontractor traffic (eg. dump trucks, hydro-vac, fuel truck) would occasionally not comply with the wet soil shutdown policy. Non-compliance with the wet soil shutdown policy occurred most often close to environmental permit deadlines ie. water crossings, and activities later in the fall leading up to the pipeline in-service deadline date. Mitigation measures when continuing with necessary construction activities on agricultural lands could have been improved with the use of construction mats in areas of wet soil conditions and greater restriction of vehicle traffic. Weather forecast information including radar that was available in real time was not always consulted by inspectors and contractor to be aware of pending significant rainfall. Upon occasion, heavy equipment still on the easement when rain arrived would have to be driven to the road access over soils that had become saturated.

Further mitigation of wet soil damage can be improved with the diligent removal of ponded water created on the easement from rainfall. Areas of subsoil that were left with ponded water for several days, particularly on clay soils, increased the risk of water infiltrating into the soil profile and lengthening the time before areas could be safely driven on or restored without causing further compaction. Low areas of a property that are predictable areas of ponding based on topography should be identified prior to construction and be discussed with each landowner to locate suitable areas off easement to pump excess water to.

Working of saturated soils by equipment was occasionally done when conditions were wet at the surface of the work area. Bulldozers were often seen scraping or blading a thin layer of wet subsoil mixing with drier material directly beneath to hasten the easement subsoil drying. By not allowing the soil to dry naturally, the natural structure and drainage capability are affected by the destructive forces causing the detachment of particles that seal pores, compact the subsoil, and reduce water infiltration. Based on observations of wet soil shutdown, the following are recommended guidelines:

a. Rainfall monitoring network data to be distributed by Environmental Inspector to staff ***and ICM*** prior to the daily construction meeting

b. Determining wet soil shutdown conditions prior to daily construction by Construction Superintendent to consider input from Environmental Inspector, ***qualified Soil Inspector and ICM***

c. Traffic, including pickup traffic, on easement throughout wet soil conditions to be avoided and restricted to ***required*** construction areas

d. Prioritizing pipe work during wet soil shutdown conditions should ***implement management practices*** (eg. construction mats) to minimize soil damage to a small area that should be recorded using GPS georeferencing

e. Awareness of impending rainfall is a responsibility of contractor to return heavy equipment to road access ***prior to soil wet up*** and possible compaction damage

f. Raise awareness of wet soil shutdown and risk of damage of wet soils by Union Gas and Contractor ***to Subcontractors***

g. Water pumping locations for removing ponding on easement to be established with each landowner ***prior to construction***

h. Pumping ponded water off easement should be a ***high priority*** to avoid causing saturated soil conditions that may lead to lengthy dry down time and additional soil compaction risk

i. Drying of easement subsoils not to be aided by scraping or blading of wet soil layer, of which removing wet layer should only be done if there are ***required*** construction areas to access

Note: The OEB Environmental Guidelines suggest that the wet weather shut down policy is to include 'During wet weather conditions, contact with topsoil should be avoided and a total restriction placed on all rubber tired vehicles and equipment traveling on the ROW. If, due to delays, construction must continue under wet soil conditions to meet an in-service date, terms and conditions must be discussed with the landowner.'

5.9.3.1 Restoration of Soil Erosion Example

Monitoring of agricultural land identified the potential risk of soil erosion from the HM34 property. The easement transected its field of long, moderately sloping hillslopes and side slopes of medium textured soil type. Concerns of the sensitive nature of the site were first noted in the daily report September 8 after a rainfall caused extensive rilling on the slopes of the property. This indicated the need to develop site specific erosion control measures for the area as it would be very susceptible to topsoil erosion overwinter and spring following construction.

Erosion of subsoil off the slopes with sediment deposition off easement continued until the grade was restored and topsoil was returned October 19. Overworking the subsoil and tilling the topsoil up and down the predominant slope added to the erosion risk. Discussion of the urgent need for enhanced erosion control measures in the area with inspectors was ongoing as significant losses with rills and small gullies was evident throughout the easement field by November 7 after only one heavy rainfall. There was difficulty in getting hold of the operator by Union Gas to discuss options that limited the implementation of effective soil protection practices. In particular, the operator had agreed to the construction practice of seeding an annual cover crop though the site warranted a winter rye cereal planted as soon after construction as possible. Union Gas and the contractor resigned to dealing with the inevitable erosion during the 2017 clean-up and restoration.

The erosion control needs of the HM34 property stream crossings were partially met November 14 with the establishment of physical barriers (line of hay bales, mulch erosion sock) across the easement at the bottom of the east facing slope, and cross slope shallow tillage on the severely eroding hillslopes. It was noted that surface runoff and soil erosion from the hillslopes would not be significantly reduced without established plant or residue cover.

The severe erosion concerns were realized with the formation of gullies visible across the HM34 property easement first observed on March 28. Soil restoration of the site was not undertaken until July 19. Circumstance prevented communication in reaching the operator, of the intention of Union Gas to restore the severe erosion, until the easement had been all worked and planted with the exception of the most severely eroded east facing toe slope area.

Restoration steps began with the grading and filling in of gullies and rock picking followed by the importation of good quality topsoil from the same source. More than 30 truckloads were used to replace some of the topsoil loss from the eroded slopes. Further erosion protection work through July 26 created narrow surface water diversion berms and a raised midslope ridge intended to break up downslope flow, as well as subsoiling and tilling on an angle to the slope. The surface was finished by seeding of an annual cereal down the predominant slope, contrary to earlier discussion of planting across the slope. The planting of the annual cover crop oats (a landowner decision) will result in it dying with the first hard frost leaving no living crop throughout the winter and in the early spring to hold unstructured soil, to provide cover and to draw moisture from the soil.

Followup investigation of the sloping HM34 lands August 12 found extensive rilling from subsequent rainfall events, breached water diversion berms from runoff, as well as little cover crop germination over the 2 week period. A more concerted effort in providing physical barriers and cover of the poorly structured, unconsolidated soils was needed. Soil restoration efforts were reengaged August 21 with the grading of surface rills, reshaping of diversion berms and the addition of erosion control mulch socks intended to also interrupt flow and encourage infiltration. Further discussion with the landowner by the LRA resulted in a commitment to seed down the easement to hay. Planting of the hay crop by the landowner was not completed, however, until 6 weeks later when the time for successful establishment was reduced. The risk of continued soil erosion losses overwinter for the site remained significant.

September 8 extensive subsoil rilling down slope indicative of susceptible erodible material

September 8 subsoil sediment deposition at toe slope from water erosion adjacent to creek

November 7 topsoil rilling on foot slope after downslope tillage and soil left unprotected

November 14 erosion sediment protection of creek but not for soil loss from susceptible slope

March 28 severe gully erosion overwinter looking west up slope

July 15 extensive gully erosion across foot slope awaiting restoration

July 26 erosion features graded out and topsoil added though limited slope erosion protection

October 10 established additional erosion protection across foot slope done on August 21

6. Conclusion

Members of the construction team recognized that pipeline construction on agricultural lands required a set of practices that protected the soil and the landowner’s concerns. The LOU was adhered to though circumstance and insufficient decision making did not permit aspects to be fully compliant. A small number of landowners were actively engaged with correcting impacts of construction to their properties particularly during clean-up and restoration but actions were followed through to amend situations as they arose. Construction during the dry summer and early fall was when the least impact to soil was most likely to occur. Timing of construction and the condition of each individual property for conducting a practice were the critical factors in managing the potential impact from construction. Improvements in practices were identified though, that could be incorporated to better protect the soil resource. Union Gas showed a willingness in management to develop improvements but implementation at the ground level was less adaptable and given a lower priority especially around construction deadlines. Significant impacts to sensitive lands and potentially to the off easement environment were the consequence. The shared goal was always to return land to preconstruction conditions ASAP; however, the realistic timeframe to complete construction and restore lands before impacts are experienced should be condensed, or accept that restoration under suitable conditions is to be completed the year after construction.

Cordner Science

Agricultural and Environmental Consultants

FINAL REPORT

Construction Monitor Services
NPS 48 Strathroy Lobo Pipeline Project
Union Gas Limited

Prepared for: The Construction Monitor Committee of the Union Gas Limited NPS 48 Strathroy Lobo Pipeline Project

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the 46 properties (not including properties owned by Union Gas) within the ROW, especially since the sandy soil types along the ROW and the weather during the 2007 construction season were very conducive to construction activities. Under these near ideal construction conditions, it was also clear to the CMT that at least seven (15%) landowners were not satisfied with the standard procedures used by Union Gas and were willing to advocate for themselves. These landowners told members of the CMT they felt they were either mislead during the pre-construction interview process, or their concerns were not addressed to their satisfaction, or promises made were not fulfilled during the construction and clean-up phases of the work.

After observing the NPS 48 Strathroy Lobo Pipeline Project, the CMT concluded there were two divergent views of pipeline work.

1. It appeared to the CMT that, notwithstanding the very positive approach exercised by Union Gas personnel in trying to resolve landowner issues, the corporate view or perspective was focused on high quality pipeline construction. Also, it appeared to the CMT that Union Gas and its contractor installed the 48" pipeline with considerable expertise and precision. The early success of the pipe-testing procedure was proof of the quality of work and professionalism involved in all aspects of the pipeline construction.

2. It appeared to the CMT the landowner's view or perspective was focused on minimizing the impacts of construction, receiving adequate compensation for the impacts of construction, long-term land rehabilitation and returning to normal farm operation as soon as possible. These sentiments were expressed to the CMT by landowners and/or the Lands Agent at various times during the project.

3. It was apparent to the CMT that these two divergent views played a role in how issues were addressed by both parties.

Second, the following table was provided to the CMT by Union Gas to describe operations during the project:

OPERATONS					
Clearing		Pipework		Water Crossing	
Stripping		Trenching		Drain Tile Repair	
Grading		Backfilling		Access/Culv/Bridge	
Fencing		Boring		Erosion Control	
Stringing		Road Xing		Clean-up	
Bending		Rail Xing		Other	

Often the terms construction or clean-up were used by workers to describe the general nature of the work in progress on a day-to-day basis. Construction involved activities including: clearing, stripping, grading, stringing, bending, pipework, trenching, backfilling, boring, crossings (road, rail, water), access (roads, culverts, bridges) and erosion control (filter fences, etc.). Clean-up activities started after backfilling and involved grading, fencing, drain tile repair and clean-up (rock picking, take-down of erosion control structures, subsoiling, cultivation, seeding, etc.). The CMT observed that construction activities were very focused on achieving the main objective of constructing a working pipeline to meet quality specifications within budget and by a specified date. Clean-up activities were less focused and regularly adjusted to fit in amongst the priorities of construction activities. As a result, equipment, size of work crew, timing and/or budget were not always best suited to meeting land remediation objectives. Also, while the construction documents provided to the CMT were considered 'final' and contained sections related to clean-up procedures, a clean-up document entitled Clean-up Procedure Package was less well prepared and was provided mid-way through the project. The first section was labeled 'draft' and the remaining sections were a compilation of sections from the construction documents previously received by the CMT. The CMT did not receive a finalized Clean-up Procedure Package during the project.

The following provide examples of poor decision-making and workmanship relative to meeting land remediation objectives during clean-up:

Example 1: A landowner believed they had requested a survey of their property (#027) prior to construction to ensure the original character and shape of the steep slopes on the property could be re-established after construction. The pre-construction survey was not done due to an apparent miscommunication during the pre-construction meeting and very little effort was made by the contractor to document the 'before' conditions so they could be re-established 'after' construction. Several attempts at re-shaping the property were made before the landowner was satisfied with the work. In the meantime, the landowner felt isolated and 'in the wrong' for insisting that the contractor continue re-shaping the land until the slopes met their expectations. The contractor did not appear to be sensitive to the landowner's perspective i.e., the landowner did not want their land 'improved' by the construction of gentler slopes; they wanted their land returned to the way it was before construction. The negotiating challenges faced by the Lands Agent and the extra expense incurred by the contractor could have been avoided with more focus on this landowner's perspective, needs and the overall objective of satisfactory land rehabilitation.

Example 2: Approximately 90 to 100 loads of topsoil were trucked onto property #038 in spring 2008 to address soil subsidence after construction over the 48" pipeline. This topsoil contained foreign material (a battery cable, pieces of plastic and concrete were observed by the CMT) and large lumps of subsoil-like clay. The landowners for properties #037 and #038 strongly resisted Union Gas's position that the material was acceptable for spreading on agricultural land. However, as listed in the LOU, the landowners should have had the opportunity to 'approve' the source of this topsoil before it was purchased and trucked on-site.

Union Gas and the contractor did not appear to be sensitive to the landowners' perspective i.e., the landowners wanted quality topsoil on their properties to minimize the long term impacts of construction on crop yields and field management practices. During on-site meetings, the CMT heard these landowners say they were concerned that poor or different topsoil conditions along the ROW would either negatively affect crop yields in years to come if the ROW was managed the same as the rest of the field, or they would have to use a different land management strategy just for the ROW in order to ensure a good crop yield on the ROW. In either case, the landowners were concerned they would lose time and/or money due to the presence of the pipeline. Union Gas's position that landowners would be compensated for any future need for additional fertilizer, extra time and/or yield loss put the onus on the landowners to pursue this option. These landowners wanted the problem dealt with up front in the best way possible to minimize the risk of having to deal with it at a later date. The negotiating challenges faced by Union Gas and the extra expense incurred by the contractor could have been avoided with more focus on the landowners' perspective, needs and the overall objective of satisfactory land rehabilitation.

Example 3: The push to complete the clean-up procedures in the fall of 2007 resulted in a decision to seed the steep slope on property #034 in November 2007. This was done in an effort to establish some vegetative growth to help stabilize the soil even though it was very late in the season to do so. (The work should have been done at least a month earlier.) The ATV broadcast seeder used to seed this slope traveled up and down the slope creating compacted areas under the tire tracks that subsequently eroded over the winter. In fall 2008, general labourers spent many hours adding topsoil to the eroded channels on this slope and then re-seeding it in an attempt to re-establish the grass. The extra expense incurred by the contractor could have been avoided with more focus on the overall objective of satisfactory land rehabilitation.

Example 4: A Brillion grass seeder was brought onto one property (#013) to re-seed a large area in 2008 where the fall 2007 attempt to establish a grass mixture had failed. This specialized piece of equipment should have been available for the entire clean-up procedure in 2007 and 2008 as many areas required grass seeding. It appeared to the CMT that while satisfactory equipment was used during the construction phase of the project it was not always used during the clean-up phase of the work. The extra expense incurred by the contractor to re-seed property #013 could have been avoided if there was more focus on the overall objective of satisfactory land rehabilitation.

Example 5: A grass waterway was constructed across the full easement on property #037. This waterway was shaped with a dozer during the final stages of clean-up in fall 2008. Workmanship during the final key step in construction of this critical erosion control structure was considered sub-standard by the CMT. Fertilizer was incorporated across the grass waterway structure with a field cultivator and the grass was seeded with an ATV spreader without any attempt to roll or firm the cultivated topsoil before or after seeding. The lack of good seed-to-soil contact will probably result in very poor or no establishment of a vegetative cover. Without cover the waterway will be prone to soil erosion due to water moving across the unprotected constructed channel.

It is anticipated by the CMT that the onus will be on the landowner to follow-up with Union Gas in the future to ask for additional remediation work on this important erosion control structure. The potential extra time, effort and expense incurred by Union Gas and the contractor when rebuilding a failed structure, and the potential extra time, effort and expense incurred by the landowner when identifying the problem, contacting Union Gas and ensuring the problem is fixed appropriately could be avoided with more focus on the overall objective of satisfactory land rehabilitation.

Third, the CMT believes the circumstances outlined in the above two lines of thinking could be substantially addressed if there is a clear separation in the management of operations associated with construction and clean-up objectives.

The benefits of this approach are powerful:
1. The pipeline contractor could continue to focus on what they do best i.e., construct high quality pipelines.

2. The clean-up contractor could develop a focus that is remediation-centred, and has the capacity to address the needs of each property and landowner every day and every time they interact.

3. The overall cost of clean-up in time, effort, and damaged good will could be reduced if more focus was placed on successful land remediation and minimizing the risk of failure of related structures and practices.

Primary Recommendation, NPS 48 Strathroy Lobo Pipeline Project:
1. *The CMT recommends future pipeline construction projects should be divided into two distinct phases i.e., Construction Phase and Remediation (formerly called Clean-up) Phase, which have clearly defined and separate objectives and budgets.*

The following concepts should be integrated into the objectives and requirements of the Remediation Phase:

Appendix E: Log Of Daily Reports

No. & Property	Pics	Notes
15 <ID# 9> 16 SF 2 17 <ID# 10> 12 <ID# 12>	Yes	Grading / removal of soil on knolls at golf course, trucking soil to the northeast corner of <ID# 9> property – just west of Saxton Road. Nematode protocol being followed for washing soil off Saxton Road and equipment. Piling of topsoil along edges of ROW Removal of subsoil from east access to <ID# 12> ppty #12 in bush; see Contact report re discussions on nematode containment
31 <ID# 27> 32 <ID# 28>	Yes	Move and grade subsoil on west side of Gold Creek Cleanup crew
29 <ID# 29>	No	Tile Drainage contractor working on tile repair and installation
48 <ID# 48>	No	Hauling of extraneous material off site
35 <ID# 35> 36 na Union Gas Ltd @ Hwy 22	yes	Clean up: ripping with grader on <ID# 35> pine woodlot; deep tillage on UGas ppty west of Hwy 22; no work between SF 9 and 10
na Union Gas Lobo Compressor	no	Fabrication, trenching for new 48", installer the S-1 scrubber, testing 48" spool (not observed)

Other Comments – Saturday Sept. 29, 2007

- conditions along the ROW were dry to moist and suitable for working
- Some work continued throughout the day at Gold Creek (<ID# 27> property). No trucking was done. Clean up crew was on site, the subsoil on ROW was moved by the hi-stick and graded by the dozer on west side of Gold Creek.
- The wash procedure for equipment and the rinse procedure for the roadway were observed at various times throughout the day. The procedures were deemed satisfactory given the working conditions.
- Access to golf course (nematode property) on the east end of the property was open. JSR observed a breach of procedure when a gator vehicle passed from the golf course to the <ID# 12> ppty at the east end of the ppty. While not within the established procedure, there was no apparent soil on the tire treads as conditions were dry to moist, therefore risk of nematode transfer from this incident is unlikely; JSR contacted Ed M who indicated he would follow up
- **Note** recommendations re nematode containment in Contact Report 29Sep07

Monitor's Signature

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE CONSTRUCTION MONITOR DAILY REPORT

Date	30Sept07	**Contractor Name**	Cordner Science
Report No.	93	**Monitor Name**	Jane Sadler Richards

LOCATION			
County	Middlesex	Township	Strathroy-Caradoc and Middlesex Centre
Conc		Lot	

From Station	Strathroy	To Station	Lobo

Landowner #s & Names

SF	Kickoff	Today	SF	6	Today
na	Union Gas Ltd Strathroy Gate		25	<ID# 25>	
1	<ID# 1>		26	<ID# 26>	
2	<ID# 2>		27	<ID# 27>	
3	<ID# 3>		28	<ID# 28>	
4	<ID# 4>		SF	7	Today
SF	1	Today	29	<ID# 29>	
5	<ID# 5>		30	<ID# 30>	
6	<ID# 6>		31	<ID# 31>	
7	<ID# 7>		32	<ID# 32>	
8	<ID# 8>		33	<ID# 33>	
9	<ID# 9>		34	<ID# 34>	
SF	2	Today	SF	8	Today
10	<ID# 10>	x	35	<ID# 35>	
11	<ID# 11>		37	<ID# 37>	
12	<ID# 12>		38	<ID# 38>	
SF	3 Bone Yard	Today	41	<ID# 41>	
13	<ID# 13>		na	Union Gas Ltd @ Hwy 22	
14	<ID# 14>		SF	9	Today
15	<ID# 15>		45	<ID# 45>	
16	<ID# 16>		46	<ID# 46>	
SF	4	Today	47	<ID# 47>, Lot8	
18	<ID# 18>		SF	10	Today
19	<ID# 19>		48	<ID# 48>	
20	<ID# 20>		49	<ID# 49>	
21	<ID# 21>		50	<ID# 50>, Lot10	
SF	5	Today	51	<ID# 51>	
22	<ID# 22>		52	<ID# 52>	
23	<ID# 23>		54	<ID# 54>	
24	<ID# 24>		SF	11	Today
			na	Union Gas Lobo Compressor	
			SF	12	Today

Road/Rail/Water Crossings	Prep for Hwy 81

WEATHER (Temperature/Rainfall/Comment)			
	Sunday	Today	Sun and cloud, High of ~ 22 ° C
	Monday	Forecast	60% chance of showers, high of ~24 °C

OPERATONS

Clearing		Pipework		Water Crossing	
Stripping		Trenching	x	Drain Tile Repair	
Grading	x	Backfilling		Access/Culv/Bridge	
Fencing		Boring		Erosion Control	
Stringing		Road Xing		Clean-up	
Bending		Rail Xing		Other	

NPS 48 Strathroy Lobo Pipeline Project, Union Gas Limited

(Temperature/Rainfall/ Comment)	Tuesday	Forecast	60% Chance of rain, High of ~19 °C

OPERATONS

Clearing		Pipework		Water Crossing	
Stripping		Trenching		Drain Tile Repair	x
Grading	x	Backfilling	x	Access/Culv/Bridge	x
Fencing		Boring		Erosion Control	x
Stringing		Road Xing		Clean-up	x
Bending		Rail Xing		Other	x

PHOTOGRAPHY

Photographs	Yes	x	No		Identifiers	15Oct07
Camcorder	Yes		No		Identifiers	

COMMENTS

No. & Property	Pics	Notes
1 <ID# 1> 2 <ID# 2>	No	Pumping water from dewatering lines into 48" line for water test. Water is also being trucked from the municipal water hydrants on Saxton to the frac tanks on <ID# 2> property. (line is approx. ½ full)
5 <ID# 5> 6 <ID# 6> 7 <ID# 7> 8 <ID# 8>	No	Cleanup, grading subsoil, pulling topsoil with hi-hoe and leveling with dozer
9 <ID# 9> 10 <ID# 10>	No	Hauling final subsoil from stockpile on west side of Saxton to rebuild slopes on course. Washing equipment for nematodes. Pulling last sheet piles along golf green.
23 <ID# 23> 24 <ID# 24>	Yes	Backfilling trench
27 <ID# 27>	No	Tile drainage on west side of Gold Creek through field to the west.
28 <ID# 28>	No	Removal of Mader drain bridge and gabion stone
31 <ID# 31> 32 <ID# 32> 33 <ID# 33>	No	Tile drain repair, Access through <ID30> property (off Ivan Drive)
34 <ID# 34>	No	Shaping roadside ditch with hi-hoe
37 <ID# 37> 38 <ID# 38>	No	Brillion and Tye Para-till deep-ripping topsoil on work and travel sides
47 <ID# 47> Lot 8	No	Leveling topsoil with grader
48 <ID# 48> 49 <ID# 49> 50 <ID# 50> Lot 10 51 <ID# 51>	No	Mechanical & hand stone picking.
na Union Gas Lobo Compressor		Continuing fabrication work (not observed)

Other Comments – Monday, Oct 15, 2007

- An error was made on the <ID# 24> property on Saturday Oct. 13th when backfilling the trench with subsoil. Since the subsoil pile had been leveled to create a flat surface for side-booms it appeared, during backfill, that there was a shortage of subsoil. A decision was made to add a layer of the coarse sand from the 402 bore hole. The landowner noticed the colour change and asked for the coarse textured sand to be removed from the trench. (see Contact Report).
- Nematode cleaning procedure began for the equipment contaminated with soil at the golf course (topsoil/subsoil movement). One of the large Volvo dump trucks was washed using a commercial power washer. The contaminated hi-hoe was moved onto the <ID# 9> ROW to pull topsoil. The uncontaminated hi-hoe - used for subsoil and topsoil on <ID# 8> property - was floated to the Boneyard for loading the remaining golf course subsoil. (did not observe washing of the small dozer and second large dump truck).

Monitor's Signature

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE CONSTRUCTION MONITOR DAILY REPORT

Date	16Oct07	**Contractor Name**	Cordner Science
Report No.	106	**Monitor Name**	Jane Sadler Richards

LOCATION

County	Middlesex	Township	Strathroy-Caradoc and Middlesex Centre
Conc		Lot	
From Station	Strathroy	To Station	Lobo

Landowner #s & Names

SF	Kickoff	Today	SF	6	Today
na	Union Gas Ltd Strathroy Gate		25	<ID# 25>	
1	<ID# 1>	x	26	<ID# 26>	
2	<ID# 2>	x	27	<ID# 27>	
3	<ID# 3>		28	<ID# 28>	x
4	<ID# 4>		SF	7	Today
SF	1	Today	29	<ID# 29>	
5	<ID# 5>		30	<ID# 30>	
6	<ID# 6>		31	<ID# 31>	
7	<ID# 7>		32	<ID# 32>	
8	<ID# 8>		33	<ID# 33>	
9	<ID# 9>	x	34	<ID# 34>	
SF	2	Today	SF	8	Today
10	<ID# 10>	x	35	<ID# 35>	
11	<ID# 11>		37	<ID# 37>	x
12	<ID# 12>		38	<ID# 38>	
SF	3 Bone Yard	Today	41	<ID# 41>	

NPS 48 Strathroy Lobo Pipeline Project, Union Gas Limited

(Temperature/Rainfall/ Comment)	Saturday	Forecast	Sunny, High 20 C

OPERATONS

Clearing		Pipework		Water Crossing	
Stripping		Trenching		Drain Tile Repair	
Grading	X	Backfilling		Access/Culv/Bridge	
Fencing		Boring		Erosion Control	X
Stringing		Road Xing		Clean-up	X
Bending		Rail Xing		Other	X

PHOTOGRAPHY

Photographs	Yes	X	No		Identifiers	23May08
Camcorder	Yes		No	x	Identifiers	

COMMENTS

No. & Property	Pics	Notes
#027 <ID# 27>	Yes	Approx. 22 loads (not counted) of topsoil were spread by dozer on the west end of the pasture to level west hill and fill in tile lines that had sunk. Steep slope on south side was reshaped, large eroded areas were repaired, silt fence was re-installed at Gold Creek.
#038 <ID# 38>, 1058202 Ont Ltd	No	Blue/tandem axle spreader moved onto ppty
#046 <ID# 46>	Yes	Pictures taken of ruts that were smoothed out by dozer (back-bladed) after topsoil spreading procedure completed on Wednesday May 21.
#048 <ID# 48>	Yes	Topsoil (27 loads) spread on trench line by Blue/tandem axle spreader. Dozer leveled topsoil. Stone picking with tractor + loader and Gator. Clarke Drainage moved in drainage plow and wheel machine for work next week.

Other Comments – Friday May 23, 2008

Soil conditions were acceptable on ROW today.

SEE FURTHER COMMENTS ON FOLLOWING PAGE REGARDING CLEANUP PROCEDURES ON THE <ID# 47> PROPERTY (#047)

<ID# 47> **PROPERTY (#047)**

A walk along <ID# 47> property showed that 6 small piles of stones and roots were dumped

Other Comments – Friday May 23, 2008

into the <ID# 47> bush (south side of easement) by Contractor during cleanup this spring (pictures taken).

The CMT has no information in the 2008 Cleanup Procedures to indicate that the landowner provided approval for stones to be dumped on this property. Stones have been hauled away on adjoining property (#048).

Observations of the trench line were topsoil (with questionable quality) was spread shows that many large lumps of clay still exist in the topsoil after being spread by the Blue/tandem axle spreader with vertical beaters.

Pictures were taken of these large lumps on the surface and it is obvious that the spreader does NOT "pulverize" or break up all lumps found in the topsoil.

The <ID# 48> property (#048) were topsoil was spread and leveled on 23May08 shows the same evidence of large lumps remaining from the addition of topsoil to the trench line to fill in subsidence.
Evidence of other debris in the topsoil (battery cable and small piece of fiberglass material) are evidence that the topsoil was not screened prior to delivery.

It is recommended that the Union Soils Inspector and other personnel view this property and the adjoining <ID# 49> property to observe the large lumps in the topsoil when the spreading and leveling procedure has been completed.

Monitor's Signature

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE CONSTRUCTION MONITOR DAILY REPORT

Date	24May08	**Contractor Name**	Cordner Science
Report No.	149	**Monitor Name**	Stephen G Redmond

LOCATION

County	Middlesex	Township	Strathroy-Caradoc and Middlesex Centre
Conc		Lot	
From Station	Strathroy	To Station	Lobo

Landowner #s & Names

SF	Kickoff	Today	SF	6	Today
na	Union Gas Ltd Strathroy Gate		25	<ID# 25>	
1	<ID# 1>		26	<ID# 26>	X
2	<ID# 2>		27	<ID# 27>	X
3	<ID# 3>		28	<ID# 28>	
4	<ID# 4>		SF	7	Today
SF	1	Today	29	<ID# 29>	

Other Comments –Monday June 2, 2008

A John Deere 750J Dozer was moved onto the <ID# 38> (#038 property) today and was used to back blade the area were poor quality topsoil was removed. There also was evidence of the dozer making approximately 3-4 passes on the entire <ID# 38> (#038) and <ID# 37> (#037) ROW to back blade the area where the new topsoil is going to be spread. The actual dozer in operation was not observed but many pictures were taken of the dozer tracks and the many wet soil areas along the easement on both the <ID# 38> and <ID# 37> properties (see picture attached).

The CMT has concerns about the wet condition of the topsoil when this procedure took place on Monday morning. The regular presence of a daily soils inspector to monitor and approve cleanup activities could have prevented this "back-blading" activity on the wet topsoil.

Many water puddles were observed and photographed on the properties as well as the evidence of topsoil smearing and large lumps from being worked when wet. John Deere tractor with loader was not moved from the parked location at the end of the day on Friday.

The CMT also took pictures of ruts on the topsoil (both <ID# 38> and <ID# 37> properties) from previous activities on the topsoil this spring when the soils were wet and loose from fall deep ripping. These ruts appear to have been made by the John Deere tractor with loader several weeks ago when an attempt was made to stone pick.(see Daily Report for 09May08) (Picture of these ruts also included with 02Jun08 Report).

Monitor's Signature

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE CONSTRUCTION MONITOR DAILY REPORT

Date	03Jun08	**Contractor Name**	Cordner Science
Report No.	157	**Monitor Name**	Stephen G Redmond

LOCATION

County	Middlesex	Township	Strathroy-Caradoc and Middlesex Centre
Conc		Lot	
From Station	Strathroy	To Station	Lobo

Landowner #s & Names

SF	Kickoff	Today	SF	6	Today
na	Union Gas Ltd Strathroy Gate		25	<ID# 25>	
1	<ID# 1>		26	<ID# 26>	
2	<ID# 2>		27	<ID# 27>	
3	<ID# 3>		28	<ID# 28>	
4	<ID# 4>		SF	7	Today
SF	1	Today	29	<ID# 29>	
5	<ID# 5>		30	<ID# 30>	
6	<ID# 6>		31	<ID# 31>	
7	<ID# 7>		32	<ID# 32>	
8	<ID# 8>		33	<ID# 33>	
9	<ID# 9>		34	<ID# 34>	

SF	2	Today	SF	8	Today
10	<ID# 10>		35	<ID# 35>	
11	<ID# 11>		37	<ID# 37>	
12	<ID# 12>		38	<ID# 38>	
SF	3 Bone Yard	Today	41	<ID# 41>	
13	<ID# 13>		na	Union Gas Ltd @ Hwy 22	
14	<ID# 14>		SF	9	Today
15	<ID# 15>		45	<ID# 45>	
16	<ID# 16>		46	<ID# 46>	
SF	4	Today	47	<ID# 47>, Lot8	
18	<ID# 18>		SF	10	Today
19	<ID# 19>		48	<ID# 48>	
20	<ID# 20>		49	<ID# 49>	
21	<ID# 21>		50	<ID# 50>, Lot10	
SF	5	Today	51	<ID# 51>	
22	<ID# 22>		52	<ID# 52>	
23	<ID# 23>		54	<ID# 54>	
24	<ID# 24>		SF	11	Today
			na	Union Gas Lobo Compressor	
			SF	12	Today

Road/Rail/Water Crossings	None

WEATHER (Temperature/Rainfall/ Comment)	Tuesday	Today	Cloudy, 40% chance of rain, High 18 C
	Wednesday	Forecast	30% chance of rain or thunderstorms, High 23 C

OPERATONS

Clearing		Pipework		Water Crossing	
Stripping		Trenching		Drain Tile Repair	
Grading		Backfilling		Access/Culv/Bridge	
Fencing		Boring		Erosion Control	
Stringing		Road Xing		Clean-up	
Bending		Rail Xing		Other	

PHOTOGRAPHY

Photographs	Yes		No	X	Identifiers	
Camcorder	Yes		No	x	Identifiers	

COMMENTS

No. & Property	Pics	Notes

Comments – Tuesday June 3, 2008

Wet Soil Shutdown continued today for stone picking on the <ID# 49>, <ID# 50> and <ID# 51> properties. Light rain showers on Tuesday early morning. (See WSS Report)

Communication via telephone with Bill Boden indicated that Ed Mozuraitis (Stantec/Union) was on site today to review the analytical data from the topsoil pile at Technivel Industries Ltd.

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE
CONSTRUCTION MONITOR CONTACTS REPORT

Date	25-Jul-07	**Contractor Name**	Cordner Science
Report No.	SGR-01	**Monitor Name**	Stephen G. Redmond (SGR)

SUMMARY OF CONTACTS (Attach Separate Records of Telephone / Discussion as needed.)

Name	File # / Agency	Concern / Action / Comment
Ed Mozuraitis	Union Gas / Stantec	Three issues discussed with Ed.
	1	SGR measured topsoil / subsoil mixture from stripping on <ID# 1> property (#001). Volume of mixed soil in separate windrow is equal to 1.2 inches of soil across the width of the stripped area. Although small areas would have been mixed to a depth greater than this average depth, the volume of mixed soil should not be an agronomic concern for this landowner. Issue Resolved.
	2	Deep ruts in sandy subsoil on <ID# 13>, <ID# 15> and other sandy soil areas of easement from stringing trucks. Ed explained that the "sugary" texture of subsoil in these areas is not conducive to compaction especially when soil is dry to depths that we are experiencing in the summer of 2007. Issue Resolved. (will continue to monitor truck traffic on other areas of easement.)
	3	Continual traffic from <ID# 19> property (#019) onto "nematode-free" ROW (fresh ATV tracks and what appears to be pick-up truck or other vehicle tracks over the last 2-3 days). Ed has placed yellow caution tape on both north and south sides of the ROW access on this property. In addition pipe was strung across ROW on Wed. July 25th. It is hoped that this will serve as an extra deterrent for traffic from this landowner's contaminated property. Ongoing monitoring of this property is required.

Monitor's Signature (Stephen G. Redmond)

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE
CONSTRUCTION MONITOR CONTACTS REPORT

Date	30-Jul-07	**Contractor Name**	Cordner Science
Report No.	AMc-04	**Monitor Name**	Alan McCallum

SUMMARY OF CONTACTS (Attach Separate Records of Telephone / Discussion as needed.)

Name	File # / Agency	Concern / Action / Comment
Ed Mozuraitis	Union Gas / Stantec	Discussed the implications of possible presence of nematodes on additional work area on <ID# 21> ppty. The affected area was fenced off and Ed took more samples from the non stripped easement adjacent to the affected area and from the additional work area where symptoms of SCN were not present.
Ed Mozuraitis	Union Gas / Stantec	
George Adams	Union Gas / Stantec	
Steve Redmond	Cordner Science	

		Ed, Steve, Alan, and George discussed the nature of SCN and its implications to crop production. It was concluded to restrict access to the affected area and construct a wash ramp on site to wash the equipment before it is moved off site. It was also concluded that Alan and Steve would do a visual survey, from the ROW, of the soybean fields to the east. (no obvious symptoms were observed)

Monitor's Signature (Alan McCallum)

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE
CONSTRUCTION MONITOR CONTACTS REPORT

Date	31-Jul-07	**Contractor Name**	Cordner Science
Report No.	SGR-02	**Monitor Name**	Stephen G. Redmond (SGR)

SUMMARY OF CONTACTS (Attach Separate Records of Telephone / Discussion as needed.)

Name	File # / Agency	Concern / Action / Comment
Bob Wood	Union Gas / Lands Agent	CMT received phone message from landowner - <ID# 41> - requesting SCN testing on property. Bob recommended a call to Ron Dagg to discuss proper procedure to respond.
Ron Dagg	Union Gas / Chief Inspector	How to respond to landowner request for SCN testing. Ron recommended calling Ed Mozuraitis to have Ed respond to landowner.
Ed Mozuraitis	Union Gas / Stantec	Landowner (<ID# 41>) has requested SCN test. Ed replied that the <ID# 41> property was tested for presence of SCN in May 2006 and tests came back negative. Need to report back through CMC that testing of this property in 2007 is not necessary.
Ed Mozuraitis	Union Gas / Stantec	Results of SCN testing on <ID# 21> property (#021) show that soybean roots and soil taken from the expanded work area on the south side of easement are infected with soybean cyst nematodes (SCN). Results of soil testing from the working area next to the trench area have not been confirmed as positive or negative for SCN. Lab testing at University of Guelph Lab should be completed on Wed. August 1st.

Monitor's Signature (Stephen G. Redmond)

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE
CONSTRUCTION MONITOR CONTACTS REPORT

Date	1-Aug-07	**Contractor Name**	Cordner Science

SUMMARY OF CONTACTS (Attach Separate Records of Telephone / Discussion as needed.)

Name	File # / Agency	Concern / Action / Comment
Bob Wood Ed Mozuraitis Steve Redmond Alan Wood <ID# 27>	Union Gas Union Gas/Stantec Cordner Science CM Committee Landowner	RE: Various issues regarding property #027 and the planned open-cut crossing of Gold Creek Concern #1: Travel on farm laneway to access ROW Concern #2: Work under wet conditions after rain on Mon-Tues-Wed. (Sept. 10, 11, 12) Concern #3: Removal of extraneous subsoil from west field after back-fill of trench. Concern #4: Plan for storage of subsoil when open-cut is made at Gold Creek and return of all subsoil to property after backfill. (see additional page for Comments and Actions)
Steve Redmond Alan Wood	Cordner Science CM Committee	Storage of topsoil on <ID# 38> property (#038) and on <ID# 51> property (#051). Is topsoil being stored outside of agreed upon area for topsoil. Action: SGR to discuss topsoil storage area measurement with Bob Wood and respond back to Alan Wood through the CMC's Daily Reports. PLEASE NOTE: A resolution exists for this item. See Comments, Point #4, on attached page and Daily Contacts Report for Sept. 13 (by Alan McCallum).

Actions and Comments regarding <ID# 27>female property # 027:

1. On September 11th, some workers and inspectors had walked into the <ID# 27>female ROW using the farm laneway to the west of the buildings. This walk was necessary to determine whether the soil conditions would allow work on the installation of well points for dewatering of Gold Creek. Bob Wood had previously used this laneway with the property tenant to access the ROW.

   Bob Wood assured SGR that this access would not be used in the future without the permission of the landowner. In Bob Wood's experience it is often difficult to contact both the tenant and the landowner on a daily basis when permission is needed for changes in construction activities or to communicate about the pipeline construction.

2. Ed Mozuraitis explained to <ID# 27>female how the subsoil has been removed and layered in some areas around Gold Creek to support the work required to dewater and cross Gold Creek with the 48-inch pipeline.

   Ed M. indicated that the entire area on the west side of Gold Creek will be re-shaped after backfill and any subsoil that becomes compacted during the crossing will be reworked such that the effects of compaction will be minimized. SGR believes that this process will allow good pasture growth after replacement of topsoil and re-seeding.

   The area immediately east of Gold Creek is a "partial strip" of the easement (topsoil stripped on the ditch and storage side but not stripped on the travel side). SGR and Ed M. observed that the topsoil in this area had some moderate ruts (tracks in topsoil but not to subsoil depth) on the morning of September 12 as workers traveled back and forth across the bridge. (See pictures from Sept. 15). The Construction Monitoring Team (CMT) and Soils Inspector will monitor this area during the pipeline crossing and record whether any topsoil is mixed with subsoil by construction vehicle traffic. The clean up protocol, supplied by Ed M., indicates that the topsoil will be deep-ripped during clean up with an agricultural subsoiler. SGR believes that this procedure for clean up will minimize the effects of compaction.

3. <ID# 27> explained that the extraneous subsoil from the field west of the pasture area was removed from the <ID# 27>female property after backfill. (Line list information provided by Union Gas states that landowner will receive subsoil). Bob Wood stated that this was an oversight by Union Gas and the Contractor and additional subsoil can be delivered to the landowner's property by Contractor during clean up of other properties.

4. Ed M. indicated that the subsoil from the crossing of Gold Creek can be stored on <ID# 27>female property on the west side of Gold Creek but will also need to be stored on the adjacent <ID# 28> property when the open-cut is made as the work area east of Gold Creek is very narrow. The CMT, Soils Inspector and Lands Agent will need to work together during the crossing and clean up to ensure that all subsoil removed from Gold Creek returns to the <ID# 27>female property. The CMT will take pictures of the subsoil storage area before and after the crossing and clean up will be monitored. SGR believes that it will be important to communicate with <ID# 27>female during clean up.

Monitor's Signature

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE CONSTRUCTION MONITOR CONTACT REPORT

Date: 13Sept07	**Contractor Name:** Cordner Science
Report No.: na	**Monitor Name:** Alan McCallum

Name	File # / Agency	Concern / Action / Comment
Bob Wood Alan McCallum	Union Gas Cordner Science	Bob Wood called A.M. stating that he received a call from Alan Wood concerning the<ID# 27>female ppty. Alan W had received a call from <ID #27>. She observed a maroon coloured truck leaving the ppty and was concerned that soil was being hauled off site. Bob Wood suggested A.M. discuss this with Bannister Forman Jack Brand.
Jack Brand Alan McCallum	Bannister Cordner Science	A.M. asked Jack if any loaded trucks had left the Gold Creek work area. Jack said no, but he had sent four trucks away around noon to other jobs, including hauling extraneous subsoil away from the ROW east of Coldstream Rd. Jack stated that the trucks were not needed at that time because they finished hauling spoil from the west side of Gold Creek up the hill to the temporary soil storage area on the south side of the ROW. Jack said he was aware that no soil was to leave the Gold Creek work area and that all soil temporarily moved to the <ID# 28> ppty for storage was to be returned to the<ID# 27>female ppty.
Alan Wood Alan McCallum	CMC Cordner Science	A.M. called Alan Wood to inform him of A.M.'s discussion with Jack B. A.W. suggested that A.M. confirm with the driver of the maroon truck that he was in fact empty when leaving the ppty. A.W. also said that <ID #27> had observed a blue truck unloading soil at a <nearby L> ppty. A.M. will report his findings to A.W. Tuesday morning.
Ken Oliver (Driver of maroon truck) Alan McCallum	Contract Trucker/Bannister Cordner Science	At ~2:45PM the maroon truck returned to the Gold Creek site with a load of gabion stone. A.M. asked the driver (Ken) if he was loaded when he left the ppty. Ken confirmed that he was empty and hadn't hauled any soil off site today.
Bob Wood Alan McCallum	Union Gas Cordner Science	Bob Wood confirmed that extraneous soil from east of Coldstream Rd was being hauled to <nearby L> ppty. A.M. is satisfied that no truckloads of soil were hauled away from the Gold Creek worksite today.

Monitor's Signature

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE
CONSTRUCTION MONITOR CONTACT REPORT

Date: 25Sept07	**Contractor Name:** Cordner Science
Report No.: na	**Monitor Name:** Alan McCallum

SUMMARY OF CONTACTS (Attach Separate Records of Telephone / Discussion as needed.)

Name	File # / Agency	Concern / Action / Comment
Bob Wood Alan McCallum Alan Wood <ID# 27>male	Union Gas Cordner Science Construction Monitor Committee Landowners	Re: Various issues regarding property #027 Concern #1 <ID# 27> observed construction trucks continuing to use farm laneway to access the ROW on morning of Sept. 24th. Bob Wood agreed to have signs posted prohibiting pipeline traffic and to have a fence installed. Sign was posted immediately and fence was installed by the end of the day. Concern #2 <ID# 27> requested that landowner issues such as use of excess gravel and drainage plans be discussed directly with the landowner and not just with the tenant. Bob Wood agreed to communicate directly with<ID# 27>female on these issues. Concern #3 <ID# 27> had concerns regarding the conduct of workers during the late evening work on the Gold Creek crossing on the evening of Sept 24th. Bob Wood agreed to raise the issue with Bannister Concern #4 Retaining extraneous subsoil on property. <ID# 27>female would like all extra soil retained and stockpiled on ppty and stated a preference for the dark soil removed from the trench near the creek. Bob Wood assured<ID# 27>female that all soil will remain on ppty. CMT will continue to monitor this process. Concern #5 <ID# 27> both observed a small amount of gravel on the ROW towards their West ppty line and were curious as to it's origin. Alan McC agreed to investigate.
Gerrod Wilson Alan McCallum	Bannister Foreman Cordner Science	A.Mc asked Gerrod if he was aware of gravel being piled in the area of the ROW in question. Gerrod didn't have specific knowledge of this location, but said it would be consistent with the use of gravel to be placed in the bottom of the "bell hole" where welders are required to lay on the trench floor to complete a weld.

CONSTRUCTION MONITOR CONTACT REPORT

Date: 15May08	**Contractor Name:** Cordner Science
Report No.:	**Monitor Name:** Alan McCallum

SUMMARY OF CONTACTS (Attach Separate Records of Telephone / Discussion as needed.)

Name	File # / Agency	Concern / Action / Comment
Ed Mozuraitis	Union Gas/Stantec	
Bill Boden	Union Gas	
Bev Wilton	Union Gas	
Peter Vitez	Banister	
Gary Niskala	Banister	
<ID# 38>	Landowner	
<ID# 37>	Landowner/CMC	
Alan McCallum	Cordner Science	

Concern / Action / Comment:

A meeting was held at 9:AM 15May08 at the ppty of <ID# 38> (1058202 Ont. Ltd.) Mr. <ID# 38> presented a copy of a list of 6 concerns regarding the work on the ROW along with the request that a report be made by June 1, 2008. Bev Wilton agreed to address the issues and respond by the requested date. The following are the concerns **as listed** by Mr <ID# 38>, along with discussion.

1. **Top soil not stripped over tile header – clay left on top.** Bill B. stated that this was standard practice for Clarke Drainage when using the wheel trencher to install tile. The wheel trencher was required instead of the plow drainage machine in order to intercept the lateral tile.

2. **Replacement top soil 1/3 blue clay and yellow clay balls.** There was considerable discussion regarding this issue. Both <ID# 38> and <ID# 37> expressed some concern that the soil texture did not match the soils on their pptys. Ed reviewed his criteria for selecting the topsoil source. This included a texture analysis and freedom from Soybean Cyst Nematodes. Ed M. felt that this source was a suitable match to the <ID# 38> and <ID# 37> pptys. It was agreed to closely monitor the topsoil for lumps of subsoil as it is being loaded for spreading. If large lumps of subsoil are found the hi-hoe operator will set them aside to be removed. After spreading Ed M. suggested monitoring the ROW area where topsoil is spread for soil quality criteria such as fertility and organic matter. <ID# 37>. requested GPS ref. of soil core locations to help confirm that samples are taken from comparable areas off the ROW for comparison. <ID# 37>. also made the point that when soybeans are planted on the area of the ROW receiving topsoil, they will need to be well inoculated as the imported topsoil may not have adequate rhizobia. The possibility of bringing in manure to improve fertility and organic matter was also discussed. Ed M. suggested waiting for the soil test results before proceeding with this option.

3. **Stripped top soil subsoil together put in one pile.** Ed M. reviewed the procedure for stripping topsoil. <ID# 38> felt there were lumps of subsoil mixed in with the topsoil pile. AMc agreed to review any photos taken of the topsoil piles on <ID# 38>' ppty

4. **Took extra land without notifying me.** Bev W. reviewed the policy on compensation for topsoil storage area. Bev agreed to review this with <ID# 38> including surveyed maps of topsoil storage area.

5. **Needs gravel lane and at pile soil where trucks turning.** This issue had apparently already been resolved with Gary N.

6. **Did not strip soil where driving by pipeline when working.** Bev W. stated that <ID# 38> had agreed to a partial topsoil strip as indicated in the original landowner agreement. Bev W. and <ID# 38> agreed to review their notes.

Monitor's Signature ______________________

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE CONSTRUCTION MONITOR CONTACT REPORT

Date: 17May08	**Contractor Name:** Cordner Science
Report No.:	**Monitor Name:** Jane Sadler Richards

SUMMARY OF CONTACTS (Attach Separate Records of Telephone / Discussion as needed.)

Name	File # / Agency	Concern / Action / Comment
Bill Boden	Union Gas	A meeting was held at 7:AM 17May08 at the ppty of <ID# 38> (1058202 Ont. Ltd) to review conditions for work. There was considerable discussion on what should take place. The poor quality of the topsoil was mentioned. Gary was persistent in his position that the beaters on the wagon would break all soil lumps into fine parts. Gary did not indicate his intention to sort out
Gary Niskala + crew	Banister	
<ID# 37>	Landowner/CMC	

Jane Sadler Richards Pete Vitez (I think he was there) Later: <ID# 38>	Cordner Science Banister Landowner	big lumps of clay as agreed yesterday. (JSR did not observe him giving instructions to this effect to the crew; nor was there an attempt to sort lumps when work proceeded at 7:20 am.) At end of meeting JSR stated to <ID# 37> she did not have the authority to call a wet soil shutdown if conditions worsened due to rain (threatening clouds were all around). Gary, Bill and <ID# 37> left the work site. Jane and work crew remained. Work proceeded at ~7:20 am. At ~8:00 am <ID# 38>, landowner, arrived and requested there be a stop work on his property today due to proposed/expected amount of traffic on his land and the potential for compaction. Also, if they draw soil to the <ID# 37> property it will cause more compaction. He had received a downpour over at his place and there was rain in the area. <ID# 38> was not available today to ask for a wet soil shutdown (he thought the Construction Monitor could do that until <ID# 37>advised him otherwise that morning by phone) as he had things to do and was going away. The crew stopped work as requested. JSR tried Bill's number 3 or 4 times to advise him of the stop work but could not get through. The crew provided Pete's number and we called him. <ID# 38> talked to Pete and then left the site as he had things to do. Gary drove in and requested to speak with <ID# 38> about the stop order. He was on the cell phone for ~15 min talking to <ID# 38> about the conditions. <ID# 38> maintained his request to stop work. The equipment was eventually moved to the <ID# 47> property to continue work there.
Alan Wood Alan McCallum Jane Sadler Richards Steve Redmond	Landowner/CMC Cordner Science	Jane, Al and Steve had previously agreed to meet at <ID# 38>'s topsoil pile at 8:30 am Sat to review the pile and discuss concerns re topsoil quality and compaction. Al Wood was invited to join the meeting as he was on site. The pile had been partially opened up by the hi hoe during the 45 min of work that morning. We probed various parts of the pile and did see lumps of blue clay (see pics next page). Whether there is enough blue clay present to show up in a quality test was discussed. Sponginess of the soil and potential for compaction was observed by all as the wagon moved across the filed surface. The CMT is concerned about: 1. Actual vs perceived quality of the topsoil; do we need testing to confirm quality; if yes, then the sampling must be thorough and include comparative samples from the actual fields on which it will be spread; 2. If spread, can the topsoil and field be rehabilitated properly to eliminate yield loss? In the opinion of the CMT, due to existing concerns, there could be written agreement to do deep tillage to alleviate compaction from topsoil spreading, check topsoil quality (compared to adjacent field) after it is spread and worked in the field, take yield checks for the next few years to verify conditions. This could be agreed to before spreading proceeds due to pre-work concerns about the topsoil and spreading conditions, so the landowner does not have to justify it later on. 3. If not spread, this delays planting and jeopardizes the growing season. A new source of topsoil would need to be found and agreed to by all parties. The current topsoil would need to be removed.
Ed Mozuraitis Bill Boden Jane Sadler Richards	Union Gas/Stantec Union Gas Cordner Science	JSR met Bill and discussed morning's stop work and concern re potential need to sample topsoil and need to discuss with Ed M. Bill contacted Ed M. Ed talked to Jane by cell phone and agreed to be on site on Tue 20May08 between 9 and 10 am to review concerns again and sample topsoil if that was the outcome of the discussion. JSR to let others know re meeting arrangements.

Monitor's Signature ______________________

Pics of clay lumps inside the large topsoil pile, Sat am, 17May08

UNION GAS LIMITED STRATHROY TO LOBO NPS 48 PIPELINE
CONSTRUCTION MONITOR CONTACT REPORT

Date: 20May08	**Contractor Name:** Cordner Science
Report No.:	**Monitor Name:** Jane Sadler Richards and Alan McCallum

SUMMARY OF CONTACTS (Attach Separate Records of Telephone / Discussion as needed.)

Name	File # / Agency	Concern / Action / Comment
George Adams	Union Gas	A second site meeting was held at 1 pm Tue 20May08 on the property of <ID# 38> (#038 1058202 Ont Ltd) at the topsoil pile. (Previous meeting was 15May08, see Contact Report. Also reference 17May08 Contact Report.) <u>After discussion, it was agreed:</u> 1. one pass of subsoiler at ~16" to loosen the compaction after topsoil spread this year 2. Heavy equipment must not drive on the tile lines 3. The pipe line centre line and the tile lines would be marked asap to ensure driving in appropriate place 4. Existing soil pile would be sampled and analyzed to determine the quality of the soil (fertility, OM, texture) 5. another discussion/meeting to review the soil quality results would be called as soon as information is available (likely some time after Friday, 23May08). <u>Discussion leading to above agreement:</u> Landowner and CMT concerns regarding the quality of the topsoil were discussed. Ed indicated the pile was mainly mixed A and B horizon soil in his opinion. Deep subsoil content was minimal. He pointed out the pile had been moved/mixed 3x so very disturbed material. Also, the pile was in place a long time in Strathroy so one could expect anaerobic conditions and tie up of phosphorus ie low P fertility. Landowners <ID# 37> and <ID# 38> indicated concern that it takes time to rehabilitate the soil. They want to make sure that even if the soil is broken up into fine particles that this does not turn back to cement when it gets wet – due to too much subsoil present in the soil. They prefer fall plough with this land. They try to work half the depth of the topsoil ie shallow plough or no till. <ID# 38> is concerned re current compaction and considering adding rye this year, plus possibly manure and wheat this fall to help with rehabilitation. Topsoil quality was further discussed along with how to determine this if the pile was sampled. It was decided that 10 composite samples from the pile and 3 composite samples from the adjacent field would be acceptable to all as indicators of pile quality in comparison with native topsoil quality.
Ed Mozuraitus	Union Gas/Stantec	
Bill Boden	Union Gas	
Gary Niskala	Banister	
Jane Sadler Richards	Cordner Science	
Alan McCallum	Cordner Science	
<ID# 38>	Landowner	
<ID# 37>	Landowner/CMC	

2. References:

Preamble:

Request: Please outline any benefits of requiring an independent monitoring report versus one completed by Enbridge or an agent of Enbridge.

Responses: CAEPLA-DCLC proposes the appointment of an independent construction monitor to be "onsite continuously to monitor construction with respect to all issues of concerns to the Landowners and the Company at all times". The scope of work for the construction monitor would include "To review construction activities for compliance with the OEB Conditions of Approval [and] Letters of Understanding ("LOU") agreed to between Landowners and Enbridge Gas Inc." This proposal is consistent with the independent construction monitor programs implemented for the Union Gas Limited Panhandle Reinforcement Project (EB-2016-0186), the Union Gas Limited Dawn Parkway 2016 Expansion Project (EB-2014-0261) and the Union Gas Limited NPS 48 Strathroy-Lobo Project (EB-2005-0550).

CAEPLA-DCLC submits that an independent construction monitor (i.e. independent from Enbridge) is required to ensure that the review of compliance with OEB Conditions of Approval and provisions in the LOU is accurate and objective. CAEPLA-DCLC landowners will not be able personally to monitor all construction and reclamation activities on their properties. The oversight of construction and reclamation by a qualified and independent monitor (with a specific focus on the requirements of the LOU) provides a large degree of comfort to landowners who would otherwise have to rely solely on Enbridge, its agents and contractors to monitor their own compliance with Enbridge's commitments.

3. References:

Preamble:

Request: Please provide an update on the current status of the MOU (or equivalent such as LOU) between Enbridge and landowners (i.e. CAEPLA members) for the proposed project.

Responses: Please refer to the letters filed by CAEPLA-DCLC in this proceeding on August 17, 2022 and August 23, 2022 for a description of the current status of settlement negotiations between Enbridge and CAEPLA-DCLC. At the present time, no agreement has been completed between Enbridge and CAEPLA-DCLC with respect to a Letter of Understanding or other similar construction protocol for the proposed project.

4. References:

Preamble:

Request: If the MOU (or equivalent such as LOU) has not been executed with all landowners, please provide a best estimate of when/if the MOU will be executed.

Responses: Please refer to the letters filed by CAEPLA-DCLC in this proceeding on August 17, 2022 and August 23, 2022 for a description of the current status of settlement negotiations between Enbridge and CAEPLA-DCLC. CAEPLA-DCLC is hopeful that scheduled negotiations will result in an agreement on the Letter of Understanding ("LOU") or other similar construction protocol for the proposed project. An agreed-upon LOU would be executed by Enbridge and individual landowners prior to the commencement of construction at a time to be determined.

5. References:

Preamble:

Request: Please highlight any benefits of having landowners as part of the decision-making process (e.g. wet soil shutdown) during a project.

Responses: CAEPLA-DCLC's proposed Letter of Understanding ("LOU") provides for landowner participation in construction and reclamation decision-making in limited areas. For instance, landowners are to be involved in decisions about topsoil stripping, over-wintering of stripped topsoil, post-installation tillage, tile drainage repair and installation, tree replacement, sourcing of imported topsoil, etc. These are decisions that will directly affect the level to which construction impacts on soils and agricultural productivity are mitigated or avoided.

Construction and reclamation decision-making is enhanced through access to landowner knowledge about the property, the soil, the drainage system, and current and future land use. Also, important decisions about the treatment of properties affected by a project imposed in the public interest are validated though the involvement of landowners in the decision-making process. It is only fair that landowners be involved in making important decisions about their own properties.

In the Wet Soils Shutdown of the LOU proposed by CAEPLA-DCLC, wet soils shutdown issues would be "decided by the Joint Committee with the assistance of the construction monitor as required." The Joint Committee would consist of two CAEPLA-DCLC landowner representatives and three Enbridge representatives. Prevention of damage to soils in wet conditions is vitally important to landowners and their properties. Landowner involvement in the wet soil shutdown decision-making process through the Joint Committee will help to ensure that decisions about working or not working in wet conditions are made in the interests of protecting soils from damage.

6. References: CAEPLA indicates that some sections of the proposed pipeline route will have six Enbridge pipelines located if this project is approved and constructed.

Preamble:

Request: a) Please provide any commitments Enbridge has made to manage environmental and socio-economic impacts when the pipelines (existing and/or new) are decommissioned and removed.

b) Please identify any landowner concerns CAEPLA is aware of related to the future decommissioning and removal of the existing and/or proposed pipeline(s).

c) Once a pipeline is approved by the OEB and constructed by Enbridge (for example, the existing pipelines crossing landowner properties), what recourse does the landowner(s) have to avoid incremental impacts during pipeline decommissioning or removal?

Responses: **NOTE:** For purposes of these responses, CAEPLA-DCLC has considered the term “decommissioning” to be used in a generic and non-technical sense to mean the permanent discontinuance of use of the pipeline.

a) Enbridge stated in its response to CAEPLA-DCLC Interrogatory 2(l) that: “The effects of pipeline abandonment would be determined at the time of such action being taken, in accordance with all regulations and policy guidance available at that time.”

For the proposed Dawn to Corunna Replacement Project NPS 36 pipeline, Enbridge’s proposed form of “Pipeline Easement” agreement provides that:

> “… the rights, privileges and easement hereby granted shall continue in perpetuity or until the Transferee, with the express written consent of the Transferor, shall execute and deliver a surrender thereof. Prior to such surrender, the <u>Transferee shall remove all debris as may have resulted from the Transferee's use of the Lands from the Lands and in all respects restore the Lands to its previous productivity and fertility so far as is reasonably possible, save and except for items in respect of which compensation is due under Clause 2, hereof</u>. As part of the Transferee’s obligation to restore the Lands upon surrender of its easement, the Transferee agrees at the option of the Transferor to remove the Pipeline from the Lands. The Transferee and the Transferor shall surrender the Easement and the Transferee shall remove the Pipeline at the Transferor’s option where the Pipeline has been abandoned. The Pipeline shall be deemed to be

> abandoned where: (a) corrosion protection is no longer applied to the Pipeline, or, (b) the Pipeline becomes unfit for service in accordance with Ontario standards. The Transferee shall, within 60 days of either of these events occurring, provide the Transferor with notice of the event. Upon removal of the Pipeline and restoration of the Lands as required by this agreement, the Transferor shall release the Transferee from further obligations in respect of restoration." [emphasis added]

CAEPLA-DCLC understands the "Pipeline Easement" agreement to require upon removal of the pipeline (or upon the surrender of the easement where the landowner does not require the removal of the pipeline) that the easement lands be restored to their previous productivity and fertility so far as is reasonably possible.

The form of "Pipeline Easement" agreement for the proposed NPS 36 pipeline project is not proposed by Enbridge to apply to its existing pipelines installed in the same corridor, though CAEPLA-DCLC has requested to Enbridge that the same pipeline easement surrender and abandonment provision be made applicable to Enbridge's existing pipelines.

b) CAEPLA-DCLC is satisfied that if Enbridge complies in the future with the surrender and abandonment provision in the "Pipeline Easement" agreement proposed for its project, which requires removal of the abandoned pipeline at the landowner's option and in all cases requires restoration of the easement lands, any concerns landowners may have about the abandoned pipeline will be satisfactorily addressed. However, there remains the risk that Enbridge will not fulfill (or will not have the financial capacity to fulfill) its contractual obligations to the landowner.

As noted in the response to a) above, the surrender and abandonment provision in the "Pipeline Easement" agreement is not proposed by Enbridge to apply to its existing pipelines on CAEPLA-DCLC lands. CAEPLA-DCLC landowners have many concerns about the environmental and socio-economic impacts that may result from the permanent discontinuance of use/abandonment by Enbridge of those other pipelines, including ground subsidence/collapse, residual contamination, the creation of water conduits and interference with future land uses. Detailed discussion of these impacts can be found in the National Energy Board Pipeline Abandonment Physical Issues Committee – Key Abandonment Issues Summary (**Attachment 2**) and Det Norske Veritas Pipeline Abandonment Scoping Study prepared for the National Energy Board (**Attachment 3**).

c) In some cases, removal of a pipeline being abandoned may be the only method of avoiding the incremental impact that abandonment may have within a multi-pipeline corridor. That should be determined by the landowner at the time of abandonment. As found by the OEB in its Leave to Construct Decision and Order in EB-2014-0261 for the Union Gas Limited Dawn Parkway 2016 Expansion Project, “the landowner should have the right to decide whether an abandoned pipeline should be physically removed from the ground or dealt with through whatever other means of abandonment may be proposed by [the Company]. Once construction of a pipeline on a piece of property is approved, the landowner is giving up certain rights to [the Company], as a distribution utility, in the public interest. However, should that pipeline no longer be needed, the landowner should be able to make the fundamental decision about how the land is to be restored.”

Where a landowner has no contractual right to require the removal of the pipeline to be abandoned or any other specific method of abandonment, the landowner likely has no recourse to avoid incremental impacts. Ontario has no regulatory regime in place to govern the abandonment of provincially-regulated pipelines such as Enbridge’s existing pipelines on CAEPLA-DCLC lands. Enbridge would decide what, if any, measures would be implemented to avoid incremental impacts.

National Energy Board Office national de l'énergie

Canada

National Energy Board

Pipeline Abandonment Physical Issues Committee - Key Abandonment Issues Summary

Potential Abandonment Knowledge Gaps

1. Ground Subsidence

There is a valid assumption that if a pipeline is left in the ground with no cathodic protection that it will deteriorate over time and potentially cause a surface disturbance in the form of ground subsidence. The gaps in knowledge on this topic include:

- How does a pipe collapse mechanism occur?
- What are contributing factors to pipe collapse (corrosion rates, size of pipes etc.)?
- What are the regional effects of soil conditions on structural failure of buried pipe (moisture, consolidation, porosity, climate etc.)?
- Does subsidence occur over a very long time and if so will it be noticeable on the ground surface?
- Is there a relationship between farm machinery and pipe collapse in fields?
- What is the potential for subsurface animal habitat being established and causing settlement?
- In what situations should the removal of pipeline or abandonment-in-place be given priority?
- What would be the best means of removing various sizes of pipe and what would be the estimated reclamation needs?
- Is there any low cost means of filling pipelines?

2. Prevention of Pipeline Collapse Under Railways and Roads

The options available for abandoning a pipeline under a road or railway include removing the pipe, filling it and leaving it as is. Gaps in knowledge include:

- The degree of subsidence of replacement material that occurs if a pipe is removed versus settlement from corrosion of a pipeline remaining in place.
- What are the tolerance for settlement under a transportation corridor and the recommended approach for different magnitudes of roads and railways?
- What design considerations should be incorporated in new designs to accommodate abandonment under transportation corridors?
- If filling is to occur what is the recommended procedure?
    - The types of fill material that could be used and their effectiveness.
    - If filling a pipeline is to occur should it be throughout the right of way?
- There is a lack of knowledge on the effects of pipe deterioration under a corridor depending on:
    - vehicle loading by type and frequency,
    - use of pipe sleeves,
    - the type of surface on the road, and
    - the size of pipe.
- The amount of increased corrosion due to factors such as vibration and drainage.

3. Additional Abandonment Issues

The period for abandonment is normally from the end of a pipe's useful life to the point where the owner has completed all required work to make the pipeline meet abandonment requirements. Typically all above ground facilities are removed and water crossings are to be dealt with in a fashion that prevents pipes from floating or becoming avenues for contamination (plugging is recommended). However, the following gaps in knowledge for this phase include:

a. Pipe Cleanliness

- What is an acceptable level of pipe cleanliness?
- Need research to identify all potential contaminants and quantify acceptable levels.
    - Run pigs and then measure residue.

  - Measure residue on abandoned pipe.
  - Accelerate internal coating decomposition.

- Is conventional cleaning procedure acceptable?

b. Right of Way Contamination

Some contamination is expected at pump stations, compressor stations, tank farms and documented spills. The NEB will determine the acceptable risk through the public hearing process and then clean up will be to standards of the day for that jurisdiction. Gaps in knowledge are:

- Given that the degree of clean up is dependent on land use;
  - Can a cross-Canada standard be arrived at to apply to all pipelines for remediation under each land use?
  - What if land use changes?
  - What assurance is there that crops will not be affected?
  - What assurance is there that agricultural workers would not be affected?
  - Is a change in standards retroactive?
- Is it possible to have the clean up exceed minimum requirements?
- What is the risk to groundwater and soil from undetected leaks?
- What would be the anticipated natural degradation of contaminants?
- How to document that contamination was cleaned up?
  - facilitates environmental assessments and land transfers.
- What are the effects of external pipe coating degradation?

4. Post-Abandonment Issues

Following physical pipeline abandonment work the pipeline enters a post-abandonment phase that lasts until either the pipeline is removed or there are no further issues. Issues of ground subsidence and transportation corridor protection have already been identified. There have been concerns expressed relating to liability, financial responsibility and jurisdiction. These are generally beyond the scope of the committee. However, some relate to being able to address physical issues. Other physical issues and potential gaps in knowledge include the following:

- The location and maintenance of records regarding the residual pipeline equipment.

- The means of ensuring signage, pipe locates and ongoing monitoring occurs.
- The mechanism to ensure land title retains the ROW when necessary. (preferred regulatory jurisdiction)
- Means of dealing with unforeseen contaminants found after abandonment (this is related to the NEB initiative to address financial issues through companies setting aside funds).
- Potential for frost heave of pipes when not in use under different soil conditions.
- What criteria should be in place for creation of a road over an abandoned pipeline?
- What approach is recommended where a land use change means a development or house is to be put over a pipeline?
- How to determine the optimum location for pipeline plugs to prevent pipelines from becoming water conduits (potentially carrying contaminated water and causing erosion).

Date Modified: 2011-10-28

DNV

DET NORSKE VERITAS

PIPELINE ABANDONMENT SCOPING STUDY

NATIONAL ENERGY BOARD (NEB)

Report No.: EP028844
Reg No.: ENACA855
November 2010

Table of Contents

EXECUTIVE SUMMARY

Det Norske Veritas (DNV) together with TERA ENVIRONMENTAL CONSULTANTS and BGC ENGINEERING INC. were contracted by the National Energy Board (NEB) to conduct a literature review regarding the current understanding worldwide with respect to the physical/technical issues associated with onshore pipeline abandonment and use the results of the literature review to critically analyze and identify gaps in current knowledge, and make recommendations as to potential future research projects that could help to fill those gaps.

The project team conducted the literature review based on more than 100 key words applicable to pipeline abandonment. Various combinations of these key words were used to search for published information dealing with issues associated with pipeline abandonment. More than 430 abstracts of published papers were reviewed and these were narrowed down to 83 relevant documents, which were obtained for more detailed reviews by the subject matter experts (SMEs). In addition, various standards from North America, South America, Australia, Europe, and the United Kingdom were reviewed for requirements specific to pipeline abandonment.

Based on the review of these documents by the SMEs, this report outlines the current level of knowledge regarding issues related to pipeline abandonment; identifies the knowledge gaps and, in Section 5, outlines additional research topics that could be completed in order to address the knowledge gaps. Topics recommended for additional study include:

Recommended Study	Estimated Cost
Detection of Residual Contamination	$140,000
Risk Assessment	$50,000
Decomposition of Pipe Materials	$25,000
Cleaning Methods and Disposal of Cleaning Fluids	$200,000
Abandonment under Water Bodies	$350,000
Pipeline Exposure Data from Existing Records	$50,000
Buoyancy Effects on Pipeline Exposure	$75,000
Standard Pipeline Products List	$25,000
Frost Heave Effects on Pipeline Exposure	$50,000/yr.
Evaluation of Previous Pipeline Abandonment programs	$100,000 plus $25,000/yr.
Collapse of Soil Under Various Conditions	$300,000
Validation of Culvert Failure Model for Abandoned Pipelines	$40,000
Validation of Structural Integrity Models	$30,000

1 INTRODUCTION

On July 6, 2010, the National Energy Board (NEB) issued a Request for Proposal (RFP) for the completion and submission of a pipeline abandonment study. The RFP indicated that a multi-stakeholder Pipeline Abandonment Physical Issues Committee wished to address specific gaps in knowledge or other issues related to the physical aspects of onshore pipeline abandonment related to both landowner and industry interests. This would include but not be limited to studies or research related to:

- Ground subsidence and frost heave;
- Soil and groundwater contamination;
- Pipe cleanliness;
- Road, railway and utility crossings;
- Water crossings;
- Erosion; and
- Creation of conduits.

The objectives of this project were to conduct a literature review regarding the current understanding worldwide with respect to the physical/technical issues associated with onshore pipeline abandonment and use the results of the literature review to critically analyze and identify gaps in current knowledge, and make recommendations as to potential future research projects that could help to fill those gaps.

Det Norske Veritas (DNV) partnered with TERA ENVIRONMENTAL CONSULTANTS and BGC ENGINEERING INC. to submit a proposal in response to the RFP and on 4, August 2010, the project team was awarded the contract.

2 APPROACH

To conduct the literature review, subject matter experts (SMEs) in Engineering, Environmental, and Geotechnical issues identified the keywords that were used to conduct the literature searches. Additional keywords were also provided by members of the NEB's Pipeline Abandonment Physical Issues Subcommittee. Based on the keyword list, titles of papers and related abstracts were identified through the literature searches. The literature searches were performed using two search engines; Engineering Village and Science Direct. Engineering Village searches all areas of engineering and includes the article abstract databases COMPENDEX and NTIS. Science Direct is a product of Elsevier B. V. and contains over 10 million articles and book chapters in the fields of science, technology, and medicine. Subject matter experts reviewed the results of the literature searches and identified specific references they considered to be potentially relevant to the study. The identified papers were then obtained and the SMEs reviewed the papers applicable to their subject area.

DNV provided overall project management as well as the SMEs to address the Engineering issues identified for the project. TERA provided SMEs to address the Environmental issues. BGC provided SMEs to address the Geotechnical issues. Land Management issues were addressed by all SMEs as applicable.

This report outlines the results of the literature review, identifies knowledge gaps, and provides scoping for further studies and research on physical abandonment issues related to onshore pipelines in Canada.

3 BACKGROUND

3.1 Past Studies

Pipeline abandonment has been a topic of discussion in the Canadian oil and gas industry for over 25 years. This summary is taken from the NEB's Land Matters Consultation Initiative, Stream 4 – Pipeline Abandonment - Physical Issues, and is based on three previous studies undertaken in 1985, 1996, and 1997.

In 1985, NEB staff reviewed technical, environmental, and financial issues associated with pipeline abandonment (the 1985 NEB Staff Paper). In 1996, the Pipeline Abandonment Steering Committee, a collaboration of the NEB, Alberta Energy Utilities Board (EUB), Canadian Energy Pipeline Association (CEPA) and Canadian Association of Petroleum Producers (CAPP), developed a discussion paper (the 1996 Discussion Paper) that examined the physical and technical issues associated with abandonment. In particular, this latter paper provides a template for abandonment planning and implementation. In 1997, the same collaboration examined legal issues relating to abandonment (the 1997 Legal Paper).

In addition, as part of the process of developing the 1996 Discussion Paper, the Pipeline Abandonment Steering Committee commissioned four reviews of specific technical issues. The reviews examine trace pipeline contaminants, corrosion, pipeline related subsidence and environmental issues respectively and are also referenced herein.

Physical and technical issues of retirement and reclamation can be organized into six principal sections:
1. Retirement options;
2. Engineering issues;
3. Land use considerations;
4. Environmental issues;
5. Post-abandonment; and
6. Principles for pipeline abandonment.

1. Retirement Options

Three approaches to pipeline retirement are possible:

a) Removal
b) Abandonment in-place
c) Reuse of facilities

Pipeline Retirement Option Matrix - a key factor influencing the choice of retirement options is present and future land use. This is reflected in the Table below, which provides a matrix adapted from the 1985 paper.

Retirement Option Matrix[1] (from PADP 1996)

Land Use		Pipeline Diameter			
		60.3 to 203 mm (2" – 8")	273 to 550 mm (10" to14")	406 to 550 mm (16" – 20")	610 to 1219 mm (24" to 48")
Agricultural	Crop	A	R	R	R
	Crop (with depth of cover considerations)	R	R	R	R
	Pasture (inc. native prairie & rangeland)	A	R	R	R
Non-Agricultural	Rock	A	A	A	A^+
	Till	A	A	A	A^+
	Cohesive Soil	A	A	A	A^+
	Granular Soil	A	A	A	A^+
	Wetlands	A^+	A^+	A^+	A^+
Urban	Suburban	A	A	A^+	A^+
	Park	A	A	A^+	A^+
	Urban	A	A^+	S	S
	Industrial	A	A^+	S	S
Crossings	River	A	A^+	A^+	A^+
	River Approaches	A	S	S	S
	Rail	A	A^+	A^+	A^+
	Road	A	A^+	A^+	A^+
	Secondary Road	A	A	A^+	A^+
	Pipeline	A	S	S	S
	Sewer	A	A	A^+	A^+
	Cable	A	A	A^+	A^+

1

Option	Description
A	Abandon in-place recommended
A^+	Abandon in-place with special treatment to prevent ground subsidence.
R	Remove pipe
S	Site-specific evaluation recommended

Note: CEPA and NEB have developed updated Retirement Option Matrices which are included Appendix B of this report.

2. Engineering Issues

a) Corrosion

The 1996 Discussion Paper and an associated corrosion study examined the causes and timing of corrosion associated with abandoned pipelines. The Corrosion Study suggested that, while coating defects affect less than one percent of the length of most pipelines, corrosion will eventually result in random perforations throughout the length of the pipeline.

b) Pipeline collapse

As the pipe becomes pitted with corrosion, it will eventually collapse. Collapse may have few consequences for small-diameter pipes (6”/168 mm or less). However, collapse of large diameter pipes can lead to subsidence, which in environmentally or geo-technically sensitive areas would require back-filling and restoration. Given the non-uniform nature of the corrosion process, it is unlikely that significant lengths of pipeline will collapse at any one time.

The 1985 NEB Staff Paper suggests options for managing concerns for large diameter pipeline collapse that includes developing a tool to collapse a line prior to abandonment and/or filling a line, or at least critical sections of it (e.g. stream crossings, under railways), with a liquid that can solidify (e.g. cement).

3. Land Use Considerations

As the previously referred to reviews have concluded, land use is the most important factor to consider when determining whether to remove a pipeline section or abandon it in place. Of particular concern are sensitive areas, including:

- Native prairie;
- Parks and ecological reserves;
- Unstable or highly erodible slopes;
- Water crossings
- Areas susceptible to wind erosion;
- Irrigated land; and,
- Road, railway, and other utility crossings.

The pipeline industry must manage these issues and land use in general within three types of land rights: easement; fee simple; and leasehold lands.

4. Environmental Issues

Both the 1985 NEB Staff Paper and the 1996 Discussion Paper examine the environmental issues associated with pipeline retirement. The 1996 report is based, in part, on a review of environmental issues for pipeline retirement commissioned by the Pipeline Abandonment Steering Committee.

a) Soil and groundwater contamination

The Committee also commissioned a study to examine the types and quantities of contaminants that could be released from pipelines abandoned in-place.

Potential sources of contamination that were identified include:

- Substances in the hydrocarbon stream;
- Pipe treatment chemicals;
- Pipeline coatings and their degradation products;
- Historical leaks and spills of product not cleaned up to current standards;
- Pump and compressor lubricants, some of which could contain PCBs from past use.

Contamination risks are arguably greatest for pipelines abandoned in-place. The pipe will eventually be perforated by corrosion, allowing contaminants to migrate into the surrounding environment. Potential also exists for corroded pipe to act as a water conduit, transporting any contaminants present to other points along the pipeline. The cleanliness of the pipe is an important factor relating to potential soil and/or groundwater contamination from abandoned pipe. The 1996 Discussion Paper indicates that the question of "how clean is clean" remains to be answered.

b) Soil resources

Where pipe is to be removed, the erosion issues will be similar to those associated with installation.

Abandonment in-place can lead to erosion in two ways. Corrosion perforated pipe can conduct water along the right-of-way to exit the pipeline in new locations. Later, as the pipeline collapses, resultant soil subsidence can create water conduits able to intercept and channel drainage along the right-of-way, potentially, at much greater velocities than natural drainage patterns would allow.

To examine ground subsidence risks for abandoned pipelines the Pipeline Abandonment Steering Committee commissioned both a geotechnical study and a survey of pipeline companies. Neither the industry survey nor follow-up discussions identified any instances of observed subsidence. However, the Committee recommended that a field observation program be put into place that would allow tolerance criteria to be developed. This remains to be done.

c) Creation of water conduits

The potential for pipelines to create water conduits as a result of abandonment creates risks of unnatural drainage and unwanted transport of materials that can include eroded soils and contaminants. Some potential exists for water movement in un-compacted, back-filled trench material that may remain after the pipe has been removed. However, the greatest concern relates to pipelines abandoned in place.

The 1996 Discussion Paper identifies measures such as pipeline plugs and trench breakers for managing the risk of undue water mobility. The material suggests that this issue is understood and manageable.

d) Pipeline water crossings

Even after pipeline retirement, water crossings remain a key environmentally sensitive location on pipeline rights-of-way. While the water quality, fisheries and geomorphology issues associated with pipeline water crossings are well documented, most work is primarily from the point of view of pipeline installation.

Pipes abandoned in-place at water-crossings could contaminate surrounding water as corroded pipe fails and/or the pipe could be exposed. Pipe can be exposed in streams by stream bank erosion and migration, scouring of the stream channel and by other similar erosion mechanisms. Pipes may be exposed in still waters and wetlands because of pipe buoyancy if control mechanisms (e.g. concrete saddle weights) fail.

5. Post-Retirement

The 1996 Discussion Paper provides a concise template for retirement planning together with information on addressing the principal technical and environmental issues. A major issue identified was the responsibility for monitoring and maintenance. The 1997 Legal Paper examines legal issues associated with retirement and focuses much of its attention on the issue of ongoing responsibility for the retired pipeline right-of-way. The Legal Working Group concluded that "*in the absence of an express provision to impose conditions which would continue after the abandonment order comes into effect, [*the NEB concluded*] that it has no authority to attach conditions subsequent to an abandonment order*". In response, to the extent that it has had to address the retirement, the Board has adopted an approach that requires regulated pipelines to satisfy conditions precedent before a retirement can take effect.

6. Summary of Outstanding Issues

a) How clean is clean?

The 1996 Discussion Paper identifies the lack of allowable threshold criteria for contaminants as a gap.

b) Corrosion and its effects

A better understanding of the rate of corrosion in various soil types and the effects of corrosion on surrounding soil is required. Also, the actual collapse mechanism of a retired pipeline failing due to corrosion is not known hence its effect on subsidence remains unknown.

c) Practical experience with pipeline related soil subsidence.

While the Pipeline Abandonment Committee undertook an industry survey in 1996, looking for examples of pipeline related soil subsidence, the responses provided little information. In response, the Paper recommended that a field investigation program be undertaken that could lead to the development of tolerance criteria for pipeline related soil subsidence.

d) Retirement of facilities at water crossings

Knowledge surrounding the impact of corrosion on water surrounding an abandoned-in place pipeline as well as the impacts of pipe exposure in a water crossing needs to be assessed.

e) The exact nature of the Board's jurisdiction and approach to retirement going forward. Responsibility for enforcing responses to problems that may occur on retired pipeline rights-of-way that was previously federally regulated appears uncertain. There may be steps that can be taken to clarify this gap.

4 RESULTS OF LITERATURE REVIEW

4.1 Codes and Standards

DNV has reviewed the code recommendations regarding pipeline abandonment, or "permanent de-commissioning" as it is known in the UK, from a variety of countries, including Canada and the United States, the United Kingdom, Australia and South America (Argentina and Chile, although no guidance is given in either of these codes). Full details, including quotations taken directly from codes, where applicable, are presented in Appendix A.

Essentially, no significant differences have been found between the various standards; all give general guidance on what pipeline operators must consider without going into detail. The majority of the standards reviewed stipulate that "the decision to abandon a section of piping, in place or through removal, shall be made on the basis of an assessment that includes consideration of current and future land use and the potential for safety hazards and environmental damage to be created by ground subsidence, soil contamination, groundwater contamination, erosion, and the creation of water conduits" or words to similar effect (the quotation is taken from CSA Z662-07).

CSA Z662-07 states, similar to most of the codes reviewed, that piping that is abandoned in place shall be:

(a) Emptied of service fluids;

(b) Purged or appropriately cleaned or both;

(c) Physically separated from any in-service piping; and

(d) Capped, plugged, or otherwise effectively sealed.

and that records shall be maintained of all piping that is abandoned in place. Such records shall include locations and lengths for each pipe diameter and where practical, burial depth.

Both ANSI/ASME B31.4 and B31.8 have very similar clauses.

With respect to UK standards, DNV has reviewed the national standard for gas pipelines, as well as the relevant ISO, European and national pipeline "standard" (the "standard" is in fact a British Standard "Published Document" as ISO and (on a hierarchal basis) European standards must be used in preference to British Standards). However, the authors have learnt that ISO and European standards are often regarded as overly generic, and companies will therefore invoke the requirements of all three "standards". Appendix A demonstrates that the requirements of both the ISO and BS EN standards are very sparse, but more details are given in PD 8010-2004; again, the guidance is similar to the North American standards, although pipeline cover is stipulated, together with the need to consider using filler materials in certain abandoned sections. The standard for gas pipelines, IGEM TD/1/Version 5, within the UK gives more detail, including:

- Considerations of alternative uses for the (to be abandoned pipeline),
- Filling with inert gas if necessary,
- Land use and legal/landowner considerations,
- Future maintenance of the pipeline, e.g. to prevent possible collapse,
- The need for line markers, and
- The removal of short, above ground sections.

Finally, the Australian national standard AS 2885.3 has been reviewed, which is similar in outline to TD/1, although it states that line markers are not required after abandonment. It is the only standard reviewed which states that cathodic protection systems may need to be continued and the system maintained after pipeline abandonment. The standard also states that, before abandoning the pipeline, landowner releases for the completed abandonment must be obtained and the pipeline operator should relinquish the easement where no future or continuing use of the easement is proposed.

4.2 Environmental & Land Use

This Section presents a summary of the key documents forming the foundation of this report and a synopsis of all relevant documents discovered by the literature search completed as described in Section 2.

This section is structured to address the nine specific environmental components identified below:

- Detection of Residual Contamination
- Environmental Standards
- Risk Assessment
- Conduit Effect
- Decomposition of Pipe Material
- Cleaning Methods and Disposal of Fluids
- Disposal of Pipe Material
- Abandonment in Sensitive Ecological Areas
- Abandonment under Water Bodies

These topics were identified by the committee to address contamination remediation, reclamation, and protection of sensitive ecological areas. From an understanding of the past studies summarized in Section 3 and by careful review by subject matter experts (SMEs) of the subsequent literature, it is believed that the list of topics is comprehensive.

For each of the nine topics, the information gleaned by the SMEs is presented in the following sub-headings:

a) *Background Information* - The key background documents (Section 3) are well known to the National Energy Board (NEB) Pipeline Abandonment Physical Issues Committee so this sub-section is not intended to summarize those reports but rather present the key observations relevant to each of the 9 specific environmental components.

b) *Recent Findings* - This sub-section builds from the key background documents drawing on the information found in the literature review.

The purpose of this report is to identify the current state of knowledge with respect to pipeline abandonment and recommend to the NEB Pipeline Abandonment Physical Issues Committee, studies, research or tasks intended to fill knowledge gaps. The environmental recommendations are presented in Section 5.1. These have been developed by the SMEs from an understanding of the key background documents, this literature review and practical knowledge of current practice in the pipeline industry. In most instances, the authors have not attempted to suggest a priority for these tasks. We feel the NEB committee is better positioned to decide priorities.

The literature search discovered 83 documents that appeared relevant to onshore pipeline abandonment. Specifically, 36 appeared to have environmental themes. All of these are listed in Section 6 and any that offered discussion or recommendations that the environmental SMEs deemed meaningful are mentioned in this section.

4.2.1 Detection of Residual Contamination

Background Information

A number of different contaminants were identified as having the potential to be present in pipelines; however, the concern is the quantity of residual contaminants left in the interior of the pipeline at abandonment. Methods for analyzing levels of *known* contaminants in soil and water as a result of spills are well established. However, developing a methodology for accurately measuring the presence and quantity of contaminants remaining in a section of abandoned pipeline remain unclear.

A review of literature indicates that it was possible for polychlorinated byphenyls (PCBs) to have entered pipelines and peripheral facilities through the use of PCBs in lubricants at some point in the history of a pipeline system. Despite the cessation of use of PCBs for over 20 years, they can persist in the environment due to their chemical stability. Measurements of PCB concentrations along gas pipelines were not lending themselves to accurate conclusions, in part because there is no systematic protocol for ensuring comparable results. Consequently, proper management of

PCBs is difficult because estimations with respect to PCB concentrations along remaining pipelines cannot be produced. Estimating PCB concentrations is also made difficult due to the lack of information on PCB dynamics within pipeline systems.

Another potentially harmful substance present in both oil and gas pipelines is naturally occurring radioactive material (NORM). During the production process, NORM flows with the oil, gas, and water mixture and can accumulate in scale, sludge and scrapings within a pipeline. It can also form a thin film on the interior surfaces of gas processing equipment and vessels. The level of NORM accumulation can vary substantially from one facility to another depending on the geological formation, operational, and other factors.

As of 1996, little research had been done in terms of the development of guidelines for the testing and handling of NORM. In general, contaminant testing would be more efficient if the types and volumes relative to different pipeline products and locations within the distribution system were better understood.

The clean up of any spills, leaks, or contaminated sites must be conducted in accordance with prevailing regulatory requirements. Any pipeline failure resulting in a release of liquid having a volume greater than 1.5 m^3 must be reported by the pipeline operator pursuant to the NEB *Onshore Pipeline Regulations 1999* (OPR). Spills, as a result of pipeline failures and facility operation activities, are also reported to provincial regulators such as the Alberta Energy Resources and Conservation Board, Saskatchewan Energy and Resources and the British Columbia Oil and Gas Commission. Guidelines and procedures for managing spills and contaminated sites have also been established by federal and provincial regulators. However, very little information can be gathered regarding the occurrence of spills following the abandonment of pipelines as very few examples of abandonment projects exist in Canada (CEPA 2007).

Recent Findings

While conducting pipeline removal, Yukon Pipelines Limited collected soil samples every 100m along the pipeline for visual observations and organic vapour monitoring (Roblin 2006).

An example of a monitoring program set in place as part of a pipeline abandonment operation using *in-situ* biological degradation of certain contaminants is provided from the Schoonebeek Oilfield, Netherlands (Kant *et al.* 2010). It was found that, depending on the progress of the degradation process, the monitoring scheme was reconsidered and adjusted at regular intervals, and if disappointing remediation results occurred, a selected remediation alternative would be considered.

In 2008, the International Association of Oil and Gas Producers (IAOGP) released NORM guidelines specific to the oil and gas industry. Mentioned in the report is that NORMs can be either directly measured or assessed in a laboratory. In Canada, guidelines are present that cover NORM detection and handling procedures, as well as limits and exemption levels for the various radionuclides that may occur (Health Canada 2000). In the absence of national regulations, current international practice will also provide such guidelines (International Atomic Energy Association [IAEA] 2010).

In a 1991 study entitled *Gas Research Institute* (GRI) *Pipeline Research Program* (Linz *et al.* 1991), the authors state that sampling and analytical procedures commonly used for PCBs by electric utilities and other industries do not apply well to gas pipelines. Further, the authors state that negotiations were ongoing at the time between the gas industry and the United States Environmental Protection Agency (EPA) regarding both development of a statistical model to use for system characterization, and a methodology or systematic protocol to quantify residual pipe contamination. At the time, the GRI was also conducting a method development task (to establish procedural methodology) using an assortment of contaminant types. In addition, GRI was studying the partitioning of PCB within different soil and water types. The study mentions that the EPA is moving toward a liquid sample based "moving average" approach as opposed to the expensive and time consuming 1% incidence approach for statistical analysis of PCB concentrations in pipelines.

In a study entitled *The TSCA PCB Regulations and Their Effect on Pipeline Removal and Abandonment Programs* (La Shier 1989), the author mentions the need for further development of statistical analysis techniques for measuring PCB concentrations in pipelines. A sound statistical model is needed because PCB concentrations vary considerably throughout the pipeline system.

A study was conducted regarding the statistical analysis of PCB data from natural gas pipelines, which aimed to further establish both a sound sample method and an understanding of statistical distribution of PCBs along pipelines (Bishop *et al.* 1990). However, due to the limited size and scope of the study, the authors felt it was "imprudent" to draw definitive conclusions regarding the implications of their results.

4.2.2. Environmental Standards

Background Information

The National Contaminated Sites Remediation Program (NCSRP) was administered through bilateral agreements between the federal government and participating provincial/territorial environment departments with the aim of developing a consistent, scientifically defensible and cost-effective assessment and remediation plan for contaminated sites (NCSRP 1993, Canadian Council of Ministers of the Environment (CCME) 2006). Canada-wide standards for soil quality guidelines have since been developed and are well established by the CCME at the closing stages of the NCSRP in 1995 (CCME 1999a). Generic guidelines have been derived to protect human health and key ecological receptors that sustain normal activities on four land use categories: agricultural, residential/parkland, commercial, and industrial. Generic land use scenarios are envisioned for each category based on how the land is used and on how sensitive and dependent the activity is on the land. Sensitivity to contamination increases among ecological or human health components most dependent on land use activities (*i.e., agricultural and residential/parkland).*

Recent Findings

CCME's environmental soil quality guidelines were derived through the determination of the threshold level of effects for maintaining important ecological functions associated with specific land uses. Direct exposure to soil is the primary derivation procedure for environmental quality guidelines regarding residential/parkland, commercial, and industrial land uses. The Canadian soil quality guidelines have been derived specifically for protection of the ecological receptors in the environment and/or for the protection of human health associated with the identified land uses. Human health soil quality guidelines provide concentrations of contaminants in soil at or below which no appreciable human health risk is expected. The protection of human health takes into account the daily background exposure from air, water, soil, food, and consumer products. Indirect exposure pathways resulting from contaminated soils were also considered during the derivation of human health guidelines. In the case of agricultural land use, another derivation procedure is used based on soil and food ingestion (CCME 2006). CCME has established its Policy for the Management of Toxic Substances (1998) for the purpose of putting in place a results-based, accelerated action plan that all jurisdictions can utilize, and provides opportunity for public and stakeholder participation.

The CCME has several specific documents that aid in appropriate management and remediation of contaminated sites associated with the oil and gas industry.

The Canada-Wide Standards for Petroleum Hydrocarbons in Soil (PHC CWS) uses a three-tiered approach as a remedial standard for contaminated soil and subsoil occurring in four land use categories. The first tier is the direct adoption of Canadian soil quality guidelines (numerical limits [CCME 2007]) while the second tier allows limited modification of Canadian soil quality guidelines by setting site-specific objectives. The third tier uses risk assessment procedures to establish remediation objectives at contaminated sites on a site-specific basis (CCME 2008).

The Canadian Soil Quality Guidelines for carcinogenic and other polycyclic aromatic hydrocarbons (PAHs) contain recent scientific information on the chemical and physical properties of potentially carcinogenic and other commonly analyzed un-substituted PAHs, a brief review of sources and emissions in Canada, the expected environmental fate, and the toxicological significance of these PAHs to soil microbial processes, plants, animals and humans (CCME 2010).

The Canadian Soil Quality Guidelines for polychlorinated biphenyls (PCBs) contain guidelines for the protection of environmental health, but also recognizes a need for remediation guidelines as interim management objectives for persistent bio-accumulative substances in soils (CCME 1999b).

The Canadian Soil Quality Guidelines for benzene, toluene, ethylbenzene and xylene (BTEX) contain guidelines for the protection of environmental health (CCME 2004).

CCME has adopted a three-tired approach for dealing with contaminated site assessment and remediation. The first tier is the direct adoption of Canadian soil quality guidelines. However, the fact that some sites might present particular conditions (*e.g.*, high natural background concentrations, complex mixtures of contaminants, or unusual exposure scenarios) must also be considered. For these sites, the second tier allows limited modification of Canadian soil quality guidelines by setting site specific objectives. Finally, the third tier uses risk assessment procedures to establish remediation objectives at contaminated sites on a site-specific basis.

In July 2010, the NEB introduced the Draft Remediation Process Guide. This Guide describes the way a company can demonstrate that a contaminated site associated with an NEB regulated facility has met remediation criteria. This Guide applies to NEB-regulated facilities under the *National Energy Board Act* (NEB Act) and the *Canada Oil and Gas Operations Act* (COGOA). At a minimum this Guide applies to:

- Remediation of residual contamination in soil and groundwater to an appropriate standard;
- Remediation of all spill sites whether the spill is reportable or not;
- Off-site contamination remediation; and
- Historic contamination events.

The NEB accepts remediation criteria established by the province or territory where the remediation site is located as a baseline but requires the use of CCME standards if the criteria are more stringent. Remediation criteria must be selected based on the type of soil and land use. Typical land use categories are industrial, commercial, residential, parkland, and agricultural. Justification for the use of particular criteria must be provided.

Provincial governments have adopted the CCME standards with some provinces using the CCME guidelines as a platform from which further directives and guidelines have been established. For example, Alberta includes natural areas as an additional land use category (AENV 2009).

In a case study of the 1996 abandonment of a Yukon Pipelines Limited pipeline stretching from Whitehorse to Skagway, contaminated soils were compared with CCME criteria, and groundwater samples were compared with both the Yukon Contaminated Site Regulation and CCME drinking water criteria.

The Canadian Guidelines for the Management of NORM have been developed by the NORM Working Group, a working group of the Federal Provincial Territorial Radiation Protection Committee (FPTRPC), representing the interests of provincial and territorial regulators and includes affected industries in the petroleum production, fertilizer manufacturing and metal recycling industry sectors. With the support and encouragement of Health Canada and the Canadian Nuclear Safety Commission, the Canadian Guidelines set out principles and procedures for the detection, classification, handling, and material management of NORM in Canada, and also include guidance for compliance with federal transportation regulations. These

Guidelines provide the framework for the development of more detailed NORM management practices and guidelines by regulatory authorities, affected industries and specific workplaces.

4.2.3 Risk Assessment

Background Information

Conducting risk assessments for abandoned pipelines is a key procedure that should be implemented to ensure protection of ecological receptors and/or for the protection of human health. To start, abandoning a pipeline in-place must be weighed against the environmental impact of removal, and should be site specific (PADP 1996).

Components considered in a site-specific risk assessment are largely related to environmental variables that may jeopardize pipeline integrity, causing stress and/or corrosion related cracks and eventual disintegration, facilitating contamination release, water displacement, point source erosion and subsidence. Although assessment of risks associated with pipeline abandonment includes external environmental variables affecting pipeline integrity, it is the potential damage that toxic substances, if released, may have on particular receptors.

To begin a risk assessment, a field study of residual contaminants in pipelines prepared for abandonment should be conducted. The study should include the determination of the nature and quantity of residual contaminants for the range of operating conditions and products typically found in Alberta (Thorne *et al.* 1996). A risk management plan should then be developed and include factors such as: type of contaminants, differences in product, pipeline construction, operating conditions and environmental sensitivity, and lack of detailed information (Thorne *et al.* 1996).

As mentioned in Section 4.2.2, Canada-wide standards for soil quality guidelines have been developed and are well established by the CCME. The soil quality guidelines provide concentrations of contaminants in soil at or below which no appreciable human health risk is expected. The protection of human health takes into account the daily background exposure from air, water, soil, food, and consumer products. Indirect exposure pathways resulting from contaminated soils, such as contaminated groundwater, contaminated meat, milk, and produce, infiltration into indoor air, and wind erosion resulting in deposition on neighbouring property were also considered during the derivation of human health guidelines.

Recent Findings

The Canadian Energy Pipeline Association (CEPA) recognizes that a risk-based, comprehensive site specific assessment is essential in determining appropriate abandonment procedures for specific pipelines (2007). However, CEPA also states that a risk-based decision process to support the required site-specific assessments has not yet been developed. In addition, the lack of environmental baseline data (*e.g.* interactions and pathways of specific contaminants released in different soil and groundwater systems) makes restoration requirements difficult to assess

(Sookdeo 2002). Furthermore, ongoing controversies pertaining to the definition of pipeline cleanliness specifications must be resolved in order to develop such a decision process (CEPA 2007). Although it is evident there are many issues to be resolved in order to develop a robust and comprehensive risk assessment approach, key considerations that should be included in any risk assessment are listed by the authors of *Decision Procedures for Pipeline Rehab* (Hodgdon *et al.* 1991). They state that risk analysis is a flexible technique that can include:

- Management assessment of risk whereby management has sufficient data and information to reach the decision that risks exist and action is necessary;
- Comparative risk assessment whereby the risks in several segments of a pipeline system are developed on a comparative basis in order to assign priorities to the segments for budget and scheduling purposes; and
- A risk analysis that determines the probabilities and seriousness of risk at a specific site.

In addition to the above recommendations, much insight can be collected from recent experiences and investigations into the matter:

The authors of *Oilfield Abandonment and Soil Restoration in the Netherlands, Experience for the Future* (Kant et al. 2010) discuss risk assessment and subsequent remediation techniques used on a large oilfield abandonment project in the Netherlands. In the Netherlands, soil-risks can be modelled in a semi-quantitative manner as a result of the establishment of Soil Protection Guidelines (based on long term collection of data) that ensure permit conditions are uniform. This allowed remediation measures to be attuned to the actual risks of residual contamination. For example, if conditions permitted, slightly contaminated soil was left or put back. This "fit for use approach, or function-oriented remediation approach, whereby pollutant concentrations in soil and groundwater were remediated to levels associated with land use, proved practical and cost effective, allowing resources to focus on areas of greatest over-all risk without compromising risks of lesser significance or immediacy. In general, however, the preferred approach (though more costly) would be multifunctional remediation, whereby all contaminated sites are remediated so that no risks exists no matter what the land use.

The authors of *Use of Risk-Based Business Approach for Characterization of Environmental Remediation Liabilities in Upstream Oil and Gas Production Facilities* (Connor et al. 2008) discuss a Risk-Based Corrective Action (RBCA) risk classification system for characterization of site conditions. This system, discussed in detail in the paper, is designed to characterize site conditions and risk distribution in terms of the magnitude and immediacy of the risks posed, thereby facilitating development of a corrective action program schedule and budget designed to address imminent concerns in the near-term and non-imminent concerns over the long-term. This RBCA risk classification system could be adopted for pipeline abandonment, used to distinguish between necessary immediate actions and actions that can be postponed until later depending on the type of monitoring information gathered or other non-immediate characteristics of the risk (e.g. location, subsidence etc).

Government Directives and Guidelines

The NEB Draft Remediation Process Guide recognizes that not all contaminated sites accommodate typical remediation approaches; for example, in the following situations:

- National criteria for a contaminant does not exist;
- Remediation to guideline-based criteria is not feasible for the targeted land use;
- Guideline-based objectives do not seem appropriate given the site specific conditions, (i.e. recovery of the contaminant is too deep or otherwise unfeasible to access) so a risk assessment is necessary to establish site specific objectives;
- Receptors of concern have been identified; or there is significant public concern, as determined by the lead agency.

In these situations, the Guide recommends a risk management approach be followed. This involves the selection and implementation of a risk control strategy based on site specific objectives. Monitoring and evaluation of the strategy's effectiveness is required. The CCME approach is recommended. Risk management may include direct remedial actions or other strategies that reduce the probability, intensity, frequency or duration of exposure to contamination through soil, water or air/vapour pathways. The latter may include controls such as zoning designations, land use restrictions or orders. The decision to select a particular risk-based strategy will be informed by risk assessment information.

Alberta Environment incorporates site-specific risk assessment (SSRA) guidance and remedial objectives in its *Tier 2 Soil and Groundwater Remediation Guidelines* (2009). Mentioned in the Tier 2 document is that in all instances, site specific remediation objectives will require use of procedures, protocols, and monitoring that are acceptable to Alberta Environment. Where there are no clear guidance documents that have been accepted by Alberta Environment, discussion with Alberta Environment will be necessary prior to acceptance of final Tier 2 SSRA remediation objectives. Site-specific risk assessment may be triggered by a number of conditions, including situations in which Tier 1 and/or Tier 2 pathway and receptor exclusion and guideline adjustment approaches are either precluded by technical or policy factors or where site specific risk assessment is clearly demonstrated to offer the same level of protection as the Tier 1 objectives. The guideline continues, addressing the basis and considerations for SSRAs, implementation of site-specific remediation objectives and identification of conditions/restrictions associated with SSRA. The guidelines also cover the roles of, and approaches to, exposure control, circumstances precluding exposure control and requirements for exposure control.

In 2004, Health Canada released a document entitled *Federal Contaminated Site Risk Assessment in Canada*. This document was released to standardize guidance for consistent assessments on federal contaminated sites. These cover hydrocarbon related contamination rather extensively, and could be considered in the oil and gas abandonment and remediation process. These preliminary quantitative risk assessment (PQRA) guidelines are different from more complex site-specific risk assessments (SSRA). Nevertheless, the two assessments are not independent and can in fact work together to produce a more accurate, precise, realistic, reliable, and defensible quantification of risks (Health Canada 2004). Health Canada is currently working on a guidance manual for conducting SSRAs which will be published when the work is complete.

4.2.4 Conduit Effect

Background Information

For in-place abandonment of pipelines, the conduit effect refers to the migration and discharge of water through the pipeline resulting from perforations caused by excessive corrosion or outside forces. Modern pipeline coatings provide substantial protection; however, an estimated 1% of external pipeline surfaces are not coated (Webster 1995). Furthermore, coatings may be improperly installed, defective or damaged from either construction or natural activities.

Significant environmental impacts have the potential to occur resulting from the conduit effect. The level of cleanliness within the pipe will determine the magnitude of the potential impacts resulting from point-source leaks along the damaged pipeline. It has been suggested that water displacement and flow as a result of perforations could lead to drainage of wetlands, or flooding of low lands. In addition, if abandoned pipelines are not completely cleaned, it has also been suggested that water within the pipeline may accumulate excessive contaminant loads, depositing them near sensitive areas (*e.g. wetlands, watercourses etc)* or in surrounding soils and groundwater (PADP 1996). In addition it has been suggested that any water discharge has the potential to cause subsurface erosion resulting in ground instability and surface subsidence.

In order to inhibit the transfer of water through a pipeline, it has been suggested that plugs could be installed at an appropriate spacing and along certain terrain features to ensure that changes in surface and ground water conditions will not result in water flow (H.R. Heffler Consulting Ltd. *et al.* 1995, PADP 1996,). When identifying plug locations, one should consider pipeline access and the resulting effects of the ground disturbance (PADP 1996). Furthermore, water discharge points should be created along slopes to reduce excessive erosion and flooding of low areas where the pipeline flattens out (PADP 1996).

The flow and displacement of water may also occur through uncompacted materials along a trench where pipeline was removed (Roblin 2006). Sediment packing, as well as installation of trench breakers and subdrains are appropriate mitigation measures (PADP 1996, Thorne *et al.* 1996, Roblin 2006).

Recent Findings

When discussing the environmental impacts and mitigation measures associated with the conduit effect, CEPA, in their 2007 report, stated that no new information was collected. Putting negative impacts aside, positive research has been done exploring pipelines abandoned in-place as conduits for alternative applications.

In a publication entitled: *Use of Abandoned Pipeline to Transport Sediment to Marshes* (Coates 1994), the author argues abandoned pipelines have the potential to be used for nourishment of existing marshes by transport of freshwater with nutrients and finer sediments. The author also considers the utilization of pipelines to transport sediment to restore marshes as technically feasible.

In a publication entitled: *Multiproduct Pipe Transport Conversion of Abandoned Single Product Pipelines* (Davis et al. 2005), the author presents a methodology for creating and controlling multiple pipelines that are installed within a larger outside diameter (O.D.) line. One benefit of this is reduced construction related environmental damages.

In a publication entitled: *Contractors' Concept of Optical Fibre in Sewers of Abandoned Pipelines* (Welch 2004) the application of pipelines as conduits for optical fibre cables is explored. Benefits of this application include fewer construction related nuisances to the public, reduced impact to the environment and safer, more compact utility corridors.

4.2.5 Decomposition of Pipe material

Background Information

Pipelines bodies consist of 97 to 99% iron by weight, followed by 0.5 to 2.0% manganese, 0.5 to 1.0% copper, nickel, molybdenum, chromium and carbon. Trace elements (less than 0.1%) are sulphur, phosphorus, tin, lead, bismuth and arsenic. The types of material associated with pipelines coatings are coal tar, enamel, polyethylene tape, asbestos, asphalt, high density polyethylene and fusion bonded epoxy. Presently, polyethylene and fusion bonded epoxy are the most widely used coatings. Pipeline coatings used in the 1950's and 1960's included blown bitumen or coal-tar pitch covered by glass-fibre cloth, bituminized paper, hessian, or asbestos felt. In Alberta, asbestos felt wrap was used into the early 1970's (Thorne *et al.* 1996).

Metals released from the pipeline body from corrosion corrode to a state of lower environmental mobility, and are generally not considered a potential environmental threat. Carcinogenic PAHs present in coal tar enamel was one of the leading causes of an industry switch to polyethylene. Polyethylene is considered safe to work with, and does not produce toxic leachates (Thorne *et al.* 1996).

Ground subsidence resulting from excessive deterioration and subsequent pipeline collapse is little understood, as of 1996 no data on the phenomenon was currently available. There are many uncertainties in predicting subsidence. For example, temporal relationships of pipeline degradation and how the magnitude and impact such degradation will influence subsidence is poorly understood. Nevertheless, it is improbable that a sudden collapse will lead to a depression of the soil cover as deep as the pipe diameter over an extended length of the pipeline (Geo-Engineering Ltd. 1996). Any subsidence is likely to be localized and intermittent.

Recent Findings

There is limited new information regarding the impacts of contaminant release resulting from pipeline decomposition. One study on subsea in-place abandonment found that, since PAH is not very water soluble; it will become a major environmental hazard only when organisms feed on particulate material (Scandpower Risk Management Inc. 2004). This could be an environmental concern in wetter areas for onshore pipeline abandonment.

In its 2007 report, CEPA concluded that pipelines of diameters greater than 12 inches will still be within tolerable ranges of subsidence, and that pipeline structural integrity would be retained for decades, if not centuries. CEPA still recognizes, however, that considerable work is needed to validate subsidence risks resulting from corrosion.

4.2.6 Cleaning methods and disposal of cleaning fluids

Background Information

The most critical determinant for ensuring pipe cleanliness is effective pigging (PADP 1996, Thorne *et al.* 1996). Preferably, in-place abandoned pipelines should be cleaned free of solids or any waxy build up (PADP 1996). However, studies have shown that significant quantities of contaminants may be left in abandoned pipelines as a result of poor pigging operations. A number of factors influence the efficacy of pigging operations such as pipeline configuration (*e.g.* bends and doglegs), pig type and proper pig use. Even with effective pigging, PCBs and NORMs have been identified as remaining in a limited number of gas transmission lines (Thorne *et al.* 1996).

Regarding disposal, all waste materials and contaminated soils must be handled, stored and disposed in accordance with approved waste management procedures. Properly engineered containment and storage equipment, proper labelling, proper disposal processes with respect to local regulations and effective spill contingency plans should be used (PADP 1996). In general, small quantities of pigging waste are usually accepted by oilfield waste disposal companies, often without conducting detailed chemical analysis (Thorne *et al.* 1996). Asbestos containing coating is removed through a high pressure water jet method, and the water used is collected, filtered and, if associated with coal tar wrap, tested for PAHs, PCBs, and chlorides. In 1996, disposal guidelines for NORMs were not yet established, and PCB disposal guidelines were currently being investigated (Thorne *et al.* 1996).

Recent Findings

Pipelines abandoned in-place should be cleaned to meet all applicable guidelines and regulatory requirements (CEPA 2007). A substantial amount of information now exists pertaining to proper detection, handling and disposal of NORMs, PCBs, and PAHs. Fluids removed from the pipeline should be discharged into tanks to allow settling and proper testing. Though there are many guidelines and standards pertaining to cleaning and proper disposal of pipelines and associated fluids, defining cleanliness, specifically in terms of land use, remain unclear (CEPA 2007). Past studies do provide insight, however, into innovative procedures for disposal and cleaning of pipelines and their related products:

The authors of *Oilfield Abandonment and Soil Restoration in the Netherlands, Experience for the Future* (Kant et al. 2010), discuss new techniques used for dealing with residual substances collected as a result of cleaning procedures. The substances were stored at temporary storage locations where they were then assessed and transported to qualified processing plants. These plants would then work to reduce the toxicity of contaminants via techniques such as anaerobic benzene degradation, land farming, in-situ chemical oxidation and aerobic biodegradation.

The authors of *Innovative Methodology for Cleaning Pipes: Key to Environmental Protection* (Buzelin *et al.* 2008), describe a successful new methodology using chemicals to remove paraffin and asphaltene. It involved the flushing of a chemical product composed of diesel, isopropane, benzene and naphthalene. This method was applied for subsea pipes that were unable to be successfully pigged to meet contaminant levels below Brazilian standards. Such an approach may be viable as a secondary cleaning procedure, ensuring areas along the line unable to be effectively pigged (doglegs, slopes etc) can still be cleaned effectively.

4.2.7 Disposal of pipe material

Background Information

There was no information covering proper disposal of pipeline and pipeline materials recovered from the background readings (PADP 1996, Thorne *et al.* 1996, H.R. Heffler Consulting Ltd. *et al.* 1995).

Recent Findings

In Alberta, waste pipe not containing any hazardous substances can typically be recycled as scrap metal. If the pipe does contain hazardous materials it can either be cleaned to an acceptable standard and recycled, or disposed of at an approved landfill (Swanson *et al.* 2010). If NORMs or PCBs are detected beyond acceptable levels even after thorough cleaning, then disposal should be in accordance with their respective established guidelines (Sections 1.1.2 and 2.2). As an example, in the U.S. no selling or reusing of pipe still containing >50ppm of PCB is permitted, and must be either cleaned to an acceptable level approved by the EPA, or disposed of at an approved incinerator (La Shier 1989).

With respect to pipeline coating materials, specifically coal tar wrap, wrapping the pipe with plastic wrap before removing it from the trench will help reduce flaking and deposition of the material onto the ground (Swanson *et al.* 2010). In a 1996 document entitled: *Utility Manages to Work with Asbestos in Coal-Tar Pipe Wrap* (Falise), research conducted into the health effects of removing coal tar wrap laden with asbestos came to several important conclusions:

- Without the use of power tools or burning apparatus, the non-friable nature of coal tar wrap ensured that its disturbance and removal did not release hazardous amounts of free asbestos into the air;
- The use of special personal protective devices during distribution activities involving wrap removal is unnecessary;
- No extraordinary labeling, packaging or disposal methods are required; and
- Scrap pipe, with the wrap still intact, can be disposed of in a construction debris landfill.

As an alternative to disposal or recycling, pipe cleaned to acceptable standards can be utilized in a number of ways: as bridge guards, support along shorelines, piers for buildings, bridge supports, road foundations, casings, culverts, corrals and cattle guards, centre posts and columns for fence/barns, flag poles etc (Howell 2010).

4.2.8 Abandonment in sensitive ecological areas

Background Information

Sensitive areas such as national and provincial parks, ecological reserves and regionally significant environmentally sensitive areas should be subject to in-place abandonment. In-place abandonment is also the preferred option for native grasslands, forests, wetlands and muskeg. As indicated in the PADP 1996, removal of pipelines in sensitive areas will cause unnecessary disturbances, particularly in muskeg and wetland environments. In wetlands, it is recommended that abandoned pipe be either filled with water or perforated to allow natural invasion of water, with plugs installed along the pipe to prevent drainage and/or contamination (H.R. Heffler Consulting Ltd. *et al.* 1995). In-place abandonment may require some level of activity (*e.g.* spot excavations), and associated impacts such as erosion and slope instability should be mitigated (PADP 1996).

In addition, in-place abandonment should be considered along unstable slopes where, over time, the pipe may act as a structural support, and its removal would damage slope integrity. Removal along slopes could also lead to extensive and expensive remediation requirements (PADP 1996).

Recent Findings

Abandonment in-place along sensitive areas and unstable slopes remains the preferred action (CEPA 2007). However, removal may be the best option in northern areas where soil, groundwater and temperature conditions encourage extensive frost heaving, potentially resulting in surface exposure of the pipeline (Mackay *et al.* 1979). If, for a number of reasons, removal is the only viable option, several mitigation measures provided in the following case studies may be utilized:

In *A Case Study from Abandonment of a Southern Alberta Pipeline* (Swanson *et al.* 2010), clearing, where absolutely necessary, was conducted by hand. To minimize disturbance in treed areas, pipeline segments were cut and pulled from one or both sides of a stand. Furthermore, disturbances in forested areas were mitigated through the use of small, maneuverable bobcats. In native prairie, large pieces of sod were salvaged from the right-of-way and replaced as soon as possible following pipe removal.

In A *Case Study of the Yukon Pipelines Limited* (Roblin 2006), removal in sensitive areas was monitored by a qualified professional, and work crews carried spill cleanup kits. Pipe buried in standing water of wetlands was cut, tested and plugged at both ends. It was then pulled out from the area at one end. One large section of pipe was removed in winter to minimize disturbance to the wetland. Soil samples were taken every 100 meters along the pipeline for visual observations and organic vapour monitoring.

When considering abandonment options in sensitive areas, factors such as burial depth and cleanliness of the pipe should be considered. In frost sensitive northern areas the discontinuation of pipelines may interrupt surface water-ground water interactions, leading to ponding, erosion and channeling along the right of way, whether the pipeline is left in-place or removed (Van Everdingen 1979).

To abandon an NEB regulated pipeline, Section 50 of the OPR states: “An application made by a company under section 74 of the NEB Act for leave to abandon a pipeline or a section of one shall include the rationale for the abandonment and the measures to be employed in the abandonment.”

The NEB will consider the application and approve (or deny) by issue of a Certificate with conditions. The Certificate will not be valid until the conditions are satisfied.

Given this process, it seems reasonable that each project-specific application will examine the land use and environmental implications for the entire system and propose environmental mitigation measures that satisfy the NEB. The environmental threat of an abandoned pipeline seems similar to that of the operating pipeline. The consequences of leaks are removed but the risk of other physical phenomena such as river scour, channel migration, floods, right-of-way erosion, landslides, etc., continue.

The process of removing a buried pipeline may create as much or more environmental disturbance as pipeline installation. Most pipelines are likely to be abandoned in place except where current or reasonably foreseeable land use dictates removal. During abandonment, site-specific study will identify appropriate environmental protection measures.

4.2.9 Abandonment under water bodies

Background Information

In general, in-place abandonment is the preferred approach for pipelines abandonment under water bodies (PADP 1996). Left in-place, the pipeline should be as clean as possible, and caps and plugs should be strategically positioned to mitigate contamination threats from trace materials along the rest of the line. If the pipeline has the potential to float it should be either perforated, with caps and plugs in place to protect from contaminants, or filled with concrete. If the line is to be removed through excavation, mitigation measures will be identical to those used in initial construction. Removing the pipeline may be required if threats of future exposure from excessive erosion seem likely (PADP 1996). It may even be prudent to remove the pipe at sag bends under threat of exposure from horizontal channel migration (Heffler Consulting Ltd. *et al.* 1995).

Recent Findings

Limited new information was acquired regarding pipeline abandonment under water bodies. In *A Case Study from Abandonment of a Southern Alberta Pipeline* (Swanson *et al.* 2010), they found that, during abandonment, the 273 mm O.D. pipeline segments could be successfully pulled from watercourses. The study also mentions the Alberta floods in 2005, where numerous creaks flooded their banks, leaving a number of pipelines exposed. Sudden exposure of pipe as a result of such scenarios, or from gradual erosion, could pose hazards for water recreation (*e.g.* obstruction, hydrology changes etc).

4.3 Geotechnical

The geotechnical section of this report presents a discussion of geohazards or "natural hazards," and focuses on the two most active natural hazard types; geotechnical (soil or slope related) and hydrotechnical hazards (surface water related). Other types of natural hazards are discussed as appropriate. Section 6 presents a summary of the key documents forming the foundation of this report. The relevant issues are summarized in Section 3. In this section a summary of key findings from the relevant literature and experience is presented.

The literature search yielded 16 documents that were geohazard-related; however, none particularly addressed geohazards for onshore pipeline abandonment. Some papers detailed characteristics of geohazards and a few were related directly to geohazard management. To supplement these sources, the book Geohazard Management in Pipeline Geo-Environmental Design and Geohazard Management, published by the American Society of Mechanical Engineers, was consulted as a reference.

A natural hazard, depending on the nature of the hazard and the scale of the occurrence and the prior condition of the right of way and pipeline can result in the following:

- No significant effect on the pipeline (i.e. a 0.5 m surface slide occurs but the pipeline is buried 4 m deep),
- Pipeline exposure (i.e. concentrated flows occur and erode 1.5 m of soil from a slope and the pipeline was buried 1 m deep), and

- Puncture of the pipeline (i.e. a large scale landslide occurs and breaks the pipeline).

As a consequence of other factors (such as pipeline removal or corrosion) the collapse of the pipeline and the surrounding soil can also occur. The collapse failure mode is not thought to be caused by a natural hazard, but by other factors leading to a condition where the soil has a void to collapse into. Soil collapse is a consequence for some land use, and could lead to other types of consequences.

Information regarding the mechanism of pipeline collapse is scarce, excepting the 1996 Geo-Engineering study (Geo-Engineering (MST) 1996) completed for the NEB. More information exists on the occurrence of exposure and puncture, almost no information is specifically for abandoned pipelines, while most information comes out of integrity work related to active pipelines.

The main geohazard concerns were identified in Section 3.1, Past Studies. These have been broadly categorized into those that could cause pipeline exposure and/or puncture, or conditions where collapse could occur. Each is associated with unique concerns in terms of land use and/or environmental consequences.

In addition, each of pipeline exposure, puncture and collapse is then a leading factor for the development of the next stage of degradation. For example, the exposure of a pipeline can increase the probability of pipeline puncture from geohazards, corrosion and outside forces. This relationship of each condition enhancing the likelihood of the next occurring is not specifically addressed in this section, although Event Trees relating causes and consequences could be developed to aid in understanding of these types of scenarios (Discussed in Section 5.1.3). To develop general guidance on pipeline abandonment, both the direct consequence of the geohazard, and the further effects that can be linked to the initial hazard, should be considered, such as is shown in Table 2: Retirement Options Matrix.

The understanding of these topics was developed based on a review of the past studies summarized in Section 3, and by careful review of literature and knowledge gained by experience of our subject matter experts (SMEs).

General Comments on Geohazards

Geohazard occurrences are largely spatially controlled. They are concentrated at: rivers, slopes, water bodies, crossings and other distinct locations. Geohazards are all principally controlled by local factors such as soil type, access to moisture and local temperature/insulation effects. Thus, any abandonment plan must review geohazards at distinct locations. Forty distinct geohazards (Rizkalla et al. 2008) are categorized for assessment as part of management of hazards for active pipeline integrity. The types of geohazards present on a particular pipeline are a function of the natural attributes of the right of way and are thought to largely persist once product is no longer flowing in the pipeline; the differences are related to the consequences.

Geohazards can be categorized in to the following general headings (after Rizkalla et al. 2008):

1. Mass movements (geotechnical)
2. Hydrotechnical
3. Seismic
4. Surface or subsurface soil erosion (normally associated with slopes)
5. Freezing
6. Thawing of permafrost
7. Geochemical
8. Volcanic
9. Others (normally associated with unique geological settings; volcanic activity, Karst, desert conditions)

The most active geohazards for typical pipelines are; hydrotechnical, surface or subsurface erosion and geotechnical (Leir 2009). Hydrotechnical hazards are associated with channelized flow of streams and rivers. The mechanism of erosion varies with river energy and the soil through which the river flows and can manifest as scour, channel degradation, bank erosion, stream encroachment and avulsion. Surface erosion of the ground varies with rainfall, channelization of local water, soil types, slope and vegetation. Geotechnical hazards are associated with various types of earth/mass movements, which vary with soil types, groundwater and changes to either the groundwater or the loading of the slope.

4.3.1 Exposure

Understanding of issue and existing information

In order to provide context for the likelihood of pipeline exposure following abandonment, an examination of the occurrence of pipeline exposure due to geohazards on active pipelines was used as a proxy. It can be expected that the rates of exposure could be higher for an abandoned pipeline due to the lack of maintenance or active visual inspections, eventual loss of buoyancy control where installed and frost heave of pipe without product within the pipeline. Pipeline exposure in an area where buoyancy control is needed is thought to be controlled by the failure of the control measures, if no other action is taken. No literature was found on the potential for frost heave to expose an abandoned pipeline, but culverts and pipelines with product near ambient temperature could be considered a proxy for further study.

The effects of pipeline exposure are threefold; interference with land use, degradation of the pipe or coating, and becoming a cause for further degradation by puncture/collapse.

Based on reviews of various pipeline systems in Western Canada (Leir 2009), the annual pipeline exposures/impact rates for active pipelines was: 1.4 exposures/impacts per 1,000 km of pipe. Of these exposures/impacts, 1.2 were due to hydrotechnical hazards and 0.2 due to surface erosion/geotechnical hazards (Leir 2009 groups surface erosion/geotechnical hazards as geotechnical hazards).

The main hydrotechnical hazard types include (Leir 2009): scour, degradation, bank erosion, encroachment and avulsion. Scour occurs in channels that are deepened where water flow becomes concentrated by obstacles in the stream; therefore, locally increasing erosion and reducing the depth of cover over a pipeline. Degradation, which is probably the most common hydrotechnical hazard leading to pipeline exposure, is the natural lowering of the channel bed that occurs when sediment supply is decreased or the erosive capacity of the stream is enhanced. Vertical erosion rates are estimated at an average 20-30 mm per year when typical flow regimes and storm events are considered together. When this erosive force is focused on the horizontal migration of the stream, bank erosion occurs, most often on the outside curve of the channel. If pipelines run parallel to a river or stream, encroachment may occur should the stream migrate to intersect the pipeline. Again, this is common at the outside curve of bends. Finally, stream avulsion can lead to pipeline exposure when the existing channel is abandoned for another route, one that intersects the pipeline. Avulsion occurs most often on debris flow fans or as a result of flooding within flat floodplains. The rate of pipeline exposure due to these hazards should not be affected by abandonment of the pipeline or the filling/plugging of the pipeline.

Surface water erosion includes erosion of the backfill directly above the pipeline or of other areas on the right of way that were cleared or disturbed for pipeline installation. The occurrence of this mode of exposure is thought to be generally increased upon abandonment, since the inspection will be reduced or eliminated. If the pipeline is removed from a slope by excavation, re-establishment of vegetation will be required to reduce the amount of erosion on the slope.

Furthermore, wind erosion and deposition can reduce or increase the cover thickness over pipelines. The effects of wind erosion are enhanced where topography is more pronounced depending on soil texture and where vegetative cover is thin.

Mass movements can sometimes result in pipeline exposure (although they normally would result in development of strain and puncture of the pipeline), especially at river banks or if the soil flows from around the pipeline. The rate of exposure is unlikely to be changed by abandonment.

4.3.2 Puncture

Understanding of issue and existing information

Similar to pipeline exposure, an estimate of the occurrence of puncture during abandonment can be estimated by the rate of pipeline failure due to geohazards. In an active pipeline, the internal product pressure has the effect of provided a bursting pressure, which may decrease the likelihood of a puncture without product as compared to an abandoned line. The effects of the puncture are much less significant without the possibility of liquid or gas product leaks or ruptures. However, a puncture would allow water access into and out of the pipeline, which in turn may produce flow in the pipe (and potentially a pathway for residual contamination or water flow) and internal corrosion. In Canada, the annual rate of pipeline failure due to geohazards is between 5.4 to 1.6 x 10^{-3} per 1,000 km of installed pipelines (Rizkalla et al. 2008). These statistics indicate that geohazards are much more likely to result in pipeline exposure rather than puncture.

The geohazard that causes most of the punctures is mass movement (landslide, debris flows or rockfall) due to overstressing of the pipeline. Although the rate of pipeline failure is much less for geohazards than other failure mechanisms, the cost of a failures due to geohazards is high (Porter et al. 2004) due to the significance of the individual events. Following abandonment, the consequences of a puncture resulting from geohazards should be about the same as for other causes of puncture.

4.3.3 Collapse

Understanding of issue and existing information

Complete pipeline collapse is not typically encountered in active pipelines, and is unlikely to result from a geohazard.

If external loading exceeds the pipe capacity, at crossings or due to corrosion of the pipe reducing its load carrying capacity, the pipe could collapse. If the pipeline is removed from the ground, or completely corroded a void would be created within the ground, which could collapse. These two scenarios create a conduit in the soil, or permit the above soil to collapse into the void. The 1996 (Geo-Engineering 1996) study undertaken for the NEB outlined the potential effects of voids and the resulting surface effects.

There have been studies conducted in attempt to determine the effects of pipeline collapse on the ground surface and establish whether significant subsidence will result, a significant subsidence is one that would result in damages to person and property. A 1996 report prepared for the Pipeline Abandonment Committee by Geo-Engineering (M.S.T.) LTD. modelled conditions wherein significant soil cover collapse would be observed. The results of the study concluded that it is improbable that substantial subsidence would occur simultaneously over a long stretch of pipe and the likely scenario would be slow loss of ground into a perforated pipe. The study also concluded that, depending on soil bulking factor and for a 1 m depth of burial, 300 mm diameter voids are the maximum size that would result in little or no subsidence. The study also indicated that more research is required with regards to soil-pipeline interaction and the effects of time on the system. It is expected that, in the long term, any pipeline left in place would eventually degrade to the point that a void exists in the ground.

4.4 Engineering

4.4.1 External Corrosion

Data from Literature

Very little information was found in the literature on the topic of external corrosion of abandoned pipelines and the inevitable collapse of these pipelines as the external corrosion progresses. On the other hand, there is a fair amount of data on underground corrosion that is useful in the assessment of this issue. The National Bureau of Standards [now referred to as the National Institute of Standards and Technology (NIST)] funded extensive research on this topic in the 1950's and this work is summarized in a report that is currently available through NACE International [Romanoff 1957]. In this research, coated and uncoated coupons of a number of different steels were exposed under freely corroding conditions in soils throughout of the United States. While it is difficult to summarize the large body of work in this report, some of the significant findings include:

- Soil corrosivity increases with decreasing pH
- Soil corrosivity increases with decreasing resistivity
- Pitting rates follow a power law, with an exponent that is generally near 0.5 and varies with soil properties

With respect to soil resistivity, Table 2 shows that soils having resistivities less than 1000 ohm-cm are generally considered to be very corrosive, while soils having resistivities greater than 10,000 ohm-cm are considered to be essentially not corrosive.

Table 1. Soil Corrosivity vs Soil Resistivity [Beavers, 1998]

Soil Resistivity, Ω-cm	**Corrosivity**
0-1000	Very Corrosive
1000-2000	Corrosive
2000-10,000	Mildly Corrosive
> 10,000	Progressively Less Corrosive

The California State Department of Transportation [Anon 1993] performed an analysis of data from perforated culverts and observed a similar correlation between soil corrosivity and the pH and resistivity of the soil. They developed an algorithm relating these factors to the time of perforation of a 52 mil culvert:

Years to Perforation = $13.97[\text{Log}_{10}R - \text{Log}_{10}(2160\text{-}2490\text{Log}_{10}\text{pH})]$

A linear corrosion rate was recommended by the authors for extrapolation to thicker culverts. This assumption is questionable, albeit conservative, if the culverts perforate by pitting, which is likely, because the power law exponent for pitting is generally less than one. Figures 1 and 2 show the predictions for perforation of a pipeline, by corrosion, for various soil resistivities and wall thicknesses. The most striking conclusion from this analysis is that the predicted perforation times are very long, > 50 years, for even moderate pipe wall thicknesses. This prediction does not appear to be consistent with pipeline industry experience in which pitting perforations are seen in much shorter time periods for pipelines with inadequate or no cathodic protection.

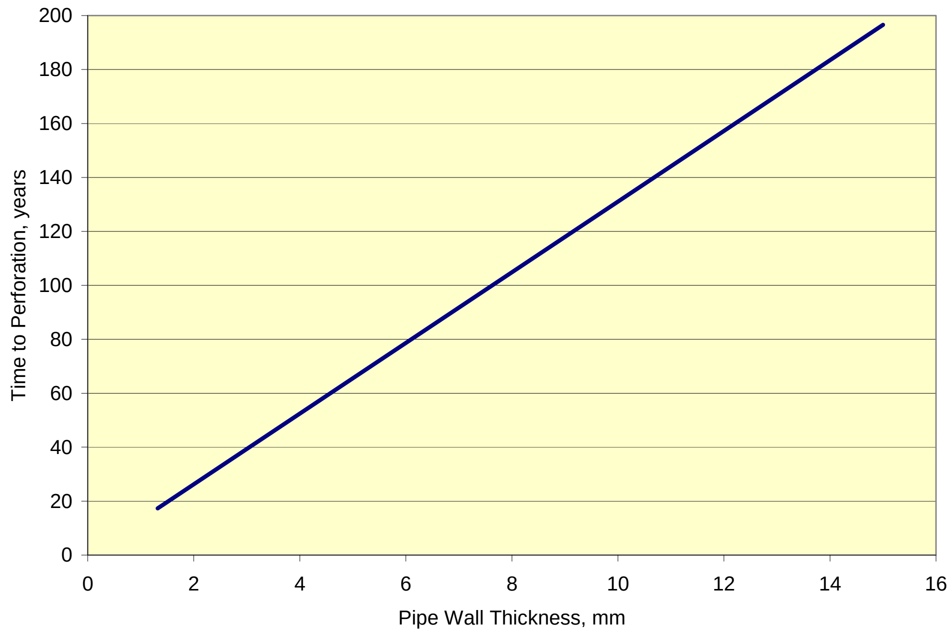


Figure 1. Time to perforation as a function of pipe wall thickness for a soil resistivity of 1000 ohm-cm and a soil pH of 7.

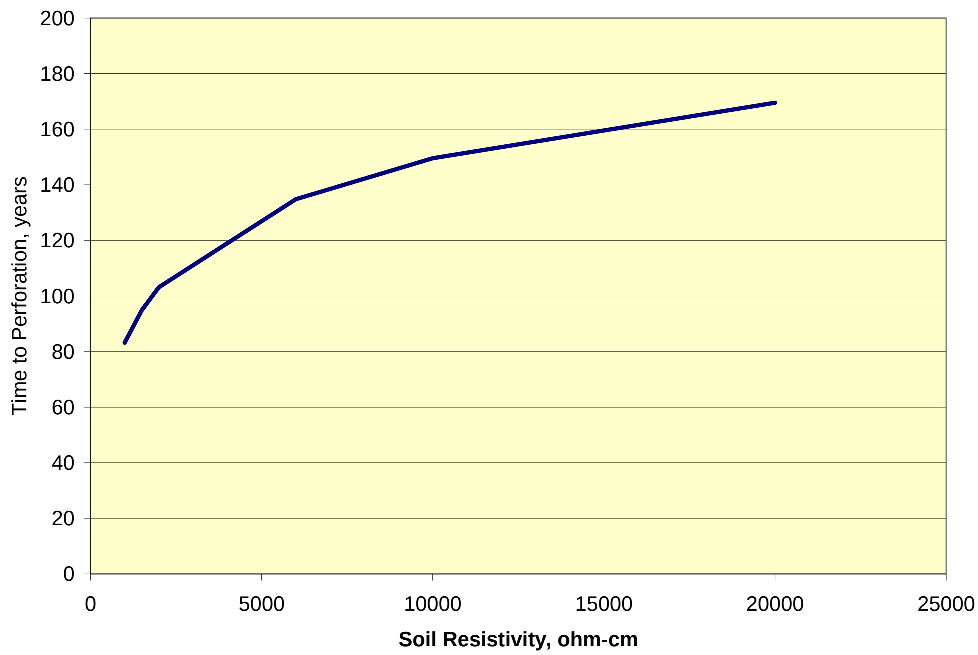


Figure 2. Time to perforation as a function of soil resistivity for a pipe wall thickness of 6.35 mm and a soil pH of 7.

While the time to perforation predictions from the culvert model appear to be unreasonably long for typical pipeline wall thicknesses, the parameters used in the model appear to be sound based on the extensive body of underground corrosion data. Therefore, a reasonable path forward is to analyze the underground corrosion data available in the literature to optimize the model for general corrosion of the thicker pipeline steels. This model could then be incorporated with an actual collapse model (described below) to predict the time to collapse from external corrosion as a function of soil properties and pipeline dimensions.

Once through-wall perforations occur in an abandoned pipeline, the pipeline is likely to fill with groundwater. This could promote internal corrosion that could ultimately contribute to pipeline collapse. While no data were found on this topic in the literature, the mechanism of aqueous corrosion, along with related literature, were used to evaluate this issue. Two cases were considered; complete filling of the pipeline with groundwater (Case 1), such as in a swamp, and partial filling (Case 2). For Case 1, it was assumed that the pipe fills with aerated groundwater. Since the solubility of oxygen in water is low (< 8 ppm), the oxygen in a pipeline will be consumed rapidly for typical corrosion rates. For example, the oxygen in a 24-inch diameter pipeline will be consumed in around one week at a corrosion rate of about 0.1 mm/y. After the oxygen is consumed, the corrosion rate will drop to negligibly low values. Anaerobic bacteria may accelerate the corrosion rate somewhat, but significant damage would not be expected based on measured corrosion rates for deep steel pilings (Beavers 1998), or buried subsea artifacts (J A.

Beavers, G. H. Koch, and W. E. Berry, "Corrosion of Metals in Marine Environments," Metals and Ceramics Information Center, MCIC Report 86-50, 1986) Furthermore, resupply of oxygen in the pipeline would be very limited unless there were a large number of large holes present in the pipeline.

Case 2 is somewhat more problematic in that the oxygen in the vapor space in a partially filled pipeline could promote continuous internal corrosion of the pipeline under aerated conditions. The most severe corrosion would likely occur at the liquid air interface where the water volume was small, because of the associated large air volume. However, under these conditions, the corrosion would be localized to the bottom of the pipe and the resulting collapse would be minimal.

The conclusion of this analysis is that external corrosion of abandoned pipelines is likely to be the largest contributor to ultimate collapse.

4.4.2 Structural Integrity

Data from Literature

No information was found in the literature on the topic of structural integrity of abandoned pipelines and on methods for assessing their collapse when external corrosion reaches a critical value. On the other hand, API 579-1/ASME FFS-1 provides methods for assessing the fitness for service of pipe with general or local metal loss and external pressure loading that could be applied to abandoned pipelines with external pressure loading from soil. Paragraph A.4.4 in Annex A of this standard provides equations for calculating allowable thickness, maximum pressure, and stress on cylindrical shells subject to external pressure. Paragraph B1.4 in Annex B1 of this standard provides guidelines for performing stress analysis to protect against collapse from buckling.

The methods in API 579-1/ASME FFS-1 may not be directly applicable to pipeline abandonment as written because they were developed for application to pressure vessels and piping in operating facilities. A detailed review and evaluation of these methods is needed to assess their applicability to pipeline abandonment issues.

5 RECOMMENDATIONS FOR FURTHER STUDIES

Based on the assessment of the literature reviewed as outlined in Section 4 above, this section recommends various research projects which could be conducted to address the knowledge gaps identified for pipeline abandonment issues.

5.1 Environmental & Land Use

5.1.1 Detection of Residual Contamination

In the opinion of the SMEs, testing protocols (both field and laboratory) for hydrocarbon contaminants (and other reasonably foreseeable elements) in soil and/or groundwater is quite well established. An area of deficiency relates to practical methods to measure the extent of residual hydrocarbons inside a segment of buried pipeline.

While there are well known practices for testing and managing PCBs, a protocol for PCB detection within a buried pipeline is not readily available.

Similarly, standard practices for detection of NORM and handling/disposal of NORM-contaminated material is relatively well known in some areas of petroleum industry activities. However, this is a potential hazard that is not well documented in connection with pipeline abandonment.

Recommendations made during the previous abandonment studies continue to be valid. These recommendations include:

- Estimation of the quantities of contaminants that might be released by an abandoned pipeline (Thorne *et al.* 1996).
- Research contaminant types and volumes relative to different pipeline products and locations within the distribution system (Thorne et al. 1996).
- Research the systematic protocols for PCB swab testing (Thorne et al. 1996).
- Review study conducted by US Institute of GAS Technology on trace contaminants in natural gas (Thorne et al. 1996).
- Investigate statistical analysis approaches for determining PCB concentrations throughout a pipeline (La Shier 1989).
- Research EPA findings on development of an appropriate methodology to quantify residual pipe contamination and development of a statistical model for PCB characterizations (*e.g.* "moving average" approach) (Linz 1991).

- Research the use of swab tests to develop surrogate contaminants that are representative of the residual contaminant load of various types of pigged and cleaned pipe in order to reduce assessment risk and cost (Thorne et al. 1996).

- Research PCB physical and chemical characteristics in natural gas environment as they are yet unstudied (Linz et al. 1991).

- Transport of PCBs as a component of various pipeline fluids is not well known (Linz *et al.* 1991).

- Research study by GRI and NIST into predicting PCB migration the physical/chemical controls that influence it (Linz *et al.* 1991).

- Research soil/water PCB partitioning study conducted by GRI and Battelle Pacific Northwest Laboratories (Linz *et al.* 1991).

Current Recommendations:

Develop practical testing protocols to accurately quantify residual contaminants remaining inside a section of buried pipe following standard cleaning procedures. The purpose of developing standard sampling protocols is twofold: for one, the chosen methodology would serve to provide an accurate representation of the nature, extent and distribution of contaminants along the pipeline; secondly, such a universal approach would provide user-friendly guidelines for companies, and ensure consistent sampling results. Such standard protocols would be developed to determine the initial likelihood of PCB and NORM contamination in the pipeline. In doing so, NORMs and/or PCBs would either be included or excluded from further testing.

Scope:

Standard testing protocols should be developed in consideration of standard practices for detection of hydrocarbons, PCBs and NORMs in pipelines. In order to integrate these contaminants into a standard testing protocol, three separate studies should be conducted:

- Methods to accurately quantify residual hydrocarbons along an abandoned pipeline.

- Develop standard practices for detection of PCBs where suspected in abandoned pipelines.

- Standard practices for detection of NORM-contaminated pipe. (This study could be limited to the pipelines regulated by the NEB. Past experience suggests that NORM contamination in oilfield pipe, fittings and tanks is more likely to be found in upstream oil and gas activities than in the transmission and distribution systems regulated by the NEB).

Expected Results:

In recommending further research into the environmental effects of pipeline abandonment, the development of a standard testing protocol takes precedence. Many decisions regarding the management and handling of abandoned pipeline hinge on the efficacy and accuracy of contaminant testing. For example, establishing a standard testing protocol may lead to:

- An accurate indication of the potential concentrations of contaminants to be transported down a section of abandoned pipeline as a result of the conduit effect;
- A greater understanding of the nature, extent and distribution of contaminants, which is the first step in developing formal risk assessment tools modelling the fate and effects of detected contaminants in an abandoned pipeline;
- Consistent results, allowing statistical studies of such results to be compiled from various abandonment projects and, over time, lead to the development of a contaminant database with the establishment of categories of expected residual contaminants based on the pipeline product and locations along the pipeline system;
- Greater support for providing an indication of effective cleaning methods; and
- Guidance for decision making on locations for pipeline abandonment in-place.

Length of Time to Conduct Research:

1 year of field work to conduct research on a representative sample of pipeline types and sizes would be required.

Types of Organizations to Conduct Research:

Oil and gas pipeline operating companies to donate segments of pipeline to conduct an assortment of sampling techniques.

Environmental consultants to provide direction on appropriate locations for sampling.

Accredited environmental laboratories to conduct analysis.

Expected Costs

Costs associated with developing a practical and accurate sampling method for hydrocarbon related contaminants are estimated at $100,000.

Costs associated with developing a practical and accurate detection method for residual PCBs in pipelines are estimated at $15,000.

Costs associated with developing a practical and accurate detection, handling and disposal procedure for NORMs are estimated at $25,000.

Standard Pipeline Products List

Background

Liquid petroleum products can consist of a complex mixture of paraffinic, cycloparaffinic and aromatic hydrocarbons covering carbon chains ranging from C1 to C60+. The composition varies depending on the source of crude and/or the refining process. Some products can contain minor amounts of sulphur, nitrogen and oxygen compounds as well as trace amounts of heavy metals such as nickel, vanadium and lead. Natural gas is a complex combination of hydrocarbons consisting of saturated aliphatic hydrocarbons predominately consisting of methane and ethane but such that constituent composition may vary.

Recommendation:

Initiate a study to identify compounds to be tested for in soil and water as a result of a pipeline leak at the abandonment phase.

Scope

A review of products shipped through NEB regulated pipeline systems. The study should include a thorough review of the Material Safety Data Sheets (MSDS) for all products shipped as well as for products that could enter the pipeline as a result of the operation and at abandonment of the pipeline system.

Expected Result

The development of a standard list compounds expected to be found as a result of a pipeline leak. The research should determine the extent to which the list can be applied to abandoned pipelines. A detailed review and evaluation of the list is needed to assess the applicability to pipeline abandonment issues.

Project Duration

The study could be completed within one month.

Types of Organizations that Could Conduct the Research

This study could be conducted by environmental consultants in cooperation with pipeline operating companies.

Expected Cost of the Research

The proposed study is expected to cost approximately $25,000.00

5.1.2 Environmental Standards

Current Recommendations:

In SMEs opinion, further enhancements of the current standards on soil and groundwater quality are beyond the scope of issues that warrant effort by the Pipeline Abandonment Physical Issues Committee (pipeline abandonment committee).

Ultimately, standards for pipeline abandonment could be proposed but currently there is insufficient practical experience in accurately measuring the presence and quantity of contaminants remaining in a section of abandoned pipeline to consider general or specific environmental standards at this time. It is recommended that NEB regulated pipelines use CCME standards to assess remediation success.

5.1.3 Risk Assessment

Recommendations made during the previous abandonment studies continue to be valid. These recommendations include:

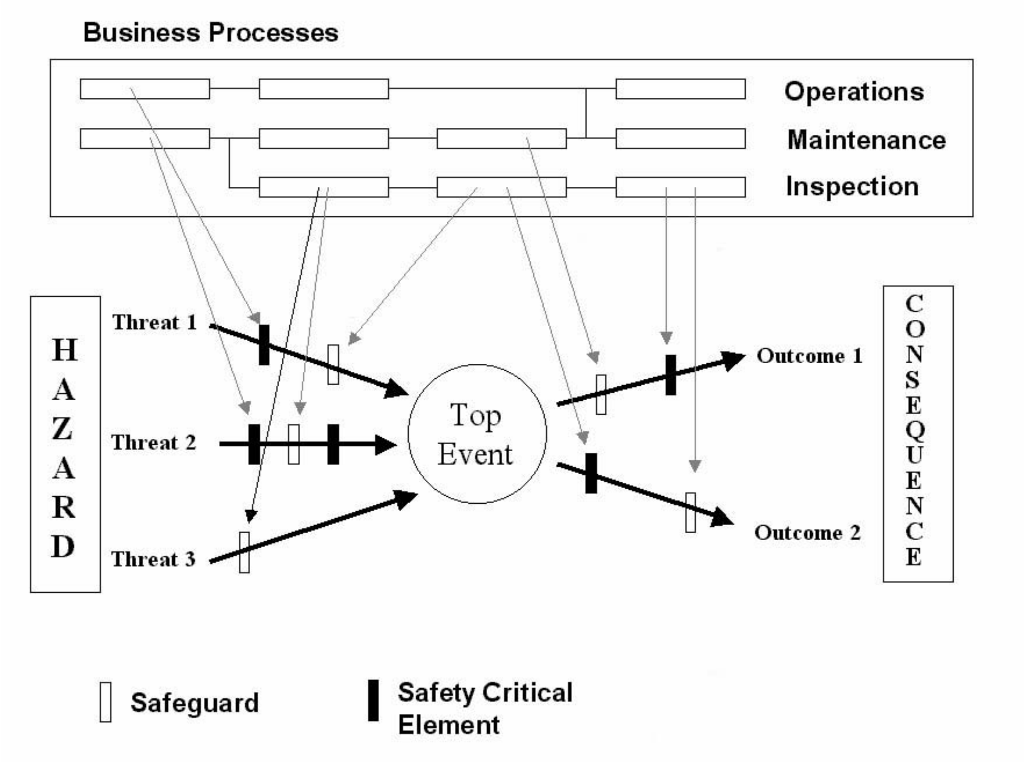
- Research and refine land use categories as part of the development of the risk based site specific assessment process (CEPA 2007).
- Research the impacts of new treatment chemicals being marketed for use in the oil and gas industry, particularly as they relate to pipeline abandonment in-place (Thorne *et al.* 1996).
- Further research into contaminant properties and their potential environmental impacts (Thorne *et al.* 1996).

Current Recommendations:

Background

Given the variability of potential causes of pipeline collapse and the consequences that vary with location and other local environmental factors, it is suggested that an event and consequence analysis be used as a tool to identify scenarios and consequences related to pipeline abandonment.

One method which may be adapted to pipeline abandonment is the Bow-Tie analysis illustrated below. In the centre of the diagram is the ‘Top Event’ or process hazard. To the left are the barriers or safeguards that aim to prevent the top event from occurring, to the right are all the safeguards that aim to mitigate the potential consequences from the top event.



Safeguards can be varied in nature from personnel with relevant experience, to training, to operational procedures, and so forth. Using this approach it is critical to know the status of each safeguard in real time to support decision making.

It can readily be seen that by analyzing all potential top events and quantifying all potential outcomes for all types of losses a picture of the risk exposure at any point in time can be built up. Safeguards to the left of the top event affect the likelihood that the event will take place, in Quantitative Risk Assessment (QRA) terms, the frequency of the event. Those to the right impact the potential consequences of an event and can increase or reduce the severity of a top event.

Objective and Scope

The objective of this research would be to identify the various scenarios and related consequences of pipeline abandonment events and identify potential consequences of those events.

Expected Result

The research would determine the potential risk exposure for various events and outline potential safeguards to reduce the frequency and/or consequences of a particular event.

Project Duration

The project could be completed within three months.

Types of Organizations that Could Conduct the Research
This research could be conducted by risk consultants.

Expected Cost of the Research
The proposed research is expected to cost approximately $50,000.

5.1.4 Conduit Effect

No examples of an abandoned pipeline acting as a conduit for water movement were found in the literature review. The potential for a pipe abandoned in place to become a conduit for water movement was discussed in Section 3.9 of the PADP 1996. If the abandoned pipeline is clean, the potential environmental risks could be related to draining wetlands or, conversely, flooding inappropriate land areas or to transport soil material inside the pipe to a down slope location where it may escape and cause impacts. If the pipe is not clean there may be a risk of transporting contaminants.

In order to address these potential issues, it is assumed that the abandoned pipe would be segmented at appropriate locations. Both the CAPP 2002 Guidelines document and the CEPA 2007 Pipeline Abandonment Assumptions document refer to Table 3-1 of the PADP 1996 for determining the appropriate locations where segmentation and plugs are recommended which remain valid today. Impermeable materials such as concrete, polyurethane foam or soil are still reasonable materials to create plugs in the pipe.

In the case of pipeline removal, water pathways through the uncompacted pipeline trench material must be prevented or interrupted. The principles governing the locations of trench breakers are the same as those governing the locations of plugs for pipelines abandoned in place.

The occurrence of the conduit effect on the outside of an abandoned pipeline is not seen as being any different than for an operating pipeline. If it was not an issue previously it should not be an issue when the line is abandoned in place.

No additional studies are recommended with respect to the potential conduit effect although this issue could be monitored as part of the study recommended in section 5.2.4 below.

5.1.5 Decomposition of Pipe material

Recommendations made during the previous abandonment studies continue to be valid. These recommendations include:

- Quantification of subsidence threats for large diameter pipelines, and the possible development of algorithms to model structural collapse of pipelines (CEPA 2007).

- Study leaching potential of coal tar coatings, and identification of the specific PAHs that may be released into the environment from the degrading coatings (Thorne *et al.* 1996).
- The potential environmental risks from asbestos left in-place should be further assessed (Thorne *et al.* 1996).
- Inspect a representative number of abandoned lines to observe rates of corrosion, internal contamination from pipeline residues, structural integrity and soil contamination (H.R. Heffler Consulting Ltd. *et al.* 1995).
- In a 1974 document entitled: Recent Developments in the Use of Mine Waste of Subsidence Control (Allen *et al.*), the authors describe the effectiveness of using sediment slurries for hydraulic filling of abandoned mines. Perhaps further research could be conducted into the applications of this technique for in-place pipeline abandonment.

Current Recommendations:

The mechanism, rates and effects of pipe corrosion warrants engineering study while considering contamination of soil or groundwater by pipe coatings and their degradation products is worthy of consideration. While not likely to be widespread or dramatic, it should not be ignored. A study of the leaching potentials of pipe coatings (especially older materials such as coal tar coatings) is warranted. Consideration should be given to the environmental and human health effects of the chemicals, the rate and nature of chemical decomposition, potential for soil and groundwater transport and recommendations leading toward improved abandonment/disposal practices.

Scope:

Study leaching potential and associated human health and environmental effects of the contaminants released from coal tar coatings. A theoretical understanding of the potential for leached contaminants to move through various soil and groundwater regimes, as well as the human and environmental consequences of such contamination, should be established. Concurrently, laboratory testing of the structural integrity and the rate and nature of chemical decomposition of coal tar coatings under simulated field conditions should be undertaken.

Expected Results:

A greater understanding of the nature and rate of coal tar wrap decomposition, dispersal of leached chemicals in the surrounding environment and the potential human and environmental effects of leached contaminants will contribute to the development of formal risk assessment models with respect to identifying the fate and effects of detected contaminants in an abandoned pipeline with coal tar coating; and the establishment of safe handling and disposal procedures / recycling options for pipelines coated with coal tar wrap.

An understanding of soil and groundwater mechanisms suggests that solution and transport of metal ions in the environment resulting from corroding pipe is worthy of thought, but is almost certainly not likely to be a widespread issue. The SMEs suggest this is a topic that can be deferred for future consideration.

Length of Time for Research:

3 – 6 months

Types of Organizations to Conduct Research:

Charter Coating, of Calgary Alberta, is an example of a company able to perform external coating evaluation tests, and is capable of undertaking integrity tests on coal tar coating to determine the rate of coating decomposition.

Analyzing the dynamics of decomposed coatings in soil and groundwater, and the associated human and environmental effects, should be undertaken by a company or companies specializing in environmental chemistry and human health.

Expected Costs:

Costs associated with undertaking integrity tests on coal tar coatings is estimated at $15,000.00

Costs associated with the study of leaching potential of coal tar coatings, and identification of contaminants that may be released into the environment from the degrading coatings is estimated at $10,000.00.

5.1.6 Cleaning methods and disposal of cleaning fluids

Recommendations made during the previous abandonment studies continue to be valid. These recommendations include:

- If pipe is going to be reused for alternative purposes, further research should be conducted in order to determine the appropriate cleanliness requirements for the intended use (Thorne *et al.* 1996).
- The development of a pigging report including information on types and quantities of pipeline scale (Thorne *et al.* 1996).
- The evidence which regulatory authorities will accept as being sufficient proof of cleanliness in terms of the residual volume of contaminants requires adequate definition (Thorne *et al.* 1996).

- There is currently insufficient data available to make a reasonable estimate of the maximum volume of contaminants that may remain in a pigged line (H.R. Heffler Consulting Ltd. *et al.* 1995).
- Adequate standards of cleanliness should be attained through accepted test procedures. Testing water slugs pushed through the line could prove a useful technique (H.R. Heffler Consulting Ltd. *et al.* 1995).
- Cleanliness parameters should be established through the development of a model recommending appropriate levels of cleanliness for abandonment (H.R. Heffler Consulting Ltd. *et al.* 1995)

Current Recommendations:

To the best of our knowledge, no published reports or field trials of pipe cleaning are available. Although such a study is recommended, it is suggested it be led by qualified engineers and pipeline operators.

Scope:

An engineer led study should be undertaken to determine effective cleaning methods in an attempt to determine cleanliness parameters for either abandoning pipeline in place, or removing sections for reuse or disposal.

Expected Results:

The development of cleanliness standards following determination of effective cleaning procedures and establishment of an accurate and acceptable sampling protocol are expected to assist in:

- Establishing safe handling and disposal methods for pipelines;
- Providing an indication of the effectiveness of cleaning operations along a given length of pipeline;
- Removing the obscurity in determining "how clean is clean" and streamline the abandonment process in a safe and responsible manner;
- Determining the environmental suitability of the cleaning compounds;
- Handling and disposal of wax, waste petroleum products, spent cleaning compounds, etc;

- The environmental safety of all practices (risk of spills, emergency preparedness, worker and public health, etc); and
- Developing achievable cleanliness standards for pipe to be abandoned in place or removed for reuse or disposal.

Length of Time for Research:

1 -2 years

Types of Organizations to Conduct Research:

Pipeline operating companies;

Materials Engineers;

Companies specializing in environmental chemistry and human health.

Expected Costs:

Costs for developing such standards are estimated at $150,000 to $200,000. The costs associated with undertaking this research result from both the necessity to involve a range of expert knowledge and opinion and the extensive period of time potential required to establish collective agreement on what contamination levels constitute a clean pipe.

5.1.7 Disposal of pipe material

Current Recommendations:

Until standards have been developed to determine acceptable concentrations of residual contaminants, recommendations for reuse and/or disposal studies cannot be made. Current options for disposal of pipe materials include complying with the requirements of a government approved landfill.

5.1.8 Abandonment under water bodies

NEB regulated pipelines are found under all types of water bodies; streams, lakes, irrigation canals, and others. (No consideration has been given in this report to offshore pipelines, although onshore pipelines crossing a large lake employing marine lay methods are quite feasible.) Water saturated soil; such as muskeg or flood irrigated lands, could be included in this discussion as well.

Again, it is assumed that most pipelines under any water body will be abandoned in place – after due consideration by way of Certificate approval. In this case, the environmental implications are related to loss of buoyancy control (*i.e.* pipe flotation) or exposure by other means. As well, since most streams are located at the bottom of a slope, the risk of surface erosion or the implications of material transport and discharge via the buried pipe acting as a conduit need to be recognized.

There will however be instances where the risk of abandonment in place dictates special treatment. Cutting and capping the pipe at each side of the water body will be warranted in some cases, as will removal of some or all of the pipe in anticipation of stream bed scour or lateral channel migration. In other cases the pipe section under the water body could be filled with cement as a permanent way to prevent flotation. This is likely to be used in special cases but it has to be admitted that, a cement filled pipe section that is exposed, could be a barrier to fish movement or to human use and enjoyment of a stream.

Removal of the underwater section of a pipeline seems a last resort since this practice could result in significant disturbance to the stream. Since this is likely to be a very infrequent practice, no comprehensive studies are suggested. There have been a few cases where a length of buried pipe has been pulled from the ground with essentially no surface disturbance, other than the locations where the pipe has to be exposed at each end necessitating land disturbance and reclamation at those locations. If successful, this technique would be especially attractive at watercourse crossings.

Current Recommendations:

It is recommended that an engineered led study to investigate techniques to remove sections of buried pipeline resulting in little to no surface disturbance with respect to abandonment under water bodies as well as sensitive ecological areas.

Scope:

Engineering field tests to determine the diameter and length of pipelines and the extent to which they can be pulled from the ground should be conducted.

Potential environmental effects associated with pulling pipe from underneath water bodies for consideration include alterations of stream hydrology as a result of subsidence and structural instability of the bed and bank complex. Potential environmental effects associated with pulling pipe from beneath sensitive ecological areas and wetlands for consideration include subsidence and terrain instability, as well as channeling of surface and subsurface water along the trench and associate subsidence and/or erosion.

Expected Results:

Recognizing the potential environmental effects associated with pulling pipe from under water bodies and sensitive ecological areas could lead to:

- The establishment of mitigation measures in response to such effects; and
- The establishment of best-practices for abandoning a section of pipeline under a water body or sensitive ecological area.

Length of Time for Research:

1-3 years to conduct field tests at a variety of locations with various diameters and lengths of pipeline.

Types of Organizations to Conduct Research:

Pipeline operating companies in cooperation with environmental consultants.

Expected Costs:

$200,000 - $350,000

5.2 Geotechnical

5.2.1 Compile Exposure Data from NEB and ERCB Records

Background

Leir, 2009 provided information related to pipeline exposure of active pipelines. NEB and ERCB records should be examined to provide an expanded database of the rate of exposure for active pipelines and their locations.

Objective and Scope

The objective of the proposed research is to expand the database by compiling an updated list of exposure instances. Using GIS and NEB/ERCB records, correlate exposures with hydrotechnical, geotechnical and wind erosion hazards (this would include third party damages due to reduced depth of cover) where possible.

Expected Result

This can help guide the committee to understand the sites most at risk due to exposure, and where exposure is unlikely.

Project Duration
It is expected that this data review work (depending on the quality and amount of data) could be completed within 3 months.

Types of Organizations that Could Conduct the Research
This type of work may be done internally by NEB or ERCB staff, or alternatively it could be completed by consultants working for these organizations.

Expected Cost of the Research

The proposed research is expected to cost approximately $50,000.

5.2.2 Examine Buoyancy Effects on Pipeline Exposure Rates

Background

A geohazard that is thought to have the potential to significantly increase the rate of exposure post-abandonment is loss of buoyancy control. Liquid pipelines depend on the weight of the product to, in part, control buoyancy. Once the pipeline is abandoned, this additional weight will be removed. For gas pipelines, buoyancy control is installed and maintained during the active phase of the pipeline use. Degradation of these control measures is likely to result in exposure if the initial conditions persist. When considering the need for this study, abandonment measures such as removal of the pipeline, installation of interior weight and puncture of the line should be considered as alternatives.

Objective and Scope
The objective of the proposed research is to study the longevity of different buoyancy control measures.

Expected Result
The results of the research will be to develop a model that could be used to predict the potential for and the timing of exposure of abandoned pipelines due to lack of or loss of buoyancy control.

Project Duration
The project can be completed within six months.

Types of Organizations that Could Conduct the Research
This research could be conducted by a University as part of a multi-year research project or could be completed by a consulting engineering firm specializing in design of buoyancy control
Expected Cost of the Research

The proposed research is expected to cost approximately $75,000 if completed by a consultant.

5.2.3 Examine Frost Heave Effects on Pipeline Exposure Rates

Background

Frost heave also has the potential to result in pipeline exposure. Once the warm product is removed, heave of the pipeline could begin to occur. The rate and importance of this mechanism is thought to depend on soil type and available moisture. No information was encountered in the literature pertaining to this geohazard and its ability to expose a pipeline once abandoned. The literature on performance of culverts could be used as a proxy but also studies could be completed on active pipelines with product near ambient temperatures or suspended pipelines. The studies could take three forms; laboratory testing of soils for frost heave properties, field measurement of heave rates in a single winter and across multiple seasons, and examination of the long term performance of pipelines that are suspended or operating at ambient temperatures.

Objective and Scope

The objective of the proposed research is to understand the mechanism of heaving of abandoned pipelines. A laboratory study could be undertaken to examine, under multiple freeze thaw cycles, the interaction of growing ice under the pipeline against resistance forces above the pipeline. This type of work has been conceived many times for cold gas pipelines, but only a limited amount of information is in the public domain, and testing of the abandonment case was not found in the literature.

The laboratory scale work should be compared to results of field studies of pipelines with product at ambient temperatures or for suspended pipelines. The field scale study would be used to determine the effect of frost on long segments of pipe, versus local frost heave effects that could be determined in the laboratory. The study should include installation of markers on the pipeline and a regular program of surveying the markers. Survey stations should be set-up in a number of different terrains and soil moisture conditions. Thermistors should be installed to monitor the development of the frost front at these stations.

An examination of pipelines operating for a long period at ambient temperatures or where operations have been suspended, should offer a good perspective on the performance of abandoned pipelines.

Expected Result

The laboratory results of the research will be to develop a numerical model to determine the effects of different soil types and moisture conditions on the potential for an abandoned pipeline to become jacked out of the ground by frost action. The result of this lab study would not be definitive, but give general guidance.

The field study of suspended pipelines or ambient temperature product pipeline would provide real scale information related to local frost heave effects on a long section of pipeline.

Project Duration
The project would have to be completed as part of a multi-year effort.

Types of Organizations that Could Conduct the Research
This research could be conducted by a University as part of a multi-year research project or a multi-year effort of pipeline examination and surveys.

Expected Cost of the Research
The proposed research is expected to cost approximately $50,000 per year.

5.2.4 Evaluate Success of Previous Pipeline Abandonment Programs

Background
Pipelines have previously been abandoned in Alberta and other jurisdictions. A review of the approved plans could be conducted to gain a general understanding of the approaches taken. Then, if site visits were conducted to determine the effectiveness of activities, valuable information could be obtained on post-abandonment conditions and performance of various abandonment procedures.

Objective and Scope
The objective of the proposed research is to compile "real time" information with respect to actual procedures used for pipeline abandonment. The scope of the project could cover any abandoned pipelines under NEB or ERCB jurisdiction. A report could be assembled detailing the approaches taken for each site and could include the study of the current ground surface effect of pipelines that are abandoned in place; the study of the current ground surface effects of pipelines that have been removed; and the selection of segments of pipelines that have been abandoned in place, remove them, and observe ground surface changes.

Expected Result
The results of the research will provide a better understanding of the effects of actual abandonment procedures.

Project Duration
The project could be conducted over a number of years, but in each year will only require about 1 month of effort and result in a summary report of observations.

Types of Organizations that Could Conduct the Research
This research could be conducted by a consultant or pipeline operating company.

Expected Cost of the Research

The proposed research is expected to cost approximately $100,000 to initially set up the monitoring stations, and then approximately $25,000 for each year the project is run. It is also assumed that $100,000 would be spent during the fifth year to assess the data collected over each five year cycle.

5.2.5 Collapse of soil under different void sizes, soil types and depth of cover

Background

The mechanism of soil collapse could be studied in three ways;

- examine already pulled pipelines to determine actual collapse and magnitude of the resulting surface effect,
- create voids in soil and accelerate the collapse (this study should examine different pipe sizes, soil types, depths of burial and moisture conditions), and
- Complete model studies using centrifuges.

Objective and Scope

The first item could be part of the study of existing abandoned pipelines, and involve setting up survey points for multiple year studies to examine the eventual collapse of the soil into the void.

The second study could be to set up a test area with a known soil type and moisture, install a pipeline and compact the soil, later remove the pipe and monitor the collapse depth and timing. Loading by different types of equipment could also be examined in this experimental set-up.

The third suggestion is very similar to that of the second, except that with the use of a centrifuge would allow control of the soil used, pipeline diameters and depth of cover. The tests are conducted on a small scale basis and the centrifuge is used to determine the long term effect.

Expected Result

The results of the research will be to develop a model to determine the effects of different soil types and moisture conditions on the potential for soil collapse once a pipeline is pulled out or fails due to corrosion.

Project Duration

The project could be conducted over a number of years.

Types of Organizations that Could Conduct the Research

This would be best undertaken as a university research project or it could be undertaken by a consultant and a commercial testing program at a university centrifuge.

Expected Cost of the Research
The proposed research is expected to cost approximately $200,000 to $300,000

5.3 Engineering

5.3.1 Validation of Culvert Failure Model for Abandoned Pipelines

Background
The California State Department of Transportation has developed a model for culvert failure from corrosion, which is based on field data for the time to perforation of culverts in various soils in California. The model is very simplistic, incorporating soil pH and resistivity, but is reasonable based on extensive research on the topic over the past century. However, the model has not been validated for thicker structures, such as underground pipelines. Estimates of penetration depth versus time for pipelines are needed, for incorporation in plastic instability models, in order to determine the time of collapse for these structures.

Objective and Scope
The objective of the proposed research is to validate the Culvert Failure Model for the thicker shell walls associated with abandoned pipelines. The scope of work will be to analyze the extensive underground corrosion data available in the literature and use relevant data to optimize the Culvert Failure Model for general corrosion of the thicker pipeline steels. This model could then be incorporated with an actual collapse model to predict the time to collapse as a function of soil properties and pipeline dimensions.

Expected Result
The results of the research will be a validated prediction model for penetration versus time of abandoned pipelines, as a function of soil properties.

Project Duration
The project can be completed within six months.

Types of Organizations that Could Conduct the Research
This research could be conducted by contract research organizations, government laboratories, or universities with extensive experience in underground corrosion of corrodible structures.

Expected Cost of the Research
The proposed research is expected to cost approximately $40,000.

5.3.2 Structural Integrity

Background

API 579-1/ASME FFS-1 provides methods for assessing the fitness for service of pipe with general or local metal loss and external pressure loading that could be applied to abandoned pipelines with external pressure loading from soil.

Objective and Scope

The methods in API 579-1/ASME FFS-1 may not be directly applicable to pipeline abandonment as written because they were developed for application to pressure vessels and piping in operating facilities. The review should include evaluating whether the fitness-for-service assessment procedures can be tailored directly to pipeline abandonment issues.

Expected Result

The research would determine the extent to which they can be applied to abandoned pipelines. A detailed review and evaluation of these methods is needed to assess their applicability to pipeline abandonment issues.

Project Duration

The project could be completed within two months.

Types of Organizations that Could Conduct the Research

This research could be conducted by contract research organizations with professional engineers familiar with API 579-1/ASME FFS-1 and pipeline fitness for service issues.

Expected Cost of the Research

The proposed research is expected to cost approximately $30,000.

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APPENDIX A - REVIEW OF RELEVANT PIPELINE CODES

A1. INTRODUCTION

In this Appendix, DNV has reviewed the findings of relevant standards from Canada, the USA, the United Kingdom, Australia, and Argentina. The actual requirements of the different standards reviewed are quoted directly.

A2. Canadian Standard CSA Z662-07 Oil and Gas Pipeline Systems

Pipeline abandonment is considered in Clause 10.17 of the above standard. The guidance provided (as with all standards reviewed) is highly generic.

10.17 Abandonment of piping

10.17.1
The decision to abandon a section of piping, in place or through removal, shall be made on the basis of an assessment that includes consideration of current and future land use and the potential for safety hazards and environmental damage to be created by ground subsidence, soil contamination, groundwater contamination, erosion, and the creation of water conduits.

10.17.2
Piping that is abandoned in place shall be:

(a) Emptied of service fluids;

(b) Purged or appropriately cleaned or both;

(c) Physically separated from any in-service piping; and

(d) Capped, plugged, or otherwise effectively sealed.

10.17.3
Records shall be maintained of all piping that is abandoned in place. Such records shall include locations and lengths for each pipe diameter and where practical, burial depth.

Note: Operating companies should consider maintaining all pertinent records related to the abandoned piping.

A3. Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids, American Society of Mechanical Engineers, ASME B31.4-2006

Pipeline abandonment is considered within section 457 of the code as follows:

457 ABANDONING A PIPING SYSTEM

In the event of abandoning a piping system, it is required that:
(a) Facilities to be abandoned in place shall be disconnected from all sources of the transported liquid, such as other pipelines, meter stations, control lines, and other appurtenances
(b) Facilities to be abandoned in place shall be purged of the transported liquid and vapor with an inert material and the ends sealed".

The stipulations are less than those of CSA Z662-07; little consideration is given to environmental protection, and the keeping of records after abandonment is not mentioned.

A4. Gas Transmission and Distribution Piping Systems, American Society of Mechanical Engineers, ASME B31.8-2006

Pipeline abandonment is considered within section 851 of the code as follows:

851.8 Abandoning of Transmission Facilities

Each operating company shall have a plan in its operating and maintenance procedures for abandoning transmission facilities. The plan shall include the following provisions:

(a) Facilities to be abandoned shall be disconnected from all sources and supplies of gas such as other pipelines, mains, crossover piping, meter stations, control lines, and other appurtenances.

(b) Facilities to be abandoned in place shall be purged of gas with an inert material and the ends shall be sealed, except that:

(c) After precautions are taken to determine that no liquid hydrocarbons remain in the facilities to be abandoned, then such facilities may be purged with air. If the facilities are purged with air, then precautions must be taken to determine that a combustible mixture is not present after purging. (See para. 841.275.)

A5. Steel Pipelines and Associated Installations for High Pressure Gas Transmission, Institution of Gas Engineers and Managers, IGEM/TD/1/Ed. 5, 2010 (U.K. Standard)

Pipeline abandonment, or permanent de-commissioning as per the term within the code, is considered within section 12.9.6:

12.9.6 Permanent de-commissioning of pipelines, sections of pipelines and associated installations

12.9.6.1 General

A pipeline, pipeline section or associated installation that is no longer to be used for the conveyance of gas shall be taken out of service, with all hazardous fluids removed and the following options considered:

- Use the asset for another purpose or
- Remove the assets or
- Leave the asset in-situ, but rendered permanently safe.

Note: This may involve removing components, for example valves, and capping open ends so as to leave all sections gas tight.

The following factors shall be taken into account when deciding on the most appropriate option:

- Public safety
- Environmental protection
- Future land use
- Legal duties and residual liabilities
- Practical difficulties and financial considerations
- Maintenance requirements, for example to prevent corrosion of the pipeline leading to pipe wall collapse or becoming a channel for the conveyance of water or gases.

12.9.6.2 For assets left in-situ, consideration shall be given to residual liabilities with the owner or operator of the assets, which may remain in perpetuity.
Note: There may be a continuing duty to monitor the condition of the pipeline and a requirement for maintenance or remedial action, for example to ensure that the pipeline route remains safe and without danger as a result of decommissioning.

12.9.6.3 Taking an asset out of service
The following steps shall be taken when taking an asset out of service:

- Consider dismantling and removal – recommended for all above ground sections but economic considerations may limit this option to short sections of buried pipeline.
- Clear and purge the pipeline of any flammable gases, vapours, or residues
- Physically separate from other parts of the system and isolate from all possible sources of gas.
- If appropriate, fill remaining pipeline sections with non hazardous material, for example by grouting, especially large diameter pipelines at road and rail crossings or at other locations sensitive to subsidence.
  Note: Practical and economic considerations may limit this to short sections of buried pipeline.
- Where it is not practicable to fill a large diameter pipeline section with grout, charge with an inert gas and seal permanently the vent and fill points. Leakage tests should be carried out and pressures checked periodically and re-charged as necessary.

12.9.6.4 Identification of permanently de-commissioned buried pipelines left in-situ

The pipeline or pipeline sections shall be identified by suitable markers.

12.9.6.5 Records of permanently de-commissioned assets left in-situ

Records of permanently de-commissioned assets left in-situ shall be maintained.

A6. Code of Practice for Pipelines, British Standards Published Document (PD) 8010-2:2004,

Part 1: Steel Pipelines on Land

Pipeline abandonment is considered within Section 14 of the code:

14.1 Arrangements for Abandonment

NOTE Attention is drawn to the Pipe-lines Act 1962(11), Regulation 25 in respect of pipeline abandonment, and to the Pipelines Safety Regulations 1996 (12) in respect of general duties to preserve safety throughout the lifetime of the pipeline (including abandonment).

Pipeline systems planned to be abandoned should be decommissioned in accordance with 13.2.4 and disconnected from other parts of the pipeline system remaining in service.

A pipeline should be deemed to be disused when it has been abandoned or when the owners cease to inspect it regularly and are no longer prepared to maintain it in an operable condition.

When the owners are no longer prepared to maintain a disused pipeline in an operable condition they should take precautions to prevent the pipeline from becoming a source of danger or nuisance or having an undesirable effect on any watercourses.

Before being abandoned, the pipeline should be completely disconnected at both ends and if necessary divided into sections. All open ends should be capped and sealed. In certain areas, e.g. those subject to subsidence or where heavy external loads can occur, it can be necessary to close the pipeline at both ends and to fill the abandoned line with a suitable filler.

Where an abandoned pipeline cannot be made safe by this method, it should be removed. In all cases where the fluid conveyed is deemed to be an environmental or safety hazard, or could become so after contact with the soil, the fluid should be completely removed from the pipeline.

The pipeline section being abandoned should always be emptied and then cleaned to ensure that no toxic material remains within the pipe.

All above-ground sections of the pipeline system should be removed to not less than 900 mm (36 in) below ground level. Backfilling and land reinstatement should be carried out in accordance with 10.12.14 and 10.12.15.

14.2 Records

A record should be kept by the owners of a pipeline to indicate that they have taken the necessary precautions. A record plan showing the size and depth of the pipeline and its location related to the surface features should also be prepared and a copy given to the owners and occupiers of the land concerned.

A7. Petroleum and Natural Gas Industries - Pipeline Transportation Systems, ISO 13623

13.5 Pipeline systems planned to be abandoned shall be decommissioned in accordance with 13.2.4 and disconnected from other parts of the pipeline system remaining in service.

Abandoned pipeline sections shall be left in a safe condition.

13.2.4 Consideration should be given to decommission pipelines planned to be out of service for an extended period. The removal of fluids shall be in accordance with 13.3.7.

Decommissioned pipelines, except when abandoned, shall be maintained and cathodically protected.

13.3.7.3 Venting and flaring

Hazards and constraints which should be considered when planning to vent or flare are:

- Asphyxiating effects of vented gases;
- Ignition of gases by stray currents, static electricity or other potential ignition sources;
- Noise level limits;
- Hazard to aircraft movements, particularly helicopters in the vicinity of offshore installations and terminals;
- Hydrate formation;
- Valve freezing;
- Embrittlement effects on steel pipework.

13.3.7.4 Draining

Liquids may be pumped, or pigged, out of a pipeline using water or an inert gas. Hazards and constraints which should be considered when planning to drain include:

- Asphyxiating effects of inert gases;
- Protection of reception facilities from overpressurization;
- Drainage of valve cavities, “dead legs”, etc.;
- Disposal of pipeline fluids and contaminated water;
- Buoyancy effects if gas is used to displace liquids;

- Compression effects leading to ignition of fluid vapour;
- Combustibility of fluids at increased pressures;
- Accidental launch of stuck pigs by stored energy when driven by inert gas.

13.3.7.5 Purging

Hazards and constraints which should be considered when preparing for purging include:

- Asphyxiating effects of purge gases;
- Minimizing the volume of flammable or toxic fluids released to the environment;
- Combustion, product contamination or corrosive conditions when reintroducing fluids.

A8. Pipelines – Gas and Liquid Petroleum. Part 3: Operations and Maintenance, Australian Standard AS 2885.3-2001

8.10 ABANDONING A PIPELINE

8.10.1 General

When a pipeline is to be abandoned, an abandonment plan, including an environmental rehabilitation plan, shall be compiled and approved. The sequence of decision making required to develop and implement the plan should be in accordance with Figure 8.10.1. When a pipeline is abandoned, it shall be disconnected from all sources of hydrocarbons that may be present in other pipelines, processing plant, meter stations, control lines and other appurtenances, and shall be purged of all hydrocarbons and vapour with a nonflammable fluid. Disposal of the purging fluid shall meet all relevant environmental and safety requirements.

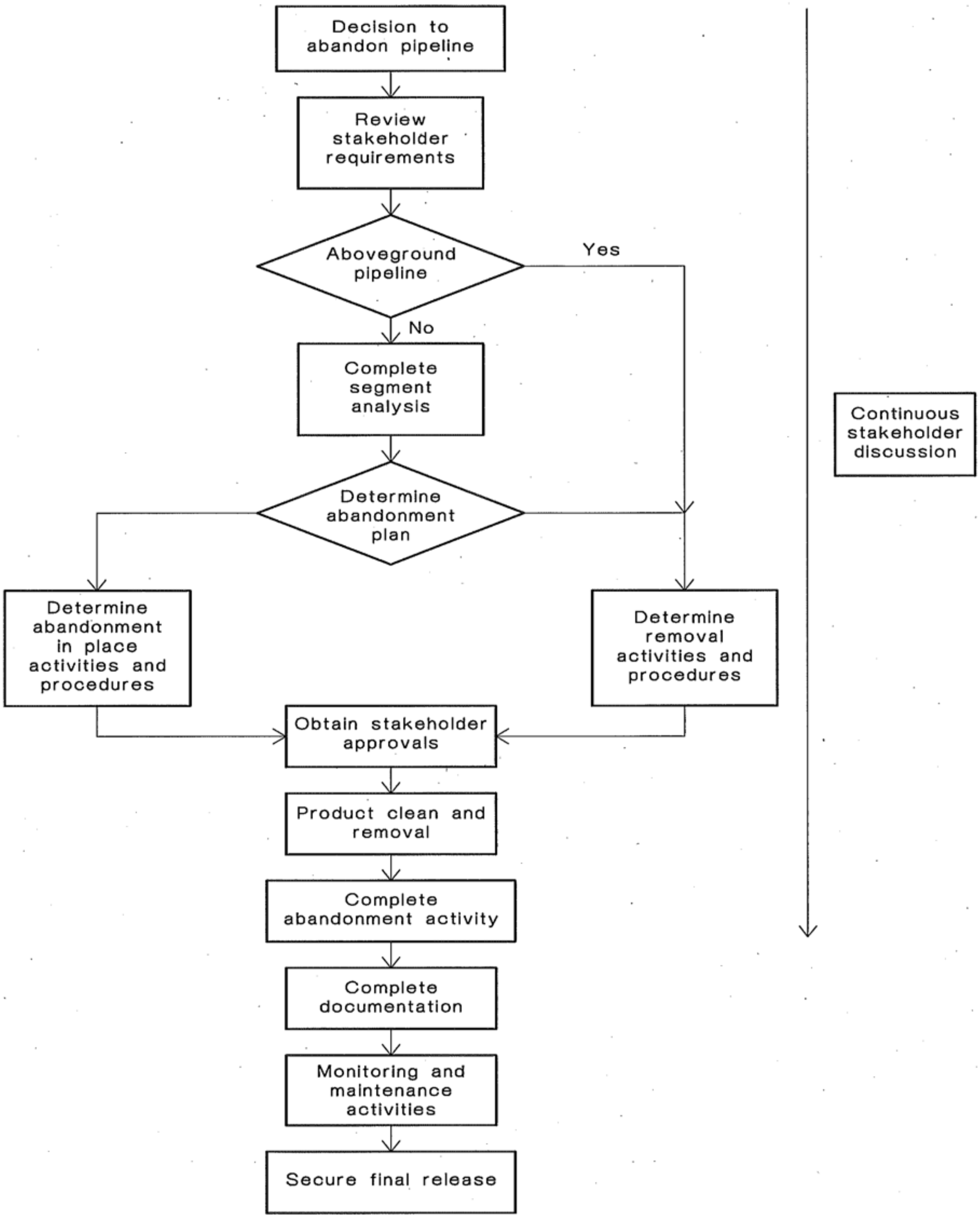

FIGURE 8.10.1 PIPELINE ABANDONMENT FLOW CHART

8.10.2 Abandonment in place
When abandonment in place is approved, the pipeline section shall be abandoned in such a way to ensure that ground subsidence and the risk of contamination of the soil or ground water are minimized.
Where cathodic protection is applied, to prevent the eventual collapse of the pipeline, the responsibility for maintenance of the system shall remain with the pipeline operator and appropriate records shall be kept.
NOTE: Consideration should be given to filling the abandoned pipeline with an inert substance.

8.10.3 Abandonment by removal
When abandonment by removal is approved, the removal of the pipeline section shall meet all relevant safety, and environmental requirements. The requirements for pipeline removal shall be considered as similar to pipeline construction, and shall comply with the relevant requirements of Clause 9.4.3 and AS 2885.1.

8.11 ABANDONMENT OF ABOVE-GROUND PIPELINES

Above-ground pipelines shall be abandoned by removal of the pipeline.

8.12 ADDITIONAL REQUIREMENTS FOR ABANDONMENT

When a pipeline is abandoned, the following additional requirements shall be completed:

(a) The cutting of all buried pipelines at a minimum of 750 mm below natural surface or at the pipeline depth, whichever is the lesser.
(b) The removal of all buildings, fences and equipment.
(c) The removal of all signage associated with the pipeline on completion of the post abandonment maintenance period.
(d) Except where cathodic protection is required in accordance with Clause 8.10.2, the cathodic protection system including buried cables, impressed current units, power lines, solar arrays and batteries are to be removed. Anode and earthing beds are to be disconnected at 600 mm below the natural surface level.
(e) All interference mitigation bonds with third party structures to be removed, that is the pipeline has to be mechanically and electrically disconnected from all other structures.
(f) Obtaining landowner releases for the completed abandonment.
(g) The relinquishing of the easement where no future or continuing use of the easement is proposed.

8.13 ABANDONMENT RECORDS
Where abandonment in place is approved, on completion of the abandonment of the pipeline section in situ, as executed drawings, complying with AS 1100.401, identifying and locating sections of the abandoned pipeline, shall be prepared as part of the relinquishment procedure.

These records shall be made publicly available to prevent possible mistakes in identifying an abandoned pipeline as an operational pipeline.
Records of approved changes of operating conditions, all engineering investigations and work carried out in connection with any change in the operating conditions shall be maintained until the pipeline is abandoned or removed.

A9. Normas Argentinas Mínimas De Seguridad Para El Transporte y Distribución de Gas Natural y Otros Gases Por Cañerías, ENARGAS (1993)

This code (in Spanish) has been reviewed but no reference to pipeline abandonment was found. DNV also has a draft copy of an Argentine code for transporting liquid hydrocarbons, but again no reference was found in relation to pipeline abandonment.

APPENDIX B – ALTERNATIVE RETIREMENT OPTION MATRICES

Retirement Option Matrix
From NEB document A1S0C1 Revisions to Preliminary Base Case Assumptions 4 March 2010

Physical Assumption by Land Use and Facility For the Purpose of Estimating Preliminary Cost Estimates					
Land Use		**Pipeline Diameter**			**Above-Ground Facilities**
		2" to 12" 60.3 to 323.9mm	14" to 24" 355.6 to 610 mm	>26" >660 mm	
Agri-cultural	Cultivated	A: 80% (R: 20%)	A: 80% (R: 20%)	A: 80% (R: 20%)	R
	Cultivated with special features	R	R	R	R
	Non Cultivated	A: 80% (R: 20%)	A: 80% (R: 20%)	A: 80% (R: 20%)	R
Non-Agri-cultural	Existing Developed Lands	A	A	A	R
	Prospective future development	R	R	R	R
	No future development Anticipated (e.g. forest)	A: 80% (R: 20%)	A: 80% (R: 20%)	A: 80% (R: 20%)	R
Other	Environmentally Sensitive Areas	A	A	A	R
	Roads & Railways	A+	A+	A+	R
	Water Crossings	A	A	A	R
	Other Crossings (Utilities)	A	A+	A+	R

Legend: A = Abandon in place,
A+ = Abandon in place with special treatment (e.g. fill with granular material),
R = Removal

Retirement Option Matrix
From CEPA Pipeline Abandonment Options, 2007

Land Use		**Pipeline Diameter**		
		2" to 12" 60.3 to 323.9mm	14" to 24" 355.6 to 610 mm	>26" >660 mm
Agricultural	**Cultivated**	A	A	A
	Cultivated with special features (depth of cover considerations)	R	R	R
	Non Cultivated (Native Prairie, Rangeland, Pasture)	A	A	A
Non-Agricultural	**Existing Developed Lands** (Commercial, Industrial, Residential)	A	A	A
	Prospective future development (Commercial, Industrial, Residential)	R	R	R
	No future development anticipated (e.g. Forest areas)	A	A	A
Other Areas	**Environmentally Sensitive Areas**	A	A	A
	Roads & Railways	A+	A+	A+
	Water Crossings	A	A	A
	Other Crossings (Utilities)	A	A+	A+

Each box in the matrix represents the primary option for pipeline abandonment for each of the land use categories. It is recognized that there will always be a certain amount of pipe that will be removed or abandoned in place for each of the categories based on site specific assessments, but the primary option is the one listed in the matrix. As well, it is recognized that further development is needed to further refine land use categories. This development will occur as part of the development of the risk based site specific assessment process.

The three recommended options available in the matrix are described below.

Primary Pipeline Abandonment Options

Abandonment Option	Description
A	pipeline is abandoned in place
A⁺	pipeline is abandoned in place with special treatment to prevent potential ground subsidence (e.g., fill pipe with concrete)
R	pipeline is removed

At the initial stages of any pipeline abandonment project, site specific assessments will be necessary and will probably determine that a combination of abandonment options be performed for the various land use categories. In doing so, pipeline companies may determine a percentage split between the primary option in the matrix and any potential secondary option. For example, the matrix recommends that all diameter ranges of pipelines be abandoned in place for a cultivated land use category. However, when the time arrives to initiate an actual abandonment project for this land use category, there is a reasonable likelihood that a small amount of pipe will require removal or abandon with special treatment after the completion of site specific assessments. A similar approach can be applied for the other land use categories.