NORTH DAKOTA FOREST SERVICE

"To care for, protect and improve forest and natural resources to enhance the quality of life for present and future generations."

July 7, 2009

RECEIVED

JUL 20 2009

PUBLIC SERVICE COMMISSION

Sanu Odugbesan
TransCanada Keystone Pipeline

RE: Pembina River Directional Drill Crossing
Sink Hole Remediation Approach / Remediation Plan Drawings

Dear Sanu,

The North Dakota Forest Service has reviewed the Sink Hole Remediation Approach Document and the attached drawing for the Pembina River Directional Drill Crossing on the Tetrault Woods State Forest located in Section 36, Township 163 North, Range 57 West, Cavalier County, North Dakota. The agency concurs with the general remediation methods and proposed steps outlined in the Sink Hole Remediation Approach.

The North Dakota Forest Service mandates according to the terms of the Right-of-Way Easement granted to TransCanada Keystone Pipeline LP in 2008, that the grantee shall, after installation of the underground pipeline, restore the lands subject to this easement to as near their original condition as reasonably possible and remove all debris, spoils, and equipment resulting from or used in connection with the installation or access to state forest lands. Further, the grantee agrees to pay for damage, including but not limited, to roads, trails, fences and growing crops arising from the construction and maintenance of the pipeline.

One error was noted on map. The location on the map legend should read "Cavalier and Pembina Counties, North Dakota," instead of Illinois.

Please continue to keep the North Dakota Forest Service informed and updated on the sink hole remediation process. We would like to be informed when work on filling the sink holes is scheduled to begin.

Sincerely,

Larry A. Kotchman
North Dakota State Forester

Docket

State Forester • Mellberg Forestry Center • 307 First Street East • Bottineau, ND 58318-1100
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TransCanada Keystone Pipeline LP

Pembina Sinkhole Remediation Plan

Paul Fuhrer, Project Manager

July 08, 2009

Docket
NR

TransCanada
In business to deliver

Pembina River Crossing

- Part of Keystone Crude Oil Pipeline

- Pembina River and Pembina Gorge are important resources in the State of North Dakota. Recognition of the environmental sensitivity of this area resulted in utilization of horizontal directional drill technique for crossing this resource with the pipeline

- Crossing was drilled and installed from September 6, 2008 through January 29, 2009

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Pembina River Crossing Location

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Appearance of Sinkholes

- Subsidence was first noticed at the end of November 2008 while reaming operations were in progress
- Additional sinkholes occurred through February 2009
- Area affected by the sinkholes extends approximately 700-feet south from the drill exit point on the north side of the Pembina River

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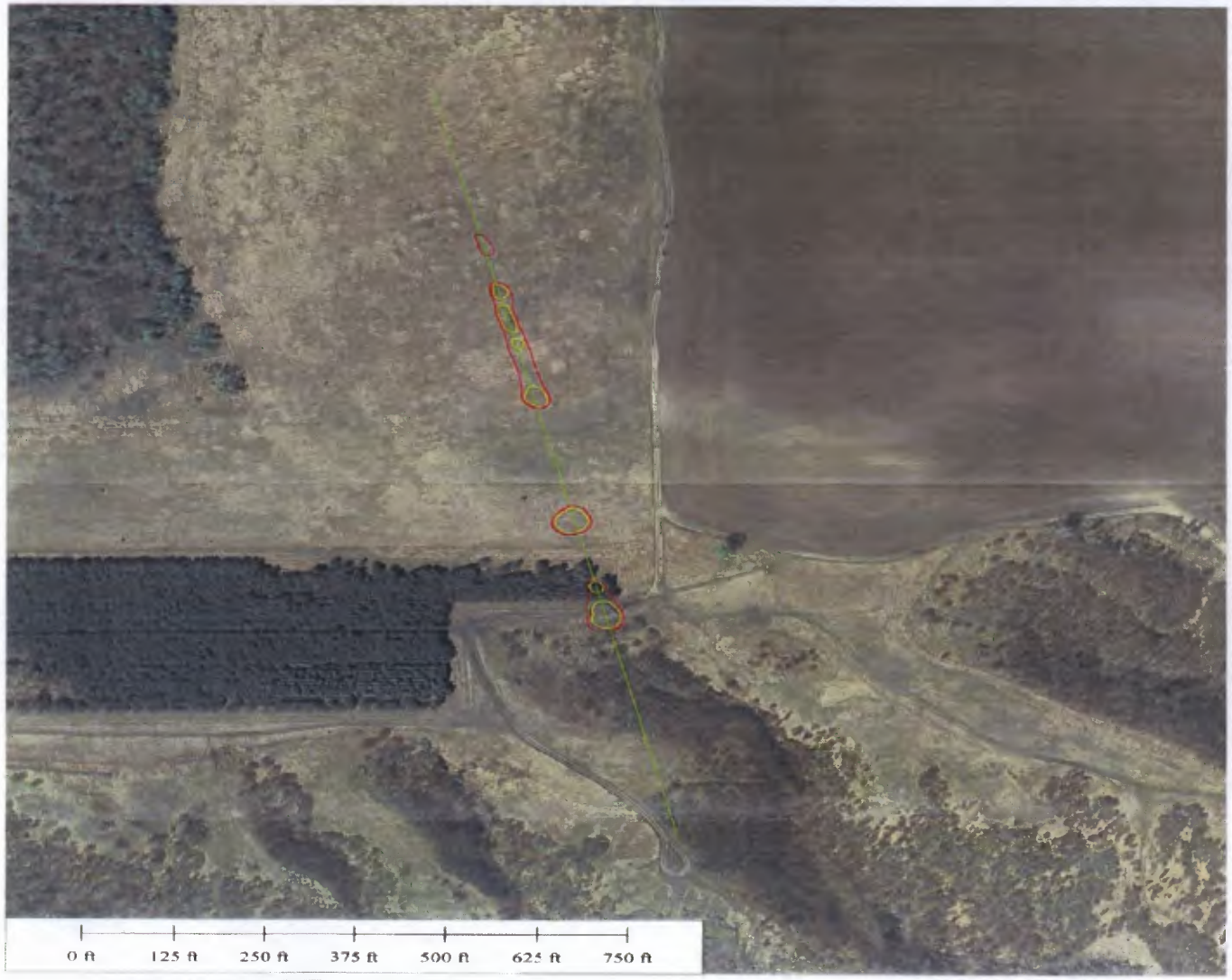
Sinkhole Location



GREEN = PIPELINE YELLOW = SINKHOLE as of 021309 RED = SINKHOLE as of 032609

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Probable Causes Of Subsidence

Observations during construction of the crossing

- Swab passes that attempted to clear the hole were continually obstructed approximately 600-feet from the drill exit point which is coincident with the area of eventual subsidence
- Drilling mud circulation was absent for extended period of time, indicating a loss of drilling mud into the subsurface formation
- Due to geotechnical conditions of the crossing profile, the installation required drilling through both soils and bedrock
- Reamers were repeatedly lodged in the vicinity of the eventual subsidence during reaming passes

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Probable Causes Of Subsidence (continued)

Probable causes of the subsidence

- The continual flow of drilling fluid over a protracted period most likely resulted in the formation of subsurface voids in the soil formation. This incidence may have been greatest near the soil-rock interface where difficulty was experienced during reaming which would have resulted in prolonged exposure to flowing drilling mud

- The presence of clayey sand layers in the formation may have allowed cavities to form without immediate expression of subsidence at the surface until the spanning capability of the cohesive layers were exceeded. Once the spanning capabilities of the cohesive layers were exceeded, this likely resulted in the sudden expression of sinkholes at the surface

Probable Causes Of Subsidence (continued)

Probable causes of the subsidence

- The frequent loss of drilling fluids during the reaming process implies that soils were being eroded and carried away

- The loss of drilling fluid circulation suggests lower mud pressure in the hole. Lower mud pressure can result in increase incidence of hole collapse. Subsequent reaming operations to open the hole necessarily remove this collapsed material allowing further collapse and the creation of voids.

Sinkhole Pictures

Sinkhole near ROW centerline in pine plantation. View is to the southeast

Sinkhole near drill exit point. View is to the south

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Immediate Actions Taken By Keystone

- Notification to agencies
- Implementation of safety measures
- Started evaluation of subsidence/sinkhole area

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North Sinkholes with Safety Measures

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Safety Measures

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Evaluations Performed

Geophysical survey field work conducted April 3-18, 2009 included the following techiques:

- Microgravity – map lateral variations in subsurface density, aid in identifying possible low-density zones or voids
- Seismic Refraction – map top of rock and variation in hardness of subsurface materials
- Multi-Channel Analysis of Surface Waves – map variation in shear-wave velocities within unconsolidated materials to find weak or loose zones
- Resistivity Imaging – map electrical variations related to sand/gravels versus silts/clays
- Three (3) Soil borings to increase understanding of the subsurface conditions

Evaluations Performed

Keystone has also passed a caliper tool through the Pembina River Drill segment to check for deformation to the pipeline on June 13, 2009

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Conclusions of Evaluations

There does not appear to be a single major anomaly at the site as a result of the sinkholes or pipeline installation

Rather, a few smaller anomalies that represent geologic variability at the site contributed to the formation of the sinkholes in this area

No indications of significant voids or weak materials have been identified

No deformation to the installed pipeline was detected by the caliper tool

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Remediation

The remediation method proposed consists of the following:

- Photographic/video Documentation of Pre-Remediation Conditions
- Baseline monumentation for use in verification of remediation
- Removal of pine trees from sinkhole

- Engineered backfill placement
  - Initial layer of soil to level bottom of each sinkhole
  - Lay geogrid fabric at bottom of each sinkhole
  - Place backfill in 5-foot layers and compact using small remote controlled equipment. Additional fill will be placed to mound 2-feet to allow for any backfill settlement
  - Final layer to be topsoil replacement

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Remediation (continued)

The remediation method proposed consists of the following:

- Re-vegetation per the Keystone Pipeline Project Plan including planting 2 year old pine trees to replace at a rate of 2 for 1 the trees lost into the sinkholes

- Post remediation monitoring
  - Visual and topographical monitoring will be performed using the baseline monumentation established
  - Monitor twice during the first month following completion of sinkhole backfill and monthly thereafter until successive measurements show no movement

Remediation Timeline

- Draft of Remediation Plan Issued: June 26, 2009
- North Dakota Forest Service concurrence with the Remediation Plan: July 7, 2009
- Obtain proposals for Remediation Work: July 15, 2009
- Award of Contract: July 22, 2009
- Mobilization of Contractor: July 31, 2009
- Completion of Remediation: September 15, 2009

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Draft
NJC

TRANSCANADA KEYSTONE PIPELINE PROJECT

Pembina River Directional Drill Crossing

Sink Hole Remediation Approach
DRAFT

Prepared for:

TransCanada Pipelines, Ltd.
450 1st Street SW
Calgary
Alberta, Canada T2P 5H1

TABLE OF CONTENTS

Keystone Pipeline

Pembina River Directional Drill Crossing

Sink Hole Remediation Approach

1. Introduction

The general remediation method suggested involves the backfilling of the existing sinkholes, without any improvement to the soils present at depth just above or below the pipe.

Due to safety constraints, direct access to supply the soil and to provide some nominal compaction during the filling process will not be allowed. Accordingly, these activities must be accomplished remotely utilizing equipment situated outside of the fenced area currently established around the sinkhole. However, based on the premise that the subsidence process seems to have come to a halt, some supplemental remediation measures may be attempted after the holes have been backfilled.

Most of the subsidence areas are located in open grassland areas. Although the two southern-most sinkholes –which eventually merged into each other- did result in the fall of several trees and also interrupted a trail/access road/snow mobile path.

The remediation method proposed consists of the following steps:

- Documentation of Pre-Remediation Conditions
- Removal of major debris
- Engineered backfill placement
- Post Remediation monitoring

2. Documentation of Pre-Construction Conditions.

A complete photographic/video record will be performed of the area inside the fence and of a 50-ft wide strip on each side of the fenced area, extending from the HDD exit point to the points where the slope descends steeply to the river.

Reference monumentation will consist of the installation of one monument at each of the holes and three, equally spaced, along the center line advancing south from the southern-most sinkholes through the point at which the slope descends to the river.

3. Removal of Major debris

Some mid size pine trees feel into the two southern-most holes. Their presence may complicate the backfill and may promote localized subsidence as the wood decays over time. This area may be more critical due to the presence of the trail/access road. The trees must be removed prior to placing fill in the sinkholes.

4. Engineered Backfilling

The sinkholes may be backfilled in accordance with the general procedures presented below.

4.1 Soil Type

Exploration performed in the vicinity of the sinkholes indicates that the natural subsoil in the upper 30 feet of the profile consists of a layer, approximately one foot think of organic topsoil overlying (predominantly) fine to medium sand mixed with silt and clay. The sandy soil exhibits loose to medium density.

It is proposed that a silty-to-clean sand soil type (SP-SM) as per the unified soil classification system be used for backfill.

4.2 Soil Stocking. Estimated Soil Volumes

In principle, we anticipate that stocking of the imported soil will take place in the vicinity of the right-of-way (ROW) on the sides of the safety fence. We estimate that the distance to the holes is enough to prevent any stability issues. However, measures must be taken to prevent disruptions to the runoff that may concentrate flows toward the sinkholes or the neighboring slopes. Marking the locations and lengths of any of these measures such as slope breakers, silt fences, etc. shall be done by the contractor in the field.

The most current measurements of footprint dimensions and approximate areas of the holes provided by Universal Ensco, Inc. (UEI), and estimated hole depths on the order of 20 to 25 feet have been used to estimate the volume of backfill material for the first four holes (advancing from south to north). To account for the section that involves the first northern-most five holes we have used the area computed by UEI and an estimated depth of 6 feet for the "depression" that engulfs these holes.

The total amount adds up to approximately 9,500 cubic yards.

Please note that this estimate is based on very rough visual assessments of depths of the holes.

4.3 Soil Placement

As indicated before, safety concerns preclude regular soil spreading within the holes. Placement may be done using conveyors or cranes. Manned equipment must remain outside the fenced area.

4.3.1 Initial Backfill Placement

As the wall of each hole has deteriorated over the past six moths or so, the soils that have slid tended to backfill each hole. Currently, the holes show an irregular surface at the bottom. In order to facilitate a more even engineered restoration, we recommend that an initial layer of soil be constructed to create a quasi-leveled surface at the bottom of each hole.

Estimating the level of the fill can be performed via visual inspection. It is suggested that this activity be conducted by crane.

A layer of geogrid (Tensar Biaxial Geogrid BX6100 or equivalent) will be laid at the top of the leveling layer. Due to the difficulties in setting the grid, it will be impractical to cover the entire footprint of the leveled bottom. However, efforts should be made to cover as much as possible. Several pieces of (overlapping) geogrid may be needed. Typically, overlaps between sections of grid need to be approximately 2 feet.

4.3.2 Subsequent Backfill Placement

Backfilling of the remaining height can be done using the same general procedure utilized for the initial leveling layer. A conveyor may be better suited to achieve a more

even gradual build-up. Placing the soil in discrete piles is not recommended, due to lower stresses and reduced densification.

The placement method described above will most likely lead to a predominantly loose state.

The natural soils exhibit loose to medium dense conditions. Given the predominantly granular nature of the backfill material suggested, it is preferable to achieve some level of compaction within the backfill material to replicate native soil densities. This compaction should be accomplished using the following method:

Backfill and compact 5 foot layers using small remote controlled equipment. The interrupted trail at the southern end of the sinkhole area will be compacted using vibro compaction to increase density of the backfilled materials.

The top one-foot layer shall consist of topsoil. The Contractor shall import soils that comply with OL-OH type as per the Unified Soil Classification System. Re-vegetation as per Keystone's plan may be used to complete the remediation plan being presented.

Due to the fact that settlement is expected to occur after completing the filling process, we recommend that additional fill be installed to compensate for the settlement. A mound height (camber) of 2 feet is suggested. Minor temporary runoff control may be installed around the mounds. Definition of the works can be done on-site as needed.

5. Post-Remediation Monitoring

Visual and topographical monitoring will be performed. As indicated before, monuments may be installed at the center of each area remediated, so that settlement can be measured. We recommend an accuracy of 0.5 inches for the measurements.

We recommend monitoring on a bi-weekly basis during the first month after completing the backfill and monthly thereafter until successive measurements show no movement. As the readings are interpreted, the frequency will be adjusted and decreased.

6. Safety Measures

Strict safety measures should be enforced during the remediation process. As usual, the firm or firms that will be hired to do the work shall produce a specific JSA for the job. Particular attention should be given to limiting access to areas near and within the sinkholes. The safety plan for this activity must be very clear in regard to excavation entry violation and exclusion area restrictions. Pre-job training must reinforce this in the most absolute terms.

Once the remediation is completed, the existing precautions, namely fencing and signs – perhaps not as alarming as the ones currently in place be kept in place for one month. As the observations and settlement measurements progress, the precautions may be relaxed.

We estimate that the remediation works may be completed by September. That leaves little room before the arrival of winter season and associated traffic of snow mobiles and hikers. More stringent controls and quick response to fix any settlement shall be implemented around the trail access road on the south end.

Soil Type

1. Backfill
   Silty or clayey fine to medium sand, classified as SM-SP
   Fine Content 0 to 20%
   No organics, roots, lumps of clay
   Occasional occurrence of gravel is allowed.

2. Topsoil
   Soils that comply with OL-OH type as per the Unified Soil Classification System.

In-hole Compaction Using Remote Controlled Equipment:

1. Equipment: Remote controlled, vibratory, with weight on the order of 3,500 pounds, minimum frequency of 30Hz and dynamic force on the order of 18,000 pounds.

2. Maximum loose lift thickness of 5 feet, estimated by eye and by amount of soil being dropped using a conveyor.

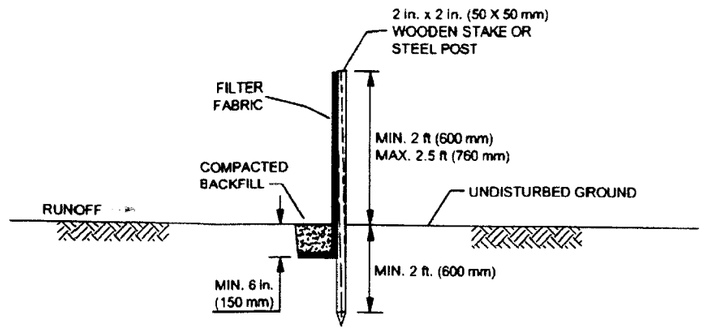
3. Number of passes per lift = 5

Compaction After Backfilling:

1. Alternative using a self-propelled roller. On a preliminary basis we suggest equipment that may be able to deliver a dynamic force on the order of 40Kips. Initial passes shall be done without any vibratory forces.

2. Compaction control. Via regular boreholes (1 per sinkhole remediated) drilled to a depth of 20 feet. Use SPT to estimate density. Blowcounts exceeding 10 blows per foot are acceptable.

3. Alternative compaction method at sinkhole that interrupted the trail/road: Compaction via closely-driven displacement piles. Wood piling with but (head) diameter of 9 inches and length of 20 feet, driven until the head is approximately 1ft below fine grade of the trail. Pile (center to center) separation of 1.5 feet.



SILT FENCE INSTALL DETAIL

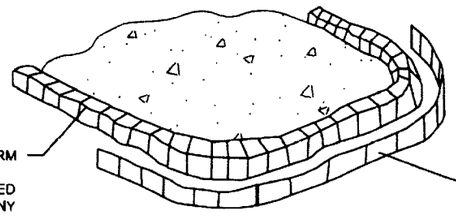
General Containment Berm Notes:

1. Care should be taken that the soil pile does not overtop the containment berm.

2. The containment berm should be dismantled and the site restored to the original condition upon completion of construction.

3. Care and attention must be taken to ensure spoil containment berms are maintained.

4. Full consideration for overall slope stability is required when selection a spoil containment location.



TEMPORARY STOCKPILE CONTAINMENT BERM

General Silt Fence install Notes:

1. T-Bar stakes are to be placed every 8ft (2.4m) or closer as conditions require.

2. Attach filter fabric at each post at a minimum of 3 locations.

3. The filter fabric (min. of 1ft (300mm)) is to be anchored in a 6in x 6in (150mm x 150mm) trench with well compacted backfill over the fabric to prevent undermining.

4. Silt fences are to be checked and maintained on a regular basis. Remove any build-up of sediment.

5. Material should be woven geotextile fabric such as Exxon GTF 180 or Mirafi 600x, or an approved equivalent. Secondary reinforcement, such as a construction barrier fence or wire mesh can also be used behind the filter fabric.

6. Where anchoring conditions for the silt fence are poor, place straw bales on downstream side of silt fence.

General Erosion Control for Stockpiles

1. Locate stockpiles away from drainage courses, storm drain inlets or concentrated flows of storm water.

2. Cover stockpiles. Application of water, dust palliatives or soil stabilization measures should only be used when covering the stockpile is not feasible.

3. Use temporary perimeter sediment barriers, such as berms, dikes, silt fences, or sandbags when stockpiles are not active; use temporary linear sediment barriers at all times.

4. Plastic sheeting have a minimum thickness of 6 mil, and shall be keyed in at the top of slope and firmly held in place with sandbags or other weights.

5. All sheeting shall be inspected periodically after installation and after significant rainstorms to check for erosion, undermining, and anchorage failure.

REFERENCE DRAWINGS

DRAWING No	TITLE

REV No	DATE	REVISION	PROJECT CODE	DRAFT BY	DRAFT CHK	DESIGN BY	DESIGN CHK	PROJ MGR
0	JULY 2, 2009	ISSUED FOR REVIEW	THE0050388S	DH	FP	FP	FP	RG

PROFESSIONAL ENGINEER/RPT | PERMIT/ ENG. APPROVAL

DATE

DRAFT

REV. NO. | DATE | PERMIT NUMBER:

CADD DRAWING: DO NOT MAKE MANUAL REVISIONS

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Trow

FIA # 1827	CHAINAGE: MP 7.1	DISCIPLINE #03

PEMBINA RIVER CROSSING
SUGGESTED SINKHOLE BACKFILL
SILT FENCE & CONTAINMENT BERM INSTALL DETAILS.
PEMBINA & CAVALIER COUNTIES,

SCALE NTS	DRAWING No 1827-03-ML-03-009	REV 0

PLOTTED SIZE: ANSI B (11x17)