Congressional Research Service

Oil Sands and the Keystone XL Pipeline: Background and Selected Environmental Issues

Jonathan L. Ramseur, Coordinator
Specialist in Environmental Policy

Richard K. Lattanzio
Analyst in Environmental Policy

Linda Luther
Analyst in Environmental Policy

Paul W. Parfomak
Specialist in Energy and Infrastructure Policy

Nicole T. Carter
Specialist in Natural Resources Policy

July 16, 2012

Congressional Research Service
7-5700
www.crs.gov
R42611

CRS Report for Congress
Prepared for Members and Committees of Congress

Exhibit 8014

Properties of Oil Sands-Derived Crudes Compared to Other Crudes

Crude oil is a complex mix of hydrocarbons, ranging from simple compounds with small molecules and low densities to very dense compounds with extremely large molecules. Three key properties of crude oils include the following:

- **API Gravity.** API[33] Gravity measures the weight of a crude oil compared to water. It is reported in degrees (°) by convention. API gravities above 10° indicate crude oils lighter than water (they float); API gravities below 10° indicate crude oils heavier than water (they sink). Although the definition of "heavy" crude oil may vary, it is generally defined by refiners as being at or below 22.3° API gravity.[34]
- **Sulfur Content.** Sulfur content in crude oil is an indication of potential corrosiveness due to the presence of acidic sulfur compounds. Sulfur content is measured as an overall percentage of free sulfur and sulfur compounds in a crude oil by weight. Total sulfur content in crude oils generally ranges from below 0.05% to 5.0%. Crudes with more than 1.0% free sulfur or other sulfur-containing compounds are typically referred to as "sour," below 0.5% sulfur as "sweet."[35]
- **Total Acid Number.** Total Acid Number (TAN) measures the composition of acids in a crude which can gauge its potential for corrosion, particularly in a refinery. TAN value is measured as the number of milligrams (mg) of potassium hydroxide (KOH) needed to neutralize the acids in one gram of oil. As a rule-of-thumb, crude oils with a TAN greater than 0.5 are considered to be potentially corrosive due to the presence of naphthenic acids.[36]

Table 1 compares Alberta's different oil sands crudes with other crude oils extracted in the United States and around the world. The data indicate that all oil sands crudes would be considered heavy crudes. Heavy crudes are found throughout the world, including the United States. The data indicate that oil sands crudes resemble other heavy crudes in terms of sulfur content and TAN.

[33] American Petroleum Institute.

[34] U.S. Energy Information Administration, Crude Oil Input Qualities, "Definitions, Sources and Explanatory Notes," web page, July 28, 2011, http://www.eia.gov/dnav/pet/TblDefs/pet_pnp_crq_tbldef2.asp. In the marine tanker industry, heavy grade crudes are defined as crudes with an API below 25.7 , as bitumen emulsions, or as certain viscous fuel oils. See McQuilling Services, LLC, "Carriage of Heavy Grade Oil," Garden City, NY, 2011, http://www.meglobaloil.com/MARPOL.pdf.

[35] JDL Oil and Gas Exploration, Inc., "Crude Oil Basics," web page, July 28, 2011, http://www.jdloil.com/oil_basics.htm.

[36] R.D. Kane and M.S. Cayard, "A Comprehensive Study of Naphthenic Acid Corrosion," Paper No. 02555, Corrosion 2002, http://www.icorr.net/wp-content/uploads/2011/01/napthenic_corrosion.pdf.

Table 1. Selected Global Crude Oil Specifications

Source	Crude Oil Name	°API Gravity	Sulfur (Weight %)	TAN (mgKOH/g)
Alberta Oil Sands Crude Oils				
- Dilbits	Access Western Blend	21.9	3.94	1.70
	Cold Lake	20.9	3.78	0.97
	Peace River Heavy	20.8	4.97	2.49
	Seal Heavy	20.5	4.64	1.86
	Smiley Coleville	20.0	2.98	0.97
	Wabasca Heavy	20.3	4.10	1.03
	Western Canadian Select	20.6	3.46	0.92
- DilSynBit	A bian Heavy	19.1	2.42	0.51
Selected Heavy Crude Oils				
Western Canada	Western Canadian Blend	20.7	3.16	0.71
U.S. (California)	Hondo Monterey	19.4	4.70	0.43
	Kern River	13.4	1.10	2.36
Venezuela	Pilon	16.2	2.47	1.60
	Bachaquero	13.5	2.30	2.63
	Tia Juana Heavy	12.3	2.82	3.90
	Laguna	10.9	2.66	2.82
	Boscan	10.1	5.40	0.91
Mexico	Maya	21.5	3.31	0.43
Italy	Tempa Rossa	20.4	5.44	0.05
United Kingdom	Captain	19.2	0.70	2.40
Indonesia	Duri (Sumatran Heavy)	20.8	0.20	1.27
Selected Medium and Light Crude Oils (> 22.3° API)				
U.S. (Alaska)	Alaskan North Slope	32.1	0.93	0.12
U.S. (Texas)	West Texas Intermediate	40.8	0.34	0.10
U.S. (Gu f of Mexico)	Hoops Blend	31.6	1.15	1.07
	Thunderhorse	28.3	0.64	0.47
	Poseidon Heavy-sour	29.7	1.65	0.41
	Mars Heavy-sour	28.9	2.05	0.51
	Southern Green Canyon Heavy-Sour	28.4	2.48	0.17
Nigeria	Bonga	30.2	0.25	0.55
Norway	Statfjord	28.3	0.64	0.47
Dubai	Dubai Fateh Heavy	30.8	2.07	0.05
Saudi Arabia	Arabian Heavy	27.5	2.95	0.40
	Arabian Light	33.7	1.96	0.05

Sources: Canadian crude data from Crude Quality Inc., Canadian Crude Quick Reference Guide, Updated June 2, 2011, at http://www.crudemonitor.ca; Other crude oil data from: Capline, Crude Oil Assays, at http://www.cap inepipe ine.com; BP Crude Assays, at http://www.bp.com; ExxonMobil, at http://www.exxonmobil.com/crudeoil/about_crudes_region.aspx; "Benchmark West Texas Intermediate Crude Assayed," *Oil and Gas Journal*, 1994; McQuilling Services, LLC, "Carriage of Heavy Grade Oil," Garden City, NY, 2011, http://www.meglobaloil.com/MARPOL.pdf; Hydrocarbon Pub ishing Co., *Opportunity Crudes Report II*, Southeastern, PA, 2011, p. 5, http://www.hydrocarbonpublishing.com/ReportP/Prospectus-Opportunity%20Crudes%20II_2011.pdf.

Notes: The crude oils listed above are not an exhaustive list, nor do they represent a specific percentage of global consumption. The crudes listed above are selected examples of different crude oils from around the world. Multiple crude oils from Venezuela are included to indicate the range of parameters in different heavy crude oils.

Section 2: Keystone XL Pipeline—Overview

As originally proposed by TransCanada in September 2008,[37] the Keystone XL pipeline would involve two major segments (**Figure 6**). The first segment—approximately 850 pipeline miles in the United States[38]—would cross the U.S.-Canadian border into Montana, pass through South Dakota, and terminate in Steele City, Nebraska. The second segment—approximately 480 miles and labeled as the "Gulf Coast Project" in **Figure 6**—would connect an existing pipeline in Cushing, Oklahoma with locations in southern Texas.[39]

As discussed below, the Department of State (DOS) announced its denial of the Keystone XL permit in January 2012. In February 2012, TransCanada announced that it would proceed with development of the southern pipeline segment as a separate proposal. As this segment is within the United States, it does not require a Presidential Permit (discussed below). Thus, the revised permit, which TransCanada submitted on May 12, 2012, only applies to the first segment that connects Canada with the United States.

The Keystone XL pipeline would have the capacity to deliver 830,000 barrels per day (bpd), a substantial flow rate compared to other U.S.-Canada import pipelines (**Table 3**).The 36-inch-diameter pipeline would require a 50-foot-wide permanent right-of-way along the route. Approximately 95% of the pipeline right-of-way would be on privately owned land, with the remaining 5% almost equally state and federal land. Private land uses are primarily agricultural—farmers and cattle ranchers. Above ground facilities associated with the pipelines include pump stations (with associated electric transmission interconnection facilities), mainline valves, and delivery metering facilities.

The Keystone XL pipeline and the "Gulf Coast Project" would combine with two existing pipeline segments to complete TransCanada's Keystone Pipeline System. This system is depicted in **Figure 6**. These existing segments include:

- The Keystone Mainline: A 30-inch pipeline with a capacity of nearly 600,000 bpd that connects Alberta oil sands to U.S. refineries in Illinois. The U.S. portion runs 1,086 miles and begins at the international border in North Dakota. The Keystone Mainline began operating in June 2010.
- The Keystone Cushing Extension: A 36-inch pipeline that runs 298 miles from Steele City, Nebraska to existing crude oil terminals and tanks farms in Cushing, Oklahoma. The Cushing Extension began operating February 2011.

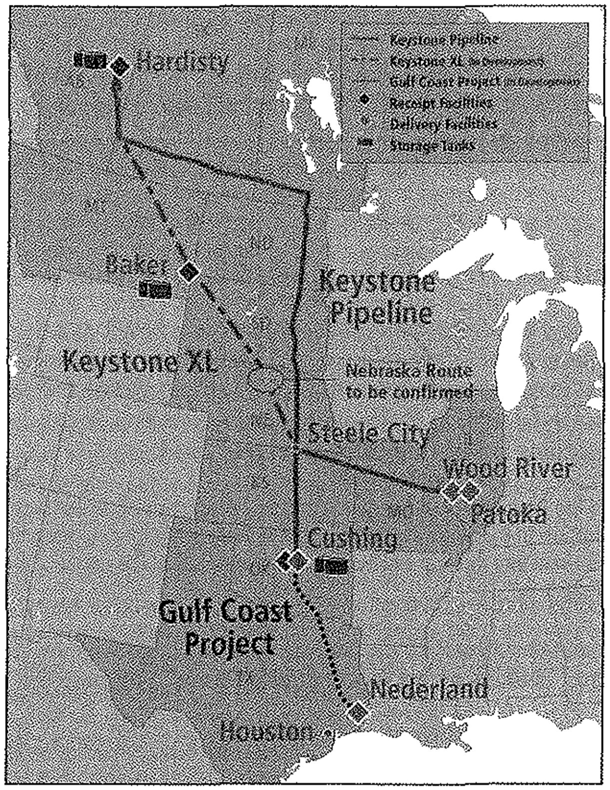
[37] The original application and related documents are available at the Department of State Keystone XL website, at http://keystonepipeline-xl.state.gov/archive/index.htm.

[38] 1,183 miles from its origin in Alberta, Canada. See U.S. Department of State, *Final Environmental Impact Statement for the Proposed Keystone XL Project*, August 2011.

[39] An additional 50-mile segment would connect to additional locations in Texas. For further details, see U.S. Department of State, *Final Environmental Impact Statement for the Proposed Keystone XL Project*, August 2011.

Figure 6. The Keystone Pipeline System

Completed and Proposed Segments of the Keystone and Keystone XL Pipelines



Source: TransCanada.

Federal Requirements to Consider the Pipeline's Environmental Impacts

When considering a Presidential Permit application, the DOS must conduct an environmental review of its actions pursuant to the National Environmental Policy Act (NEPA, 42 U.S.C. §4321 et seq.). This process highlighted many environmental impacts associated with the construction, operation, and maintenance of the pipeline system and associated facilities.

Issues that arose and environmental impacts identified during DOS efforts to process TransCanada's application for a Presidential Permit ultimately resulted in the denial of its permit application. With TransCanada's May 4, 2012 reapplication for a permit to construct the Keystone XL pipeline project, the Presidential Permit process and NEPA compliance process begin anew.

Generally, federal agencies have no authority to control siting of oil pipelines, even interstate pipelines.[40] Instead, the primary siting authority for oil pipelines generally would be established

[40] This is in contrast to interstate natural gas pipelines, which, under Section 7(c) (15 USC §717f(c)) of the Natural Gas Act, must obtain a "certificate of public convenience and necessity" from the Federal Energy Regulatory Commission.

under applicable state law (which may vary considerably from state to state).[41] However, in accordance with Executive Order 13337, a facility connecting the United States with a foreign country, including a pipeline, requires a Presidential Permit from DOS before it can proceed.[42]

Key elements of the Presidential Permit process, including DOS efforts to identify environmental impacts associated with the TransCanada's 2008 permit application are discussed below. Included in that discussion are relevant activities and requirements associated with DOS compliance with NEPA and its obligation to determine whether the proposed pipeline would serve the national interest.

Presidential Permit Requirements for Cross-Border Pipelines

A decision to issue or deny a Presidential Permit application is based on a determination that the proposed project would serve the "national interest." This term is not defined in the Executive Orders. In the course of making that determination, DOS may consider a wide range of factors such as the project's potential impacts to the environment, economy, energy security, foreign policy, and others. Regarding its determination, DOS has stated:

> Consistent with the President's broad discretion in the conduct of foreign affairs, DOS has significant discretion in the factors it examines in making a National Interest Determination. The factors examined and the approaches to their examination are not necessarily the same from project to project.[43]

However, the Department has identified the following as key factors it considered in making *previous* national interest determinations for oil pipeline permit applications:

- Environmental impacts of the proposed projects;
- Impacts of the proposed projects on the diversity of supply to meet U.S. crude oil demand and energy needs;
- The security of transport pathways for crude oil supplies to the United States through import facilities constructed at the border relative to other modes of transport;
- Stability of trading partners from whom the United States obtains crude oil;

[41] Federal laws and regulations address other matters, including worker safety and environmental concerns. See CRS Report R41536, *Keeping America's Pipelines Safe and Secure Key Issues for Congress*, by Paul W. Parfomak and CRS Report RL33705, *Oil Spills in U.S. Coastal Waters Background and Governance*, by Jonathan L. Ramseur.

[42] This authority was originally vested in the U.S. State Department with the promulgation of Executive Order 11423, "Providing for the performance of certain functions heretofore performed by the President with respect to certain facilities constructed and maintained on the borders of the United States," in 1968. Executive Order 13337, "Issuance of Permits With Respect to Certain Energy-Related Facilities and Land Transportation Crossings on the International Boundaries of the United States," of April 30, 2004, amended this authority and the procedures associated with permit review for energy-related projects, but did not substantially alter the exercise of authority or the delegation to the Secretary of State in E.O. 11423. Due to the particular significance to Presidential Permit issuance for pipelines, provisions in E.O 13337 will be cited in this report. For further information on the Executive Order authority and related issues, see CRS Report R42124, *Proposed Keystone XL Pipeline Legal Issues*, by Adam Vann et al.

[43] The U.S. State Department, *Final Environmental Impact Statement for the Keystone XL Project,* August 2011, "Introduction" (as amended September 22, 2011), p. 1-4, available at http://keystonepipeline-xl.state.gov/archive/dos_docs/feis/index.htm#.

- Relationship between the United States and various foreign suppliers of crude oil and the ability of the United States to work with those countries to meet overall environmental and energy security goals;
- Impact of proposed projects on broader foreign policy objectives, including a comprehensive strategy to address climate change;
- Economic benefits to the United States of constructing and operating proposed projects; and
- relationships between proposed projects and goals to reduce reliance on fossil fuels and to increase use of alternative and renewable energy sources.[44]

DOS may consider additional factors to inform its national interest determination for a given project. However, pursuant to E.O. 13337, for each permit application it receives for an energy-related project, DOS must request the views of the Attorney General, Administrator of the Environmental Protection Agency (EPA), and Secretaries of Defense, the Interior, Commerce, Transportation, Energy, and Homeland Security (or the heads of those departments or agencies with relevant authority or responsibility over relevant elements of the proposed project). DOS may request the views of additional federal department and agency heads, as well as additional local, state, or tribal agencies, as it deems appropriate for a given project. DOS must also invite public comment on the proposed project.

If, after considering the views and assistance of various agencies and the comments from the public, DOS finds that issuance of a permit would serve the national interest, then a Presidential Permit may be issued. Specific to the Keystone XL pipeline, in its May 2012 Presidential Permit application, TransCanada states

> The project will serve the national interest of the United States by providing a secure and reliable source of Canadian crude oil to meet the demand from refineries and markets in the United States, by providing critically important market access to developing domestic oil supplies in the Bakken formation in Montana and North Dakota, and by reducing U.S. reliance on crude oil supplies from Venezuela, Mexico, the Middle East, and Africa. The project will also provide significant economic and employment benefits to the United States, with minimal impacts on the environment.[45]

It is during the NEPA process that DOS will determine the degree to which the proposed pipeline project may impact the environment, as well as identify potential mitigation measures or protections necessary to reduce the potential for adverse environmental impacts. When the NEPA process is complete, DOS may use that assessment of environmental impacts, with other factors, to determine if the project does, in fact, serve the national interest.

---

[44] Ibid.

[45] TransCanada Keystone Pipeline, L.P., "Application of TransCanada Keystone Pipeline L.P. for a Presidential Permit Authorizing the Construction, Operation, and Maintenance of Pipeline Facilities for the Importation of Crude Oil to be Located at the United States-Canada Border," U.S. Dept. of State, May 4, 2012, pp. 1-2, available at http://www.keystonepipeline-xl.state.gov/.

Identification of Environmental Impacts During the NEPA Process[46]

The DOS review of a Presidential Permit application explicitly requires compliance with multiple federal environmental statutes.[47] Environmental requirements identified within the context of the NEPA process has drawn considerable attention.

Pursuant to NEPA, in considering an application for a Presidential Permit, DOS must take into account environmental impacts of a proposed facility and directly related construction. In complying with NEPA, federal agencies must prepare an Environmental Impact Statement (EIS) for projects determined to have "significant" environmental impacts. DOS concluded that issuance of a Presidential Permit for the proposed construction, connection, operation, and maintenance of the Keystone XL Pipeline and its associated facilities at the United States border may have a significant impact on the environment within the meaning of NEPA.[48] As a result, DOS prepared an EIS to identify the reasonably foreseeable impacts from the proposed Keystone XL pipeline.[49] Similarly, an EIS will likely be required for the pipeline project for which the May 4, 2012 permit application was filed.

EIS preparation is done in two stages, resulting in a draft and final EIS. NEPA regulations require the draft EIS to be circulated for public and agency comment, followed by a final EIS that incorporates those comments.[50] The agency responsible for preparing the EIS, in this case DOS, is designated the "lead agency." In developing the EIS, DOS must rely on information provided by TransCanada. For example, TransCanada's original permit application included an Environmental Report which was intended to provide the State Department with sufficient information to understand the scope of potential environmental impacts of the project.[51]

In preparing the draft EIS, the lead agency must request input from "cooperating agencies," which include any agency with jurisdiction by law or with special expertise regarding any environmental impact associated with the project.[52] The original Keystone XL permit process involved 11 federal cooperating agencies, including the Environmental Protection Agency (EPA),

---

[46] For more detailed NEPA information, see CRS Report RL33152, *The National Environmental Policy Act (NEPA) Background and Implementation*, by Linda Luther.

[47] DOS is explicitly directed to review the project's compliance with the National Historic Preservation Act (16 U.S.C. §470f), the Endangered Species Act (16 U.S.C. §1531 et seq.), and Executive Order 12898 of February 11, 1994 (59 *Federal Register* 7629), concerning environmental justice.

[48] U.S. Department of State, "Notice of Intent to Prepare an Environmental Impact Statement and to Conduct Scoping Meetings and Notice of Floodplain and Wetland Involvement and to Initiate Consultation under Section 106 of the National Historic Preservation Act for the Proposed TransCanada Keystone XL Pipeline," 74 *Federal Register* 5020, January 28, 2009.

[49] In preparing an EIS associated with a Presidential Permit application, NEPA regulations promulgated by both the Council of Environmental Quality (CEQ) and the State Department would apply to the proposed project. CEQ regulations implementing NEPA (under 40 C.F.R. §§1500-1508) apply to all federal agencies. NEPA regulations applicable to State Department actions, which supplement the CEQ regulations, are found at 22 C.F.R. §161.

[50] For information regarding NEPA requirements, see CRS Report RL33152, *The National Environmental Policy Act (NEPA) Background and Implementation*, by Linda Luther.

[51] Documents submitted by TransCanada for its initial 2008 Presidential Permit application, now archived by DOS, are available at http://keystonepipeline-xl.state.gov/archive/proj_docs/index.htm.

[52] 40 C.F.R. §1508.5. Also, Executive Order 13337 directs the Secretary of State to refer an application for a Presidential Permit to other specifically identified federal departments and agencies on whether granting the application would be in the national interest.

as well as state agencies. **Table A-1** (in the **Appendix**) provides a list of various agencies and their roles in the pipeline permitting process.

In addition to its role as a cooperating agency, EPA is also required to review and comment publicly on the EIS and rate both the adequacy of the EIS itself and the level of environmental impact of the proposed project.[53] EPA's role in rating draft EISs for the Keystone XL pipeline project had a significant impact on the NEPA process for TransCanada's 2008 Presidential Permit application.

The State Department released its draft EIS for the proposed Keystone XL Pipeline project for public comment on April 16, 2010.[54] On July 16, 2010, EPA rated the draft EIS "Inadequate."[55] EPA found that potentially significant impacts were not evaluated and that the additional information and analysis needed was of such importance that the draft EIS would need to be formally revised and again made available for public review. DOS issued a supplemental draft EIS on April 15, 2011.[56] In addition to addressing issues associated with EPA's inadequacy rating, the supplemental draft EIS addressed comments received from other agencies and the public. On June 6, 2011, EPA sent a letter to the State Department that rated the supplemental draft EIS as having "Insufficient Information" and having "Environmental Objections" to the proposed action.[57] EPA acknowledged that DOS had "worked diligently" to develop additional information in response to EPA's comments on the draft EIS, but additional analysis was needed on several points, including potential oil spill risks and lifecycle greenhouse gas emissions associated with the proposed project.

In its June 6, 2011 letter, EPA refers to agreements with DOS that certain deficiencies identified in the supplemental draft EIS would be addressed in the final EIS. On August 26, 2011, DOS did issue the final EIS for the proposed Keystone XL Pipeline (hereafter referred to as 2011 FEIS).[58] Although DOS addressed stakeholder comments, including those of EPA, in its 2011 FEIS,[59] it is unknown whether EPA made any additional comments to DOS during the 90-day public review period marking the national interest determination (discussed below). Regardless, EPA will have

[53] Rating the EIS takes place after the draft is issued. The EIS could be rated either "Adequate," "Insufficient Information," or "Inadequate." EPA's rating of a project's environmental impacts may range from "Lack of Objections" to "Environmentally Unsatisfactory." In rating the impact of the action itself, EPA would specify one of the following: "Lack of Objections," "Environmental Concerns," "Environmental Objections," or "Environmentally Unsatisfactory." The federal agency would then be required to respond to EPA's rating, as appropriate. For more information, see the U.S. Environmental Protection Agency's "Environmental Impact Statement (EIS) Rating System Criteria" at http://www.epa.gov/compliance/nepa/comments/ratings.html.

[54] EISs prepared by DOS for TransCanada's 2008 Presidential Permit application, now archived by DOS, are available at http://keystonepipeline-xl.state.gov/archive/dos_docs/index.htm.

[55] U.S. Environmental Protection Agency's July 16, 2010, letter to the U.S. Department of State commenting on the draft EIS for the Keystone XL project is available at http://yosemite.epa.gov/oeca/webeis.nsf/%28PDFView%29/20100126/$file/20100126.PDF.

[56] See footnote 54.

[57] U.S. Environmental Protection Agency's June 6, 2011 letter to the U.S. Department of State commenting on the supplemental draft EIS for the Keystone XL project is available at http://yosemite.epa.gov/oeca/webeis.nsf/%28PDFView%29/20110125/$file/20110125.PDF?OpenElement.

[58] U.S. Department of State, *Final Environmental Impact Statement for the Proposed Keystone XL Project*, August 26, 2011 (with portions amended September 22, 2011), available at http://keystonepipeline-xl.state.gov/archive/dos_docs/feis/index.htm.

[59] 2011 final EIS, "Appendix A, Responses to Comments and Scoping Summary Report," available at http://keystonepipeline-xl.state.gov/archive/dos_docs/feis/vol3and4/appendixa/index.htm.

an opportunity to comment on NEPA documentation prepared for TransCanada's May 2012 permit application.

Identification of Environmental Impacts During the National Interest Determination

Generally, the NEPA review is considered complete when (or if) the federal agency issues a final Record of Decision (ROD), formalizing the selection of a project alternative. However, for a project subject to a Presidential Permit, issuance of a final EIS marks the beginning of a 90-day public review period during which DOS gathers additional information necessary to make its national interest determination. For previous Presidential Permits, a ROD and National Interest Determination were issued as the same document.[60]

Issuance of the ROD and National Interest Determination involve distinctly different, yet interrelated requirements. Under NEPA, DOS must fully assess the environmental consequences of an action and potential project alternatives *before* making a final decision. NEPA does not prohibit a federal action that has adverse environment impacts; it requires only that a federal agency be fully *aware of* and *consider* those adverse impacts before selecting a final project alternative. That is, NEPA is intended to be part of the decision-making process, not dictate a particular outcome.

The DOS's national interest determination, however, does dictate a particular outcome—approval or denial of a Presidential Permit. Issuance of a Presidential Permit is predicated on the finding that the proposed project would serve the national interest. While NEPA does not prohibit federal actions with adverse environmental impacts, a project's adverse environmental impacts may lead the DOS to determine that the project is not in the national interest.

Table 2 summarizes milestones in the national interest determination for TransCanada's initial permit application.[61]

[60] U.S. Department of State, *Department of State Record of Decision and National Interest Determination, TransCanada Keystone Pipeline, LP Application for Presidential Permit*, February 25, 2008.

[61] A more comprehensive timeline is provided in CRS Report R41668, *Keystone XL Pipeline Project Key Issues*, by Paul W. Parfomak, Linda Luther, and Adam Vann.

Oil Spills

A primary environmental concern of any oil pipeline is the risk of a spill. The impacts of an oil spill depend on multiple factors, including: the type of oil spilled and the size and location of the spill.[75] Location is generally considered the most important factor, as highlighted by DOS:

> The greatest concern would be a spill in environmentally sensitive areas, such as wetlands, flowing streams and rivers, shallow groundwater areas, areas near water intakes for drinking water or for commercial/industrial uses, and areas with populations of sensitive wildlife or plant species.[76]

Location-specific concerns played a key role in DOS's November 2011 decision to obtain additional information before making its national interest determination for TransCanada's 2008 Presidential Permit application. Regarding its decision, DOS stated:

> [P]articularly given the concentration of concerns regarding the environmental sensitivities of the current proposed route through the Sand Hills area of Nebraska, the Department has determined it needs to undertake an in-depth assessment of potential alternative routes in Nebraska.[77]

In part as a result of DOS's decision, TransCanada announced that it would work with the Nebraska Department of Environmental Quality to identify a potential pipeline route avoiding the Nebraska Sand Hills (**Table 2**).

Pipeline integrity concerns—whether real or perceived—were magnified by a 2010 oil sands crude pipeline spill in Michigan. On July 26, 2010, a 40-year old pipeline, operated by Enbridge, released approximately 800,000 gallons of oil sands crude oil[78] into Talmadge Creek, a waterway that flows into the Kalamazoo River (Michigan).[79] The National Transportation Safety Board (NTSB) issued a synopsis of its upcoming investigatory report in July 25, 2012.[80] The synopsis did not include a probable cause analysis, but it concluded that internal corrosion was not a factor in the incident.

Based on experience with pipelines historically, the Keystone XL pipeline will likely lead to some number of oil spills over the course of its operating life, regardless of design, construction, and safety measures. However, the frequency, volume, and location of spills are unknown. Some contend that proponents of the pipeline understate oil spill risks; others contend that pipeline opponents overstate the risks.

---

[75] See CRS Report RL33705, *Oil Spills in U.S. Coastal Waters Background and Governance*, by Jonathan L. Ramseur.

[76] 2011 FEIS, "Executive Summary," p. ES-9, available at http://keystonepipeline-xl.state.gov/archive/dos_docs/feis/vol1/index.htm.

[77] U.S. Department of State, "Keystone XL Pipeline Project Review Process: Decision to Seek Additional Information," Media Note, PRN 2011/1909, Office of the Spokesperson, November 10, 2011.

[78] See the Enbridge response website "Frequently Asked Questions" at http://www.response.enbridgeus.com/response/main.aspx?id=12783#Type_of_oil.; and *Tar Sands Pipelines Safety Risks* (citing a conference call with Enbridge CEO).

[79] For more up-to-date information, see EPA's Enbridge oil spill website at http://www.epa.gov/enbridgespill/index.html.

[80] See http://www.ntsb.gov/news/events/2012/marshall_mi/index.html. The final report is expected in the Fall of 2012 (personal communication with the NTSB, March 19, 2012).

A key question for policymakers is whether the Keystone XL proposed pipeline is different from other pipelines. For example, would the project impose a greater or lesser risk of an oil spill than another oil pipeline?

Oil Sands Crudes—Characteristics

Some environmental groups have argued that the pipeline would pose additional oil spill risks due to the material being transported.[81] They have asserted that diluted bitumen (Dilbit) poses particular concerns of volatility and corrosivity that may pose additional risks to the pipeline's integrity. Whether or not these issues warrant concern is debatable. Regardless, the concerns led Congress to enact provisions in P.L. 112-90 calling for further study. These issues are discussed below.

Volatility

According to a 2011 environmental groups' report, "at high temperatures, the mixture of light, gaseous condensate, and thick, heavy bitumen, can become unstable."[82] It is uncertain what constitutes a high temperature in this context. For example, would the temperature be within the range of the pipeline's operating parameters? Regardless, some have questioned this conclusion.[83]

One of the citations in the 2011 report that is cited as support for the above statement is an "expert viewpoint"[84] that does not specifically address pipeline transportation, but seems to discuss behavior of oil sands in the reservoir. The other is a study modeling liquid-column separation in oil pipelines—perhaps a relevant issue (discussed below)—but this study does not appear to distinguish between different crude oil types.[85]

Related to the assertion of volatility, the 2011 report highlights a process—described as liquid-column separation—that could potentially occur in pipelines when changes in pipeline pressure causes some of the natural gas liquid component to change into a gas bubble. According to the report, when these gas bubbles burst they release high pressure that can damage a pipeline (a process described as cavitation). The report states that "instability of DilBit can render pipelines particularly susceptible to ruptures caused by pressure spikes."[86]

However, DOS countered this assertion stating that it:

---

[81] Anthony Swift et al, *Tar Sands Pipelines Safety Risks*, Joint Report by Natural Resources Defense Council, National Wildlife Federation, Pipeline Safety Trust, and Sierra Club, February 2011 (hereafter *Tar Sands Pipelines Safety Risks*); see also Anthony Swift et al, *Pipeline and Tanker Trouble The Impact to British Columbia's Communities, Rivers, and Pacific Coastline from Tar Sands Oil Transport*, Joint Report by Natural Resources Defense Council, Pembina Institute, and Living Oceans Society, November 2011 (hereafter *Pipeline and Tanker Trouble*).

[82] *Tar Sands Pipelines Safety Risks*.

[83] See Crude Quality Inc., *Report regarding the U.S. Department of State Supplementary Draft Environmental Impact Statement*, May 2011; and Energy Resources Conservation Board, Press Release, "ERCB Addresses Statements in Natural Resources Defense Council Pipeline Safety Report," February 2011.

[84] As cited by *Tar Sands Pipelines Safety Risks*: Expert Viewpoint (John Shaw, University of Alberta) – Phase Behaviors of Heavy Oils and Bitumen," Schlumberger Ltd., 2011. The cited website no longer leads to this source, but CRS located the material using the Internet "Wayback Machine," at http://web.archive.org.

[85] Changjun Li et al., *Study on Liquid-Column Separation in Oil Transport Pipeline*, American Society of Civil Engineers, International Conference on Pipelines and Trenchless Technology 2009.

[86] *Tar Sands Pipelines Safety Risks*.

> contacted the author [that NRDC cited to support the above statement]… to address this concern and determined that it would not be valid to infer from this research that dilbits are any more or less stable than other crude oils, or that they are more likely to cause pressure spikes during transport in pipelines or otherwise pose an increased risk to pipeline safety.[87]

Corrosivity

Some argue that DilBit pipelines may be more likely to fail than other crude oil pipelines because the bitumen mixtures they carry are "significantly more corrosive to pipeline systems than conventional crude."[88] Three DilBit properties of particular interest are acidity, sulfur content, and solids content, all of which may influence the overall corrosiveness of a given blend of crude oil. The 2011 report also focuses on these specific DilBit properties and their potential influence on pipeline corrosion, asserting:

> Compared to "conventional" crudes, DilBit blends are thicker and more acidic, and contain more sulfur, chloride salts, and quartz sand particles. These characteristics create a "combination of chemical corrosion and physical abrasion [that] can dramatically increase the rate of pipeline deterioration."[89]

To what extent these claims may be correct is the subject of debate. Alberta's Energy Resources Conservation Board (ERCB), among other stakeholders, has rejected the claims from the 2011 report, stating that "there is no reason to expect this product to behave in any substantially different way than other oil...."[90] Additional background on the specific DilBit characteristics of concern may offer a greater understanding of the corrosion mechanisms at issue, but not necessarily resolve the debate.

Total Acid Number

As indicated in **Table 1** (above) Canadian DilBit total acid numbers (TANs) range between 0.92 to 2.49. This range is generally higher than lighter crude oils, but comparable with other heavy oils. It is well-established that the presence of naphthenic acids in high TAN crudes can considerably increase corrosion potential in the parts of refinery distillation units operating at high temperature—above 400°F.[91] However, pipeline transportation of DilBit is expected to occur at much lower temperatures: the maximum operating temperature for Keystone XL is 150°F. Moreover, DilBit pipeline corrosion rates may not have a direct correlation with TAN values. There is evidence of more than 1,000 napthenic acid varieties with varying corrosivity, which may comprise a single TAN number.[92] TAN values depend upon the specific content and types of

---

[87] 2011 FEIS, "Potential Releases," p. 3-13.45, available at http://keystonepipeline-xl.state.gov/archive/dos_docs/feis/vol2/env/index.htm.

[88] *Tar Sands Pipelines Safety Risks*.

[89] *Tar Sands Pipelines Safety Risks*.

[90] Canadian Energy Resources Conservation Board (ERCB), "ERCB Addresses Statements in Natural Resources Defense Council Pipeline Safety Report," Press release, Calgary, Alberta, February 16, 2011.

[91] Dennis Haynes, *Naphthenic Acid Bearing Refinery Feedstocks and Corrosion Abatement*, Presentation to the AIChE Chicago Symposium, 2006, p. 7; Bruce Randolph, James Scinta, Eric Vetters, et al., *Challenges in Processing Canadian Oilsands Crude – A US Refiners' Perspective,* Canadian Crude Quality Technical Association, June 25, 2008.

[92] See Anne Shafizadeh et al., "High Acid Crudes," Presentation to the Crude Oil Quality Group New Orleans Meeting, January 30, 2003, http://www.coqa-inc.org/20030130High%20Acid%20Crudes.pdf.

compounds in specific crudes—which may vary significantly from crude to crude.[93] Some testing of pipeline steels has shown that Canadian oil sands crudes exhibit "very low corrosion rates" despite high TAN numbers, in part because they contain other "inhibitor" compounds that reduce the corrosivity of the bitumen.[94] Therefore, it is uncertain whether refiners' experiences with corrosion from high TAN crudes can be directly extended to DilBit transmission pipelines.

Sulfur Content

Another factor in crude oil corrosivity is sulfur content. Crude oils sent to U.S. refineries typically contain 0.5% to 2.5% sulfur.[95] As indicated in **Table 1**, DilBits have sulfur content substantially above this range—between 3% and 5%. In sour crudes (> 1% sulfur content), sulfur is present as hydrogen sulfide (H_2S),[96] which can combine with water to form sulfuric acid (H_2SO_4), a strongly corrosive acid. Like napthenic acid corrosion (discussed above), sulfidic corrosion is a high temperature phenomenon, beginning above 500°F.[97] In pipelines, H_2S can also interact with napthenic acids, carbon dioxide (CO_2) and solids, complicating the possible corrosion processes at work. Research and refiner experience suggest that sulfuric and napthenic acid corrosivity can be inhibited or augmented by the presence of specific sulfur compounds depending upon the chemical characteristics of those compounds (e.g., how readily they decompose into H_2S), whether they are in liquid or vapor phase, and other factors.[98] In some cases, H_2S can form a protective sulfide coating that actually prevents corrosion.[99] Thus, as in the case of TAN levels, sulfur content in crude oil may not accurately reflect corrosivity, notwithstanding the common use of sulfur content to indicate sulfidic corrosion potential in refinery equipment.[100] For these reasons, the direct application of sulfidic corrosion experience in refineries to lower temperature crude oil pipelines may be inconsistent with chemical processes involved.

---

[93] Canadian Crude Quality Technical Association, TAN Phase III Project, Meeting Minutes of June 23, 2009, http://www.ccqta.com/docs/documents/Projects/TAN_Phase_III/TAN%20Phase%20III%20March%202009%20Minutes.pdf.

[94] Rena Liviniuk, et al., "Organic Acid Structure – A Correlation With Corrosivity," AM-09-20, Presented to the National Petrochemical and Refiners Association, Annual Meeting, March 22-24, 2009, San Antonio, TX, p. 9.

[95] U.S. Energy Information Administration, "Crude Oil Input Qualities: Sulfur Content, Annual," Internet table, June 29, 2011, http://www.eia.gov/dnav/pet/pet_pnp_crq_a_EPC0_YCS_pct_a.htm.

[96] H_2S is generated at temperatures greater than 392 F (200 C) through a reaction between carbon-containing and sulfur-containing compounds in the crude. Thus, H_2S can be generated during the oil sands thermal extraction process. See: G.G. Hoffmann, et al., "Thermal Recovery Processes and Hydrogen Sulfide Formation," Presented at the Society of Petroleum Engineers International Symposium on Oilfield Chemistry, San Antonio, Texas, February 14-17, 1995.

[97] H.M. Shalaby, "Refining of Kuwait's Heavy Crude Oil: Materials Challenges," Workshop on Corrosion and Protection of Metals, Arab School for Science and Technology, Kuwait, December 3-7, 2005, p. 5; http://www.arabschool.org/pdf_notes/20_REFINING_OF_KUWAITS_HEAVY_CRUDE_OIL.pdf.

[98] Ibid., p.6; Heather Dettman, et al, "Refinery Corrosion: The Influence of Organic Acid and Sulphur Compund Structure on Global Crude Corrosivity," Presentation to the 5th NCUT Upgrading and Refining Conference 2009, Edmonton, Alberta, September 14 - 16, 2009; Dennis Haynes, 2006, p. 8.

[99] Gregory R. Ruschau, and Mohammed A. Al-Anez, *Oil and Gas Exploration and Production*, Appendix S, Corrosion Prevention, p. S6, in: CC Technologies Laboratories, Inc., *Corrosion Costs And Preventive Strategies In The United States*, Report to the U.S. Federal Highway Administration, Office of Infrastructure Research and Development, Report FHWA-RD-01-156, September 2001, http://www.corrosioncost.com/pdf/oilgas.pdf.

[100] H.M Shalaby, 2005, p. 6.

Abrasive Solids

Solids suspended in crude oil have the potential to accelerate corrosion in pipelines either by settling out (forming corrosive conditions beneath them) or through abrasion. Abrasion has been raised as a particular concern for DilBit pipelines because DilBit may contain significantly more solids than conventional crudes.[101] These solids, it is argued, might wear away the interior walls of a pipeline and exacerbate wall loss from acidic corrosion. Some have compared this process to sandblasters.[102] However, CRS is not aware of publically available research that has examined whether the conditions exist for significant internal abrasion of DilBit pipelines. Crude oils with high solids content are also generally filtered to meet the quality specifications set by pipelines and refiners. Thus DilBit blends may have solids content higher than other types of crudes, but still within an acceptable range for pipeline and refinery operations.

Keystone XL Pipeline Operating Parameters

Multiple parties submitted comments to DOS, highlighting the Keystone XL pipeline operating parameters as a particular concern.[103] The 2011 environmental groups' report claims that "the risks of corrosion and the abrasive nature of DilBit are made worse by the relatively high heat and pressure."[104]

The report asserts the pipeline will be operating at temperatures "up to 158° F," which is substantially higher than conventional crude pipelines, which, according to the report, operate at less than 100° F.[105] TransCanada has stated that "oil in a line like this comes into our pipeline between 80-120°F, and it stays within that temperature range during transport."[106] In the 2011 FEIS, DOS states that the maximum operating temperature of the proposed pipeline would not exceed 150° F. It is uncertain whether this 150° F mark is an upper bound that might be approached on rare occasions, or whether the operating temperature would typically hover near this maximum. Either way, it is below the maximum operational temperature cited by some environmental groups.

According to the report, conventional crude pipeline pressure is 600 pounds per square-inch (PSI), while diluted bitumen requires a pipeline pressure of 1,440 psi[107] A subsequent 2011 report lists this figure as 2,130 psi.[108] Regardless, the 2011 FEIS lists the Keystone XL operating pressure as 1,308 psi.

---

[101] Baker Hughes Inc., *Planning Ahead for Effective Canadian Crude Processing*, Sugar Land, TX, 2010, p. 4, http://www.bakerhughes.com/assets/media/whitepapers/4c2a3c8ffa7e1c3c740001d/file/28271-canadian_crudeoil_update_whitepaper_06-10.pdf.pdf&fs=1497549.

[102] *Tar Sands Pipelines Safety Risks.*.

[103] See 2011 final EIS, "Appendix A, Responses to Comments and Scoping Summary Report," available at http://keystonepipeline-xl.state.gov/archive/dos_docs/feis/vol3and4/appendixa/index.htm.

[104] *Tar Sands Pipelines Safety Risks.*

[105] *Tar Sands Pipelines Safety Risks.*

[106] TransCanada, "TransCanada's Keystone XL Pipeline – Know the Facts," fact sheet, May 2011, http://www.transcanada.com/docs/Key_Projects/know_the_facts_kxl.pdf.

[107] *Tar Sands Pipelines Safety Risks.*

[108] *Pipeline and Tanker Trouble.*

The degree to which the Keystone XL pipeline's operating parameters differ from other oil pipeline operating parameters is beyond the scope of this report. In general, the Keystone XL operating parameters are different, because diluted bitumen (and heavy crude oils) are more viscous (resistant to flow) than conventional crude oil. According to a 2011 review of heavy crude transportation:

> Pipelining of heavy oil presents problems like instability of asphaltenes, paraffin precipitation and high viscosity that cause multiphase flow, clogging of pipes, high-pressure drops, and production stops.[109]

The same review describes several options that may be used "to resolve or improve pipelining of heavy and extra-heavy crude oil." These options include dilution with other substances and increasing/conserving the oil's temperature. Both of these options would reduce viscosity and both seem to be part of the Keystone XL proposed operations.

DOS states that the proposed pipeline would satisfy the Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) regulations (49 CFR Part 195) that apply to hazardous liquid pipelines. In addition, Keystone agreed to implement 57 additional measures developed by PHMSA. In consultation with PHMSA, DOS determined that incorporation of those conditions:

> would result in a Project that would have a degree of safety over any other typically constructed domestic oil pipeline system under current code and a degree of safety along the entire length of the pipeline system similar to that which is required in High Consequence Areas (HCAs) as defined in 49 CFR 195.450.[110]

The *degree* to which the additional 57 measures mitigate risk is debatable. For instance, the primary author of the 2011 environmental groups' report argued that only 12 of these conditions actually differ in some way from minimum requirements.[111]

Oil Pipeline Spill Data from Alberta

Many stakeholders have argued a comparison of oil spill data from Alberta and the United States indicates that internal corrosion has led to substantially more oil spills in the Alberta pipeline system than the U.S. system.[112] They reason that this difference is likely related to high proportion of oil sands crudes, which have been in the Alberta system since the 1980s. In contrast, the first dedicated oil sands crudes pipeline in the United States, the Alberta Clipper, began operating in 2010.[113]

DOS rejected this assertion, stating:

---

[109] Rafael Martinez-Palou et al., "Transportation of Heavy and Extra-Heavy Crude Oil by Pipeline: A Review," *Journal of Petroleum Science and Engineering*, Vol. 75, pp. 274-282, January 2011.

[110] 2011 FEIS, "Project Description," p. 2-23, available at http://keystonepipeline-xl.state.gov/archive/dos_docs/feis/vol1/index.htm.

[111] Anthony Swift, "Clinton's Tar Sands Pipeline 'Safety Conditions' are Smoke and Mirrors," August 19, 2011, at http://switchboard.nrdc.org.

[112] 2011 FEIS, Appendix A (see footnote 59).

[113] *Tar Sands Pipelines Safety Risks*.

> [T]here is no evidence that the transportation of oil sands derived crude oil in Alberta has resulted in a higher corrosion related failure rate than occurs in the transportation of the variable-sourced crude oils in the U.S. system.[114]

Further, DOS pointed out that a comparison of the oil spill data is problematic for various reasons. In particular, the scopes of the data collected in each nation are different. Canadian data includes smaller spills and spills from certain pipelines not covered by PHMSA regulations. To address these discrepancies in data collection, PHMSA prepared a comparison of pipeline incidents of similar scopes between the two databases. This comparison was part of the 2011 FEIS and is provided below in **Table 4.**

Table 4. PHMSA Comparison of Oil Pipeline Incidents in Alberta and United States

2002 - 2010

Crude Oil Pipeline Failures U.S. and Alberta \ (2002-2010)		
U.S. Crude Oil Pipeline Incident History[a]		
Incident/Failure Case	**Failures/Year**	**Failures per 1,000 Pipeline Miles per Year**
Corrosion - External	9.8	0.19
Corrosion - Internal	22.1	0.42
All Failures	89.3	1.70
Alberta Crude Oil Pipeline Incident History[b]		
Corrosion - External	2.3	0.21
Corrosion - Internal	3.6	0.32
All Failures	22.0	1.97

Source: Reproduced by CRS; original table from 2011 FEIS, , p. 3.13-38 (Table 3.13.5-4).

Notes: The following notes are included in the table in the 2011 FEIS:

a. PHMSA includes spill incidents greater than 5 gallons. U.S. had 52,475 miles of crude oil pipe ines in 2008.

b. Alberta Energy and Utility Board Report, includes spills greater than and less than 5 bbls. Alberta had 11,187 miles of crude oil pipelines in 2006.

This comparison indicates that internal corrosion failures (per 1,000 miles of pipeline) were approximately 30% higher in the U.S. system (0.42 vs. 0.32). Regardless, such comparisons are challenging, if not impossible, considering the range of potential factors—pipeline age, enforcement, etc.—that may affect the underlying data. For this reason, the above comparison might be described as preliminary.

Keystone XL Spill Frequency Estimates

Spill frequency estimates for the Keystone XL project have been a subject of debate. During the NEPA process, Keystone submitted a spill frequency estimate of 0.22 spills per year. The company derived this estimate by using historical databases from PHMSA and then applying

[114] 2011 FEIS, "Potential Releases," p. 3.13-38 (see footnote 87).

project-specific factors, such as regulatory requirements, material strength, and technological advances.

However, some questioned Keystone's modified estimate, arguing that the pipeline's operating parameters—temperatures and pressures higher than conventional crude pipelines—would yield spill frequencies above historical averages, rather than below.[115]

Subsequent to Keystone's estimate, the DOS estimated that a spill over 50 barrels would occur between 1.2 to 1.8 times per year; spills of any size would occur between 1.8 to 2.5 times per year.[116]

Another potential source of data is the pipeline operating history of Keystone. Keystone has operated the Keystone Mainline pipeline and the Cushing Extension since 2010. Since that time the Keystone pipeline has generated 14 unintentional releases. DOS cites personal communication with PHMSA staff, who stated that these incidents are "not unusual start-up issues that occur on pipeline and are not unique."[117] Regardless, this figure is considerably higher than the Keystone XL spill frequency estimates DOS included in its 2011 FEIS.

Spill Size Estimates

Citing the PHMSA significant incident database,[118] DOS indicates that between 1990 and 2010, the average spill size for onshore hazardous liquid pipelines, which includes both oil and other materials, was less than 1,000 barrels (42,000 gallons).[119] Using this database, CRS calculated the exact average spill to be 918 barrels (38,556 gallons). Per the spill size classification included in the 2011 FEIS, the average spill would be considered a "large spill."[120]

One may question whether this database is the best tool for predicting spill size from the Keystone XL pipeline. The database includes oil and other hazardous liquids; pipelines of varying sizes and pressures; and pipelines of varying ages. A more refined comparison may offer policymakers a better prediction of possible spill size, but the PHMSA database is not immediately amenable to a more tailored assessment.

In its 2011 FEIS, DOS seems to suggest that "very large spills" (defined as greater than 5,000 barrels or 210,000 gallons) would require a dramatic event. According to DOS:

> A very large spill from the pipeline would likely require the occurrence of an event that would shear the pipeline such as major earth movement resulting from slides, major earth movement resulting from an earthquake, major flood flows eroding river banks at non-HDD

[115] See John Stansbury, *Analysis of Frequency, Magnitude and Consequence of Worst-Case Spills from the Proposed Keystone XL Pipeline*, Submitted as a comment to the supplemental draft EIS and later cited in the 2011 FEIS.

[116] 2011 FEIS, "Potential Releases," pp. 3.13-18 – 3.13-21 (see footnote 87).

[117] 2011 FEIS, "Potential Releases," p. 3.13-11 (see footnote 87).

[118] The significant incident database represents a subset of all incidents. To qualify as "significant" an incident must result in one of the following: (1) a fatality or injury requiring in-patient hospitalization; (2) $50,000 or more in total costs, measured in 1984 dollars; (3) a highly volatile liquid release of 5 barrels or more or other liquid releases of 50 barrels or more; or (4) a liquid releases resulting in an unintentional fire or explosion.

[119] 2011 FEIS, "Potential Releases," p. 3.13-15 (see footnote 87).

[120] Ibid.

> crossings, mechanical damage from third-party excavation or drilling work, or vandalism, sabotage, or terrorist actions.[121]

This assertion will be tested when the NTSB releases its investigation results for the July 2010 Enbridge oil spill.[122] That spill was a "very large spill," releasing over 800,000 gallons into the Kalamazoo River in Michigan.

Regardless, an average spill can require substantial cleanup efforts in certain locations. The July 2011 ExxonMobil spill into the Yellowstone River was approximately 42,000 gallons. The EPA is overseeing this oil spill response. In August 2011, over 1,000 personnel were engaged in cleanup and shoreline assessment efforts.[123] As of February 2012, the federal government has assigned $3.8 million from the Oil Spill Liability Trust Fund to address response activities.[124] This figure would not capture the expenses from the responsible party.

Environmental Impacts of Spills of Oil Sands Crude

Some contend that the distinct chemical composition of oil sands crude (e.g., DilBit) would pose a greater environmental risk from an oil spill than other crudes.[125] CRS is not aware of an authoritative study that has examined this assertion. Although parallels may be drawn between the possible behavior of conventional crudes and DilBit, studies are scarce regarding spills of heavy crudes with the specific composition of Canadian heavy crudes.

The behavior of crude oil spills and the fate of crude oil in the subsurface have been studied extensively around the world for a wide range of conventional crudes and other petrochemicals in both experimental settings and actual spills (e.g., Bemidji, Minnesota in 1979).[126] These include studies of specific chemical components that may be present in DilBit (e.g., benzene).[127] Based on extensive experience with other crudes and DilBit constituents, analysts may claim

---

[121] Ibid.

[122] Although a synopsis of this report was made available July 10, 2012, NTSB has not released the final report. See http://www.ntsb.gov/news/events/2012/marshall_mi/index.html.

[123] See EPA Update on Yellowstone River Oil Spill (Silvertip Pipeline), August 12, 2011, at http://www.epa.gov/yellowstoneriverspill/.

[124] Personal communication with U.S. Coast Guard, February 14, 2012.

[125] Swift et al, p. 7.

[126] See, for example, work compiled by the U.S. Geological Survey about the 1979 crude oil spill near Bemidji, MN, which contaminated a shallow aquifer: U.S. Geological Survey, "Crude Oil Contamination in the Shallow Subsurface: Bemidji, Minnesota," Internet page, July 20, 2011, http://toxics.usgs.gov/sites/bemidji_page.html. See also: M. Whittaker, S.J.T. Pollard, and T.E. Fallick, "Characterisation of Refractory Wastes at Heavy Oil-Contaminated Sites: A Review of Conventional and Novel Analytical Methods," *Environmental Technology*, Vol. 16, No. 11, November 1, 1995, pp. 1009-1033; S Khaitan et al., "Remediation of Sites Contaminated by Oil Refinery Operations," *Environmental Progress*, Vol. 25, No. 1, April 2006, pp. 20-31.

[127] See, for example: Lisa M. Geig et al., "Intrinsic Bioremediation of Petroleum Hydrocarbons in a Gas Condensate-Contaminated Aquifer," *Environmental Science and Technology*, vol. 33, no. 15 (1999), pp. 2550-2560; Paul E. Hardisty, et al., "Characterization of LNAPL in Fractured Rock," *Quarterly Journal of Engineering Geology & Hydrogeology*, Vol. 36, No. 4, November 2003, p. 343-354; J.L. Busch-Harris, e al., "In Situ Assessment of Benzene Biodegradation Potential in a Gas Condensate Contaminated Aquifer," Proceedings of 11th Annual International Petroleum Environmental Conference, Albuquerque, NM, October 12-15, 2004; John A. Connor, et al., "Nature, Frequency, and Cost of Environmental Remediation at Onshore Oil and Gas Exploration and Production Sites," *Remediation*, Vol. 21, No. 3, Summer 2011, pp. 121-144; Bruce E Rittmann, et al., *Natural Attenuation for Groundwater Remediation*, National Academy Press, 2000.

considerable confidence in models of DilBit behavior around groundwater. For example, the Energy Resources Conservation Board has stated that "DilBit should behave in much the same manner as other crude oils of similar characteristics.[128]

All spilled oil begins to "weather" or separate into different components over time. In general, heavier oils, like DilBit, are more persistent and may present greater technical challenges in oil removal operations than lighter crude oils. For a land spill, the heavier and more viscous components (i.e., the asphaltenes) would likely remain trapped in soil pores above the water table. It is also likely that the lighter constituents would partly evaporate and not be transported down through the soil with the heavier components.

However, if an oil spill reached the water table, some of the more soluble portions would likely dissolve into the groundwater and be transported in the direction of regional groundwater flow. The ultimate extent, shape, and composition of a groundwater contaminant plume resulting from a DilBit spill would depend on the specific characteristics of the soil, aquifer, and the amount and duration of the accidental release.

The heavier components of a DilBit spill would be difficult to remove from the soil during cleanup operations, and may require wholesale soil removal instead of other remediation techniques.[129] These challenges may come at a higher cost. In an oil spill model prepared for EPA, the model estimates that spills of heavy oil will cost nearly twice as much to clean up as comparable spills of conventional crude oil.[130]

Crude oils may contain multiple compounds that present toxicity concerns. DOS stated that "based on the combination of toxicity, solubility, and bioavailability, benzene was determined to dominate toxicity associated with potential crude oil spills."[131] Benzene and other BTEX compounds (benzene, toluene, ethyl benzene, and xylene) are generally in greater proportions in the lighter crude oils and particularly in refined products like gasoline.[132] In its 2011 FEIS, DOS compared the BTEX content of crude oil derived from oil sands (DilBit and DilSynBit) with conventional crude oils from Canada. The BTEX content of oil sands crudes ranged from 5,800 parts per million (ppm) to 9,100 ppm. The BTEX contents of conventional crude oils ranged from 5,800 ppm to 29,100 ppm.[133]

Other toxic compounds of concern in crude oils are polycyclic aromatic hydrocarbons (PAHs). Generally, PAHs are more toxic than BTEX and evaporate at a slower rate, but they are less soluble in water. The National Research Council's *Oil in the Sea* report stated that with

[128] Canadian Energy Resources Conservation Board (ERCB), "ERCB Addresses Statements in Natural Resources Defense Council Pipeline Safety Report," Press release, Calgary, Alberta, February 16, 2011.

[129] One such other method is "pump and treat," which involves cleaning soil and groundwater contamination by pumping and capturing the contaminated groundwater, then treating it at the surface to remove the contaminants. The same technique may be used to extract soil gas vapor from contaminated soil above the water table. For more information, see Environmental Protection Agency, *Basics of Pump-and-Treat Ground-Water Remediation Technology*, EPA/800/8-90003, March 1990.

[130] Dagmar Etkin, *Modeling Oil Spill Response and Damages Costs*, Proceedings of the 5th Biennial Freshwater Spills Symposium, 2004, at http://www.environmental-research.com.

[131] 2011 FEIS, "Potential Releases," p. 3.13-80 (see footnote 87).

[132] For a comprehensive discussion, see National Research Council, *Oil in the Sea III Inputs, Fates, and Effects*, National Academies of Science, February 2003.

[133] 2011 FEIS, "Potential Releases," Table 3.13.5-6, p. 3.13-45 (see footnote 87).

weathering/evaporation and the resulting loss of BTEX, PAHs become more important contributors to the remaining oil's toxicity.[134]

Unlike BTEX, the 2011 FEIS does not include a comparison of PAH concentrations across different crude oils. DOS states that PAH concentrations of crude oils that would be transported in the Keystone XL pipeline are unknown, because this information is proprietary.[135] Some commenters, including EPA, took issue with this during the EIS review process.[136]

Heavy metals may also be a concern. A 2011 NRDC report states that Dilbit contains quantities of heavy metals, particularly vanadium and nickel, that are "significantly larger" than conventional crude oil.[137] Assuming conventional oil means lighter crudes, this statement is largely correct.[138] However, the heavy metal concentrations in DilBit are similar to some other heavy crude oils, such as Mexican and Venezuela crudes that are processed in Gulf Coast refineries.[139] Most, if not all, of this crude oil arrives in the United States via vessel.[140]

Further Study

DOT officials acknowledge that they have not performed any specific studies nor reassessments of pipeline safety risks that might be unique to DilBit.[141] In addition, DOS points out that "a focused, peer-reviewed study of the potential corrosivity/erosivity of WCSB oil sands derived crude oils relative to other crude oils has not yet been conducted."[142]

Some in Congress have called for a review of DOT pipeline safety regulations to determine whether new regulations for Canadian heavy crudes are needed to account for any unique properties they may have. Accordingly, P.L. 112-90 requires PHMSA to review whether current regulations are sufficient to regulate pipelines transmitting "diluted bitumen," and analyze whether such oil presents an increased risk of release (§16).

Oil Sands Extraction Concerns

Opponents of the Keystone XL pipeline and oil sands development often highlight the environmental impacts that pertain to the region in which the oil sands resources are extracted. In general, these local/regional impacts from Canadian oil sands development may not directly

134 National Research Council, 2003, p. 126.

135 2011 FEIS, "Potential Releases," p. 3.13-31 (see footnote 87).

136 See footnote 57 regarding EPA's June 6, 2011 comments.

137 Anthony Swift, Susan Casey-Lefkowitz, and Elizabeth Shope, *Tar Sands Pipelines Safety Risks*, Natural Resources Defense Council (NRDC), February 2011.

138 Based on a comparison of crude oil assays from sources listed in Table 1.

139 2011 FEIS, "Potential Releases," Table 3.13.5-7 (see footnote 87).

140 Although a considerable percentage of oil imports come from Mexico (e.g., approximately 12% of crude oil imports in 2010), the EIA states that "Mexico does not have any international pipeline connections, with most exports leaving the country via tanker from three export terminals in the southern part of the country." EIA, Country Analysis Briefs, at http://www.eia.gov/cabs/Mexico/Full.html.

141 The Honorable Cynthia L. Quarterman, Administrator, Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, Testimony before the U.S. House Committee on Energy and Commerce, Subcommittee on Energy and Power, Hearing on "The American Energy Initiative," June 16, 2011.

142 2011 FEIS, "Potential Releases," p. 3.13-43 (see footnote 87).