From:	Brad Hageman
To:	Ek, Scott (PUC); *COMM_Pipeline Comments; Hartman, Larry (COMM); enbridgeinmn@enbridge.com
Subject:	Sandpiper
Date:	Sunday, May 08, 2016 9:28:24 PM

Thank you for sending out the notice of availability of scoping EAW and draft scope for sandpiper pipeline and line 3 replacement projects and schedule for EIS scoping meetings.
I have property just north of McGregor, 2 miles 24-48-24 Jevene Township and supposedly the sandpiper pipeline is still coming through my property? I never had a land agent discuss purchasing it. All my friends, cousins and relatives within a couple miles to the east and west and north of me have all been paid. One land agent called me early this winter and said he'd be contacting me again in a couple of weeks. That was three or four months ago. I voiced my opinion's about no one talking to me and even offering any money. I have been a proponent of not having the sandpiper come through where they want it. I have offered other alternate routes to the south end of my property and to the north but again no land agent has contacted me. Now I've got your letter here about eminent domain if the route permit is given by the PUC they might use eminent domain to take the land.
Is it possible that no land agent has contacted me because I did voice my opinion of not wanting the sandpiper pipeline? If it is coming through I definitely will sell versus having it just taken.
Please assist me by letting me know what is going on and what can be done. I will be at the Wednesday, May 11 meeting in Eastlake community center McGregor.
Brad Hageman 320-293-4663
Bradhageman@aol.com

Sent from my iPhone

MINNESOTA DEPARTMENT OF COMMERCE

Comment Form: Scoping
Energy Environmental Review and Analysis

Please provide your contact information. This information and your comments will be publicly available.

Name: Brad Hageman Phone: 320-293-4663

Street Address: 11861 Hwy 25 NE

City: Foley State: MN ZIP: 56329

Email: bradhageman@aol.com

My comments pertain to:

- [x] Sandpiper Pipeline Project
- [ ] Line 3 Replacement Project
- [ ] Both Projects

I made & sent emails to Scott EK, Jamie MacAlister, and enbridgeinmn@enbridge.com earlier in the week of 5-16. My concern was eminent domain and losing my property. I have been a proponent of not having the pipeline on my property. I sent in paper work last year on alternative routes and according to Mike Morris 218-212-1327 they are going entirely on the property to the right of mine. According to a picture & note from Scott EK it is still on my property. At the East Lake meeting I was told it did move to the North and not on mine. But, the orange lines and dotted pink lines still are. How can Route Width and environmental survey lines still be on mine? Here is more confusion. Enbridge people at the meeting stated pink line represents an easement right. How can that be as no one has paid me for an easement? Also, if the EIS shows it would be best on my property, (which it will) then they still would bring it on my land. If eminent domain would be used I would rather sell the easement. No land agent has ever discussed purchassing with me.

If including additional pages please number them and tell us how many you are providing: 2 pages

2nd page

I was under the impression that when I drew up alternative routes last year if moved there would be nothing on my land. Please move all "Route width" marks to the North also as Jack Olson was paid for the pipeline. Please move Environmental Pink Survey lines to the North also.

To say the least this is confussing with Mr. Morris saying it was moved and Mr. EK saying it was not moved. Sand piper officials at East Lake meeting stated they could still come onto my land if it was deemed desirable or necessary. My property is sand, Jacks is peat bog

Brad Hageman 320-293-4663
Jevene township Section 24 T48 N R24 W
Aitkin County 2 miles North of McGregor.

From:	Brian Hanson
To:	*COMM_Pipeline Comments
Subject:	Scoping EIS comment for Sandpiper (13-473 & 13-474) and Line 3 Replacement (14-916 & 15-137)
Date:	Wednesday, May 25, 2016 7:09:01 PM
Attachments:	Enbridge Comments 5_26_16.docx

Thank you for allowing me the opportunity to comment on these matters. I have attached a document and provided the same text in this email, below.

Brian W Hanson
President & CEO
APEX
306 W Superior St
Suite 902
Duluth, MN 55802

O 218.740.3667
C 218.730.7330

May 25, 2016

RE: SANDPIPER PIPELINE PROJECT – Docket Nos: CN-13-473 and PPL-13-474
LINE 3 REPLACEMENT PROJECT – Docket Nos: CN 14-916 and PPL-15-137

To Jamie MacAlister and the Minnesota Department of Commerce:

Since 2003, the Area Partnership for Economic Expansion (APEX) and our 70+ investor-members, have played an active role in business development in the APEX region of northeast Minnesota and northwest Wisconsin, including the Twin Ports of Duluth and Superior. APEX investor-members represent some of the most influential companies in the region, with a collaborative approach to promoting sustainable economic growth. Throughout the past thirteen years, APEX's collective efforts have impacted more than 4,000 jobs in the region, resulting in a regional payroll of over $164 million and contributing to over $22 million in state and local taxes annually. We are proud of that contribution to our economy.

To measure the economic impact of the Sandpiper and Line 3 Replacement projects, the Bureau of Business and Economic Research (BBER) at the University of Minnesota Duluth's Labovitz School of Business was commissioned by the Minnesota Ag/Energy Alliance to conduct an economic impact study. Findings indicated these projects would inject more than $2.3 billion in direct spending to Minnesota's economy. In a two-year

timeframe, Enbridge's Sandpiper and Line 3 projects will have a direct impact on more than 4,800 and 7,700 jobs in our region respectively, representing a significant contribution to state and local taxes. In addition, the study indicated non-local construction workers will spend approximately $138 million in northern Minnesota during the two-year construction period in retail, lodging and food service sectors, supporting a combined 2,600 jobs in those industries. Finally, when construction is completed, these two projects will contribute an estimated $44.5M in property taxes to state and local government on an annual basis.

Statewide, Sandpiper and Line 3 will ensure the safe delivery of abundant, dependable energy that is vital to Minnesotans' homes, fueling cars and airplanes, and generating electricity for residential and industrial use. Here in the APEX region, Enbridge directly employs hundreds, and supports a contractor workforce numbering hundreds more. These dedicated professionals are part of a carefully crafted team that administers construction projects all across North America. These teams have led construction projects in several states and provinces. Unfortunate delays here in the state of Minnesota are putting these jobs, significant investment, and our regional economy, at great risk. If delays continue, there are no guarantees that Enbridge can continue to move forward with the Minnesota builds in a time when all of Minnesota, especially the northern part of our state, could use the economic boost.

A fair, timely, and final evaluation of this project has been delayed for far too long. Any entity attempting to do business in Minnesota relies on a predictable and timely regulatory process. I ask that the Department of Commerce adhere to the 280-day time limit to prepare the EIS to keep the project on track.

The scope of the EIS is vital. It needs to serve the public and private purpose of the Sandpiper project. It should not be so narrow that it would be inadequate, but it should also not be too broad as to exceed established timeframes. A balance must be met.

The economic benefits, safety and efficiency of shipping oil through pipelines, and public support for this project should emphasize the importance of seeing this process through, in a timely and effective manner.

Thank you for the work you do for the state of Minnesota and thank you for your dedication in moving this project forward.

Sincerely,

Brian W. Hanson
APEX President & CEO

Ingrid Kimball

From: ejejpj@comcast.net
Sent: Thursday, May 26, 2016 9:45 AM
To: *COMM_Pipeline Comments
Subject: Enbridge/Sandpiper pipeline

JOHN AND EVONNE HALVORSEN
3517 Ridgewood Road, Arden Hills, MN 55112
Phone: 651.636.3713; E-mail: ejejpj@comcast.net

May 26, 2016

To whom it may concern,

The reason for this communication is to address the proposed Enbridge pipeline route that would run through the Big Sandy Lake watershed to Superior, WI.

Our extended family has owned a cabin on Davis Bay on Big Sandy Lake since the 1940's and we, along with many others, are very concerned about the negative impact that leaky pipelines will have on the native land/culture, wildlife, wild rice, fishing and tourism in the area. In addition, Savanna State Park (www.dnr.state.mn.us/state_parks/savanna_portage/index.html), the US Army Corp of Engineers Campground (www.recreation.gov/camping/sandy-lake/r/campground), Covenant Pines Camp (www.covenantpines.org), Catholic Youth Camp (www.cycamp.org) and Sandy Lake Camp (www.bigsandycamp.com) all stand to be adversely affected if an accident befalls the area and damages the lake.

This is a local and state issue, and a federal one as well. A federal dam to the Mississippi is located on the northwest corner of Big Sandy Lake and Rice Lake National Wildlife Refuge (www.fws.gov/refuge/Rice_Lake) is situated 12 miles to the south. The pipeline route favored by Enbridge runs 7 miles north of the refuge between McGregor and Big Sandy Lake.

The Enbridge map for Aitkin County shows that the pipeline crosses the Mississippi River at Palisade and the Sandy River below Flowage Lake. Since the Sandy River flows into Big Sandy through Flowage Lake and out of Big Sandy into the Mississippi at the dam, if a leak occurred, in addition to polluting Big Sandy Lake, the Mississippi could be implicated twice in the McGregor area alone. Flowage Lake is also where many fish spawn that find their way into Big Sandy. Locating a pipeline along side what is essentially a fish hatchery is reckless to say the least.

Wherever a pipeline is located it will impact someone. At the very least, it should run above ground for ease of monitoring and repairing leaks. In the rush for the U.S. to become energy independent and to stimulate job growth, however, we need to make sure that Minnesota's resources are not sacrificed in the process. The Enbridge pipeline route needs to be altered to protect the Mississippi Headwaters and our northern lakes so that Minnesota does not become just a land bridge from Canada and North Dakota to Lake Superior over which to move oil for someone else's profit and consumption. Our hope is that you would help us work to that end.

Sincerely,
John and Evonne Halvorsen

Ingrid Kimball

From: ejejpj@comcast.net
Sent: Thursday, May 26, 2016 10:21 AM
To: *COMM_Pipeline Comments
Subject: Sandpiperline3

JOHN AND EVONNE HALVORSEN
3517 Ridgewood Road, Arden Hills, MN 55112
Phone: 651.636.3713; E-mail: ejejpj@comcast.net

May 26, 2016

To whom it may concern,

Our family has had a cabin on Big Sandy Lake since the 1940's, and we're very concerned about the proposed /preferred Sandpiper pipeline route between Big Sandy Lake and the city of McGregor, MN running through the watershed. Because of our concern, we request your help in seeing that the following things are done before any decision is made.

First, we request a full and comprehensive Environmental Impact Statement that takes all possible pipeline route alternatives into consideration and that is supervised by specialists/scientists at Minnesota's lead environmental agencies. We will not accept Department of Commerce efforts to provide a substitute or 'equivalent' environmental review.

Second, we request a full risk assessment for potential oil spills.

Third, we insist that the EIS allow for public input.

Our hope is that in the effort to become energy independent, Minnesota is protected from becoming the land bridge for moving one state's oil to be refined and used by yet another state's people leaving Minnesotans to bare the environmental impact and risk.

Thank you in advance.

Sincerely,

Evonne Halvorsen John Halvorsen

From: Tom Hanowski
To: *COMM_Pipeline Comments
Subject: Public Comment
Date: Wednesday, April 20, 2016 11:38:31 AM

I'm a landowner in Little Falls (south of Camp Ripley) having 2 existing natural gas pipelines going through my property between my house and shed. It frustrates me that I have no access to the natural gas from these lines. Other neighbors around me also wish they could connect to this source of natural gas. The proposed oil pipeline will be an opportunity to connect me and my neighbors to the existing natural gas lines, since a low pressure natural gas line could be laid in the same trench as the new oil lines, feed from the pressure reducing station only 1 mile from my house along the same route as the proposed line. This would be a wonderful opportunity to help local folks and build good-will for the project and companies involved, especially for landowners like me who will, once again, be forced to give up land through eminent domain. Helping local land owners like this should be included in the scope of the proposed new project. Thank you for your consideration. I would gladly discuss this further if you wish.

Tom Hanowski
20346 Ginger Road
Little Falls, MN 56345
Phone: 320-232-9726

From:	Lance Hapka
To:	*COMM_Pipeline Comments
Subject:	Enbridge
Date:	Thursday, May 26, 2016 8:51:35 AM

As a past owner of land being utilized by Enbridge for their pipe system I would like to express my support for the line 3 project. With many years of working with Enbridge on new project and maintenance digs they have always kept us well informed and been very cooperative in resolving situations.
Sincerely,
Leon Hapka

Ingrid Kimball

From: Norley Hansen <Norbonh@paulbunyan.net>
Sent: Thursday, May 26, 2016 7:26 PM
To: *COMM_Pipeline Comments
Subject: Comments on Sandpiper and Line 3 Replacement Piplelines

As I was unable to make any of the meetings, I will do so by email. I would like to start out by saying that I am completely befuddled by Enbridge looking to use a new corridor for these pipelines. With many pipelines passing through my farmstead and a great segment of my property is mostly now unusable why now have Enbridge spoil a new area? It seems very prudent to follow this very same right-of-way and remove old line Number 3 and then place the new pipe Number 3 in the same trench and place the Sandpiper Line in this same corridor as close as possible. I have many concerns about leaving a unused pipe that is in such bad shape that it has to be replaced in the ground. The salvage value of this old pipe would be great!!

There are many rumors of why Enbridge is seeking a new corridor with the number 1 reason is they would not have to work with the Native Americans and the second is that they are dealing with land owners that have not experienced the negative effect of working with Enbridge. I would ask that Enbridge be required to use the existing corridor(s).

Thank you,

Norley L. Hansen
Cohasset, MN

Roberta Haskin

9641 Vincent Avenue South

Bloomington, MN 55431

roberta.haskin@gmail.com

I am opposed to the Sandpiper pipeline. I have read the report, Enbridge Over Troubled Waters, which details the risk and destruction posed by Enbridge's plan for new pipelines throughout the Great Lakes region. I urge you to take heed of the details of the report and specifically, to implement the report's many recommendations.

I am testifying for a personal reason as well as for concern for planet earth. I consume the wild rice from the wild rice paddies in Northern Minnesota. The wild rice paddies are threatened by Enbridge's proposed pipelines. I am very concerned that the Sandpiper pipeline will disrupt those paddies. I support the rights of indigenous peoples to maintain the harvesting of wild rice from the paddies.

The Sandpiper pipeline is dangerous. Enbridge has a terrible record of spills.

The Sandpiper pipeline is outdated as we enter a time of commitment to post-fossil fuels.

The Sandpiper pipeline will carry dirty tar sands throughout the Great Lakes region endangering waterways and watersheds. The health of the water is essential for a stable climate.

The Sandpiper pipeline project does not recognize the sovereign native populations' rights over the land.

I stand against the Sandpiper pipeline project and urge you to deny this massive crude oil transportation corridor project.

Thank you.

Roberta Haskin

May 9, 2016

St Paul, MN

Ingrid Kimball

From: Noreen <noreen.998@gmail.com>
Sent: Thursday, May 26, 2016 2:41 PM
To: *COMM_Pipeline Comments
Subject: PUC DOCKET #'S: Proposed Sandpiper pipeline, PL-6668/CN-13-473; PPL-13-474; and Line 3, PL-9/CN-14-916; and PPL-15-137

My comments for entry into the record:
--The EIS for the proposed Sandpiper Oil Pipeline and Line 3 MUST include:
*Complete disclosure of the plan to maintain the pipelines after abandonment-- including financial responsibilities and assurances; legal and financial commitments for how the line will be kept from leaking or impacting the water or land should the company owning the pipelines be sold or go bankrupt
*A complete "oil well to wheels impact analysis" to the environment, including, but not limited to, the cumulative impact over time to human/plant/animal/bird/watershed/air quality/soil health
*An impact analysis on the Anishinabe Peoples' culture, survival and health of ghe proposed pipelines, including, but not limited to, the spills resulting in the destruction or decrease of wild rice ecosystems; psychological impacts of the youth experiencing the ongoing stress and fear of oil spills and the resultant destruction of their foodsource and basis for their culture; psychological impacts of the Elders fearing for the survival of the Anishinabe People, the animals, the fish, the plants, the birds, etc.
Thank you for considering these comments. Thank you for responding, in written form, to each point made, and the relevant concerns expressed by each point.
Noreen Hautala

JAMES C. AND JUDY A. HAWLEY

May 23, 2016

State of Minnesota Public Utilities Commission
121 7th Place East, Suite 350
St. Paul, MN 55101-2147

Public Utilities Commission (PUC) Docket Number: PL-6668/CN-13-474, PPL-13-474; PL-9/CN-14-916, PPL-15-137
Regarding the Sandpiper/Line 3 Pipeline Corridor Route

Dear Commissioners:

Thank you for considering our comments.

On March 16, 2014, we wrote to you expressing our concern regarding the risk inherent in the proposed routing of the Sandpiper pipeline (which we will refer to as the Sandpiper corridor going forward, given the Line 3 replacement project that has been proposed to also follow the Sandpiper route), particularly as to where the route crosses the Big Sandy Lake Watershed. We proposed to you that, after considering the definition and approaches to dealing with risk management, the most effective way to mitigate Sandpiper's inherent risk was via a different routing.

Nothing has occurred in the intervening two years to change our basic viewpoint. That is, pipelines are preferable to truck and rail transport, but to most effectively mitigate the inherent risk the routing of pipelines should follow the least environmentally sensitive route – determined via reliance on those with the scientific expertise to properly make such an assessment. In Minnesota, the designated stewards of the environment are the MNPCA and MNDNR.

John Adams is quoted, "Facts are stubborn things." We believe the spirit of that quote applies in this situation, as follows.

- There is inherent risk in the Sandpiper corridor projects. Equipment can fail, even when conscientiously maintained. We have all experienced that. People make mistakes. The Michigan spill that Enbridge has spent millions of dollars to remediate was not caused by equipment failure. It has been attributed to human error. The 2015 oil spill near Santa Barbara, California was commented upon by the Pipeline and Hazardous Materials Safety Administration (PHMSA) in a report issued in February 2016. PHSMA observed, "… an inspection weeks before the leak incorrectly measured the amount of pipeline corrosion on both the line that leaked (901) and a nearby line (903)" (ksby.com).

  Professor Robert Bea, University of California Berkley, in commenting on the 2015 California oil spill stated – related to the presence of a smart pig in the ruptured pipeline, "As you may guess, the primary weaknesses show up in the human interpretation. They're only as smart as the people who are interpreting the signals." He said human error is responsible for 80 percent of such lapses (oilprice.com, June 8, 2015). Enbridge has emphasized smart pig technology in their Sandpiper/Route 3 presentations.

- Two agencies, the Minnesota PCA and DNR, assigned with stewardship responsibility related to natural resources have expressed concern over the proposed pipeline routing.

51976 209TH PLACE • McGREGOR, MN • 55760
PHONE: 218-426-4476 • EMAIL: jjhawley@frontiernet.net
hawleyjudy@gmail.com

- Claims have been made that alternate routing would be onerously expensive for Enbridge.
    - First, Enbridge identified multiple routes as viable in their January 2014 environmental report.
    - Further, we submit that Enbridge has the financial strength to deal with an alternate route. In their 2015 yearend financial statements, Enbridge announced operating income of $1.340 billion ($Canadian); and reported cash and cash equivalents on their balance sheet of $755 million; and with their 2014 financial results announced a 33 percent increase in their cash dividends to shareholders.
    - On March 26, 2015, an Enbridge representative appearing on a Lakeland Public Television program stated that the company does not commence a project without supply commitments from customers. This clearly mitigates a portion of the company's financial risk.
    - Finally, the Minneapolis/St. Paul Business Journal reported that Enbridge finished second on the 2015 list of organizations ranked by total spent on lobbying in Minnesota, moving up from fifth place in 2014 – representing $2.2 million and $1.3 million dollars of spending, respectively. They were not on the top 25 list in 2013.

  We submit this represents a level of financial strength, and thus flexibility, to support an alternate routing.

- Judge Eric Lipman stated in his April 2015 letter to you that a spill in Aitkin or Carlton Counties "… would be very bad." We absolutely agree. It would be very bad, and steps should be taken to mitigate such an occurrence.

We believe that Enbridge desires to construct a safe system. We have met several of their associates and they appear to be good people, interested in doing a good job. That does not outweigh, however, the inherent risk in their project that must be taken into consideration.

This is a project whose impact extends a number of years, frankly, more than we have left in our lives. Near-term construction jobs are valuable, and they will follow whatever routing is determined. Ensuring the safety of our natural resources over the decades-long life of the Sandpiper corridor projects is more valuable.

In conclusion, we strongly encourage you to decide to support pipeline constructions, but require routing of the Sandpiper corridor away from northern Minnesota's priceless lakes areas. For certain, when it comes to routing we recommend you follow the recommendations and input from those state agencies best positioned to provide reasoned counsel based on scientific expertise.

Thank you again for considering these comments, and we wish you well in your continued deliberations and decisions relating to this important project.

Very truly yours,

James C. and Judy A. Hawley
51976 209th Place
McGregor, Minnesota 55760

MINNESOTA DEPARTMENT OF COMMERCE

Comment Form: Scoping

Energy Environmental Review and Analysis

Please provide your contact information. This information and your comments will be publicly available.

Name: Jim Hazeltine Phone: 320-558-1106

Street Address: 155 Cardinal Lane

City: Clearwater State: MN ZIP: 55320

Email: Jim4166@hotmail.com

My comments pertain to:

- ☐ **Sandpiper Pipeline Project**
- ☐ **Line 3 Replacement Project**
- ☒ **Both Projects**

These pipline projects will make many jobs for workers in the construction indistery. They also can go to refinerys in Minnesota. That would be good for them and may help Keep The cost of gasoline down.

If including additional pages please number them and tell us how many you are providing: _____ pages

From:	Rick Hemmer
To:	*COMM_Pipeline Comments
Subject:	Scoping EIS comment for Sandpiper (13-473 & 13-474) and Line 3 Replacement (14-916 & 15-137)
Date:	Saturday, May 07, 2016 8:10:04 AM

Dear Ms. MacAlister,

I am asking you to please approve the Sandpiper Pipeline and Line 3 Replacement Projects. Job creation and energy independence is good for America's national security and economy. If the projects are built with union labor there will be no safer way to transfer the product because of the skill level the unions require of their members.

Sincerely,

Rick Hemmer
445 Sturgeon Cir
Russellville, AR 72802

From:	Lory Fedo
To:	*COMM_Pipeline Comments
Subject:	Scoping EIS comment for Sandpiper (13-473 & 13-474) and Line 3 Replacement (14-916 & 15-137)
Date:	Monday, May 23, 2016 11:50:05 AM

Dear Ms. MacAlister,

Department staff and members of the Public Utilities Commission,

The Sandpiper Pipeline project is vital to the economy in the state of Minnesota. Sandpiper will ensure the safe delivery of dependable energy that will power Minnesotans' homes, fuel cars and airplanes, and provide electricity for industrial use. It's likely that many Hibbing residents will directly benefit from jobs in construction but also certainly benefit from the economic opportunity created alongside the project. We're a mining community and we know that there doesn't need to be a tradeoff between the economy and environment – we do it every day.
A fair, timely, and final evaluation of this project has been delayed for far too long. It is important that Minnesota maintains a predictable and timely regulatory process in order to continue attracting business to our state.

As the President of the Hibbing Area Chamber of Commerce, I can understand how much this pipeline will benefit our state. I ask that in order to start building this project, you adhere to the 280-day time limit to prepare the EIS to keep the project schedule on track. The scope ought to be thorough, not too broad, but not narrow enough to be inadequate. It is critical that this balance is met.

Thank you for your dedication to the state of Minnesota and for continuing to work to move this project forward.

Sincerely,

Lory Fedo
President
Hibbing Area Chamber of Commerce

Sincerely,

Lory Fedo
PO Box 328
Side Lake, MN 55781
lfedo@hibbing.org

MINNESOTA DEPARTMENT OF COMMERCE

Comment Form: Scoping

Energy Environmental Review and Analysis

Please provide your contact information. This information and your comments will be publicly available.

Name: WARREN L. HIGH Phone: 218-722-9409

Street Address: 507 W 5TH ST.

City: DULUTH State: MN ZIP: 55806

Email: HIGHINDULUTH@AOL.COM

My comments pertain to:

- ☐ **Sandpiper Pipeline Project**
- ☐ **Line 3 Replacement Project**
- ☒ **Both Projects**

Climate change is ONE OF the most CRITICAL issue to use in evaluating the environmental statement. Headwaters of all lakes, brooks, streams, and Rivers need to be avoided by pipelines to protect our natural water sources for use, are to have Drinkable water for human survival in future years. Also natural disasters such as wild Fires and improved Rain storms (now Frequent) need to be considered as I'm 75 year old person I have experienced many things most of society is yet to survive.

Each decision need to be made BY STOP LIVING ON THE EARTH
START LIVING WITH THE EARTH!!

If including additional pages please number them and tell us how many you are providing: _____ pages

From: Janet Hill
To: *COMM_Pipeline Comments
Subject: Comment for Sandpiper EIS
Date: Monday, May 23, 2016 10:49:04 AM

We have reviewed the primary documents, and request that the following be included in the scoping of the Sandpiper EIS:

1. Study the economic realities of each area that the "preferred" route crosses.

   The EAW lists water bodies, forests, and lands that the pipeline route crosses, but says nothing about how pipeline construction or a spill could negatively affect specific localities.

   For example, in Aitkin County, the EAW states simply that the preferred route doesn't cross Big Sandy Lake. This is a half-truth; in fact, the pipeline would pass under the inflow river to Big Sandy before crossing the width of the Big Sandy watershed, the entirety of which empties into Big Sandy Lake and then into the Mississippi. This just as dangerous as if the pipeline crossed Big Sandy outright.

   Furthermore, it's not mentioned that Big Sandy Lake is the foundation of our local economy and the home of the largest tax base in Aitkin County. A major spill anywhere in the Big Sandy Watershed would ravage the economy of Aitkin County — and 50 years from now, when the aging Sandpiper begins to leak from age and weathering, there *will* be oil in Big Sandy Lake if Enbridge's preferred route is approved. Big Sandy residents learned in the 2012 flood the reality of being the lowest basin in the watershed, when Big Sandy Lake rose six feet a week after a 20- inch downpour in Duluth. Everything in this watershed passes through Big Sandy on its way to the Mississippi.

   In the case of an oil spill anywhere in this watershed, the already tenuous local economy would take a hit that could take years to recover from, if it ever could recover. Similar scenarios likely exist in other areas along Enbridge's proposed route that are not mentioned in the EAW. The risks in this watery area of the state far outweigh the relatively meager and temporary benefits.
2. Section 1.1 of the DSDD states that "The DOC-EERA, with assistance of the MDNR and MPCA have prepared this DSDD." Be absolutely certain that the MDNR and MPCA help prepare the EIS, and do *not* dismiss their judgment as was done in the previous ALJ report.
3. Section 1.3 of the DSDD states that the previous alternatives could be removed as a result of this scoping process. Minnesota citizens want SA-04 and SA-03 (no spur) included, so do *not* remove them.
4. Section 1.4 of the DSDD describes the procedural history but doesn't mention the bidding process used to hire Cardno. Cardno has a working relationship with Enbridge, which makes it seem likely they will be biased toward Enbridge's preferred route. Minnesota citizens will insist on more transparency in the bidding process for this job.
5. Section 3.1.2.1 of the DSDD states that "the purpose of the project is to transport growing crude oil production. . ." but Bakken oil production is not growing. Fix the project purpose to reflect reality. Minnesota citizens will insist that the project purpose is strong enough — and truthful — to warrant this immense, land-altering project.
6. Section 3.1.2.2 of the DSDD states that "DOC-EERA will assess reasonableness . . . [for] overall state energy needs . . ."

   But the oil is not coming to Minnesota exclusively, and we are currently getting our needs met without the Sandpiper pipeline. Furthermore, if it's determined that the train option continues to be the best way to get oil from the Bakken to market, then we must focus on making the trains safe.

   Choosing the train option won't leave us with abandoned pipelines when the Bakken is used up, which will happen in our grandchildren's lifetimes — and which begs the question, what will those future generations use for oil if we choose to take it all for ourselves, rather than transition to greener energy and reasonably ration what oil is left? The decision you are making is long-ranging and complex, and has consequences for future generations that you *must* take into consideration.
7. Section 4.4 of the DSDD states that "Potential social, environmental, and economic effects of the proposed project have been identified and described in the Scoping EAW." This is not true. Please identify and describe the potential social, environmental, and economic effects of the proposed project in this section.
8. Section 4.4.3.5 of the DSDD discusses Recreation and Tourism. Be sure to include the Big Sandy Lake area in Aitkin County in this section.
9. Section 4.4.8 of the DSDD discusses High Consequence Areas (HCAs) — Enbridge's preferred route passes through many HCAs, due to the abundance of ecological resources that are unusually sensitive to environmental damage. The

U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration's (PHMSA) Final Report of their Leak Detection Study states that if a spill occurs in an HCA, remediation takes an extremely long time, and costs of remediation are at least two to three times higher than in non-HCA areas. Please include this information when comparing the preferred route to system alternative routes.

The report states that there have been 201 major incidents in an HCA or with volumes over 1,000 gallons related to liquid leaks in the U.S. over the last ten years. The "average" pipeline therefore has a 57% probability of experiencing a major leak, with consequences over the $1 million range, in a ten-year period.

1. In Section 4.5 of the DSDD, include information about leak detection systems.

   Enbridge says on their website, "We invest heavily in leading-edge tools and technologies to ensure our system is safe." In reality, the technology is not up to the task, according to the. The study found that crude oil and hazardous liquid pipelines spilled more volume over the 30 month period than refined product pipelines, and goes into detail about the questionable track record of leak detection systems.

   Many major spills have gone undetected by systems that can't always distinguish between normal fluctuations and leaks. Last year in Alberta Canada a massive oil spill went undetected by Nexen's leak detection system in a one-year-old pipeline. In March 2016, a Keystone pipeline spill was not detected by technology. In fact, more oil spills are discovered by citizens than by leak detection systems, yet Enbridge continues to overstate the dependability of leak detection systems.

   New leak detection technologies include acoustic sensors, infrared imaging, and fiber-optic cables, which sound impressive. However, a study commissioned by the PHMSA found that most pipeline operators are reticent to upgrade to these new systems, fearing higher costs and false alarms. One way to possibly smooth public acceptance of a crude oil pipeline through the waters of northern Minnesota would be to require that Enbridge have the most robust leak detection systems in place — but this would raise the cost to a point where the project isn't profitable. In other words, if the Enbridge's route is approved, Minnesota waters will be put at an avoidable risk to ensure profitability for Enbridge.

   According to a study by TechSci Research, the global oil and gas pipeline leak detection industry is expected to surpass $1.8 billion in the next five years. This is in part due to the increase in oil and gas leaks over the past few years. Houston Public Media reported that, in Texas alone, the frequency of leaks, fires and other hazardous events has more than doubled since 1995. Research shows that weather, age and corrosion are all common causes of leaks. The pipelines in Enbridge's preferred route will weather, age, and corrode in time, into our most vulnerable wetlands, which drain into the Mississippi.
2. In Section 4.6 of the DSDD, include information from the National Academies of Science report, "Spills of Diluted Bitumen from Pipelines. "

   The report states, "protection of water supplies is a focus of spill response activities. …[and] weathered diluted bitumen has a greater potential to submerge or sink, presenting a greater potential for chronic contamination of a water supply that may result in a long closure time for drinking water sources. Another serious outcome in the case of incomplete removal of sunken weathered bitumen could be a longer lasting impairment of a surface-water source of drinking water. …Diluted bitumen spills in the environment pose particular challenges when they reach water bodies."

   The report also states, "Until there is more research targeting diluted bitumen, the acute, chronic, sublethal and longer-term toxicities of diluted bitumen relative to conventional crude oils will be poorly known." And this: "Cleanup of land spills is usually completed in weeks to months. When groundwaters are contaminated, cleanup is far more challenging and can extend over decades of time, with associated high costs."

   The Minnesota DOC *cannot* ignore this study when determining the safety of a crude oil pipeline built upstream from millions of people who depend on the Mississippi River for their drinking water, and who are becoming more aware of what's in it.
3. Include Enbridge's plans for restoring uniquely northern Minnesota situations along the proposed route, such as pipeline construction and oil spills in natural wild rice beds. Also, address the potential social impacts of a ruined wild rice bed to indigenous people.
4. When comparing routes, refer to the maps created by Friends of the Headwaters (friendsoftheheadwaters.org),

showing how Enbridge's preferred pipeline route bisects areas with the most clear lakes, the most wild rice beds, the most permeable soils, and the most wetlands in Minnesota.

5. Address which Minnesota state legislation is in place to protect our land and water from spills and accidents.

   In particular, address laws pertaining to pipeline abandonment. If there are none, then the Enbridge plan to "decommission" Line 3 must be studied for possible impacts.

   Enbridge claims in bold letters on their website, "When we decommission a pipeline, we continue to look after it. Landowners are not responsible for Enbridge's decommissioned pipelines—we are. Forever." This last statement is patently ridiculous, and suggests that Enbridge doesn't take its responsibility seriously, calling into question how seriously they take *any* of Minnesota's environmental concerns. Please don't trust them to tell you the truth, in other words; they are known to be quite biased to get what they want.

6. Include a history of pipeline spills in Minnesota.

   Oil spills of over 3200 barrels occurred in Minnesota in 2002, 2006, 2007, 2009, and 2010. Three of these were Enbridge pipelines, yet they publicly claim they have operated safely in Minnesota for 65 years. This in not only untrue, it ignores the fact that on November 28, 2007, two pipeline workers were *killed* after a large fire erupted while they were repairing a leak in an Enbridge pipeline. If this is Enbridge's idea of safety, it's further proof that they can't be trusted to do the right thing for our water.

7. Use realistic job data.

   Please get data from the Minnesota Dept. of Employment and Economic Development to compare jobs created during Sandpiper construction with similar jobs available in the green energy sector. If Minnesota laborers are able to find permanent jobs in green energy rather than temporary jobs in pipeline construction, the state doesn't need the pipeline construction jobs.

8. Make sure that the EIS defers to MEPA law.

Minnesota citizens will not accept an EIS that ignores the input of the MN DNR and Minnesota Pollution Control Agency, that ignores the research and concerns of some very capable, competent citizens who have spoken at the hearings, or that fails to consider the alternative system routes SA-04 and SA-03 (no spur). Do an honorable job, worthy of the state of Minnesota, so we can stop revisiting this. Thank you.

Janet Hill
50569 218th Place
McGregor, MN 55760

From:	Bobby Hinson
To:	*COMM_Pipeline Comments
Subject:	Scoping EIS comment for Sandpiper (13-473 & 13-474) and Line 3 Replacement (14-916 & 15-137)
Date:	Friday, May 06, 2016 8:50:06 AM

Dear Ms. MacAlister,

I am a union member and I am urging you to pass the proposed Enbridge Line expansion path.

Sincerely,

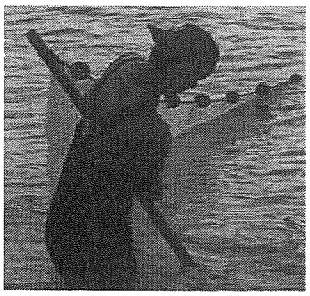
Bobby Hinson
514 Switzerland Rd
Hohenwald, TN 38462

TREATY RIGHTS AND OIL PIPELINES:
What You Need To Know

Follow us on facebook:
@Winona LaDuke Honor the Earth

WWW.HONOREARTH.ORG

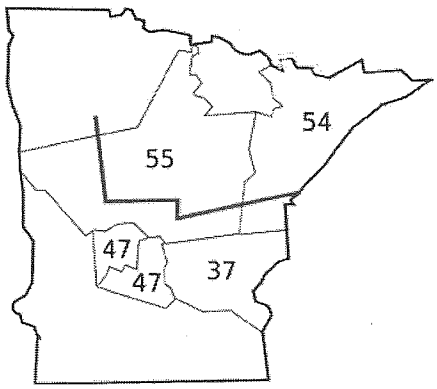
SUMMARY:
Even on ceded territory (off-reservation), Ojibwe tribal members retain certain property rights that allow them to "make a modest living from the land." These use-rights are called usufructuary rights, and are guaranteed by the treaties between Ojibwe bands and the US government, protected by the US Constitution, and affirmed by the US Supreme Court. They include the rights to hunt, fish, gather medicinal plants, harvest and cultivate wild rice, and preserve sacred or culturally significant sites.



The proposed new oil pipelines in northern MN violate the treaty rights of the Anishinaabeg by endangering critical natural resources in the 1854, 1855, and 1867 treaty areas. All pipelines leak, and catastrophes like Enbridge's 1 million gallon spill in 2010 on the Kalamazoo River are not unlikely. The pipelines threaten the culture, way of life, and physical survival of the Ojibwe people. Where there is wild rice, there are Anishinaabeg, and where there are Anishinaabeg, there is wild rice. It is our sacred food. Without it we will die. It's that simple.

HISTORY:

• **1837 White Pine Treaty** (aka Treaty of St. Peters) – July 29, 1837 at Fort Snelling.
The Ojibwe nations ceded to the US a large tract of modern-day MN and WI (east of the Mississippi River and south of Lake Superior). The purpose was to exploit the region's lumber resources, especially giant white pines, for use in the construction boom across the country. The United States bought millions of acres for about $24,000. In turn, Article 5 granted the signatory Ojibwe bands usufructuary rights to hunt, fish and gather within the ceded territory. An Ojibwe chief from Leech Lake known as Eshkibagikoonzhe (Flat Mouth) demanded that his people retain the right to "get their living from the lakes and rivers" because "we cannot live, deprived of our lakes and rivers."



• **1855 Treaty with the Chippewa** – February 22, 1855 in Washington DC.
The Ojibwe ceded 10 million acres of northern Minnesota lake country, including the headwaters of the Mississippi River, and the US government established 9 small reservations.

• **The Voigt Decision (1983)** - In the 1970s, the Lac Court Orielles Band of Ojibwe challenged Wisconsin's efforts to regulate their hunting and fishing off-reservation. The conflict started when 2 Ojibwe men were arrested for harvesting fish with spears, and charged with poaching. In 1983, the US 7th Circuit Court of Appeals delivered the "Voigt Decision" in *LCO Band of Chippewa Indians v. Lester P. Voigt, et al*, affirming Ojibwe rights to hunt and fish anywhere on ceded territory, even on privately owned land. Over the next 8 years, which were marked by civil unrest and racial conflict as white sport fishermen protested tribal members' exercising of treaty rights, the US District Court rejected repeated appeals by the State of Wisconsin. The US Supreme Court refused to hear the case, and the Voigt decision still stands today.

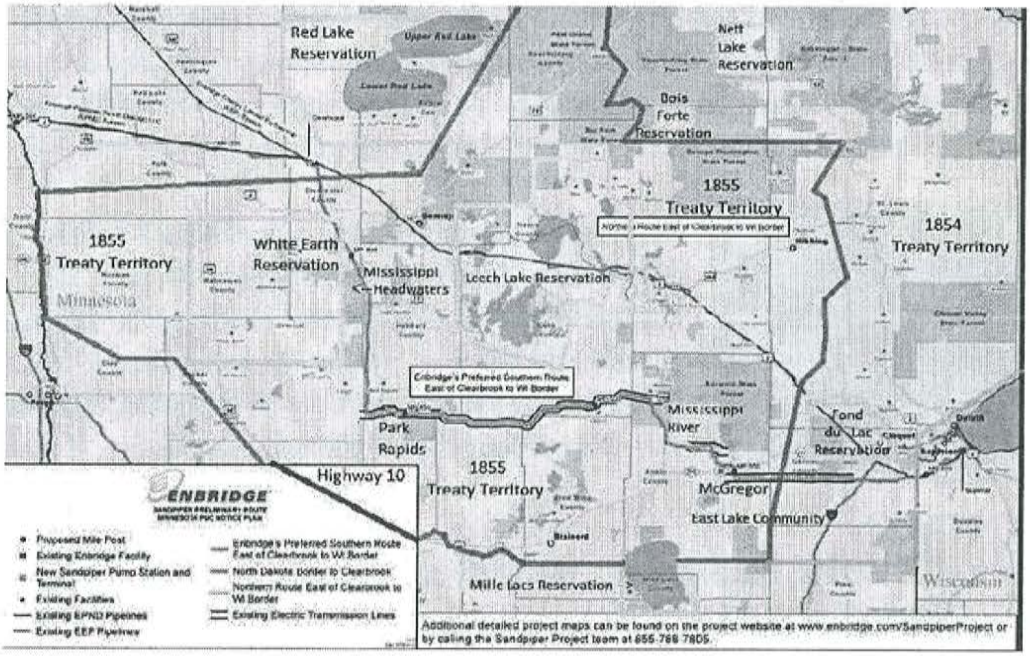
HONOR THE EARTH PO Box 63 • Callaway, MN 56521 • 218-375-3200 • info@honorearth.org

• 1999 Supreme Court Decision - Minnesota v. Mille Lacs Band of Chippewa Indians

This is the landmark decision. During the 70s and 80s, Ojibwe tribal members in Minnesota were repeatedly arrested and harassed for asserting their fishing rights. This led to a series of protracted legal battles, culminating in the 1999 U.S. Supreme Court decision *Minnesota v. Mille Lacs*. The Court ruled that the Ojibwe retained hunting, fishing, and gathering rights on the lands it had ceded to the federal government in the 1837 White Pine Treaty and that the state governments of MI, MN, and WI, had unfairly asserted authority of hunting and fishing rights without regard for treaty rights guaranteed to the Ojibwe before those states were even formed. The Court also concluded that the same protections survived in the 1855 Treaty, even though it did not explicitly outline usufructuary rights, because the Chippewa delegates that signed it clearly did not believe they were relinquishing such rights.

• 2015 Squarehook case

Operation Squarehook was a large multi-year state and federal investigation into black market walleye. On Feb. 10, 2015, the 8th Circuit U.S. Court of Appeals ruled that the federal government could not prosecute 4 Ojibwe men for netting walleye on Leech Lake Reservation and selling them. This upheld the 2013 US District Court decision to toss the cases. The men were accused of selling hundreds of thousands of dollars' worth of netted fish and charged with wildlife trafficking under the Lacey Act. The court upheld the rights guaranteed by the 1837 White Pine Treaty as the same rights the signatory Chiefs would have understood in 1855, even though the 1855 treaty did not directly apply because the Leech Lake Reservation did not exist yet. In its decision, the court repeatedly referenced the Supreme Court's landmark 1999 Mille Lacs decision. It effectively ended Operation Squarehook.



TRIBAL INTERVENTION AGAINST THE SANDPIPER/LINE 3 CORRIDOR:

Tribal nations have federally protected property rights in the treaty areas, yet have not even been consulted about the Sandpiper/Line 3 corridor. The PUC bluntly denied requests for public hearings on the reservations. So in June 2015, the White Earth and Mille Lacs Bands each held their own public hearings to document public sentiment and expert testimony on potential impacts. The bands also wrote letters to the PUC asking for a stay on the permitting process until tribes could be property consulted, and letters to Governor Mark Dayton asking him to fulfill his responsibilities for cooperation with tribal governments as outlined in Executive Order 13-10. Approval of this pipeline corridor is a declaration of war against the Anishinaabeg, a slap in the face of tribal governments, and a threat to the precious fresh water of Minnesota. Tribal governments are now exploring options for intervention at the federal level and expect a long and protracted legal and regulatory battle over the coming years.

LOVE WATER NOT OIL

VISIT OUR WEBSITE FOR RESOURCES AND WAYS TO TAKE ACTION TODAY!

WWW.HONOREARTH.ORG

Follow us on facebook:
@Winona LaDuke Honor the Earth

HONOR THE EARTH PO Box 63 • Callaway, MN 56521 • 218-375-3200 • info@honorearth.org

THE CASE AGAINST MARATHON

Withdraw from the Sandpiper Pipeline!

HONOR THE EARTH

Follow us on facebook:
@Winona LaDuke Honor the Earth

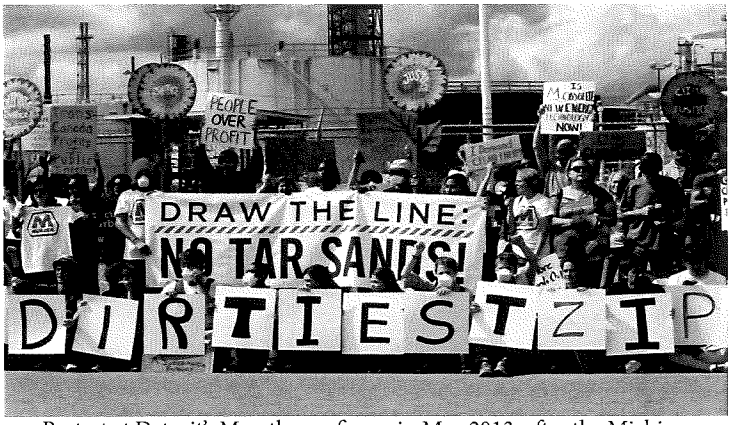
WWW.HONOREARTH.ORG

BACKGROUND:

The proposed Sandpiper pipeline is a joint venture between Enbridge Energy and Marathon Petroleum Corporation. Marathon is the "anchor shipper" that makes the project economically viable by committing to use the pipeline to transport oil they extract in North Dakota. Marathon plans to pay 37.5% of the Sandpiper's construction costs in exchange for a 27% ownership interest in the project. The MN PUC issued a Certificate of Need for the Sandpiper based on Marathon's interest and "need." But Marathon doesn't need this pipeline. None of us need this pipeline. It's time for Marathon to witrhdraw from the Sandpiper because it is a losing project - financially, and for all of us.

RISKY BUSINESS FOR MARATHON:

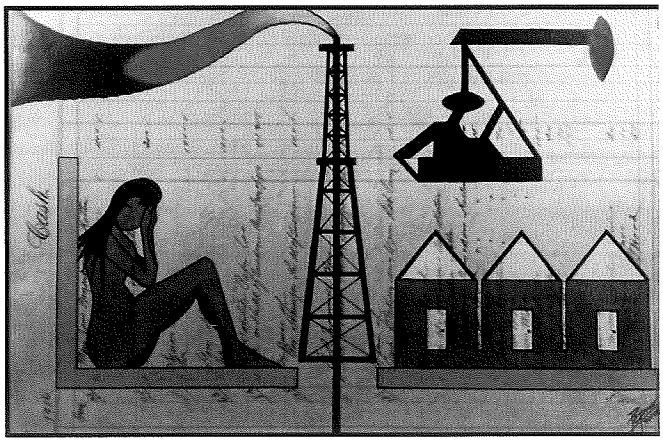
Marathon should withdraw from the Sandpiper because it is financially disastrous for them. With oil prices remaining at historic lows, Bakken drillers are going bankrupt. There were only 29 active rigs in April 2016, down from over 220 just a few years ago. Marathon recently had 7 active rigs in the Bakken, but as of April 2016, they have ZERO. Continued delays on the Sandpiper/Line 3 corridor are increasing project costs, and Minnesota's regulatory agencies are still debating how to proceed. It is not clear that the project will move forward. And Marathon is not in a position to make mistakes. Marathon Petroleum Corporation's stock prices have dropped more than 50% from recent highs in 2015. Marathon Oil Corporation, the sister subsidiary that does all the drilling, saw their prices drop more than 75% from recent highs. Last year they posted $2.2 billion in losses, cut their capital investments in half, and laid off over 10% of their employees.



Protest at Detroit's Marathon refinery in May 2013, after the Michigan OSHA announced it was giving Marathon a safety award, one week after the refinery had an explosion. (Photo by Emma Lockridge)

A "WELLS TO WHEELS" VIEW OF IMPACT:

Infrastructure impact analysis should start at the oil well and finish at the gas tank. Marathon has been one of the major drillers in the Bakken, in Mandan, Hidatsa, and Arikara territory. Their wells are located mostly around the sacred waters of Lake Sakakawea, on and near the Ft. Berthold Reservation. This is "fracked" oil, extracted by blasting millions of gallons of water and a slurry of toxic chemicals deep into the bedrock of Mother Earth. It's "Extreme Extraction," proven to cause earthquakes and poison aquifers, and has been banned outright in a long list of cities, states, provinces, and countries around the world. Our relatives in the Three Affiliated Tribes are facing epidemics of health problems, drug and sex trafficking, violent crime, and traffic deaths. Oil companies should be responsible for the damages their extraction causes to our communiites. Marathon is responsible for the major diesel spill on the Wabash River in April 2016 - not a drop of the 50,000 gallons was recovered. Marathon also operates a refinery in Detroit that is poisoning the surrounding neighborhoods. The refinery processes tar sands oil, one of the dirtiest fuels on the planet, and its emissions are causing serious health problems in the African-American neighborhood of Boynton (see reverse for details).



"Woman Lost in Man Camp," John Isaiah Pepion.

HONOR THE EARTH PO Box 63 • Callaway, MN 56521 • 218-375-3200 • info@honorearth.org

TAKING ACTION:

As our opposition to the Sandpiper continues to grow, we ask you to join us in calling on Marathon to withdraw from the project. The Mille Lacs Band of Ojibwe has terminated the leases at all 3 of its Marathon gas stations. And we are contacting Marathon station owners in MN and asking them to switch to a more responsible alternative that supports the local economy and avoids these blatant human rights violations.

Marathon should not poison the people of Boynton at their Detroit refinery. They should buy those people out. Marathon should not be fracking in the Bakken. And they should not push that volatile Bakken crude oil throgh our territory and through the Great Lakes. The Sandpiper would be too destructive to our water, our wild rice, our climate, and our way of life as Anishinaabe. We have enough fossil fuel infrastructure, and it is time to transition to a new economy.

WHAT YOU CAN DO:

1. Contact Marathon and ask them to withdraw from the proposed Sandpiper pipeline project:
   Gary Heminger, CEO, Marathon Petroleum Corporation, 539 South Main St., Findlay, OH 45840
2. Help us tell people the truth about Marathon's projects - share our literature and images broadly.
3. Support our work by donating thru our website, or signing up for a monthly contribution.

ENVIRONMENTAL INJUSTICE IN DETROIT

The Marathon refinery in Detroit is located in zip code 48217, the most polluted in the state, where the MI Department of Health has documented consistently elevated rates of cancer, respiratory disease, and kidney failure. Emma Lockridge, a nearby resident, says "We don't live next to the refinery, we live IN the refinery...it is just horrific. We are a sick community." When the refinery switched from conventional oil to tar sands, Marathon bought the homes of about 200 people in the mostly white neighborhood of Oakwood Heights, which is not even directly in the prevailing path of emissions, as the mostly black neighborhood of Boynton is. They've left the black folks in Boynton there to suffer, consistently denying their requests for buyouts and emergency evacuation. Lockridge, a leader in the resistance movement, says: "There's 10 empty houses on my block...people don't even want the houses. We can't even get squatters." She says the message from Marathon and state regulators is clear: "Walk away or die...at the end of the day, they're killing us." Marathon is now applying for permits to increase emissions even more, in order to produce cleaner-burning vehicle fuel as required by new federal standards. In other words, this neighborhood is being further sacrificed in order to reduce pollution elsewhere. The MI Department of Environmental Quality says it is "poised to approve the project," despite a threatened lawsuit from Detroit Mayor Mike Duggan and a a statement from a coalition of state senators calling on them to reject it, comparing the situation to the poisoned water crisis in Flint. Residents filed a class-action lawsuit against Marathon in US District Court on February 23, 2016.

Emma Lockridge, neigborhood resident and activist demanding a buyout from Marathon in order to evacuate the Detroit refinery area.

LOVE WATER NOT OIL

VISIT OUR WEBSITE FOR RESOURCES AND WAYS TO TAKE ACTION TODAY!

WWW.HONOREARTH.ORG

Follow us on facebook:
@Winona LaDuke Honor the Earth

HONOR THE EARTH PO Box 63 • Callaway, MN 56521 • 218-375-3200 • info@honorearth.org

LINE 3 PIPELINE ABANDONMENT:
What You Need To Know

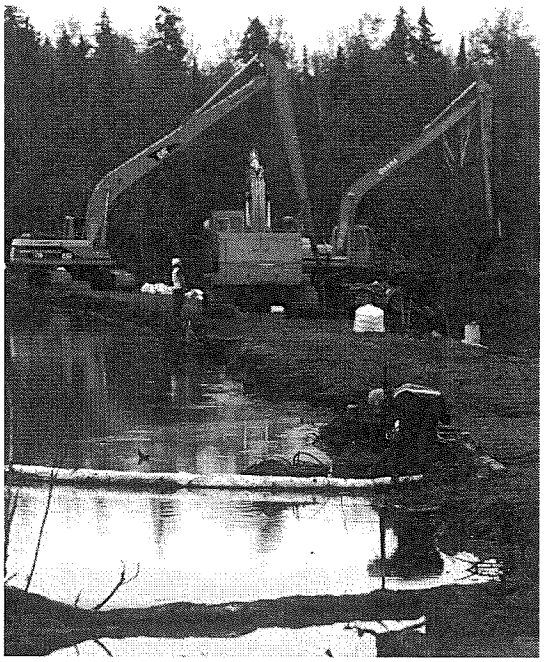
HONOR THE EARTH

Follow us on facebook:
@Winona LaDuke Honor the Earth

WWW.HONOREARTH.ORG

SUMMARY:
Enbridge's Line 3 Pipeline ships Tar Sands crude from Alberta to Superior, WI, spanning over 300 miles across Northern Minnesota, crossing the Red Lake, Leech Lake and Fond du Lac reservations and the 1855 and 1842 treaty areas. Line 3 was built in 1961 and now has significant structural integrity problems. Enbridge's latest public estimates indicate over 900 integrity "anomalies" in the pipeline. Instead of fixing it or removing it, they want simply to abandon the pipeline and build a new one, the Line 3 Replacement, in the Sandpiper corridor. The State of Minnesota has absolutely no regulatory guidelines for pipeline abandonment. Although Enbridge receives powers of eminent domain to build its pipelines, they are not required to assume any responsibility for them when they die. They are allowed to leave behind what is likely a superfund site. Tribal members, homeowners, local businesses, and people across the north are standing up to say no, and demand a state ordinance and regulatory process, as well as an insurance requirement.

DEATH OF A PIPELINE:
Enbridge has gathered extensive integrity data on Line 3 throughout its operation. The data shows a high number of integrity anomalies – specifically, corrosion and long seam cracking. As a result of these anomalies, Line 3 has experienced a number of failures during its 54 years of history. As a result, Line 3 requires a high level of integrity monitoring and an extensive on-going integrity dig and repair program to maintain safe operation. Approximately 4,000 integrity digs in the US alone are currently forecasted for Line 3 over the next 15 years, just to maintain its current level of operation. This would result in repeated impacts to landowners and the environment.



REGULATORY FAILURE (AGAIN):
At the state level, there are no abandonment guidelines or definitions for intrastate gas, liquids, or oil pipelines. Any mention of abandonment of pipeline procedures follows the federal guidelines for disconnecting from active gas service and purging of any hazardous substance. If Enbridge is not required to remove the pipeline and restore the damaged ecosystems, there may never be a full accounting of the on-going and future contamination surrounding the pipeline. All those "structural anomalies" mean there is likely a lot of oil in the soil now. This contamination would become the responsibility of nearby landowners, if discovered.

PIPELINE ABANDONMENT IN CANADA:
The US has vague and inadequate laws on pipeline abandonment, but the Canadian Energy Board has a pipeline abandonment guidance document. It includes info on pipeline corrossion and soil subsidence, reccommending any pipeline owner/operator considering the abandonment of a pipeline to conduct a professional, site-specific analysis to evaluate potential impact. Potential sources of soil and groundwater contamination include:

- substances produced in the reservoir and deposited on the walls of the pipeline;
- treatment chemicals in the pipeline;
- the line pipe and associated facilities;
- pipeline coatings and their degradation products;

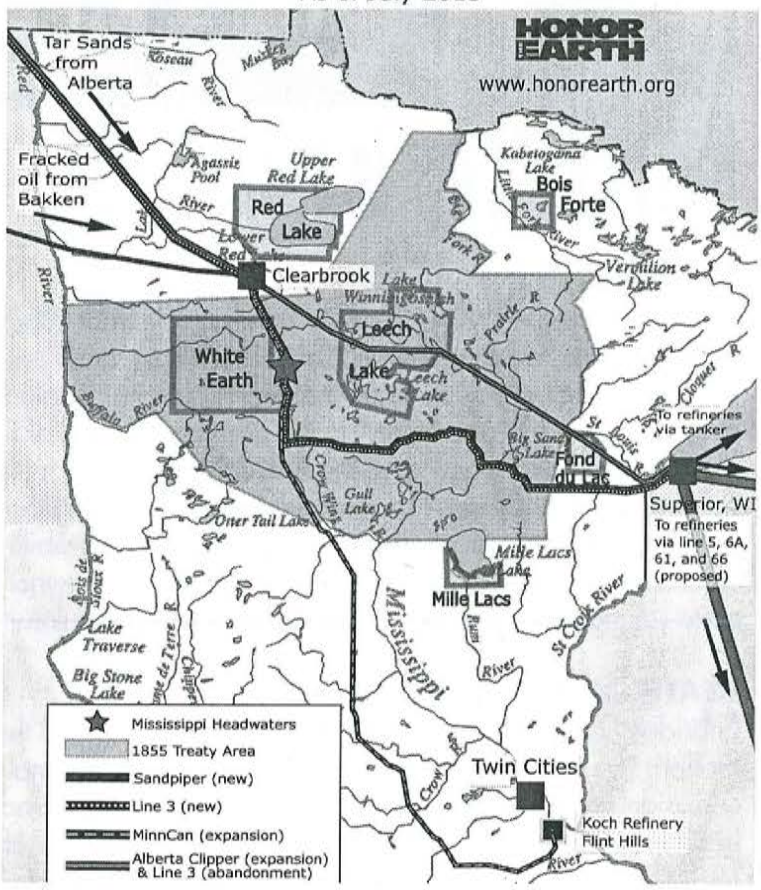
HONOR THE EARTH PO Box 63 • Callaway, MN 56521 • 218-375-3200 • info@honorearth.org

- historical leaks and spills;
- possible PCB contamination, from lubricants.

The document also discusses the enormous hydrological impact of abandoning a pipeline, which can transform over time into water conduits. Eventually, corrosion allows water to enter the pipe, which leads to unnatural drainage of areas such as muskegs, sloughs, or marshes, affecting the natural balance of the ecosystem and increasing the risk of soil and water contamination, especially in wetlands. Any water that infiltrates the pipeline is likely to carry residual contaminants left in the abandoned pipeline as it flows.

MINNESOTA OIL PIPELINE PROPOSALS

As of July 2015



PUBLIC HEARINGS ON LINE 3:

There is no regulatory process for the proposed abandonment of Line 3, so the public should voice their concerns at the MN Public Utilities Commission's public hearings on the new Line 3 construction permit, and recorded in that docket. Public hearings will be held in August 11-26, in 11 different towns across Northern Minnesota. See our website for details (honorearth.org/events) or the PUC website (mn.gov/puc). The Certificate of Need docket is CN-14-916 and the Route Permit docket is PPL-15-137. Comments are accepted through September 30, 2015. Always Include docket numbers! There are 4 ways to submit:

1. Online: mn.gov/commerce/energyfacilities/#comment
2. Email to jamie.macalister@state.mn.us
3. Fax to 651-539-0109
4. mail to: Jamie MacAlister, Environmental Review Manager, Minnesota Department of Commerce
   85 7th Place East, Suite 500, St. Paul MN 55101

Tribal governments, environmental organizations, and citizens continue to intervene in the Sandpiper/Line 3 corridor. We expect federal intervention and a protracted legal and regulatory battle over the coming years.

OTHER WAYS TO TAKE ACTION:

1. Stay informed. Follow us on facebook + our website, come to our events this summer, contact us.
2. Speak out: Contact your tribal leaders, your City Councilmembers, County Commissioners, and especially Governor Mark Dayton (651-201-3400). Tell them they have a responsibility to protect Minnesota's precious resources, honor our treaties, and work with tribal governments.
3. Connect with your local environmental groups or faith communities.
4. Support our work by donating thru our website,, or signing up for a monthly contribution.

LOVE WATER NOT OIL

VISIT OUR WEBSITE FOR RESOURCES AND WAYS TO TAKE ACTION TODAY!

WWW.HONOREARTH.ORG

Follow us on facebook: @Winona LaDuke Honor the Earth

HONOR THE EARTH PO Box 63 • Callaway, MN 56521 • 218-375-3200 • info@honorearth.org

STOP THE ENBRIDGE ENERGY CORRIDOR!

Join thousands of tribal members, homeowners, farmers, townships, businesses, and citizen groups opposing an oil superhighway across the northland. Love Water Not Oil!

Follow us on facebook:
@Winona Laduke Honor the Earth

HONOREARTH.ORG

BACKGROUND:

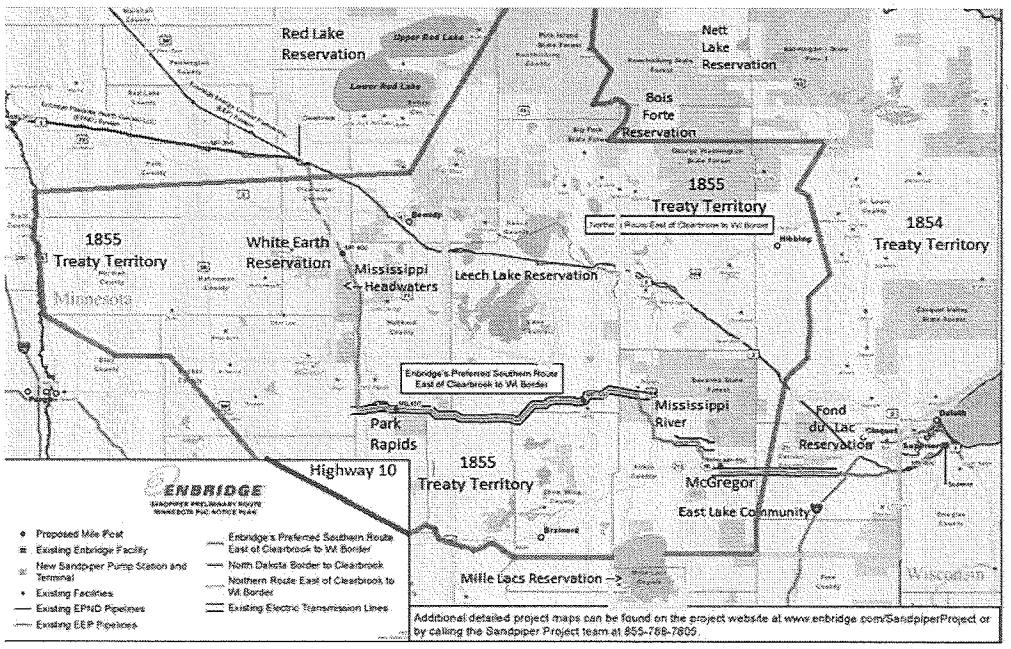
The development of new fossil fuel infrastructure is accelerating in Minnesota. We are becoming a superhighway for oil that we neither produce or consume, yet we take all the risk. Enbridge, a Canadian corporation, is proposing to transport 1.4 million barrels of oil per day through a new southern route, from the North Dakota border to Superior, WI. This is a dramatic increase from the original Sandpiper proposal of 375,000 bpd. To put this in context, this is more than triple the current capacity of the Alberta Clipper pipeline (450,000 bpd) and almost double the capacity of the proposed Keystone XL pipeline (830,000 bpd).

THE PIPELINES:

- **Sandpiper:** This new pipeline would carry highly volatile Bakken Crude oil, at an initial capacity of 375,000 barrels per day, with the potential to increase to 640,000 bpd.
- **Line 3 Replacement:** Enbridge is proposing to build the replacement of Line 3 along the same corridor as the Sandpiper, and abandon the old, rusted Line 3 pipeline, with unkown consequences. The new line would move up to 760,000 bpd of dirty Alberta Tar Sands oil.

THE ROUTE:

The proposed route crosses through some of the most delicate soils, aquifers and pristine lakes in northern Minnesota, the watersheds of Rice Lake , the Mississippi Headwaters, Crow Wing, Big Sandy Lake, Rice Lake Refuge and into Superior.



THE PROBLEMS:

- **Inevitable Spills:**

Enbridge has promised that safety will be of the upmost concern, but their history suggests otherwise. They have had over 800 spills in the last 15 years, including the largest inland oil spill in US history (1.2 million gallons) on the Kalamazoo River in 2010. In late December 2014, an Enbridge line leaked in Canada, spilling 57,000 gallons of oil in a few minutes. On Jan 2, 2015, tanks exploded at its offices

HONOR THE EARTH PO Box 63 • Callaway, MN 56521 • 218-375-3200 • info@honorearth.org

in Williston, ND. In the last 2 years, over 300 pipeline spills went unreported in North Dakota alone! A full rupture of the Sandpiper would release over 20,000 gallons of oil per minute, making million-gallon spills entirely possible. Smaller spills are harder to detect and can last for days.

• Refusal to Respond Appropriately:
In the past MN legislative session, Enbridge lobbied agressively against legislation that would improve disaster response, and refused to agree with many reasonable measures that would improve preparedness, prevention, containment, and cleanup.

• Treaty Rights Violations:
The US government has a responsibility under federal law to honor the rights guaranteed to tribal members in their treaties. The proposed pipelines would violate the treaty rights of the Anishinaabeg by endangering primary areas of hunting, fishing, wild rice harvest, medicinal plant harvest, and organically certified wild rice crops outlined in the 1867, 1855 and 1854 treaty areas. The US Supreme Court has upheld the rights of native peoples to hunt, fish, and subsist off the land. An important February 2015 decision by the US 8th Circuit Court of Appeals upheld the rights of Ojibwe people to hunt and sell fish in the 1855 treaty area. These pipelines threaten the culture, way of life, and physical survival of the Ojibwe people.

• Property Rights and Insurance:
On June 5, 2015, the MN Public Utilities Commission granted Enbridge a Certificate of Need for the Sandpiper pipeline, which gives the company eminent domain, on grounds that it is a public utility providing a public benefit. This allows them to take property without landowner consent. This is a problem: Enbridge is a private Canadian corporation that will earn billions in profit by carrying privately owned oil for privately owned oil-companies. Enbridge is now suing North Dakota family James and Krista Botsford for their land, and the case may set precedent. The Botsfords found that no insurance company would insure their farm in case of a spill, and that is after an Enbridge cleanup.

GET INVOLVED:

This battle is just getting started!! The next phase of the PUC process is the route permit, and an alliance of tribes, landowners, and citizen groups are working to at least push the route south of the lake country. Meanwhile, our resistance is building and the tribes are asserting their political power, preparing for legal and regulatory interventions at the federal level. Here's how you can get involved:

1. Stay informed. Follow us on facebook + our website, come to our events this summer, contact us.
2. Speak out: Contact your tribal leaders, your City Councilmembers, County Commissioners, and especially Governor Mark Dayton (651-201-3400). Tell them they have a responsibility to protect Minnesota's precious resources, honor our treaties, and work with tribal governments.
3. Connect with your local environmental groups or faith communities.
4. Support our work by donating thru our website,, or signing up for a monthly contribution.

LOVE WATER NOT OIL

Visit our website for articles, videos, and resources to stay informed and organize:

HONOREARTH.ORG

Follow us on facebook:
@Winona Laduke Honor the Earth

HONOR THE EARTH PO Box 63 • Callaway, MN 56521 • 218-375-3200 • info@honorearth.org

THE CLIMATE COSTS OF ENBRIDGE OIL PIPELINES

Follow us on facebook:
@Winona LaDuke Honor the Earth

WWW.HONOREARTH.ORG

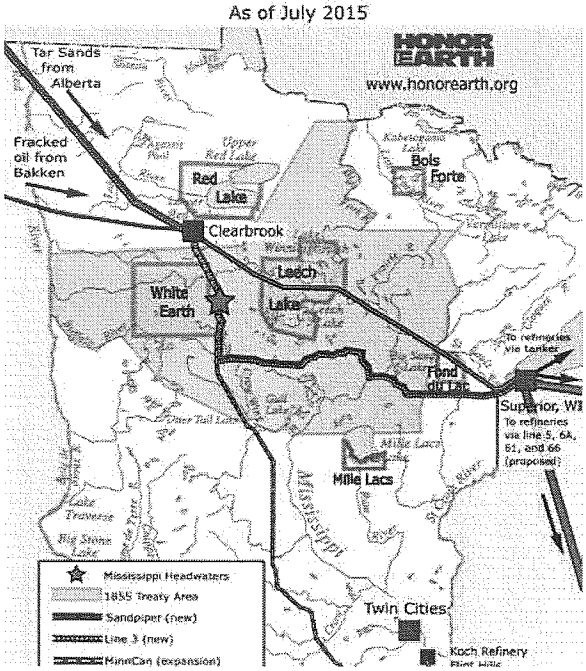
Accounting for the Climate Costs of Oil

As global leaders talk carbon capping at COP21 in Paris, Honor the Earth has prepared an invoice for the climate costs of Enbridge's proposed oil pipelines in Minnesota. Enbridge is liable for the carbon emissions their pipeline system enables. We want Enbridge to establish a fund to repair the damage they would cause with new lines and expansions.

Carbon Costs

To calculate the carbon costs of these pipelines, we take the total volume of oil moving through three pipelines - the Sandpiper, Line 3, and the Alberta Clipper - and convert that to carbon equivalents. This tells us how many metric tons of carbon will be released into the atmosphere through the refining and use of the oil. We then calculate the cost to remove that carbon. The American Physics Society estimates that removing carbon from the atmosphere costs $600 per metric ton. The total cost for these 3 pipelines would be over **$198 billion, annually!**

MINNESOTA OIL PIPELINE PROPOSALS
As of July 2015



Ecosystem costs

We also calculate costs for the loss of vital ecosystems. Our boreal forests and wetlands sequester carbon, stabilize fluctuations, and provide a buffer against climate impacts. A full carbon accounting must include the loss of these ecological services. To do that, we first calculate the land area lost to tailing ponds. Each barrel of oil creates approximately 16.9 barrels of toxic tailings.[1] We multiply this by the proposed volume in the pipelines, and convert it to hectares. We also estimate the total area of wetlands destroyed during the construction of the new corridor, which Enbridge has no plan to restore. We then place values these areas of land using estiamtes from the field of Ecosystem Services Valuation.[2] The total cost of the loss of ecosystem services for the three pipelines is over **$26 billion, annually.** Our estimates for area impacted and cost per hectare are probably both extremely low.

An Incomplete Total

Adding these costs together give us a full cost of over **$224 billion annually.** Of course, there are currently no real plans to remove the carbon or restore the forests and wetlands. So these annual costs should be set aside for future generations. Even at a conservative compound interest rate of 1%, the costs for the next seven generations (140 years) total over **$68 trillion!!** Of course, we are still far from accounting for the TRUE cost of oil. We have not included the cost of climate conflicts, natural disasters caused by extreme weather events, the loss of biodiversity, or the inevitable damages to our fresh water and sacred manoomin when (not IF) these pipelines spill. Some things simply cannot be monetized.

LOVE WATER NOT OIL

---

1 "Waste Streams of Mined Oil Sands: Characteristics and Remediation," Kasperski and Mikula, Elements, Dec 2011 vol 7 pp 387-392.

2 For boreal forest we use $160/hectare/yr (Canadian Forest Congress, http://bit.ly/1m3MuL0). For wetlands we use $5,625/acre/yr (Earth Economics, "The Value of Nature's Benefits in the St. Louis River Watershed")

HONOR THE EARTH PO Box 63 • Callaway, MN 56521 • 218-375-3200 • info@honorearth.org

~~Pine Lake~~

MINNESOTA DEPARTMENT OF COMMERCE

Comment Form: Scoping
Energy Environmental Review and Analysis

Please provide your contact information. This information and your comments will be publicly available.

Name: CHUCK HOLM Phone: 218 776-3209

Street Address: 46581 189TH AVE

City: CLEARBROOK State: MN ZIP: 56634

Email: ceholm.65@gmail.com

My comments pertain to:

- ☐ **Sandpiper Pipeline Project**
- ☐ **Line 3 Replacement Project**
- ☒ **Both Projects**

RECENTLY THE PREFERRED ROUTE FOR LINE 3 REPLACEMENT + THE SANDPIPER WAS A LOOP AROUND THE EAST SIDE OF DEEP LAKE JUST SOUTHEAST OF THE CLEARBROOK TERMINAL. NOW THE PREF ROUTE IS TO THE WEST OF DEEP LAKE. THIS IS MUCH PREFERRED BY MYSELF AND MANY LAKE AREA RESIDENTS WHO COULD NOT ATTEND TODAY.

ERRED

If including additional pages please number them and tell us how many you are providing: _____ pages

From: Mr. & Mrs. Jeffrey Hoskinson
To: *COMM_Pipeline Comments
Subject: Scoping EIS comment for Sandpiper (13-473 & 13-474) and Line 3 Replacement (14-916 & 15-137)
Date: Monday, May 23, 2016 2:30:06 PM

Dear Ms. MacAlister,

Please consider the following impacts within the scope of your EIS:

Economic benefits of pipeline construction and operation - jobs, tax revenue, generation of economic activity for local and regional businesses
"No build" alternative - reliability and security of energy supplies; increased energy transportation costs
Oil being transported by an alternative method, such as rail or truck
Route alternatives in more developed, densely populated areas
Route alternatives that are longer
Benefits of following existing rights of way
Further delays to these projects (jobs, tax revenue, business dependability)
Maintaining focus on alternatives that meet the underlying purpose of the project by delivering oil in Clearbrook

Sincerely,

jeffrey hoskinson
7445 SE Eagle Ln
Riverton, KS 66770
micara928@msn.com

From:	Harry Houser
To:	*COMM_Pipeline Comments
Subject:	Scoping EIS comment for Sandpiper (13-473 & 13-474) and Line 3 Replacement (14-916 & 15-137)
Date:	Thursday, May 12, 2016 3:30:05 PM

Dear Ms. MacAlister,

I support this project. Please help out American families and our economy buy also supporting this.
Harry H Houser

Sincerely,

Harry H Houser
15360 County Rd W
Weldona, CO 80653
weld4cash@gmail.com

Ingrid Kimball

From: Peter Hovde <hovde@cord.edu>
Sent: Tuesday, May 24, 2016 8:00 AM
To: MacAlister, Jamie (COMM)
Subject: Frost upheaval article and my comments on the Preferred Route
Attachments: Frost Heave and Pipeline Upheaval Buckling.pdf; Preferred Route comments.pdf

Follow Up Flag: Follow up
Flag Status: Completed

Categories: Purple Category

Hi Jamie MacAlister,

Very nice to meet you at the Rice Lake Community Center. I'm sorry that we arrived late for the meeting—I would have liked to hear the others' testimony—but the notification we got from the Sierra Club incorrectly stated the meeting was from 6-9pm. We really appreciated letting us bend your ear, and having the court reporter take down our concerns.

I just sent off my comments to the Pipeline.Comments email address. Since you and your staff were interested in the article on pipeline frost upheaval, both my comments and the article are attached in pdf format.

Some political intelligence. The local Enbridge representative has been gathering support from regional township board using typical Enbridge tactics. She calls the board an hour or so before the meeting to announce she will be attending (I assume to insure than no one is there to present the other side of the issue). Her case is that all the money which will flow into government coffers, and that "all" other township boards are supporting her. Our township board would not take a position, leaving it up to each resident to make up there own minds. So, when Enbridge trots out this less-than-honestly-obtained measure of support…

Thanks again for the really important work you are doing,

Peter Hovde

Comments on Sandpiper and Line 3 Replacement Routing
Peter Hovde, rural Bagley, MN

The following is part of my rationale for opposing the “Preferred Route” for the Line 3 Replacement and the Sandpiper pipelines. I’ll make just three points. In general, the closer one looks at Enbridge’s proposals, the benefits shrink, and the costs and risks multiply even more so. (Disclaimer. We do not live hear enough to the “Preferred Route” to be directly affected by it.)

Pipeline Upheaval Buckling. Frost heave of buried pipelines is of particular concern in climates with seasonably cold temperatures, such as Minnesota. An article in the *Canadian Geotechnical Journal* (attached) examines exactly those risks [Andrew C. Palmer and Peter J. Williams (2003) "Frost heave and pipeline upheaval buckling." *Canadian Geotechnical Journal*. 40: 1033-1038]. Just a sampling of problems: Upheaval buckling is a well-known phenomenon in buried pipelines: it can lead to large upward movements of a segment of the pipeline. As the pipeline arches upward, the top wall of the pipeline radically thins, making fracture much more likely.

Stresses in pipelines due to frost heave occur because of the differences in the amount and rate of frost upheaval. When the pipeline passes from sandy ground (which shows little frost heave) to silty ground (which commonly shows significant heave) and freezing occurs, the pipe will be lifted in the silty segment and restrained in the sandy segment. The points of transition from one type of soil to another are of particular concern. Freely available ground water is also highly conducive to frost heave as water expands as it turns to ice. When the water seasonably melts, the pipeline often does not go back to it original state, but keeps the bend, which will likely increase even further due to freeze and melt processes in subsequent years.

The photos taken by the Honor the Earth White Earth Ojibwe people riding the route of existing pipeline show pipelines emerging out of the ground from such frost heaving. The riders also reported their horses would not go near the pipeline. It is well known that animals—both domestic and wild--shy away from odors they are unused to. Petroleum leaks would cause of that equine avoidance.

With the high variability of adjacent soil types and high water content in the Itasca glacial terminal moraine—over which almost the entire length of the north-south portion of the pipeline is planned—provides a disturbingly large number of opportunities for frost heavy and upheaval buckling, and disturbingly large consequences for the area should the line rupture. The DNR has identified over 70 bodies of water through which the two proposed pipelines would pass. This mix of soils and all that water make the “Preferred Route” inherently unsuitable for pipelines, and these problems *cannot* be engineered around.

Pipeline Operations. Enbridge wants to lay the new Sandpiper pipeline of

large diameter to increase its capacity to move oil. The Sandpiper would carry lighter Bakken oil from North Dakota, the most volatile form of crude, responsible for several spectacular explosions and fires. Sandpiper would run alongside the existing Line 3 pipeline.

Embridge wants to replace that existing Line 3 pipeline with a larger diameter and greater capacity pipe. (Enbridge plans to pump nearly twice as much each day, from 390,000 barrels to 760,000 per day.) The Line 3 Replacement pipeline will mostly move heavy tar sands crude from Canada.

Tar sands diluted bitumen (or DilBit) crude is 15-20 times more acidic and 5-10 times more sulfuric than conventional crude (which can weaken the pipe). Dilbit contains abrasive sand which can erode pipes and fittings. Dilbit crude so viscous (up to 70 times more than conventional crude) it has to be mixed with liquified natural gas (a threat of fire and explosions if leaked) and heated (to 158 degrees F.) so it can move through the pipeline. Even so, pipeline pressures have to be increased to 1,440 pounds per square inch to move the Dilbit (normal crude only requires 600 psi), making any oil spill from pipeline rupture that much worse.

Unlike conventional crude which floats on water, Dilbit sinks to the bottom, making clean up difficult to impossible. When oil spills in a forested area, the oil follows the roots down into the earth, having an easier time getting into the groundwater. That oil affects not only plant respiration and nutrient uptake, but the oil in the groundwater would contaminate wells of home and cabin owners in the lake district.

Threat to Pristine Places. What I find most extraordinary about the “Preferred Route” is the willingness of Enbridge to place pipelines in close proximity two of the most pristine and precious wild places south of the BWCA, Itasca State Park and the Mississippi Headwaters and to put those places at risk of major and permanent damage.

For the above reasons, and many more, I urge the Department of Commerce to recommend a route as far away as possible from the Crown Jewel of our park system, the supposedly protected first 40 miles of the Mississippi River, and those who live in or retreat to Minnesota’s lake district.

Thank you,

Peter Hovde

Frost heave and pipeline upheaval buckling

Andrew C. Palmer and Peter J. Williams

Abstract: Frost heave of soils varies greatly with the type of soil and the moisture and thermal conditions of the ground. Consequently, the initially level trench-bottom profile of a pipeline can become uneven. Upheaval buckling is a well-known phenomenon in buried pipelines: it can lead to large upward movements of a pipeline and is caused by the interaction between the longitudinal compressive force present during operation and overbend irregularities in the profile. This paper examines the possibility that frost heave and upheaval buckling can interact adversely and threaten the security of Arctic pipelines.

Key words: Arctic, buckling, frost heave, permafrost, pipelines.

Résumé : Le soulèvement des sols dû au gel varie grandement avec le type de sol, l'humidité et les conditions thermiques du terrain. En conséquence, le profil initialement au niveau du fond de la tranchée peut devenir inégal. Le flambage par soulèvement est un phénomène bien connu dans les pipelines enfouis: il peut conduire à des soulèvements importants d'un pipeline, et est causé par l'interaction entre la force de compression longitudinale présente durant l'opération et les irrégularités de courbure dans le profil. Cet article examine la possibilité que le soulèvement dû au gel et le soulèvement dû au flambage puissent interagir défavorablement et menacer la sécurité des pipelines de l'Arctique.

Mots clés : Arctique, flambage, soulèvement dû au gel, pergélisol, pipelines.

[Traduit par la Rédaction]

Introduction

This paper describes the interaction between two well-known phenomena, frost heave and upheaval buckling, and how they might together threaten the safety of an Arctic pipeline.

When soils freeze, ice forms within the pores between the particles, often as discrete lenses. Only part of the water freezes when the temperatures falls below the freezing point of pure water, and some water remains unfrozen at much lower temperatures. Water migrates in the unfrozen soil towards the freezing front and continues to migrate within the partially frozen soil. If the surface is free to move, it heaves, because of the expansion that accompanies freezing, especially that of the water from lower unfrozen layers. If movement is partly restrained, by a foundation for instance, the force is often large enough to lift the foundation. The force required to completely prevent heave is very large. Williams and Smith (1991) give a fuller account of frost heave.

Upheaval buckling occurs in longitudinally constrained buried pipelines. It has been known for a long time in land pipelines and has been seen in Russia, Iran, the United Arab Emirates, and Canada. Figure 1 is a photograph and profile of a buckled 1020 mm (40 in.) pipeline near Tashkent in Uzbekistan (Aynbinder and Kamershtein 1982). At one time upheaval was believed not to be a problem for marine pipelines, but a well-documented case in the Danish sector of the North Sea (Nielsen et al. 1990) was followed by other cases (Breivik et al. 1990) and generated a series of research programs (Palmer et al. 1990, 1994) and much expenditure to prevent upheaval.

The driving force for upheaval is the longitudinal force induced by operation of the pipeline. That force is almost invariably compressive. Upheaval is initiated at an overbend (convex upwards) vertical curve in the pipeline profile. If the weight of the pipeline and the uplift resistance of the cover are not large enough to hold the line in place, it moves upwards. When it moves upward, the local curvature increases, and so more force would be required to maintain the pipeline in place, but the uplift resistance tends to decrease because the pipe comes closer to the surface of the cover. The pipeline becomes unstable and jumps upward to a new equilibrium position like the one seen in Fig. 1. Although the same forces are present in sagbends (convex-downward profiles), there the pipe tends to move downwards, and large movements do not occur because the resistance to downward movement increases with depth.

Many gas pipelines operate at a temperature lower than the ambient temperature, because of Joule–Thomson cooling, and conduction can therefore further lower the soil temperature around the pipeline and cause freezing and heave. Kharionovsky (1992) ascribes to frost heave the failure of a 426 mm gas pipeline. The geotechnical conditions that determine the magnitude of frost heave vary naturally along the length of a pipeline, and so some sections will move upwards more than others (Williams 1989). Even if the as-

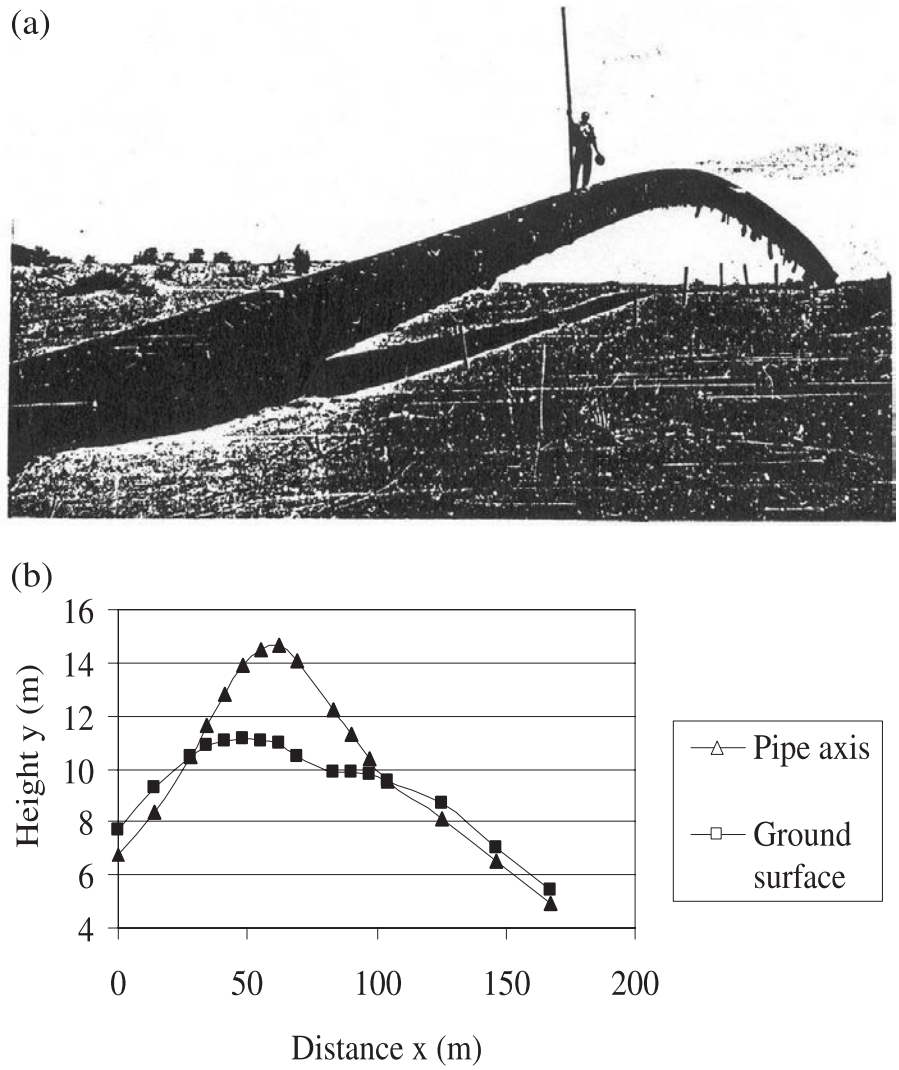
Received 31 July 2002. Accepted 9 May 2003. Published on the NRC Research Press Web site at http://cgj.nrc.ca on 8 October 2003.

A.C. Palmer.[1] University Engineering Department, Trumpington Street, Cambridge CB2 1PZ, U.K.
P.J. Williams. Geotechnical Science Laboratories, Carleton University, Colonel By Drive, Ottawa, ON K1S 5B6, Canada, and Scott Polar Research Institute, Cambridge, U.K.

[1]Corresponding author (e-mail: acp24@eng.cam.ac.uk).

 doi: 10.1139/T03-044 © 2003 NRC Canada

Fig. 1. Photograph (*a*) and ground surface and pipeline axis profiles (*b*) of pipeline upheaval near Tashkent, Uzbekistan.



constructed profile is level and straight, the heaved profile will be irregular and will have overbends. Those overbends can then produce a further uplift.

Uniform vertical movement does not affect the functioning of a pipeline, and neither does a uniform gradient, but movements that induce curvature can overstress a pipeline to a dangerous extent. The potential problem is therefore an adverse interaction between longitudinal variability of frost heave, the propensity of heave-induced overbends to initiate much larger pipeline movements as a result of the upheaval phenomenon, and the extent to which the flexural stiffness of the pipeline can moderate the movements.

The next sections of the paper discuss the magnitude of heave-induced overbends and the conditions under which they might lead to upheaval.

Heave-induced overbends

The discrete bodies of ice ("segregated ice") bigger than pore size that characterize frost-heaving soil vary greatly in form and extent (Mel'nikov and Spesitsev 2000). The accumulations follow from the thermodynamic potential established because the water and ice are confined in a fine porous matrix (Edlefsen and Andersen 1943; Defay and Prigogine 1951; Williams and Smith 1991; Rempel et al. 2001). The pressure in the unfrozen water is less than the mean compressive stress in the ice and is often negative (a tensile stress, a state of suction).

As the ice is in bodies larger than pore or grain size, it will bear the stress generated by the weight of overburden. A further component of the ice pressure is the resistance of the frozen soil to the growth of the ice body. When the temperature and the pore-water pressure (itself a function of the soil environment) are such that the ice has a pressure equal to these two stresses, the ice increases in amount, displacing (heaving) the soil.

The capillary effects resulting from the fine porous nature of soils lower the freezing point of the pore water. Progressively smaller pores become filled with ice as the temperature falls. When the ice fills a pore, there is still a layer of adsorbed film water between the ice and the mineral surfaces of the particles. The pore-size distribution, and the specific surface area of the soil, will therefore be important in determining both the amount of frost heave and the forces

© 2003 NRC Canada

associated with it. When the rate of heave is considered, the changing permeability of the soil (in the unfrozen and frozen states) is also important.

Engineering solutions to the problem of frost heave in roads, airports, and building foundations are well established. For pipelines in permafrost regions the situation is less clear. A pipeline in permafrost is liable to stresses from frost heave that develop over many years (unlike a highway, for example, where thawing in spring and summer releases stresses due to winter freezing).

The permafrost stratum may underlie virtually all of the terrain or the greater part of the terrain, or it may be represented by scattered bodies or islands of permafrost. If it is decided to operate a pipeline with the gas at a temperature below 0 °C to avoid problems of thaw settlement of the pipe, then as the temperature of the gas cannot always be finely controlled, there will inevitably be new freezing around sections of the pipe in formerly unfrozen ground. The nature of the ground and the moisture conditions define where differential frost heave is to be expected. Freely available groundwater is highly conducive to frost heave. Wherever the pipe passes from permafrost into unfrozen ground is a site of special concern.

Stresses in the pipe due to frost heave occur because of the differences in the amount and rate of frost heave. Frost heave generates forces great enough to bend even the largest diameter pipe. Pipelines are such long structures that there will obviously sometimes be abrupt changes of ground along the right-of-way (ROW), and therefore sharply differential frost heave. More difficult to assess are the innumerable changes of soil form and properties over short distances which follow from local geological and geomorphological history.

It is uncertain which forms of frost heave constitute the greatest threat to the stability of a pipeline. Several distinct situations occur:

(1) Where the pipeline passes from sandy ground (which shows little frost heave) into, say, silty ground (which commonly shows significant heave) and freezing occurs, the pipe will be lifted in the silty segment and restrained by the sand. This situation has been investigated in experimental models, and the pipe and soil displacements and stresses measured (Williams et al. 1993).

(2) Where the pipeline crosses a slope, any frost heave will usually be associated with a downslope creep movement, which may apply significant additional downslope forces transverse to the pipeline (Borodavkin 1982).

(3) Where the pipeline runs essentially downslope (even on slight slopes), the processes of frost heave, and especially the summertime thawing of the overlying layers, result in weakening of the soil, which can then be subject to erosion by running water. Under these conditions the pipe may rise, with failure of the overlying materials. The processes promote further thawing, and pipelines over permafrost are often seen to be lying in a continuously forming watercourse (Williams et al. 1998).

(4) The location of ice segregations may be important (Smith and Williams 1990, 1995). Cavities up to 10 cm in depth and 20–30 cm in length were found immediately below a pipeline that had been subjected to frost heave (Williams et al. 1998). As frost penetrates into the ground, a layer of ice forms below boulders and other buried objects. This gives rise to the "growing stones" familiar to residents in cold places. This may also occur with pipelines. Ice segregation has a localized effect, because the cavities are quite short.

(5) Temperature conditions, rather than soil conditions, can provide the conditions for differential heave. A pipe laid through discontinuous permafrost crosses many transitions between frozen ground and unfrozen ground. It has been demonstrated experimentally (Riseborough 1993; Riseborough et al. 1993) that the resistance to movement of the pipe restrained by a frozen-in section leads to development of significant pipe deformation and stress when the ground adjacent to it begins to freeze and heave.

Natural variations of soil and thermal conditions

Soils occur in an infinite variety, both in terms of the grain-size composition and the mineralogy of the components. Measurable frost heave does not occur in sands and coarser materials. At the other extreme, an ice segregation in silt or another fine-grained material may grow for a long time without any further penetration of the isotherm.

In highway construction, heave-susceptible materials are replaced. When annual freezing and thawing is the concern, only the depth affected is considered. This depth varies from a few centimetres to 3–4 m in certain conditions (Williams 1997). Pipelines are on occasion placed within this active layer. If pipelines lie within the permafrost proper, the problems are those of a continuing deformation of frozen ground, instead of the disturbances of annual freezing and thawing. This raises distinctly different problems. Relatively little is known about the ongoing heave of frozen soils, although there is ample evidence that it occurs (Smith and Patterson 1989). The permeability to water of the frozen ground appears to be a controlling factor, and little is known about this parameter. Deformation occurs slowly, but the pressures developed will tend be greater than for seasonally freezing ground.

From a practical point of view it is important to know how often and how great are the changes in frost heave properties along the ROW. Uncertainty as to the exact amount of heave to be expected for a given soil is less important than the variability of the soil and its moisture conditions. It is the transitions from one soil to another that cause the problematic differential heave, and in extreme cases they may occur every few metres. Variations in heave properties parallel variations in thaw-settlement properties, which are known to have significant effects on pipelines (Palmer 1972).

Areas of relatively uniform soils occur particularly where the topographic form is a plain. In some clays, for example, a geological origin as marine deposits explains their lack of variability. An extreme contrast is deposits laid under glaciofluvial conditions, which vary sharply, over metres or less, reflecting the depositional conditions that were constantly changing during the period of deglaciation. Those deposits may be clays, silts, or coarser materials.

© 2003 NRC Canada

The surface and near-surface materials in well-populated areas are well known and represented on soil and Quaternary geology maps. Combined with a knowledge of topography and vegetation, the engineer can plan foundations and supplement the existing data by limited sampling. In the cold regions, however, there are often large tracts where the subsurface conditions have barely been recorded, and a large amount of sampling is necessary for a long pipeline. A superficial analysis of the landscape will give some idea of the variability of the materials and thus of the frequency of situations where differential frost heave will necessitate specific design provisions. The topographic relief and the moisture conditions are important considerations already in the initial planning stages. Russian practice, deriving from experience with extensive pipeline networks in permafrost regions, involves a logical and systematic analysis of ground conditions, proceeding from initial broad surveys to the fine-detailed investigations along proposed ROWs (Yershov 1998; Williams and Warren 1999).

Thermal conditions in the near-surface layers depend on the geographic location and the meteorological conditions, but only in a general sense. Meteorological observations do not reflect the influence of microclimates related to vegetation and soil type. The mean annual temperature depends significantly on the surface cover (vegetation, snow, etc.), directional exposure and climatic and weather conditions, and the thermal properties of the ground materials themselves, because the energy exchange at the ground surface is modulated by the nature of the heat energy transfer processes involved, sensible heat transfer, evaporation condensation, and radiative exchange. Even in apparently uniform terrain, the mean annual ground temperature can vary by a degree or more over a horizontal distance of a few metres (Williams 1998).

Upheaval

The effects described previously combine to generate a significant degree of horizontal variability in the magnitude of frost heave movements. Pipeline upheaval is triggered by localized overbends in the pipeline profile. Even if the as-built profile is smooth, frost heave can make it uneven and set off upheaval. This section of the paper quantifies the movements that might be troublesome.

A pipeline can be idealized as a thin-walled cylindrical shell for almost any practical purpose. Assuming the pipeline to remain elastic and counting tensile stress as positive, the longitudinal stress in a fully constrained line is

$$[1] \qquad s_L = \frac{\nu p D}{2t} - E\alpha\theta$$

where D is the mean diameter (twice the mean radius, measured from the centre to half way through the wall), t is the wall thickness, E is Young's modulus, ν is Poisson's ratio, α is a linear thermal expansion coefficient, p is the operating pressure, and θ is the change of temperature (measured from the construction or tie-in temperature, increase positive). The longitudinal stress s_L has two components, the first related to pressure and the second to temperature. The cross-sectional area of the pipeline wall is πDt. The longitudinal force in the pipeline wall is therefore

$$[2] \qquad \pi D t s_L = \frac{1}{2}\nu\pi D^2 p - \pi D t E\alpha\theta$$

There is an additional component of longitudinal force in the pipeline contents. The cross-sectional area of the contents is $\pi D^2/4$, and the longitudinal stress in the contents is $-p$ (consistently counting tension positive), and so the longitudinal force in the contents is

$$[3] \qquad -\frac{\pi D^2}{4} p$$

The total longitudinal force is therefore

$$[4] \qquad -(1-2\nu)\frac{\pi D^2}{4} p - \pi D t E\alpha\theta$$

and has both a pressure term and a temperature term. The compressive pressure term is present because the compressive force in the contained fluid more than balances the longitudinal tensile pressure-induced component of the longitudinal force in the pipeline wall. It tells us that pressure alone can cause upheaval buckling. This is occasionally thought to be surprising, but the need to include in the analysis the force in the contained fluid is confirmed by theory, laboratory-scale experiment (Palmer and Baldry 1974), and field experience.

Equation [4] gives the resultant force in a fully constrained pipeline in which all axial movement is prevented. Expansion loops, doglegs, and snaked configurations allow some longitudinal expansion movement to occur, and the longitudinal force is then less compressive.

Consider an element of pipeline in an arbitrary profile defined by a height y (measured positive upwards from a datum) which is a function of horizontal distance x. In Fig. 2, P is the longitudinal force (now compressive positive, in contrast to the tension-positive convention applied earlier), S is the shear force, q is the external vertical force per unit length, and M is the bending moment; S and M vary along the length of the pipeline. From vertical and moment equilibrium of the element

$$[5] \qquad q = -\frac{\mathrm{d}S}{\mathrm{d}x}$$

$$[6] \qquad P\frac{\mathrm{d}y}{\mathrm{d}x} + \frac{\mathrm{d}M}{\mathrm{d}x} - S = 0$$

and therefore, differentiating eq. [6] and eliminating $\mathrm{d}S/\mathrm{d}x$,

$$[7] \qquad q = -p\frac{\mathrm{d}^2y}{\mathrm{d}x^2} - \frac{\mathrm{d}^2M}{\mathrm{d}x^2}$$

If the pipe remains elastic,

$$[8] \qquad M = F\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$$

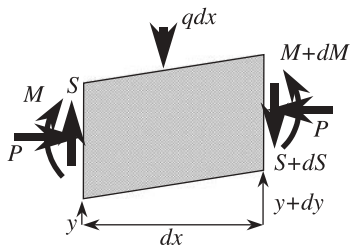
where F is flexural rigidity, given by

$$[9] \qquad F = \frac{\pi D^3 t E}{8}$$

for a thin-walled elastic cylinder with elastic modulus E, and then

© 2003 NRC Canada

Fig. 2. Pipeline element.



$$[10] \qquad q = -p\frac{\mathrm{d}^2y}{\mathrm{d}x^2} - F\frac{\mathrm{d}^4y}{\mathrm{d}x^4}$$

In eqs. [7] and [10], the first term on the right is a curvature term, the product of the longitudinal force and the curvature $\mathrm{d}^2y/\mathrm{d}x^2$, which is negative in overbends (where the pipeline tends to push upwards, and therefore requires a positive value of q to hold it down, as we would expect) and positive in sagbends. The less obvious second term is proportional to changes in shear force and vanishes when the curvature is uniform.

If the pipeline moves far enough, it begins to bend plastically. In the case illustrated in Fig. 1, the original cover appears to have been about 0.4 m thick on the left of the profile and 0 m on the right. The original profile had a hill about 3 m high over a length of 150 m. If the pipe initially had a uniform cover 0.4 m thick and was unstressed in that position, the bending strain at the highest point of the buckle in Fig. 2 is approximately 0.005, which is more than twice the yield strain of a typical pipeline steel. Plastic bending substantially reduces the incremental flexural rigidity, and therefore influences the post-buckling behavior.

Quantification of interaction with heave

Imagine a localized region of enhanced frost heave that lifts an initially straight and level pipeline from its initial position, and suppose that the deflection profile from the initial to the deformed position can be idealized as an arc of a circle with uniform overbend curvature κ (so that $\mathrm{d}^2y/\mathrm{d}x^2$ is $-\kappa$ and the overbend radius is $1/\kappa$).

The force available to hold the pipeline down is the sum of the pipeline weight w per unit length and the uplift resistance provided by the cover. The uplift resistance r per unit length is usually calculated from

$$[11] \qquad r = \gamma DH\left(1 + \frac{fH}{D}\right)$$

where γ is the unit weight of the soil above the pipeline, H is the thickness of the cover (measured from the top of the pipeline to the surface of the soil), and f is an uplift resistance coefficient determined experimentally (Palmer et al. 1994; Baumgard 2000).

Assembling the results from eqs. [4], [7], [10], and [11], and taking the temperature rise θ to be zero, the pipe becomes unstable if

$$[12] \qquad -P\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = q > w + r$$

$$[13] \qquad \frac{\pi D^2}{4}(1-2\nu)p\kappa > w + \gamma DH\left(1 + \frac{fH}{D}\right)$$

which can be rewritten

$$[14] \qquad \kappa > \frac{1}{1-2\nu}\frac{\gamma}{p}\left[\frac{w}{\frac{\pi}{4}D^2\gamma} + \frac{4}{\pi}\frac{H}{D}\left(1 + \frac{fH}{D}\right)\right]$$

The nondimensional term $w/(\pi/4)D^2\gamma$ in eq. [14] has a simple physical interpretation as the relative density of the pipeline, relative *to the soil it is buried in* (not to water). The last term highlights the importance of the ratio of cover thickness to pipeline diameter H/D.

Typical values envisaged for a gas pipeline in the Arctic are γ = 18 kN/m^3, $p = 2 \times 10^4$ kPa (20 MPa, 2900 psi), $w/(\pi/4)D^2\gamma = 1$, $H/D = 0.70$ (corresponding to a 0.75 m thick cover on a 1066 mm diameter (42 in.) pipeline), ν = 0.3 for steel, and $f = 0.5$ (Palmer et al. 1994; Baumgard 2000).

The corresponding overbend curvature at which the pipeline becomes unstable is 0.0050 m, which corresponds to an overbend radius of 200 m. Any overbend more sharply curved than that will become unstable. Over a 20 m length, this corresponds to a 0.25 m high "hill" in the profile. A temperature increase above the tie-in temperature makes upheaval more likely.

These numbers suggest that discontinuities in frost heave can be enough to destabilize a high-pressure pipeline and induce upheaval, even if the original as-laid profile is perfectly straight and level. The most likely scenario is that heave occurs during the winter and that upheaval follows in the summer, when the operating temperature is higher (because the ground is warmer) and the uplift resistance is reduced (because the soil above the pipeline has thawed).

Conclusion

Our conclusion is that frost heave and upheaval can in some circumstances interact to threaten the integrity of Arctic pipelines.

Acknowledgment

Andrew Palmer thanks the Jafar Foundation for its continuing support.

References

Aynbinder, A.B., and Kamershtein, A.G. 1982. Raschet magistral'nykh truboprovodov na prochnost' i ustoichivost' (Calculation of trunk pipelines for strength and stability). Nedra, Moscow. [In Russian]

Baumgard, A.J. 2000. Monotonic and cyclic soil responses to upheaval buckling in offshore buried pipelines. Ph.D. dissertation, Cambridge University, Cambridge, U.K.

Borodavkin, P.P. 1982. Podzemnye magistral'nye truboprovodov (Underground trunk pipelines). Nedra, Moscow. [In Russian]

Breivik, J., Ferdinandsen, J., and Hansen, H.B. 1990. Tommeliten flowlines: stabilisation of the upheaval buckle. *In* Proceedings of the Society for Underwater Technology Conference on Ad-

© 2003 NRC Canada

vances in Subsea Pipeline Engineering and Technology, London 30–31 May 1990.

Defay, R., and Prigogine, I. 1951. Tension superficielle et adsorption. Traite de thermodynamique, conformement aux méthodes de Gibbs et De Donder. Editions Desoer, Liége, France.

Edlefsen, N.E., and Andersen, A.B.C. 1943. Thermodynamics of soil moisture. Hilgardia, **15**: 31–298.

Kharionovsky, V.V. 1992. Enhancing Arctic gas pipeline reliability. *In* Proceedings of the International Conference on Pipeline Reliability, Calgary. CANMET and Gulf Publishing, Houston, Tex., Vol. 1. pp. II-3-1-9.

Mel'nikov, V.P., and Spesitsev, V.I. 2000. Kriologennye obrazovaniya v litosfere zemli (Cryogenic formations in the earth's lithosphere). SO RAN, Novosibirsk, and RITP, Scott Polar Research Institute, Cambridge, U.K. pp. 1–9. [In Russian.]

Nielsen, N.-J.R., Lyngberg, B., and Pedersen, P.T. 1990. Upheaval buckling failures of insulated flowlines: a case story. *In* Proceedings of the 22nd Annual Offshore Technology Conference, Houston, Tex., 7–10 May 1990. Vol. 4. Offshore Technology Conference, Richardson, Tex. Paper OTC6488, pp. 581–592.

Palmer, A.C. 1972. Settlement of a pipeline on thawing permafrost. Transportation Engineering Journal, ASCE, **TE3**: 477–491.

Palmer, A.C., and Baldry, J.A.S. 1974. Lateral buckling of axially-compressed pipelines. Journal of Petroleum Technology, **26**: 1283–1284.

Palmer, A.C., Ellinas, C.P., Richards, D.M., and Guijt, J. 1990. Design of submarine pipelines against upheaval buckling. *In* Proceedings of the 22nd Annual Offshore Technology Conference, Houston, Tex., 7–10 May 1990. Vol. 2. Offshore Technology Conference, Richardson, Tex. Paper OTC6335, pp. 551–560.

Palmer, A.C., Carr, M., Maltby, T., McShane, B., and Ingram, J. 1994. Upheaval buckling: what do we know, and what don't we know? *In* Proceedings of the Offshore Pipeline Technology Seminar, Oslo, Norway, 3–4 February 1994. IBC Technical Services Ltd.

Rempel, A.W., Wettlaufer, J.S., and Worster, M.G. 2001. Interfacial premelting and the thermodynamic force: thermodynamic buoyancy. Physical Review Letters, **87**: 088501-4.

Riseborough, D.W. 1993. Current work, 1992. The Canada–France pipeline-frost heave transition experiment. *In* Proceedings of the Seminar on Gas Pipelines, Oil Pipelines and Civil Engineering in Arctic Climates, Caen and Paris, France, 2–4 Oct. 1991. *Edited by* P.J. Williams. Geotechnical Science Laboratories, Carleton University, Ottawa, Ont. pp. 162–170.

Riseborough, D.W., Williams, P.J., and Smith, M.W. 1993. Pipelines buried in freezing soil: a comparison of two ground thermal conditions. *In* Proceedings of the 12th International Conference on Offshore Mechanics and Arctic Engineering, Glasgow, Scotland, 21 June 1993. American Society of Mechanical Engineers, New York, Book G00681, pp. 187–193.

Smith, M.W., and Patterson, D.E. 1989. Detailed observations on the nature of frost heaving at a field scale. Canadian Geotechnical Journal, **26**: 306–312.

Smith, S.L., and Williams, P.J. 1990. Ice lens orientation around a chilled buried pipe. *In* Proceedings of the 5th Canadian Permafrost Conference. Centre d'études nordique, Université Laval, Collection Nordicana, No. 54, pp. 83–87.

Smith, S.L., and Williams, P.J. 1995. Ice lens formation at a silt–sand interface. Canadian Geotechnical Journal, **32**: 488–495.

Williams, P.J. 1989. Pipelines and permafrost: science in a cold climate. Carleton University Press, Ottawa, Ont.

Williams, P.J. 1997. The seasonally frozen layer, geotechnical significance and needed research. *In* Proceedings of the International Symposium on Physics, Chemistry and Ecology of Seasonally Frozen Soils, Fairbanks, Alaska, 10–12 June 1997. USACRREL Special Report 97-10. pp. 9–15.

Williams, P.J. 1998. The freezing of soils: ice in a porous medium and its environmental significance. *In* Ice physics in the natural and endangered environment. *Edited by* J.S. Wertlaufer, J.G. Dash, and N. Untersteiner. NATO ASI Series 1, Vol. 56. Springer, Berlin, pp. 219–239.

Williams, P.J., and Smith, M.W. 1991. The frozen earth: fundamentals of geocryology. Cambridge University Press, Cambridge, U.K.

Williams, P.J., and Warren, I.M.T. 1999. The English version of the geocryological map of Russia and the neighbouring republics. Collaborative Map Project, Cambridge University, Cambridge, U.K., University of Moscow, Moscow, Russia, and Carleton University, Ottawa, Canada.

Williams, P.J., Smith, M.W., and Riseborough, D.W. 1993. The France–Canada joint study of deformation of an experimental pipe line by differential frost heave. International Journal of Offshore and Polar Engineering, **3**: 56–60.

Williams, P.J., White, T.L., and Torrance, J.K. 1998. The significance of soil freezing for stress corrosion cracking. *In* Proceedings of the International Pipeline Conference, Calgary, Alta., June 1998. American Society of Mechanical Engineers, New York, Book G1075A-1998, Vol. 1, pp. 473–478.

Yershov, E.D. 1998. General geocryology. *Edited by* P.J. Williams. Cambridge University Press, Cambridge, U.K.

© 2003 NRC Canada

Copyright of Canadian Geotechnical Journal is the property of Canadian Science Publishing and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.

RECEIVED

MAY 23 2016

MAILROOM

HUBBARD COUNTY HC COLA
P.O. BOX 746
PARK RAPIDS, MN 56470
www.HubbardCOLAmn.org
HCCOLAmn@gmail.com

May 15, 2016

Jamie MacAlister
Environmental Review Manager
Minnesota Department of Commerce
85 7th Place East, Suite 500
St. Paul, MN 55101

Re: PUC Docket Numbers - Sandpiper: PL- 6668/CN-13-473 and PPL-13-474
Line 3: PL-9/CN-14-916 and PPL-15-137

Dear Ms. MacAlister:

Hubbard County Coalition of Lake Associations ("HC COLA") is a coalition of 29 lake associations and their approximate 2,100 members that represent 37 lakes in Hubbard County. HC COLA's mission is to protect and enhance the quality of our lakes and rivers, preserve the economic, recreational and natural environmental values of our shore lands and promote the responsible use of our waters and related habitats. HC COLA's mission enhances, promotes and protects the interests of lakeshore property owners, lake associations, local government, the general public and future generations.

HC COLA has the following comments and recommendations regarding the Public Utilities Commission's scoping for the Environmental Assessment Worksheet (EAW) and Environmental Impact Study (EIS) for the Sandpiper and Line 3R pipeline projects.

Our goal is to insure that the EIS for the Sandpiper and Line 3R oil pipelines crossing Minnesota fully comply with all State laws and provides for the highest level of protection of its natural resources.

Hubbard county is blessed with an abundance of natural resources, and is especially noted for its clean lakes and rivers. The proposed route of the Sandpiper and Line 3R pipelines, if approved, would carry over 1.1 million barrels of dirty, explosive crude oil per day across this pristine environment. A spill in this area would be catastrophic to its land, waters, wildlife and inhabitants.

Since the PUC has never completed an EIS for an oil pipeline, HCCOLA is respectfully requesting you to seriously consider the following suggestions enabling a thorough, comprehensive review.

The membership of HCCOLA request the following:

1. The Memo of Understanding (MOU) with the MN Department of Natural Resources (DNR) and the MN Pollution Control Agency (PCA) should be strengthened by the inclusion of specific provisions and tasks that turn potential assistance and oversight into actual assistance and oversight. Currently marginalized by the Department of Commerce, scientists, specialists and managers at the MPCA and the MN DNR should have active opportunities to monitor and supervise the EIS.

2. As authorized by MEPA, we request the establishment of an expert panel to provide oversight and assistance with the scientific, economic, technical and procedural aspects of EIS scoping.

3. Any outside consultant contracts used in the EIS scoping should be awarded based on an open, unbiased bid procedure.

4. All "system alternative routes" submitted for this pipeline corridor should be included and compared in the EIS analysis.

Thank you for considering HC COLA's comments and recommendations. If you have any questions or want to discuss these matters further, please contact Lynn Goodrich at tripplake1@mac.com.

Hubbard County COLA

Lynn Goodrich
President

MINNESOTA DEPARTMENT OF COMMERCE

Comment Form: Scoping

Energy Environmental Review and Analysis

Please provide your contact information. This information and your comments will be publicly available.

Name: DENNIS & PATRICIA HUMPHREYS Phone: 651 330-3524

Street Address: 333 BURKE AVE W.

City: ROSEVILLE State: MN ZIP: 55113

Email: redlinebeacon@comcast.net

My comments pertain to:

- ☐ **Sandpiper Pipeline Project**
- ☐ **Line 3 Replacement Project**
- ☒ **Both Projects**

If including additional pages please number them and tell us how many you are providing: _____ pages

We strongly oppose both the Sandpiper Pipeline and the Line 3 Pipeline Replacement Project. With many pipelines already in place across Minnesota is it really necessary to have more? The risk of leaks in years to come is inevitable and the potential of ruining Minnesota wildlife, land, environment and water quality of our lakes and rivers is great.

The proposed alternate route (RA-37) along Highway 210 would directly affect our lake home on Torchlight Lake south of Sawyer, MN, as well as the stream running to Bob Lake. A spill or leak would be devastating to the lake, fish, drinking water as well as lake home values. It is not a matter of **if** a leak will occur but **when**. We have thought about selling our home in town and moving to the lake but would have reservations of doing this if the pipeline were to go through. Regardless, we do plan to pass the lake home on to our children and grandchildren with the assumption of a usable lake place for years to come.

With the possibility of the Federal Government stopping shipping of crude oil on the Great Lakes, there would seem to be no need to pipe the oil to Superior, Wisconsin.

It has been portrayed that theses pipelines will provide many jobs and financial gain to communities along the route. Long term risk significantly outweigh any short term economical boosts to the areas. Having had conversations with welders who worked on the recent pipeline through the Fond du Lac Reservation we learned they were from Oklahoma. So not all local workers may benefit.

Thank you for letting us voice our concerns and taking them into consideration in your decision.

RECEIVED

MAY - 4 2016

MAILROOM

From:	Peter Hovde
To:	*COMM_Pipeline Comments
Subject:	Sandpiper & Replacement Line 3 "preferred route" comments
Date:	Tuesday, May 24, 2016 9:59:09 AM
Attachments:	Frost Heave and Pipeline Upheaval Buckling.pdf

Comments on Sandpiper and Line 3 Replacement Routing

Peter Hovde, rural Bagley, MN

The following is part of my rationale for opposing the “Preferred Route” for the Line 3 Replacement and the Sandpiper pipelines. I’ll make just three points. In general, the closer one looks at Enbridge’s proposals, the benefits shrink, and the costs and risks multiply even more so. (Disclaimer. We do not live hear enough to the “Preferred Route” to be directly affected by it.)

Pipeline Upheaval Buckling. Frost heave of buried pipelines is of particular concern in climates with seasonably cold temperatures, such as Minnesota. An article in the *Canadian Geotechnical Journal* (attached) examines exactly those risks [Andrew C. Palmer and Peter J. Williams (2003) "Frost heave and pipeline upheaval buckling." *Canadian Geotechnical Journal*. 40: 1033-1038]. Just a sampling of problems: Upheaval buckling is a well-known phenomenon in buried pipelines: it can lead to large upward movements of a segment of the pipeline. As the pipeline arches upward, the top wall of the pipeline radically thins, making fracture much more likely.

Stresses in pipelines due to frost heave occur because of the differences in the amount and rate of frost upheaval. When the pipeline passes from sandy ground (which shows little frost heave) to silty ground (which commonly shows significant heave) and freezing occurs, the pipe will be lifted in the silty segment and restrained in the sandy segment. The points of transition from one type of soil to another are of particular concern. Freely available ground water is also highly conducive to frost heave as water expands as it turns to ice. When the water seasonably melts, the pipeline often does not go back to it original state, but keeps the bend, which will likely increase even further due to freeze and melt processes in subsequent years.

The photos taken by the Honor the Earth White Earth Ojibwe people riding the route of existing pipeline show pipelines emerging out of the ground from such frost heaving. The riders also reported their horses would not go near the pipeline. It is well known that animals—both domestic and wild--shy

away from odors they are unused to. Petroleum leaks would cause of that equine avoidance.

With the high variability of adjacent soil types and high water content in the Itasca glacial terminal moraine—over which almost the entire length of the north-south portion of the pipeline is planned—provides a disturbingly large number of opportunities for frost heavy and upheaval buckling, and disturbingly large consequences for the area should the line rupture. The DNR has identified over 70 bodies of water through which the two proposed pipelines would pass. This mix of soils and all that water make the "Preferred Route" inherently unsuitable for pipelines, and these problems *cannot* be engineered around.

Pipeline Operations. Enbridge wants to lay the new Sandpiper pipeline of large diameter to increase its capacity to move oil. The Sandpiper would carry lighter Bakken oil from North Dakota, the most volatile form of crude, responsible for several spectacular explosions and fires. Sandpiper would run alongside the existing Line 3 pipeline.

Embridge wants to replace that existing Line 3 pipeline with a larger diameter and greater capacity pipe. (Enbridge plans to pump nearly twice as much each day, from 390,000 barrels to 760,000 per day.) The Line 3 Replacement pipeline will mostly move heavy tar sands crude from Canada.

Tar sands diluted bitumen (or DilBit) crude is 15-20 times more acidic and 5-10 times more sulfuric than conventional crude (which can weaken the pipe). Dilbit contains abrasive sand which can erode pipes and fittings. Dilbit crude so viscous (up to 70 times more than conventional crude) it has to be mixed with liquified natural gas (a threat of fire and explosions if leaked) and heated (to 158 degrees F.) so it can move through the pipeline. Even so, pipeline pressures have to be increased to 1,440 pounds per square inch to move the Dilbit (normal crude only requires 600 psi), making any oil spill from pipeline rupture that much worse.

Unlike conventional crude which floats on water, Dilbit sinks to the bottom, making clean up difficult to impossible. When oil spills in a forested area, the oil follows the roots down into the earth, having an easier time getting into the groundwater. That oil affects not only plant respiration and nutrient uptake, but the oil in the groundwater would contaminate wells of home and cabin owners in the lake district.

Threat to Pristine Places. What I find most extraordinary about the "Preferred

Route” is the willingness of Enbridge to place pipelines in close proximity two of the most pristine and precious wild places south of the BWCA, Itasca State Park and the Mississippi Headwaters and to put those places at risk of major and permanent damage.

For the above reasons, and many more, I urge the Department of Commerce to recommend a route as far away as possible from the Crown Jewel of our park system, the supposedly protected first 40 miles of the Mississippi River, and those who live in or retreat to Minnesota’s lake district.

Thank you,

Peter Hovde, rural Bagley

Frost heave and pipeline upheaval buckling

Andrew C. Palmer and Peter J. Williams

Abstract: Frost heave of soils varies greatly with the type of soil and the moisture and thermal conditions of the ground. Consequently, the initially level trench-bottom profile of a pipeline can become uneven. Upheaval buckling is a well-known phenomenon in buried pipelines: it can lead to large upward movements of a pipeline and is caused by the interaction between the longitudinal compressive force present during operation and overbend irregularities in the profile. This paper examines the possibility that frost heave and upheaval buckling can interact adversely and threaten the security of Arctic pipelines.

Key words: Arctic, buckling, frost heave, permafrost, pipelines.

Résumé : Le soulèvement des sols dû au gel varie grandement avec le type de sol, l'humidité et les conditions thermiques du terrain. En conséquence, le profil initialement au niveau du fond de la tranchée peut devenir inégal. Le flambage par soulèvement est un phénomène bien connu dans les pipelines enfouis: il peut conduire à des soulèvements importants d'un pipeline, et est causé par l'interaction entre la force de compression longitudinale présente durant l'opération et les irrégularités de courbure dans le profil. Cet article examine la possibilité que le soulèvement dû au gel et le soulèvement dû au flambage puissent interagir défavorablement et menacer la sécurité des pipelines de l'Arctique.

Mots clés : Arctique, flambage, soulèvement dû au gel, pergélisol, pipelines.

[Traduit par la Rédaction]

Introduction

This paper describes the interaction between two well-known phenomena, frost heave and upheaval buckling, and how they might together threaten the safety of an Arctic pipeline.

When soils freeze, ice forms within the pores between the particles, often as discrete lenses. Only part of the water freezes when the temperatures falls below the freezing point of pure water, and some water remains unfrozen at much lower temperatures. Water migrates in the unfrozen soil towards the freezing front and continues to migrate within the partially frozen soil. If the surface is free to move, it heaves, because of the expansion that accompanies freezing, especially that of the water from lower unfrozen layers. If movement is partly restrained, by a foundation for instance, the force is often large enough to lift the foundation. The force required to completely prevent heave is very large. Williams and Smith (1991) give a fuller account of frost heave.

Upheaval buckling occurs in longitudinally constrained buried pipelines. It has been known for a long time in land pipelines and has been seen in Russia, Iran, the United Arab Emirates, and Canada. Figure 1 is a photograph and profile of a buckled 1020 mm (40 in.) pipeline near Tashkent in Uzbekistan (Aynbinder and Kamershtein 1982). At one time upheaval was believed not to be a problem for marine pipelines, but a well-documented case in the Danish sector of the North Sea (Nielsen et al. 1990) was followed by other cases (Breivik et al. 1990) and generated a series of research programs (Palmer et al. 1990, 1994) and much expenditure to prevent upheaval.

The driving force for upheaval is the longitudinal force induced by operation of the pipeline. That force is almost invariably compressive. Upheaval is initiated at an overbend (convex upwards) vertical curve in the pipeline profile. If the weight of the pipeline and the uplift resistance of the cover are not large enough to hold the line in place, it moves upwards. When it moves upward, the local curvature increases, and so more force would be required to maintain the pipeline in place, but the uplift resistance tends to decrease because the pipe comes closer to the surface of the cover. The pipeline becomes unstable and jumps upward to a new equilibrium position like the one seen in Fig. 1. Although the same forces are present in sagbends (convex-downward profiles), there the pipe tends to move downwards, and large movements do not occur because the resistance to downward movement increases with depth.

Many gas pipelines operate at a temperature lower than the ambient temperature, because of Joule–Thomson cooling, and conduction can therefore further lower the soil temperature around the pipeline and cause freezing and heave. Kharionovsky (1992) ascribes to frost heave the failure of a 426 mm gas pipeline. The geotechnical conditions that determine the magnitude of frost heave vary naturally along the length of a pipeline, and so some sections will move upwards more than others (Williams 1989). Even if the as-

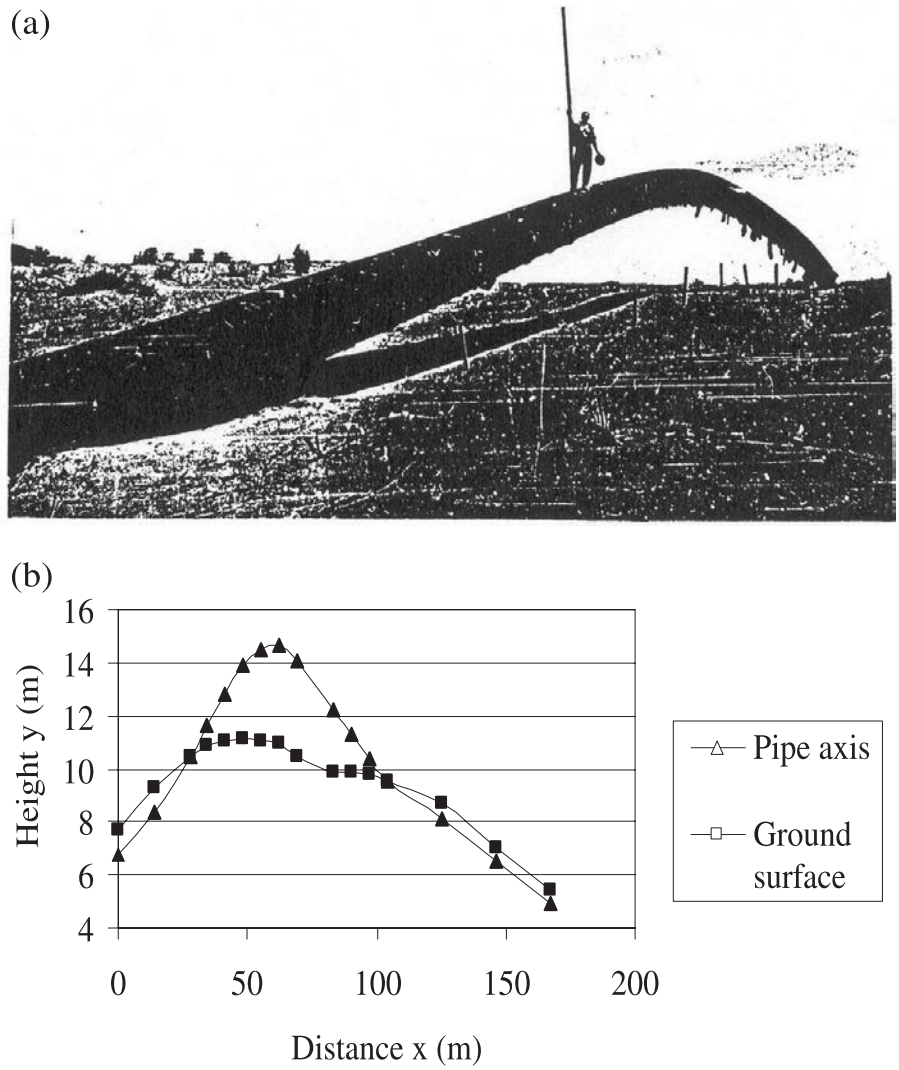
Received 31 July 2002. Accepted 9 May 2003. Published on the NRC Research Press Web site at http://cgj.nrc.ca on 8 October 2003.

A.C. Palmer.[1] University Engineering Department, Trumpington Street, Cambridge CB2 1PZ, U.K.
P.J. Williams. Geotechnical Science Laboratories, Carleton University, Colonel By Drive, Ottawa, ON K1S 5B6, Canada, and Scott Polar Research Institute, Cambridge, U.K.

[1]Corresponding author (e-mail: acp24@eng.cam.ac.uk).

 doi: 10.1139/T03-044 © 2003 NRC Canada

Fig. 1. Photograph (*a*) and ground surface and pipeline axis profiles (*b*) of pipeline upheaval near Tashkent, Uzbekistan.



constructed profile is level and straight, the heaved profile will be irregular and will have overbends. Those overbends can then produce a further uplift.

Uniform vertical movement does not affect the functioning of a pipeline, and neither does a uniform gradient, but movements that induce curvature can overstress a pipeline to a dangerous extent. The potential problem is therefore an adverse interaction between longitudinal variability of frost heave, the propensity of heave-induced overbends to initiate much larger pipeline movements as a result of the upheaval phenomenon, and the extent to which the flexural stiffness of the pipeline can moderate the movements.

The next sections of the paper discuss the magnitude of heave-induced overbends and the conditions under which they might lead to upheaval.

Heave-induced overbends

The discrete bodies of ice ("segregated ice") bigger than pore size that characterize frost-heaving soil vary greatly in form and extent (Mel'nikov and Spesitsev 2000). The accumulations follow from the thermodynamic potential established because the water and ice are confined in a fine porous matrix (Edlefsen and Andersen 1943; Defay and Prigogine 1951; Williams and Smith 1991; Rempel et al. 2001). The pressure in the unfrozen water is less than the mean compressive stress in the ice and is often negative (a tensile stress, a state of suction).

As the ice is in bodies larger than pore or grain size, it will bear the stress generated by the weight of overburden. A further component of the ice pressure is the resistance of the frozen soil to the growth of the ice body. When the temperature and the pore-water pressure (itself a function of the soil environment) are such that the ice has a pressure equal to these two stresses, the ice increases in amount, displacing (heaving) the soil.

The capillary effects resulting from the fine porous nature of soils lower the freezing point of the pore water. Progressively smaller pores become filled with ice as the temperature falls. When the ice fills a pore, there is still a layer of adsorbed film water between the ice and the mineral surfaces of the particles. The pore-size distribution, and the specific surface area of the soil, will therefore be important in determining both the amount of frost heave and the forces

© 2003 NRC Canada

associated with it. When the rate of heave is considered, the changing permeability of the soil (in the unfrozen and frozen states) is also important.

Engineering solutions to the problem of frost heave in roads, airports, and building foundations are well established. For pipelines in permafrost regions the situation is less clear. A pipeline in permafrost is liable to stresses from frost heave that develop over many years (unlike a highway, for example, where thawing in spring and summer releases stresses due to winter freezing).

The permafrost stratum may underlie virtually all of the terrain or the greater part of the terrain, or it may be represented by scattered bodies or islands of permafrost. If it is decided to operate a pipeline with the gas at a temperature below 0 °C to avoid problems of thaw settlement of the pipe, then as the temperature of the gas cannot always be finely controlled, there will inevitably be new freezing around sections of the pipe in formerly unfrozen ground. The nature of the ground and the moisture conditions define where differential frost heave is to be expected. Freely available groundwater is highly conducive to frost heave. Wherever the pipe passes from permafrost into unfrozen ground is a site of special concern.

Stresses in the pipe due to frost heave occur because of the differences in the amount and rate of frost heave. Frost heave generates forces great enough to bend even the largest diameter pipe. Pipelines are such long structures that there will obviously sometimes be abrupt changes of ground along the right-of-way (ROW), and therefore sharply differential frost heave. More difficult to assess are the innumerable changes of soil form and properties over short distances which follow from local geological and geomorphological history.

It is uncertain which forms of frost heave constitute the greatest threat to the stability of a pipeline. Several distinct situations occur:

(1) Where the pipeline passes from sandy ground (which shows little frost heave) into, say, silty ground (which commonly shows significant heave) and freezing occurs, the pipe will be lifted in the silty segment and restrained by the sand. This situation has been investigated in experimental models, and the pipe and soil displacements and stresses measured (Williams et al. 1993).

(2) Where the pipeline crosses a slope, any frost heave will usually be associated with a downslope creep movement, which may apply significant additional downslope forces transverse to the pipeline (Borodavkin 1982).

(3) Where the pipeline runs essentially downslope (even on slight slopes), the processes of frost heave, and especially the summertime thawing of the overlying layers, result in weakening of the soil, which can then be subject to erosion by running water. Under these conditions the pipe may rise, with failure of the overlying materials. The processes promote further thawing, and pipelines over permafrost are often seen to be lying in a continuously forming watercourse (Williams et al. 1998).

(4) The location of ice segregations may be important (Smith and Williams 1990, 1995). Cavities up to 10 cm in depth and 20–30 cm in length were found immediately below a pipeline that had been subjected to frost heave (Williams et al. 1998). As frost penetrates into the ground, a layer of ice forms below boulders and other buried objects. This gives rise to the "growing stones" familiar to residents in cold places. This may also occur with pipelines. Ice segregation has a localized effect, because the cavities are quite short.

(5) Temperature conditions, rather than soil conditions, can provide the conditions for differential heave. A pipe laid through discontinuous permafrost crosses many transitions between frozen ground and unfrozen ground. It has been demonstrated experimentally (Riseborough 1993; Riseborough et al. 1993) that the resistance to movement of the pipe restrained by a frozen-in section leads to development of significant pipe deformation and stress when the ground adjacent to it begins to freeze and heave.

Natural variations of soil and thermal conditions

Soils occur in an infinite variety, both in terms of the grain-size composition and the mineralogy of the components. Measurable frost heave does not occur in sands and coarser materials. At the other extreme, an ice segregation in silt or another fine-grained material may grow for a long time without any further penetration of the isotherm.

In highway construction, heave-susceptible materials are replaced. When annual freezing and thawing is the concern, only the depth affected is considered. This depth varies from a few centimetres to 3–4 m in certain conditions (Williams 1997). Pipelines are on occasion placed within this active layer. If pipelines lie within the permafrost proper, the problems are those of a continuing deformation of frozen ground, instead of the disturbances of annual freezing and thawing. This raises distinctly different problems. Relatively little is known about the ongoing heave of frozen soils, although there is ample evidence that it occurs (Smith and Patterson 1989). The permeability to water of the frozen ground appears to be a controlling factor, and little is known about this parameter. Deformation occurs slowly, but the pressures developed will tend be greater than for seasonally freezing ground.

From a practical point of view it is important to know how often and how great are the changes in frost heave properties along the ROW. Uncertainty as to the exact amount of heave to be expected for a given soil is less important than the variability of the soil and its moisture conditions. It is the transitions from one soil to another that cause the problematic differential heave, and in extreme cases they may occur every few metres. Variations in heave properties parallel variations in thaw-settlement properties, which are known to have significant effects on pipelines (Palmer 1972).

Areas of relatively uniform soils occur particularly where the topographic form is a plain. In some clays, for example, a geological origin as marine deposits explains their lack of variability. An extreme contrast is deposits laid under glaciofluvial conditions, which vary sharply, over metres or less, reflecting the depositional conditions that were constantly changing during the period of deglaciation. Those deposits may be clays, silts, or coarser materials.

© 2003 NRC Canada

The surface and near-surface materials in well-populated areas are well known and represented on soil and Quaternary geology maps. Combined with a knowledge of topography and vegetation, the engineer can plan foundations and supplement the existing data by limited sampling. In the cold regions, however, there are often large tracts where the subsurface conditions have barely been recorded, and a large amount of sampling is necessary for a long pipeline. A superficial analysis of the landscape will give some idea of the variability of the materials and thus of the frequency of situations where differential frost heave will necessitate specific design provisions. The topographic relief and the moisture conditions are important considerations already in the initial planning stages. Russian practice, deriving from experience with extensive pipeline networks in permafrost regions, involves a logical and systematic analysis of ground conditions, proceeding from initial broad surveys to the fine-detailed investigations along proposed ROWs (Yershov 1998; Williams and Warren 1999).

Thermal conditions in the near-surface layers depend on the geographic location and the meteorological conditions, but only in a general sense. Meteorological observations do not reflect the influence of microclimates related to vegetation and soil type. The mean annual temperature depends significantly on the surface cover (vegetation, snow, etc.), directional exposure and climatic and weather conditions, and the thermal properties of the ground materials themselves, because the energy exchange at the ground surface is modulated by the nature of the heat energy transfer processes involved, sensible heat transfer, evaporation condensation, and radiative exchange. Even in apparently uniform terrain, the mean annual ground temperature can vary by a degree or more over a horizontal distance of a few metres (Williams 1998).

Upheaval

The effects described previously combine to generate a significant degree of horizontal variability in the magnitude of frost heave movements. Pipeline upheaval is triggered by localized overbends in the pipeline profile. Even if the as-built profile is smooth, frost heave can make it uneven and set off upheaval. This section of the paper quantifies the movements that might be troublesome.

A pipeline can be idealized as a thin-walled cylindrical shell for almost any practical purpose. Assuming the pipeline to remain elastic and counting tensile stress as positive, the longitudinal stress in a fully constrained line is

$$[1] \qquad s_L = \frac{\nu p D}{2t} - E\alpha\theta$$

where D is the mean diameter (twice the mean radius, measured from the centre to half way through the wall), t is the wall thickness, E is Young's modulus, ν is Poisson's ratio, α is a linear thermal expansion coefficient, p is the operating pressure, and θ is the change of temperature (measured from the construction or tie-in temperature, increase positive). The longitudinal stress s_L has two components, the first related to pressure and the second to temperature. The cross-sectional area of the pipeline wall is πDt. The longitudinal force in the pipeline wall is therefore

$$[2] \qquad \pi D t s_L = \frac{1}{2}\nu\pi D^2 p - \pi D t E\alpha\theta$$

There is an additional component of longitudinal force in the pipeline contents. The cross-sectional area of the contents is $\pi D^2/4$, and the longitudinal stress in the contents is $-p$ (consistently counting tension positive), and so the longitudinal force in the contents is

$$[3] \qquad -\frac{\pi D^2}{4} p$$

The total longitudinal force is therefore

$$[4] \qquad -(1-2\nu)\frac{\pi D^2}{4} p - \pi D t E\alpha\theta$$

and has both a pressure term and a temperature term. The compressive pressure term is present because the compressive force in the contained fluid more than balances the longitudinal tensile pressure-induced component of the longitudinal force in the pipeline wall. It tells us that pressure alone can cause upheaval buckling. This is occasionally thought to be surprising, but the need to include in the analysis the force in the contained fluid is confirmed by theory, laboratory-scale experiment (Palmer and Baldry 1974), and field experience.

Equation [4] gives the resultant force in a fully constrained pipeline in which all axial movement is prevented. Expansion loops, doglegs, and snaked configurations allow some longitudinal expansion movement to occur, and the longitudinal force is then less compressive.

Consider an element of pipeline in an arbitrary profile defined by a height y (measured positive upwards from a datum) which is a function of horizontal distance x. In Fig. 2, P is the longitudinal force (now compressive positive, in contrast to the tension-positive convention applied earlier), S is the shear force, q is the external vertical force per unit length, and M is the bending moment; S and M vary along the length of the pipeline. From vertical and moment equilibrium of the element

$$[5] \qquad q = -\frac{\mathrm{d}S}{\mathrm{d}x}$$

$$[6] \qquad P\frac{\mathrm{d}y}{\mathrm{d}x} + \frac{\mathrm{d}M}{\mathrm{d}x} - S = 0$$

and therefore, differentiating eq. [6] and eliminating $\mathrm{d}S/\mathrm{d}x$,

$$[7] \qquad q = -p\frac{\mathrm{d}^2y}{\mathrm{d}x^2} - \frac{\mathrm{d}^2M}{\mathrm{d}x^2}$$

If the pipe remains elastic,

$$[8] \qquad M = F\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$$

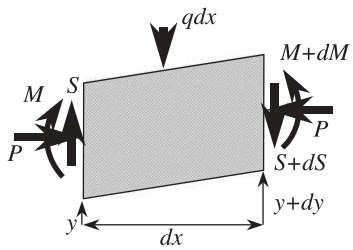
where F is flexural rigidity, given by

$$[9] \qquad F = \frac{\pi D^3 t E}{8}$$

for a thin-walled elastic cylinder with elastic modulus E, and then

© 2003 NRC Canada

Fig. 2. Pipeline element.



$$[10] \qquad q = -p\frac{\mathrm{d}^2y}{\mathrm{d}x^2} - F\frac{\mathrm{d}^4y}{\mathrm{d}x^4}$$

In eqs. [7] and [10], the first term on the right is a curvature term, the product of the longitudinal force and the curvature $\mathrm{d}^2y/\mathrm{d}x^2$, which is negative in overbends (where the pipeline tends to push upwards, and therefore requires a positive value of q to hold it down, as we would expect) and positive in sagbends. The less obvious second term is proportional to changes in shear force and vanishes when the curvature is uniform.

If the pipeline moves far enough, it begins to bend plastically. In the case illustrated in Fig. 1, the original cover appears to have been about 0.4 m thick on the left of the profile and 0 m on the right. The original profile had a hill about 3 m high over a length of 150 m. If the pipe initially had a uniform cover 0.4 m thick and was unstressed in that position, the bending strain at the highest point of the buckle in Fig. 2 is approximately 0.005, which is more than twice the yield strain of a typical pipeline steel. Plastic bending substantially reduces the incremental flexural rigidity, and therefore influences the post-buckling behavior.

Quantification of interaction with heave

Imagine a localized region of enhanced frost heave that lifts an initially straight and level pipeline from its initial position, and suppose that the deflection profile from the initial to the deformed position can be idealized as an arc of a circle with uniform overbend curvature κ (so that $\mathrm{d}^2y/\mathrm{d}x^2$ is $-\kappa$ and the overbend radius is $1/\kappa$).

The force available to hold the pipeline down is the sum of the pipeline weight w per unit length and the uplift resistance provided by the cover. The uplift resistance r per unit length is usually calculated from

$$[11] \qquad r = \gamma DH\left(1 + \frac{fH}{D}\right)$$

where γ is the unit weight of the soil above the pipeline, H is the thickness of the cover (measured from the top of the pipeline to the surface of the soil), and f is an uplift resistance coefficient determined experimentally (Palmer et al. 1994; Baumgard 2000).

Assembling the results from eqs. [4], [7], [10], and [11], and taking the temperature rise θ to be zero, the pipe becomes unstable if

$$[12] \qquad -P\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = q > w + r$$

$$[13] \qquad \frac{\pi D^2}{4}(1-2\nu)p\kappa > w + \gamma DH\left(1 + \frac{fH}{D}\right)$$

which can be rewritten

$$[14] \qquad \kappa > \frac{1}{1-2\nu}\frac{\gamma}{p}\left[\frac{w}{\frac{\pi}{4}D^2\gamma} + \frac{4}{\pi}\frac{H}{D}\left(1 + \frac{fH}{D}\right)\right]$$

The nondimensional term $w/(\pi/4)D^2\gamma$ in eq. [14] has a simple physical interpretation as the relative density of the pipeline, relative *to the soil it is buried in* (not to water). The last term highlights the importance of the ratio of cover thickness to pipeline diameter H/D.

Typical values envisaged for a gas pipeline in the Arctic are γ = 18 kN/m^3, $p = 2 \times 10^4$ kPa (20 MPa, 2900 psi), $w/(\pi/4)D^2\gamma = 1$, $H/D = 0.70$ (corresponding to a 0.75 m thick cover on a 1066 mm diameter (42 in.) pipeline), ν = 0.3 for steel, and $f = 0.5$ (Palmer et al. 1994; Baumgard 2000).

The corresponding overbend curvature at which the pipeline becomes unstable is 0.0050 m, which corresponds to an overbend radius of 200 m. Any overbend more sharply curved than that will become unstable. Over a 20 m length, this corresponds to a 0.25 m high "hill" in the profile. A temperature increase above the tie-in temperature makes upheaval more likely.

These numbers suggest that discontinuities in frost heave can be enough to destabilize a high-pressure pipeline and induce upheaval, even if the original as-laid profile is perfectly straight and level. The most likely scenario is that heave occurs during the winter and that upheaval follows in the summer, when the operating temperature is higher (because the ground is warmer) and the uplift resistance is reduced (because the soil above the pipeline has thawed).

Conclusion

Our conclusion is that frost heave and upheaval can in some circumstances interact to threaten the integrity of Arctic pipelines.

Acknowledgment

Andrew Palmer thanks the Jafar Foundation for its continuing support.

References

Aynbinder, A.B., and Kamershtein, A.G. 1982. Raschet magistral'nykh truboprovodov na prochnost' i ustoichivost' (Calculation of trunk pipelines for strength and stability). Nedra, Moscow. [In Russian]

Baumgard, A.J. 2000. Monotonic and cyclic soil responses to upheaval buckling in offshore buried pipelines. Ph.D. dissertation, Cambridge University, Cambridge, U.K.

Borodavkin, P.P. 1982. Podzemnye magistral'nye truboprovodov (Underground trunk pipelines). Nedra, Moscow. [In Russian]

Breivik, J., Ferdinandsen, J., and Hansen, H.B. 1990. Tommeliten flowlines: stabilisation of the upheaval buckle. *In* Proceedings of the Society for Underwater Technology Conference on Ad-

© 2003 NRC Canada

vances in Subsea Pipeline Engineering and Technology, London 30–31 May 1990.

Defay, R., and Prigogine, I. 1951. Tension superficielle et adsorption. Traite de thermodynamique, conformement aux méthodes de Gibbs et De Donder. Editions Desoer, Liége, France.

Edlefsen, N.E., and Andersen, A.B.C. 1943. Thermodynamics of soil moisture. Hilgardia, **15**: 31–298.

Kharionovsky, V.V. 1992. Enhancing Arctic gas pipeline reliability. *In* Proceedings of the International Conference on Pipeline Reliability, Calgary. CANMET and Gulf Publishing, Houston, Tex., Vol. 1. pp. II-3-1-9.

Mel'nikov, V.P., and Spesitsev, V.I. 2000. Kriologennye obrazovaniya v litosfere zemli (Cryogenic formations in the earth's lithosphere). SO RAN, Novosibirsk, and RITP, Scott Polar Research Institute, Cambridge, U.K. pp. 1–9. [In Russian.]

Nielsen, N.-J.R., Lyngberg, B., and Pedersen, P.T. 1990. Upheaval buckling failures of insulated flowlines: a case story. *In* Proceedings of the 22nd Annual Offshore Technology Conference, Houston, Tex., 7–10 May 1990. Vol. 4. Offshore Technology Conference, Richardson, Tex. Paper OTC6488, pp. 581–592.

Palmer, A.C. 1972. Settlement of a pipeline on thawing permafrost. Transportation Engineering Journal, ASCE, **TE3**: 477–491.

Palmer, A.C., and Baldry, J.A.S. 1974. Lateral buckling of axially-compressed pipelines. Journal of Petroleum Technology, **26**: 1283–1284.

Palmer, A.C., Ellinas, C.P., Richards, D.M., and Guijt, J. 1990. Design of submarine pipelines against upheaval buckling. *In* Proceedings of the 22nd Annual Offshore Technology Conference, Houston, Tex., 7–10 May 1990. Vol. 2. Offshore Technology Conference, Richardson, Tex. Paper OTC6335, pp. 551–560.

Palmer, A.C., Carr, M., Maltby, T., McShane, B., and Ingram, J. 1994. Upheaval buckling: what do we know, and what don't we know? *In* Proceedings of the Offshore Pipeline Technology Seminar, Oslo, Norway, 3–4 February 1994. IBC Technical Services Ltd.

Rempel, A.W., Wettlaufer, J.S., and Worster, M.G. 2001. Interfacial premelting and the thermodynamic force: thermodynamic buoyancy. Physical Review Letters, **87**: 088501-4.

Riseborough, D.W. 1993. Current work, 1992. The Canada–France pipeline-frost heave transition experiment. *In* Proceedings of the Seminar on Gas Pipelines, Oil Pipelines and Civil Engineering in Arctic Climates, Caen and Paris, France, 2–4 Oct. 1991. *Edited by* P.J. Williams. Geotechnical Science Laboratories, Carleton University, Ottawa, Ont. pp. 162–170.

Riseborough, D.W., Williams, P.J., and Smith, M.W. 1993. Pipelines buried in freezing soil: a comparison of two ground thermal conditions. *In* Proceedings of the 12th International Conference on Offshore Mechanics and Arctic Engineering, Glasgow, Scotland, 21 June 1993. American Society of Mechanical Engineers, New York, Book G00681, pp. 187–193.

Smith, M.W., and Patterson, D.E. 1989. Detailed observations on the nature of frost heaving at a field scale. Canadian Geotechnical Journal, **26**: 306–312.

Smith, S.L., and Williams, P.J. 1990. Ice lens orientation around a chilled buried pipe. *In* Proceedings of the 5th Canadian Permafrost Conference. Centre d'études nordique, Université Laval, Collection Nordicana, No. 54, pp. 83–87.

Smith, S.L., and Williams, P.J. 1995. Ice lens formation at a silt–sand interface. Canadian Geotechnical Journal, **32**: 488–495.

Williams, P.J. 1989. Pipelines and permafrost: science in a cold climate. Carleton University Press, Ottawa, Ont.

Williams, P.J. 1997. The seasonally frozen layer, geotechnical significance and needed research. *In* Proceedings of the International Symposium on Physics, Chemistry and Ecology of Seasonally Frozen Soils, Fairbanks, Alaska, 10–12 June 1997. USACRREL Special Report 97-10. pp. 9–15.

Williams, P.J. 1998. The freezing of soils: ice in a porous medium and its environmental significance. *In* Ice physics in the natural and endangered environment. *Edited by* J.S. Wertlaufer, J.G. Dash, and N. Untersteiner. NATO ASI Series 1, Vol. 56. Springer, Berlin, pp. 219–239.

Williams, P.J., and Smith, M.W. 1991. The frozen earth: fundamentals of geocryology. Cambridge University Press, Cambridge, U.K.

Williams, P.J., and Warren, I.M.T. 1999. The English version of the geocryological map of Russia and the neighbouring republics. Collaborative Map Project, Cambridge University, Cambridge, U.K., University of Moscow, Moscow, Russia, and Carleton University, Ottawa, Canada.

Williams, P.J., Smith, M.W., and Riseborough, D.W. 1993. The France–Canada joint study of deformation of an experimental pipe line by differential frost heave. International Journal of Offshore and Polar Engineering, **3**: 56–60.

Williams, P.J., White, T.L., and Torrance, J.K. 1998. The significance of soil freezing for stress corrosion cracking. *In* Proceedings of the International Pipeline Conference, Calgary, Alta., June 1998. American Society of Mechanical Engineers, New York, Book G1075A-1998, Vol. 1, pp. 473–478.

Yershov, E.D. 1998. General geocryology. *Edited by* P.J. Williams. Cambridge University Press, Cambridge, U.K.

© 2003 NRC Canada

Copyright of Canadian Geotechnical Journal is the property of Canadian Science Publishing and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.