This Professional Services Contract (the "**Contract**") is agreed to between the Michigan Departments of Attorney General, Environmental Quality, and Natural Resources and the Michigan Agency for Energy (the "**State**") and Dynamic Risk Assessment Systems, Inc. ("**Contractor**"). This Contract is effective on August 24, 2016 ("**Effective Date**"), and unless terminated, expires on October 31, 2017 (the "**Term**").

The parties agree as follows:

1. **Definitions**. For the purposes of this Contract, the following terms have the following meanings:

   "**Business Day**" means a day other than a Saturday, Sunday or other day on which the State is authorized or required by Law to be closed for business.

   "**Confidential Information**" has the meaning set forth in **Section 16**.

   "**Contract**" has the meaning set forth in the preamble.

   "**Contract Administrator**" is the individual appointed by each party to (a) administer the terms of this Contract, and (b) approve any Change Notices under this Contract. Each party's Contract Administrator will be identified in **Section 5**.

   "**Contractor**" has the meaning set forth in the preamble.

   "**Contractor personnel**" means all employees of Contractor or any Subcontractors involved in the performance of Services and creation of Deliverables under this Contract.

   "**Deliverables**" means documentation, reports, and all other materials that Contractor or any Subcontractor is required to or otherwise does provide to the State under this Contract and otherwise in connection with any Services, including all items specifically identified as Deliverables in the Statement of Work.

   "**Effective Date**" has the meaning set forth in the preamble.

   "**Key Personnel**" means any Contractor Personnel identified as key personnel in this Contract or and the Statement of Work.

   "**Services**" means any of the services Contractor, or any Subcontractor, is required to or otherwise does provide under this Contract and the Statement of Work.

   "**State**" has the meaning set forth in the preamble.

   "**Statement of Work**" has the meaning set forth in **Section 2**.

   "**Subcontractor**" has the meaning set forth in **Section 3**.

2. **Statement of Work.** The Statement of Work is attached hereto as Exhibit A and includes the following:

   a. A detailed description of the Services to be provided by Contractor;
   b. A listing of the Key Personnel;
   c. A detailed description of the Deliverables to be developed or otherwise provided by Contractor, including any required milestone dates associated with such Deliverable;

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d. Key project assumptions;
e. A detailed description of the technical methodology and approach; and
f. Fees payable under the Statement of Work, the manner in which such Fees will be calculated, the due dates for payment and any invoicing requirements, including any milestones on which any such Fees are conditioned, and such other information as the parties deem necessary.

3. **Performance of Services.**

a. **Performance Warranty**. Contractor represents and warrants that its Services hereunder shall be performed by competent personnel and shall be of professional quality consistent with generally accepted industry standards for the performance of such services and shall comply in all respects with the requirements of this Contract and the specifications set forth in the Statement of Work.

b. **Contractor Personnel**. Contractor is solely responsible for all Contractor personnel and for the payment of their compensation, including, if applicable, withholding of income taxes, and the payment and withholding of social security and other payroll taxes, unemployment insurance, workers' compensation insurance payments and disability benefits.

c. **Subcontractors**. Except as provided in the Statement of Work, Contractor will not, without the prior written approval of the State, which consent may be given or withheld in the State's sole discretion, engage any third party to perform Services (including to create any Deliverables). The State's approval of any such third party (each approved third party, a "**Subcontractor**") does not relieve Contractor of its representations, warranties or obligations under this Contract. Without limiting the foregoing, Contractor will:

i. be responsible and liable for the acts and omissions of each such Subcontractor (including such Subcontractor's employees who, to the extent providing Services or creating Deliverables, shall be deemed Contractor personnel) to the same extent as if such acts or omissions were by Contractor or its employees;

ii. name the State a third party beneficiary under Contractor's contract with each Subcontractor with respect to the Services and Deliverables;

iii. be responsible for all fees and expenses payable to, by or on behalf of each Subcontractor in connection with this Contract, including, if applicable, withholding of income taxes, and the payment and withholding of social security and other payroll taxes, unemployment insurance, workers' compensation insurance payments and disability benefits; and

iv. prior to the provision of Services or creation of Deliverables by any Subcontractor, if requested by the State:

1. obtain from such Subcontractor confidentiality agreements, in form and substance acceptable by the State giving the State rights consistent with those set forth in **Section 8** and, upon request, provide the State with a fully-executed copy of each such contract; and

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2. with respect to all Subcontractor employees providing Services or Deliverables, comply with its obligations under **subsection b** above.

4. **Notices.** All notices and other communications required or permitted under this Contract must be in writing and will be considered given and received: (a) when verified by written receipt if sent by courier; (b) when actually received if sent by mail without verification of receipt; or (c) when verified by automated receipt or electronic logs if sent by facsimile or email.

If to State:	If to Contractor:
Robert P. Reichel 525 W. Ottawa Lansing, MI 48933 reichelb@michigan.gov Phone: 517-373-7540 Fax: 517-373-1610	Trevor MacFarlane 208 – 1324 17th Ave SW Calgary, Alberta, Canada trevor_macfarlane@dynamicrisk.net Phone: 403-547-8638 Fax: 403-547-8628

5. **Contract Administrators.** The Contract Administrator for each party is the only person authorized to modify any terms and conditions of this Contract and are identified below:

State:	Contractor:
Robert P. Reichel 525 W. Ottawa Lansing, MI 48933 reichelb@michigan.gov Phone: 517-373-7540 Fax: 517-373-1610	Trevor MacFarlane 208 – 1324 17th Ave SW Calgary, Alberta, Canada trevor_macfarlane@dynamicrisk.net Phone: 403-547-8638 Fax: 403-547-8628

6. **Insurance Requirements.** Contractor must maintain the insurances identified below and is responsible for all deductibles. All required insurance must: (a) protect the State from claims that may arise out of, are alleged to arise out of, or result from Contractor's or a subcontractor's performance; (b) be primary and non-contributing to any comparable liability insurance (including self-insurance) carried by the State; and (c) be provided by a company with an A.M. Best rating of "A" or better and a financial size of VII or better.

Insurance Type	Additional Requirements
Commercial General Liability Insurance	
<u>Minimal Limits:</u> $1,000,000 Each Occurrence Limit $1,000,000 Personal & Advertising Injury Limit $2,000,000 General Aggregate Limit $2,000,000 Products/Completed Operations <u>Deductible Maximum:</u> $50,000 Each Occurrence	Contractor must have their policy endorsed to add "the State of Michigan, its departments, divisions, agencies, offices, commissions, officers, employees, and agents" as additional insureds using endorsement CG 20 10 11 85, or both CG 2010 07 04 and CG 2037 07 0.

Contractor must: (a) provide insurance certificates to the Contract Administrator, containing the agreement or purchase order number, at Contract formation and within 20 calendar days of the expiration date of the applicable policies; (b) require that subcontractors maintain the required insurances contained in this Section; (c) notify the Contract Administrator within 5 Business Days if any insurance is cancelled; and (d) waive all rights against the State for damages covered by

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insurance up to insurance limits. Failure to maintain the required insurance does not limit this waiver.

This Section is not intended to and is not to be construed in any manner as waiving, restricting or limiting the liability of either party for any obligations under this Contract (including any provisions hereof requiring Contractor to indemnify, defend and hold harmless the State).

7. **Independent Contractor.** Contractor is an independent contractor and assumes all rights, obligations and liabilities set forth in this Contract. Contractor, its employees, and agents will not be considered employees of the State. No partnership or joint venture relationship is created by virtue of this Contract. Contractor, and not the State, is responsible for the payment of wages, benefits and taxes of Contractor's employees and any Subcontractors. Prior performance does not modify Contractor's status as an independent contractor.

8. **Intellectual Property Rights**. Contractor hereby acknowledges that the State is and will be the sole and exclusive owner of all right, title, and interest in the Services and Deliverables and all associated intellectual property rights, if any, unless otherwise specified. Contractor shall, subject to this Contract on a royalty free basis, have free use of the Services and Deliverables irrevocably and in perpetuity. Such Services and Deliverables are works made for hire as defined in Section 101 of the Copyright Act of 1976. To the extent any Services and Deliverables and related intellectual property do not qualify as works made for hire under the Copyright Act, Contractor will, and hereby does, immediately on its creation, assign, transfer and otherwise convey to the State, irrevocably and in perpetuity, throughout the universe, all right, title and interest in and to the Services and Deliverables, including all intellectual property rights therein. Notwithstanding the above, both parties agree that any pre-existing intellectual property rights and improvements thereto remain the property of the party who developed them.

9. **Assignment.** Contractor may not assign this Contract to any other party without the prior written approval of the State.

10. **Payment.** Using funds drawn solely from the escrow account established under the Escrow Agreement among Enbridge Energy Company, Inc., the State of Michigan and U.S. Bank National Association dated August 18, 2016, the State shall pay Contractor $2,825,294.00 for its Services as specified in this Contract and the Statement of Work. The State will make payments under this Contract in accordance with the Statement of Work by directing the Escrow Agent to disburse payments by electronic funds transfers to the Contractor's designated bank account under the terms of the Escrow Agreement. The State will not make any payments from the State Treasury.

    Invoices must conform to the requirements set forth in the Statement of Work. All undisputed amounts are payable within 45 days of the State's receipt pursuant to the timing set out hereinabove at Section 4 of this Contract. Contractor may only charge for Services and Deliverables performed as specified in the Statement of Work. Invoices must include an itemized statement of all charges. The State is exempt from State sales tax for direct purchases and may be exempt from federal excise tax, if Services and Deliverables purchased under this Contract are for the State's exclusive use. Notwithstanding the foregoing, all prices are inclusive of taxes, and Contractor is responsible for all sales, use and excise taxes, and any other similar taxes, duties and charges of any kind imposed by any federal, state, or local governmental entity on any amounts payable by the State under this Contract.

    The State has the right to withhold payment of any disputed amounts until the parties agree as to the validity of the disputed amount. The State will notify Contractor of any dispute within 15 Business Days of receipt of the invoice. Payment by the State will not constitute a waiver of any rights as to Contractor's continuing obligations, including claims for deficiencies or substandard Services or Deliverables. Contractor's acceptance of full and final payment by the State constitutes a waiver of all claims by Contractor against the State for payment under

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this Contract, other than those claims previously filed in writing on a timely basis and still disputed.

11. **Termination for Cause.** The State may terminate this Contract, in whole or in part if Contractor, as determined by the State, acting upon commercially reasonable grounds: (a) becomes insolvent, petitions for bankruptcy court proceedings, or has an involuntary bankruptcy proceeding filed against it by any creditor; or (b) breaches any of its material duties or obligations under this Contract or the Statement of Work and fails to cure a breach within 30 days of receipt of a notice of breach from the State. Any reference to specific breaches being material breaches within this Contract will not be construed to mean that other breaches are not material.

    If the State terminates this Contract under this Section, the State will issue a termination notice specifying whether Contractor must: (a) cease performance immediately, or (b) continue to perform for a specified period. If it is later determined that Contractor was not in breach of the Contract, the termination will be deemed to have been a Termination for Convenience, effective as of the same date, and the rights and obligations of the parties will be limited to those provided in **Section 12**, Termination for Convenience.

    The State will only pay for amounts due to Contractor for Services and Deliverables accepted by the State on or before the date of termination, subject to the State's right to set off any amounts owed by the Contractor for the State's reasonable costs in terminating this Contract.

12. **Termination for Convenience.** The State may, upon thirty (30) days' notice to Contractor, terminate this Contract, in whole or in part without penalty and for any reason. The termination notice will specify whether Contractor must: (a) cease performance of the Services immediately, or (b) continue to perform the Services in accordance with **Section 13,** Transition Responsibilities. If the State terminates this Contract for convenience, the State will pay all reasonable costs, as determined by the State, for State approved Transition Responsibilities.

13. **Transition Responsibilities.** Upon termination or expiration of this Contract for any reason, Contractor must, for a period of time specified by the State (not to exceed 90 calendar days), provide all reasonable transition assistance requested by the State, to allow for the expired or terminated portion of the Services to continue without interruption or adverse effect, and to facilitate the orderly transfer of such Services to the State or its designees.

14. **General Indemnification.** Contractor must defend, indemnify and hold the State, its departments, divisions, agencies, offices, commissions, officers, and employees harmless, from and against any and all actions, claims, losses, liabilities, damages, costs, attorney fees, and expenses (including those required to establish the right to indemnification), arising out of or relating to: (a) any breach by Contractor (or any of Contractor's employees, agents, subcontractors, or by anyone else for whose acts any of them may be liable) of any of the promises, agreements, representations, warranties, or insurance requirements contained in this Contract; (b) any infringement, misappropriation, or other violation of any intellectual property right or other right of any third party; (c) any bodily injury, death, or damage to real or tangible personal property occurring wholly or in part due to action or inaction by Contractor (or any of Contractor's employees, agents, subcontractors, or by anyone else for whose acts any of them may be liable); and (d) any acts or omissions of Contractor (or any of Contractor's employees, agents, subcontractors, or by anyone else for whose acts any of them may be liable).

    The State will notify Contractor in writing if indemnification is sought; however, failure to do so will not relieve Contractor, except to the extent that Contractor is materially prejudiced or if such request for indemnification is sought more than two (2) years after the date of which the State knew or ought to have known of an incident which would entitle the State to seek

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indemnification from Contractor under this Contract. Contractor must, to the satisfaction of the State, demonstrate its financial ability to carry out these obligations.

The State is entitled to: (i) regular updates on proceeding status; (ii) participate in the defense of the proceeding; and (iii) employ its own counsel. Contractor will not, without the State's written consent (not to be unreasonably withheld), settle, compromise, or consent to the entry of any judgment in or otherwise seek to terminate any claim, action, or proceeding. To the extent that any State employee, official, or law may be involved or challenged, the State may, at its own expense, control the defense of that portion of the claim.

Any litigation activity on behalf of the State, or any of its subdivisions under this Section, must be coordinated with the Department of Attorney General. An attorney designated to represent the State may not do so until approved by the Michigan Attorney General and appointed as a Special Assistant Attorney General.

15. **Limitation of Liability.** IN NO EVENT WILL EITHER PARTY BE LIABLE, REGARDLESS OF THE FORM OF ACTION, WHETHER IN CONTRACT, TORT, NEGLIGENCE, STRICT LIABILITY OR BY STATUTE OR OTHERWISE, FOR ANY CLAIM RELATED TO OR ARISING UNDER THIS CONTRACT FOR CONSEQUENTIAL, INCIDENTAL, INDIRECT, OR SPECIAL DAMAGES, INCLUDING WITHOUT LIMITATION LOST PROFITS AND LOST BUSINESS OPPORTUNITIES. IN NO EVENT WILL THE AGGREGATE LIABILITY OF EITHER PARTY TO THE OTHER PARTY UNDER THIS CONTRACT, REGARDLESS OF THE FORM OF ACTION, WHETHER IN CONTRACT, TORT, NEGLIGENCE, STRICT LIABILITY OR BY STATUTE OR OTHERWISE, FOR ANY CLAIM RELATED TO OR ARISING UNDER THIS CONTRACT, EXCEED THE MAXIMUM AMOUNT OF FEES SPECIFIED IN THE STATEMENT OF WORK.

16. **Non-Disclosure of Confidential Information**. The parties acknowledge that each party may be exposed to or acquire communication or data of the other party that is confidential, privileged communication or data not intended to be disclosed to third parties. The provisions of this Section survive the termination of this Contract.

    a. Meaning of Confidential Information. For the purposes of this Contract, the term "**Confidential Information**" means all information and documentation of a party that: (a) has been marked "confidential" or with words of similar meaning, at the time of disclosure by such party; (b) if disclosed orally or not marked "confidential" or with words of similar meaning, was subsequently summarized in writing by the disclosing party and marked "confidential" or with words of similar meaning; or, (c) should reasonably be recognized as confidential information of the disclosing party. The term "Confidential Information" does not include any information or documentation that was or is: (a) subject to disclosure under the Michigan Freedom of Information Act (FOIA) by the receiving party; (b) already in the possession of the receiving party without an obligation of confidentiality; (c) developed independently by the receiving party, as demonstrated by the receiving party, without violating the disclosing party's proprietary rights; (d) obtained from a source other than the disclosing party without an obligation of confidentiality; or, (e) publicly available when received, or thereafter became publicly available (other than through any unauthorized disclosure by, through, or on behalf of, the receiving party.

    b. Obligation of Confidentiality. The parties agree to hold all Confidential Information in strict confidence and not to copy, reproduce, sell, transfer, or otherwise dispose of, give or disclose such Confidential Information to third parties other than employees, agents, or subcontractors of a party who have a need to know in connection with this Contract or to use such Confidential Information for any purposes whatsoever other than the performance of this Contract. The parties agree to advise and require their respective employees, agents, and subcontractors of their obligations to keep all

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Confidential Information confidential. Disclosure to a subcontractor is permissible where: (a) use of a subcontractor is authorized under this Contract; (b) the disclosure is necessary or otherwise naturally occurs in connection with work that is within the subcontractor's responsibilities; and (c) Contractor obligates the subcontractor in a written contract to maintain the State's Confidential Information in confidence. At the State's request, any employee of Contractor or any subcontractor may be required to execute a separate agreement to be bound by the provisions of this Section.

17. **Warranties and Representations.** Contractor represents and warrants to the State that: (a) it will perform all Services in a professional and workmanlike manner in accordance with best industry standards and practices for similar services, using personnel with the requisite skill, experience and qualifications, and will devote adequate resources to meet its obligations under the applicable Statement of Work; (b) the Services and Deliverables provided by Contractor will not infringe the patent, trademark, copyright, trade secret, or other proprietary rights of any third party; (c) it has the full right, power, and authority to enter into this Contract, to grant the rights granted under this Contract, and to perform its contractual obligations; and (d) all information furnished and representations made in connection with the award of this Contract is true, accurate, and complete, and contains no false statements or omits any fact that would make the information misleading. A breach of this Section is considered a material breach of this Contract, which entitles the State to terminate this Contract under **Section 11**, Termination for Cause.

18. **Conflicts and Ethics.** Contractor will uphold high ethical standards and is prohibited from: (a) holding or acquiring an interest that would conflict with this Contract; (b) doing anything that creates an appearance of impropriety with respect to the award or performance of the Contract; or (c) attempting to influence or appearing to influence any State employee by the direct or indirect offer of anything of value.

19. **Compliance with Laws.** Contractor must comply with all federal, state and local laws, rules and regulations.

20. **Nondiscrimination.** Under the Elliott-Larsen Civil Rights Act, 1976 PA 453, MCL 37.2101, *et seq.*, and the Persons with Disabilities Civil Rights Act, 1976 PA 220, MCL 37.1101, *et seq.*, Contractor and its subcontractors agree not to discriminate against an employee or applicant for employment with respect to hire, tenure, terms, conditions, or privileges of employment, or a matter directly or indirectly related to employment, because of race, color, religion, national origin, age, sex, height, weight, marital status, or mental or physical disability. Breach of this covenant is a material breach of this Contract.

21. **Unfair Labor Practice.** Under MCL 423.324, the State may void any Contract with a Contractor or subcontractor who appears on the Unfair Labor Practice register compiled under MCL 423.322.

22. **Governing Law.** This Contract is governed, construed, and enforced in accordance with Michigan law, excluding choice-of-law principles, and all claims relating to or arising out of this Contract are governed by Michigan law, excluding choice-of-law principles. Any dispute arising from this Contract must be resolved in Michigan Court of Claims. Contractor consents to venue in Ingham County, and waives any objections, such as lack of personal jurisdiction or *forum non conveniens*. Contractor must appoint agents in Michigan to receive service of process.

23. **Force Majeure.** Neither party will be in breach of this Contract because of any failure arising from any disaster or acts of God that are beyond their control and without their fault or negligence. Each party will use commercially reasonable efforts to resume performance. Contractor will not be relieved of a breach or delay caused by its subcontractors. If immediate performance is necessary to ensure public health and safety, the State may immediately contract with a third party.

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24. **Dispute Resolution.** The parties will endeavor to resolve any Contract dispute in accordance with this provision. The dispute will be referred to the parties' respective Contract Administrators. Such referral must include a description of the issues and all supporting documentation. The parties must submit the dispute to a senior executive if unable to resolve the dispute within 15 Business Days. The parties will continue performing under this Contract while a dispute is being resolved, unless the dispute precludes performance. A dispute involving payment does not preclude performance.

Litigation to resolve the dispute will not be instituted until after the dispute has been elevated to the parties' senior executive and either concludes that resolution is unlikely, or fails to respond within 15 Business Days. The parties are not prohibited from instituting formal proceedings: (a) to avoid the expiration of statute of limitations period; (b) to preserve a superior position with respect to creditors; or (c) where a party makes a determination that a temporary restraining order or other injunctive relief is the only adequate remedy. This Section does not limit the State's right to terminate the Contract.

25. **Media Releases.** News releases (including promotional literature and commercial advertisements) pertaining to the Contract or project to which it relates must not be made without prior written State approval, and then only in accordance with the explicit written instructions of the State.

26. **Severability.** If any part of this Contract is held invalid or unenforceable, by any court of competent jurisdiction, that part will be deemed deleted from this Contract and the severed part will be replaced by agreed upon language that achieves the same or similar objectives. The remaining Contract will continue in full force and effect.

27. **Waiver.** Failure to enforce any provision of this Contract will not constitute a waiver.

28. **Survival.** The provisions of this Contract that impose continuing obligations, including warranties and representations, termination, transition, insurance coverage, indemnification, and confidentiality, will survive the expiration or termination of this Contract.

29. **Entire Agreement.** This Contract, including the Statement of Work, constitutes the sole and entire agreement of the parties to this Contract with respect to the subject matter contained herein, and supersedes all prior and contemporaneous understandings and agreements, both written and oral, with respect to such subject matter. In the event of any conflict between the terms of this Contract and those of the Statement of Work or other document, the following order of precedence governs: (a) first, this Contract; and (b) second, the Statement of Work as of the Effective Date of that Statement of Work. NO TERMS ON CONTRACTOR'S INVOICES, WEBSITE, BROWSE-WRAP, SHRINK-WRAP, CLICK-WRAP OR OTHER NON-NEGOTIATED TERMS AND CONDITIONS PR OVIDED WITH ANY OF THE SERVICES, OR DOCUMENTATION HEREUNDER WILL CONSTITUTE A PART OR AMENDMENT OF THIS CONTRACT OR IS BINDING ON THE STATE FOR ANY PURPOSE. ALL SUCH OTHER TERMS AND CONDITIONS HAVE NO FORCE AND EFFECT AND ARE DEEMED REJECTED BY THE STATE, EVEN IF ACCESS TO OR USE OF SUCH SERVICE OR DOCUMENTATION REQUIRES AFFIRMATIVE ACCEPTANCE OF SUCH TERMS AND CONDITIONS.

30. **Counterparts.** This Contract may be signed in any number of counterparts, each of which is a duplicate original, and all of which taken together form a single Contract.

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MICHIGAN DEPARTMENT OF ATTORNEY GENERAL

By:______________________________

Title:______________________________

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

By:______________________________

Title:______________________________

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

By:______________________________

Title:______________________________

MICHIGAN AGENCY FOR ENERGY

By:______________________________

Title:______________________________

DYNAMIC RISK ASSESSMENT SYSTEMS, INC.

By:______________________________

Title: T.K. MacFarlane, President.

Exhibit A

Statement of Work

INDEPENDENT ALTERNATIVES ANALYSIS FOR THE STRAITS PIPELINES

STATEMENT OF WORK AND PROJECT TECHNICAL EXECUTION PLAN

August 15, 2016

Michigan Departments of Environmental Quality and Natural Resources, the Michigan Agency for Energy, and the Michigan Office of Attorney General

Table of Contents

This Project Technical Execution Plan is made effective [August 19, 2016] ("Effective Date") by and between Michigan Departments of Environmental Quality and Natural Resources, the Michigan Agency for Energy, and the Michigan Office of Attorney General (the State) and Dynamic Risk Assessment Systems, Inc. ("Contractor") and is for Independent Alternatives Analysis for the Straits Pipelines by Contractor as described in this document. Contractor will provide the services set forth below to the State in accordance with the Professional Services Contract entered into by the parties on [August 19, 2016].

Introduction

The State of Michigan has contracted Dynamic Risk to evaluate a number of engineering alternatives to the existing pipelines crossing at the Straits of Mackinac on Enbridge's Line 5 (Straits Pipelines). Dynamic Risk shall conduct an independent review of the risks, costs and economic impacts associated with each of the alternatives contemplated by the State of Michigan. The alternatives are briefly described as follows:

Alternative 1: The construction of one or more new pipelines that do not cross open waters of the Great Lakes, and then decommissioning the existing Straits Pipelines.

Alternative 2: The utilization of existing pipeline infrastructure located in Canada, other states, and elsewhere in Michigan that do not cross the open waters of the Great Lakes, and then decommissioning the existing Straits Pipelines.

Alternative 3: The utilization of alternative transportation methods as outlined below, and then decommissioning the existing Straits Pipelines:

i) Rail
ii) Tanker Truck
iii) Oil Tankers and Barges
iv) Others

Alternative 4: Replacement of the existing Straits Pipelines using the best available design and technology.

Alternative 5: Maintaining the existing Straits Pipelines, including an analysis of the effective life of the existing pipelines.

Alternative 6: Eliminating all transportation of petroleum products and natural gas liquids through, and then decommissioning, the Straits of Mackinac segment of Enbridge's Line 5.

a. Maintaining a north-western leg of Line 5 which would transport NGLs to delivery points in the upper peninsula of Michigan as well as well as a south-eastern leg of Line 5 which would transport oil produced in Michigan to the terminus of Line 5 in Sarnia, Ontario
b. No longer transporting to market the petroleum products and natural gas liquids currently transported through the Straits of Mackinac segment of Enbridge's Line 5 and the remainder of Line 5 located within Michigan.

Project Scope

A brief description of the analysis that will be performed is described below for each of the Alternatives as defined above.

Alternative 1 – New Pipeline Route

In this alternative, quantitative evaluations of failure probability and associated release magnitudes will be made for the replacement pipeline infrastructure. This will serve as the basis of a risk assessment for the replacement pipeline infrastructure, wherein risk is defined as the probability of incurring a release and the associated consequences of a release. The results of the risk analysis will be used to inform the cost and economic impact analysis, which in addition to addressing the potential costs associated with spills, will include a complete cost analysis for construction of the replacement pipeline infrastructure.

Alternative 2 – Other Pipeline Infrastructure

The analysis will include consideration of other pipeline infrastructure located in Canada, other states, and elsewhere in Michigan. In addition, the change risk that is associated with this Alternative will be determined as the risk that might be associated with offloading Line 5 volumes onto existing pipeline infrastructure. That risk will be evaluated by determining the incremental failure probability, along with the associated incremental magnitudes of release that are attributed to increased load on existing infrastructure.

The results of the risk analysis will be used to inform the cost and economic impact analysis, which in addition to addressing the potential costs associated with incremental spill frequency and magnitude, will include costs associated with utilizing existing pipeline infrastructure for alternate land based routes.

Alternative 3 - Utilization of alternative transportation methods

For the rail option associated with this Alternative, the analysis will consider current technology, safety standards and regulatory requirements associated with rail cars. The analysis will also consider the availability of existing rail infrastructure and the number of rail cars needed to meet demand of oil transportation if the Straits Pipelines were shut down. In addition, estimates will be made of incremental spill frequencies and magnitudes associated with incremental rail usage. This incremental spill frequency and associated magnitude of release will serve as the basis of a risk assessment, which in turn, will be used to inform the cost and economic impact analysis. In addition to addressing costs and economic impacts associated with spills along rail infrastructure, this cost and economic analysis will compare rail transportation costs to pipeline transportation, and will address the cost of transporting a unit of product by rail, relative to pipeline transportation costs.

For the tanker truck, oil tanker and barge, and other options associated with this Alternative, a feasibility review will be conducted to establish whether each transportation method could be a volumetrically and environmentally viable option. If any of these options prove viable, then an assessment of spill probability and magnitude will be undertaken for that option, which will serve as the basis of a risk assessment, cost and economic analysis, as described for the rail option. Otherwise, if it is established that the transportation option is not considered viable, no further analysis will be undertaken on these options.

Alternative 4 – Pipeline Replacement

This alternative will include a comprehensive review of technology and design that could be used to replace the current Straits Pipelines. The Contractor has identified two viable options for this Alternative which will be fully-developed in the analysis:

i) Conventional replacement, which utilizes current state-of-the art offshore technology to design, construct and install a pipeline, buried in a trench through the length of the Straits crossing; and,
ii) Tunneling. Since the time of the original installation of Enbridge Line 5, tunneling technology has evolved to a point where it is no longer considered to be unconventional or technologically challenging to install utility infrastructure, such as pipelines in tunnels beneath oceans, rivers or lake beds that are too long to be considered for horizontal directional drilling. Such tunnels have advantages over other types of installations, in part, because they provide a self-contained environment that is isolated from the natural environment by sealed walls. Furthermore, a pipeline that is contained within a sealed tunnel can be accessed at any time for routine inspection and maintenance. An added benefit of a tunnel crossing is that it is well suited to existing hydrocarbon detection technologies that can be deployed within the tunnel to detect leaks that would otherwise be below the detection limits of a conventional liquids pipeline mass balance system.

For each of the above two options, quantitative evaluations of failure probability and associated release magnitudes will be made for the replacement pipeline infrastructure. This will serve as the basis of a risk assessment for the replacement pipeline infrastructure, which in turn, will be used to inform the cost and economic impact analysis. In addition to addressing costs and economic impacts associated with spills along the replacement pipeline infrastructure, this cost and economic analysis will include a complete cost analysis for construction of the replacement pipeline infrastructure.

Alternative 5 – Existing Pipeline

This alternative will include a comprehensive engineering analysis of the current condition and operation of the existing Straits pipelines. The comprehensive engineering analysis of current conditions will include a review of the Enbridge integrity standards for the pipeline and protocols for detecting and responding to deviations from those standards. The analysis will also consider how long the existing pipelines can reasonably be operated without replacement as well as the course of action for replacement based on the estimated useful life of existing pipelines. This analysis will form the basis of a “base case” risk assessment against which all other Alternatives can be compared. As part of this risk assessment, quantitative evaluations of failure probability and associated release magnitudes will be made for the existing pipeline infrastructure. This risk assessment will be used to inform the cost and economic impact analysis that will address costs and economic impacts associated with spills for the existing Straits pipelines, as well as costs of maintaining those pipelines through their operating life.

Alternative 6 – Decommissioning the Pipeline

The analysis will consider the feasibility and impacts of two scenarios:

a. Decommissioning the Straits pipelines and maintaining only a north-western leg of Line 5 which would transport NGLs to delivery points in the upper peninsula of Michigan as well as a south-eastern leg of Line 5 which would transport oil produced in Michigan to the terminus of Line 5 in Sarnia, Ontario.

b. No longer transporting to market the petroleum products and natural gas liquids currently transported through the Straits of Mackinac segment of Enbridge's Line 5 and the remainder of Line 5 located within Michigan

For both Scenarios (a) and (b), the analysis will only consider the potential economic impacts to the Great Lakes Region.

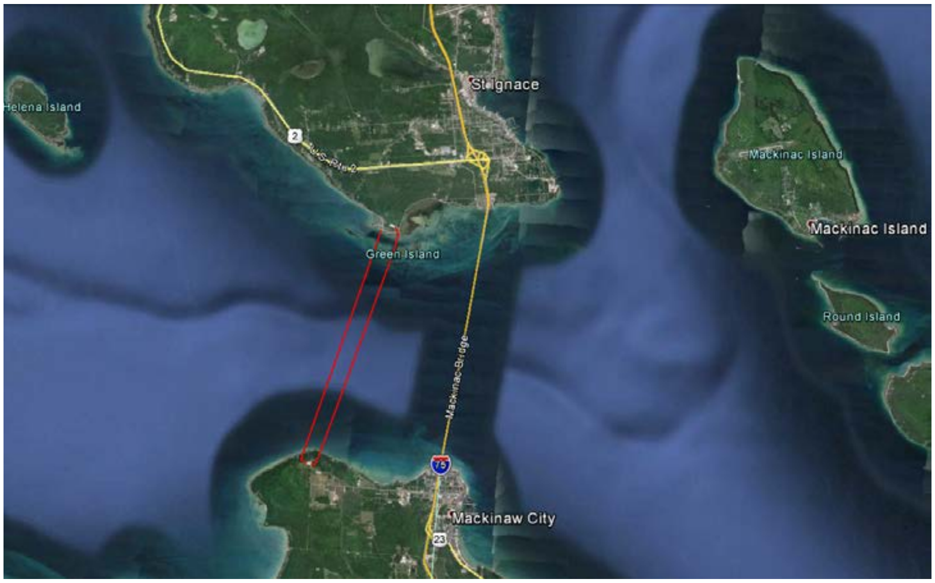


Figure 1 - Straits of Mackinac – (The Straits Pipelines)

Analysis Outcome

The consequences and the risk associated with each alternative will be presented for the following categories:

1. Health & Safety:
    - There are a range of health and safety consequences, ranging from fatalities to lesser-effects, by convention with industry practice, health and safety risk will be characterized in units of fatalities per year of operation. By proxy, this characterization imputes less severe consequences as well. Other H&S consequences, including toxicity are accounted for in the environmental impact analysis.
2. Environmental Impacts

- As there are no standards or government regulation in existence that enables environmental impacts to be evaluated quantitatively, environmental consequences will be evaluated using a qualitative index scoring system. The evaluation of environmental risk will account for the frequencies of occurrence of a range of release magnitudes, and their associated consequences. It will also account for seasonal conditions; such as ice cover. The resulting risk evaluation will therefore represent the combined consideration of a range of release magnitudes and the probability of incurring those releases under a range of conditions.

3. Potential natural resources damages, including, but not limited to, damages to the Great Lakes; potential response and clean-up costs; and potential economic impacts to the Great Lakes Region.
    - Each of these measures of consequence will be expressed quantitatively in units of $ impact.

Costs and economic impacts for each Alternative will be expressed in US dollars, and will address financial feasibility, capital and/or operating costs (as applicable), and socio-economic impacts (as applicable).

Project Methodology and Design for the Analysis

Dynamic Risk has completed a detailed review of the Request for Proposal documents, the included references and the public domain documents prepared by Enbridge Energy, such as the *"Operational Reliability Plan, Line 5 and Line 5 Straits of Mackinac Crossing"*. Our technical approach is in consideration of the objectives set out by the State and the assumptions on available information from the pipeline operator.

Dynamic Risk shall perform a quantitative risk analysis that will quantify the failure probability and consequences for the existing Straits Pipelines (base case) and each of the proposed alternatives (assuming that they meet the general feasibility requirements). The results of the risk analysis will be used to inform the cost and economic impact analysis associated with each Alternative. The results of the risk and cost analysis will enable to State to compare each Alternative against all other Alternatives on an equal basis.

Pipeline Risk Analysis

Estimation of Failure Probability and Associated Magnitude of Release

The risk associated with an oil transmission pipeline spill can be defined as the product of the probability of having a release, and the consequences that are associated with that release magnitude:

$$R = \sum_{All\ i} \left(PF_i \times C_i \right)$$

Where,

PF_i = Probability of having a release of magnitude i, and

C_i = Consequences associated with a release of magnitude i

Pipeline failures occur over a range of release magnitudes, ranging from small pinhole leaks to full-bore ruptures. Consequently, risk, being a compound measure of both the likelihood of incurring an adverse event and the consequences of that event, must incorporate an assessment of failure probability over a range of potential release magnitudes. A review of the US Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) Hazardous Liquids Incident Data illustrates that within a range of possible release magnitudes, the probability of incurring a failure of a given magnitude varies as a function of the underlying cause of failure. These causes of failure are termed ‘threats’, which are classified into categories, such as corrosion and outside force damage, as well as subcategories (internal corrosion vs. external corrosion, maritime equipment, etc.).

In light of the above, in order to support evaluations of the potential health and safety, environmental and socio-economic consequences associated with a pipeline release, threat-specific estimates of failure probability per year of operation will be provided as a function of release magnitude. In this way, probabilities of incurring representative release magnitudes will be estimated for each threat. Release magnitudes, in turn, may be estimated from industry incident data, or outflow models, as appropriate. Threat-specific probabilities will then be combined to arrive at all-threat probabilities for each of several representative release magnitudes. Each release magnitude may then be incorporated into a separate assessment of Health & Safety, Environment, and Socioeconomic consequence by considering one or more scenarios that are associated with that release magnitude.

Failure Probability Assessment – General

For the purposes of the analysis that will be performed, the term ‘failure’ refers to loss-of-containment, and the release of products. As discussed above, in order to ensure that the context of the failure probability analysis is consistent with other aspects of the study, such as assessment of Health & Safety, Environment, and Socioeconomic consequences, failure probability will always be associated with a given magnitude of release.

With the above considerations in mind, quantitative estimates of annual failure probability will be made on a threat-by-threat basis. A number of basic approaches for estimating failure probability exist, and will be employed as is appropriate, based on the type and availability of data, as well as the threat being considered. One method of estimating failure probability is to use industry incident statistics, such as the US Department of Transportation PHMSA Hazardous Liquids Incident Data as the basis for the making the estimate. Where this method is employed, care will be taken to select a database that is most representative of the pipeline segment being considered, including type of product, era of installation, and operating environment. In addition, some incident datasets lend themselves to a limited amount of filtering, which may be undertaken in order to account for materials, design and operations considerations.

Another method is to estimate failure probability is based on a first-principles approach, known as ‘reliability methods’. Should detailed in-line inspection, material property, and operating data be made available, this would be the preferred approach for assessing the threats that are addressed by the in-line-inspection data.

Yet another approach, specific to geotechnical and hydrotechnical hazards involves the systematic characterization of hazards to examine how they will interact with the pipeline. This assessment methodology expresses failure probability as the product of the potential for a geohazard to occur, the frequency of occurrence, the unmitigated system vulnerability, and the effects of the mitigations used in the segment.

Straits Pipelines Failure Probability Analysis

The failure probability analysis of the Straits crossing will employ all available design, materials, assessment and operating data.

Prior to undertaking a quantitative analysis of failure frequency, a Threat Assessment will be undertaken to evaluate the susceptibility of all threats, employing API 1160 "Managing System Integrity for Hazardous Liquid Pipelines" as a guideline in performing that task. API 1160 characterizes 12 different threat categories for hazardous liquids pipelines, as follows:

Time-Dependent Threats

1. External corrosion
2. Internal corrosion
3. Selective seam corrosion (internal or external)
4. Stress corrosion cracking
5. Pressure-cycle-induced fatigue of pre-existing non-injurious anomalies

Potentially Time Dependent Threats

6. Manufacturing defects (defective seams and pipe body)
7. Construction and fabrication defects (defective girth welds, fabrication welds, wrinkle bends, buckles, stripped threads/broken pip/coupling failure)
8. Mechanical damage (previously damaged pipe causing delayed failure or vandalism)

Time Independent Threats

9. Equipment failure (gasket or o-ring failure, control/relief equipment failure, etc.)
10. Mechanical damage (causing an immediate failure or from vandalism)
11. Incorrect operations
12. Weather and outside force

As noted in API 1160, not all of the above 12 threat categories may apply to every hazardous liquid pipeline. Therefore, as part of the threat assessment, a review of all attributes for each of the above threat categories will be undertaken, including design parameters, material properties, construction and installation practices, and operating conditions and environment. As owner and operator of the pipeline, Enbridge will be requested to provide information and data that is critical to this analysis. But Enbridge will not participate in the evaluation of that information and data in this analysis.

Through the threat assessment, the relevance and severity of each threat will be assessed. In the process of undertaking the threat assessment, all threat attributes will be reviewed in terms of their relevance as well as in terms of data availability. The availability and type of data that are available will dictate the optimal approach to be used. Therefore, the other primary goal of a threat assessment is to establish an optimal approach for estimating failure likelihood for each threat, based on the availability, quality, and completeness of the data.

Using the threat assessment as a foundation, quantitative estimates of failure frequency will be undertaken for each applicable threat, employing threat-specific approaches that are identified during the threat assessment as being optimal, based on the availability and quality of supporting data. Where high-resolution in-line assessment data is available, (i.e., volumetric wall loss data for internal corrosion and external corrosion, or crack tool data for manufacturing defects or cracking) it will be leveraged in a reliability-based analysis of failure likelihood and design life.

Reliability methods have been widely adopted in the nuclear and aerospace industry, where they are used to identify and manage threats. In recent years, the pipeline industry has moved towards adopting this as a tool for risk studies, and pipeline industry research organizations such as PRCI and EPRG have spent much time and resources in the past several years in developing reliability-based models for various threats. Reliability models employ limit state functions for the specific damage mechanism of interest in which the load variables and resistance variables are characterized in terms of probability density functions. This enables the use of reliability modeling techniques such as Monte Carlo Analysis to characterize the probability of incurring a failure on a pipeline. Reliability methods represent a powerful tool for making accurate, quantitative predictions on likelihood of failure and expected lifespan.

The Figure below illustrates how reliability methods are utilized to quantify the probability of failure, based on a defendable approach:

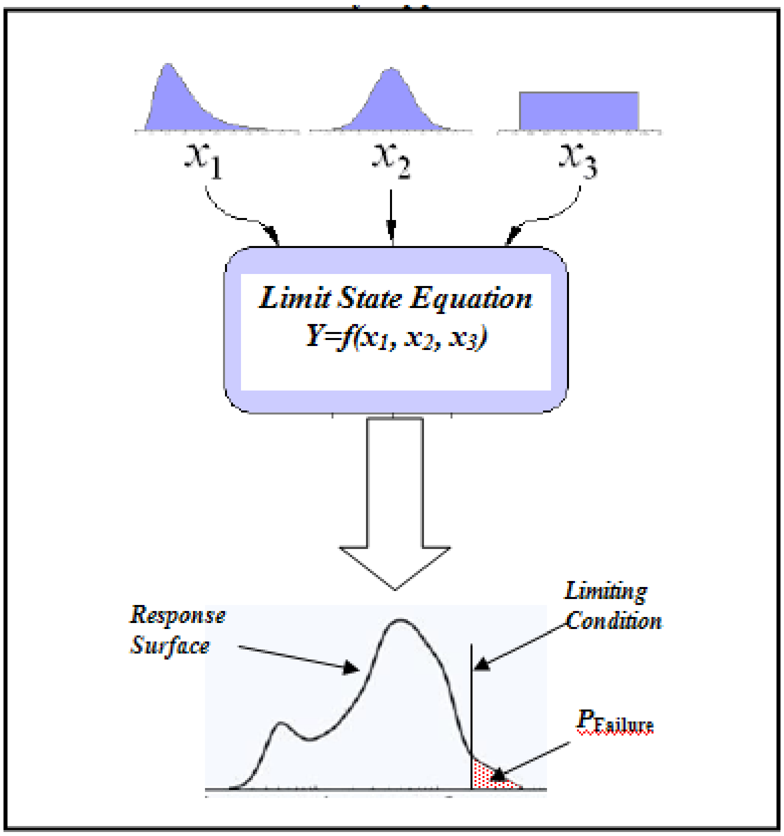


Figure 2 - Reliability Approach

In the above Figure, a Limit State Function represents the basis of a reliability analysis, as it defines the point of failure (the limiting state) of the pipeline. Where variables representing both damage (e.g., defect size) and resistance (e.g., material strength) are characterized in terms of their known probability distributions, the resulting response (e.g., failure pressure) can likewise be characterized as a distribution.

Failure occurs where the response falls below a value that defines the onset of failure (e.g., failure pressure ≤ operating pressure).

A reliability approach is not possible for some threats, however where in-line inspection data exists, it will be used in the reliability analysis, employing known defect detection and sizing capabilities specific to the in-line inspection tool.

Using volumetric wall loss (internal corrosion and external corrosion) as an example, a description of the reliability method is provided below, based on an analysis of in-line inspection (ILI) data, and a methodology described in a paper presented by Dynamic Risk at the 2012 International Pipeline Conference.[1]

Employing ILI data as the basis of the analysis, a Monte Carlo approach is used to assimilate distributions derived from ILI data and pipe properties. Monte Carlo analysis was first developed to assist with thermonuclear calculations during the Manhattan Project, and is now a common analysis technique used in reliability analysis. It is a computer-based stochastic resampling technique in which variables from defined probability distributions are randomly selected and evaluated over a large number of iterations. When used in a structure reliability analysis, the randomly selected variables are used as input to a limit state function, which establishes whether the structure (in this case, a pipeline with wall loss attributed to internal corrosion or external corrosion) is within or outside of its safe operating envelope.

An example of a limit state function that is applicable to internal or external corrosion is the modified ASME B31G failure criterion:

$$\sigma_f = \bar{\sigma} \cdot \left[\frac{1 - 0.85\frac{d}{t}}{1 - 0.85\frac{d}{t \cdot M_T}} \right]$$

Equation 1

Where,

$$M_T = \sqrt{1 + 0.6275\frac{L^t}{D \cdot t} - 0.003375\frac{L^4}{D^2 \cdot t^2}} \text{ for } \frac{L^2}{D \cdot t} \leq 50$$

$$M_T = 0.032\left(\frac{L^2}{D \cdot t}\right) + 3.3 \text{ for } \frac{L^2}{D \cdot t} > 50$$

σ_f = Hoop stress at failure
t = Wall thickness
D = Pipe diameter
$\bar{\sigma}$ = Material flow stress
d = Depth of feature

[1] Mihell, J.N., Rout, C., "Risk Assessment of Modern Pipelines", Proceedings of the 2012 9th International Pipeline Conference, IPC2012-90072, September, 2012.

L = Length of feature

In a Monte Carlo analysis utilizing wall loss ILI data, distributions for the variables of pipe dimensions, material properties, defect size and growth rate, as well as model error are employed to generate the probability of failure. Corrosion feature depth and feature length are sampled stochastically, based on the nominal feature dimensions and tool-specific measurement error distributions. When using ILI data for the purposes of establishing these distributions, it is important to recognize that the quantities derived represent values at a particular point in time (i.e., the date of last inspection). The probability distributions on corrosion feature size must therefore be adjusted to account for feature growth. This is illustrated in Figure 3, which shows how the flaw distribution flattens and translates with time, t. Specifically, as can be seen in the Figure below, as time increases, the mean of the flaw depth distribution increases, and that the standard deviation of the flaw depth distribution also increases.

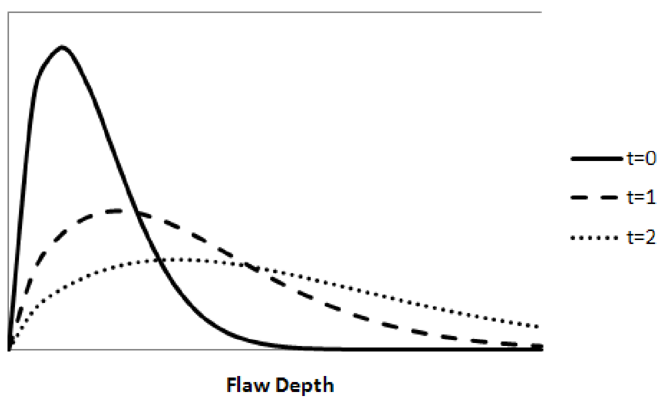


Figure 3 - Illustration of How Flaw Depth Distribution Changes With Time

By accounting for corrosion feature growth, the probability of failure can be established over time. Failure probability can be further broken down by failure mode (leak vs rupture). ILI features that have the potential to fail by means of rupture as opposed to by leak can be determined though a comparison of feature length with the critical through-wall flaw size. This latter is a property of pipeline design, material properties and operating conditions, and can be established by means of the NG-18 flaw equation:

$$K_c^2 = \frac{12 \cdot C_v \cdot E}{A_c} = \frac{8 \cdot c \cdot \bar{\sigma}^2}{\pi} \ln \sec\left[\frac{\pi \cdot M_T \cdot \sigma_h}{2 \cdot \bar{\sigma}}\right]$$

Equation 2

Where,

K_c = fracture initiation toughness,
C_v = Charpy toughness
E = Young's modulus
c = half-length of a through-wall flaw,
$\bar{\sigma}$ = Material flow stress
A_c = Charpy specimen fracture area,
M_T = Folias correction factor,
σ_h = Hoop stress,

The above relationship can be used to determine the maximum size defect that will leak rather than rupture. At high toughness values, it represents a flow-stress or plastic instability criterion (typical of the failure mode of most corrosion features), whereas at lower toughness values, it may represent a conservative representation of the leak/rupture boundary for corrosion features. By employing leak / rupture evaluation criteria, failure probability over a defined pipeline segment length can be broken down into 'leak probability' and 'rupture probability' values.

The specific circumstances associated with the 20" pipeline crossings of the Straits of Mackinac involve pipelines laid on the surface of the lakebed beneath a busy shipping channel. These circumstances warrant special consideration for the estimation of failure probability through this crossing. In addition to the threat-based analysis described above, the unique threat environment associated with the Straits demands that threats specific to this crossing be addressed in a rigorous, in-depth manner. Through the Straits crossing, threats related to currents, movement or erosion of lake-bottom sediments, and the potential for spanning exist, along with those that are related to ship traffic, such as dragged anchors, dropped objects and ship loss.

The threat imposed on pipelines due to shipping depends on a number of factors, such as:

- Number of ships crossing per period of time (e.g., per year)
- Ship size distribution
- Ship speed distribution
- Water depth
- Protective measures (trenched vs un-trenched, armoring, etc.)

With respect to shipping-related hazards, well-documented approaches, supported by incident data are available to estimate the failure probability[1,2,3,4]. Among these references are a variety of approaches that may be selected, as appropriate, depending upon the information that is available for analysis, and each may be used to estimate the probability of incurring a failure due to shipping activity.

With respect to geohazards and hydrotechnical hazards, a detailed analysis of the Straits will be undertaken that includes hazards related to seismicity, water currents and various forms of ground movement, such as lake bed erosion and loss of support, and submarine landslides. The approach that will be adopted involves the systematic characterization of hazards through the Straits crossing to examine how these potential hazards will interact with the pipeline. This assessment methodology follows the framework as set out in Rizkalla (2008)[5] and expresses failure probability as the product of the potential for a geohazard to occur, the frequency of occurrence, the unmitigated system vulnerability, and the effects of the mitigations used in the segment. This analysis will consist of the following steps:

- Project Data Collection and Organization – Within the defined Straits crossing area, collect data from available internal and publically available sources, and organize information within a GIS system;

- Terrain Analysis – Using the available data, produce a description of the physical environment through the Straits crossing, including but not limited to lakebed sediments and bedrock conditions. This is presented on a series of maps and compendium documents as necessary;

- Geohazard List – Develop a list of credible geohazards possible within the Straits crossing.

- Geohazard Inventory – Develop a list of spatial polygons using a general list of potential geohazards through the Straits crossing;

- Susceptibility Calculations – Calculate pipeline susceptibility to geohazards in a systematic fashion according to the product of factors related to the potential for occurrence of a geohazard; the assessed frequency of occurrence; and the system vulnerability to occurrence in each case. This results in an outcome expressed using numerical order-of-magnitude level factors; and,

- Reporting - Complete a final report describing the geohazard assessment and outcomes, including assessment of failure probability associated with geohazards.

Straits Pipelines Evaluation of Safe and Reliable Operating Life

As outlined above, the threats that are applicable to hazardous liquids pipelines are categorized as being 'Time-Dependent' (or 'Potentially Time-Dependent') and 'Time Independent'. As the properties of steel do not change appreciably with time, it is the Time-Dependent and Potentially Time Dependent threats that influence the way that reliability of a pipeline changes with time. How the degradation mechanisms that are associated with these threats manifest themselves over time, and the way those degradation mechanisms can be managed through conventional maintenance and 'Inspect and Repair' strategies determines the useful engineering life of a pipeline. High-resolution in-line inspection tools exist that can identify and size defects associated with Time Dependent and Potentially Time Dependent threats. For example:

- Conventional magnetic flux leakage or ultrasonic tools can detect and size volumetric wall loss features that are associated with internal corrosion and external corrosion,
- Transverse-field magnetic flux leakage tools can detect and size selective seam corrosion features, as well as some crack-like features,
- Cracking tools employing ultrasonic technology, Electromagnetic Acoustic Transducer (EMAT) or Ultra Scan Crack Detection (USCD) can detect and size crack or crack-like defects, such as those related to fatigue and manufacturing defects,
- Pipe size and deformation in-line inspection tools can be used to detect and size mechanical damage due to installation damage, buckling, and other forms of mechanical damage.

By leveraging high-resolution inspection data, all of the above forms of damage can be evaluated in reliability models that account for degradation mechanisms by utilizing the appropriate growth model(s) (i.e., corrosion growth models, environmental crack growth models, corrosion fatigue growth models, or straight-fatigue growth models) to arrive at estimates of failure probability as a function of time.

The lifespan analysis will be based on the specific design, materials, environmental and operating characteristics of the Straits pipelines. The useful engineering life of a pipeline can be defined as the point at which time-dependent degradation mechanisms can no longer be managed by normal maintenance practices and 'Inspect and Repair' strategies without incurring unrealistic costs and/or without incurring undesirable levels of risk. The structural reliability analysis described above, which leverages in-line inspection data, and which accounts for flaw detection reliability, flaw measurement accuracy, mechanisms of flaw growth, and safe operating limits, will be employed to provide estimates of failure probability over time on a go-forward basis. Those failure probability / time profiles will form the basis of the analysis of useful engineering lifespan by evaluating failure probability / time profiles against realistic maintenance and 'Inspect and Repair' scenarios.

References

[1] Recommended Failure Rates for Pipelines", Report No / DNV Reg No.: 2009-1115, Rev 1, 2010-11-16
[2] Stefani, V. and Carr, P. "A Model to Estimate the Failure Rates of Offshore Pipelines", IPC2010-31230, Proceedings of IPC 2010 8th International Pipeline Conference, Calgary, Canada, September, 2010.
[3] OGP Risk Assessment Data Directory, Riser and Pipeline Release Frequencies, Report No. 434-4, March, 2010
[4] Pipeline and Riser Loss of Containment (PARLOC) Report Series, Oil & Gas UK.
[5] Rizkalla, 2008. Pipeline Geo-Environmental Design and Geohazard Management. ASME, New York, NY

Oil Spill Fates and Effects Analysis

The project team will assess the fate of an oil spill on the aquatic environment and terrestrial ecological environment associated with the six alternatives.

Focus is placed on an oil spill in the Great Lakes either from operation or decommissioning of the pipeline options, plus the water born transportation option associated with Alternative 3. The level of assessment of the transport, fate and consequence of such oil spills in the Great Lakes will be in depth, but will not include the collection of primary data. For the land options, the level of environmental assessment will be qualitative.

Technical Approach

The scope of consequence analysis of this study can be summarized into three main tasks:

Oil spill modelling including:

- Establishing a detailed hydrodynamic and wave model in the area of interest;
- Simulation of a range of spill scenarios, as defined by the failure probability analysis, for various current, wave and wind conditions at the time of spill; and,
- Determine areas that will be impacted and determine the associated amounts.

Environmental Assessment including:

- Investigate sensitive habitats in the project area; and,
- Assess the impact to the environment based on the results of the oil spill modelling.
- Health and safety impacts

Prior to the two main tasks, a data acquisition and consolidation exercise will ensure that all relevant data is available for the tasks.

Data Collection

The data collection can be split into two separate areas:

- Data collection for the preparation of the models; and,
- Data collection for the environmental habitats.

Where available site specific data for the Straits of Mackinac will be in the used in the analysis

Collection of Hydrodynamic Data, Wave Data and Meteorological Data

The project team will utilize an existing operational forecast model for the Great Lakes area. The model has been originally prepared for Ontario Ministry for Natural Resources and Forestry (Peterborough, ON) to understand flooding issues of communities along the Great Lakes.

The two-dimensional model is set up for Lake Superior, Lake Huron, Lake St. Clair, Lake Erie and Lake Ontario and consists of the following major components of relevance to the project:

- Established link to the existing WISKI database where the near real-time water level data for the lakes are stored
- Data assimilation included in the model. Model is pre-calibrated/validated at the regional scale
- Established link to meteorological forcing from Environment Canada
- A calibrated hydrodynamic model and a wave model for each lake which can be readily integrated to project team's existing model for Lake Michigan

These models will be used as a starting point for the preparation of the dedicated hydrodynamic and wave models for the oil spill modelling. Where available additional bathymetry information will be sourced in the area of the pipeline to increase resolution and local calibration / validation will be carried out against existing data sets.

Model Setup (Hydrodynamic, Wave and Oil Spill)

The hydrodynamic model and wave model will be based on the operational forecast model developed for the Great Lakes. However, these models are only 2 dimensional depth integrated and in order to ensure a realistic representation of an oil spill due to pipeline failure, a 3 dimensional model will be required. The in-house software MIKE model (see Appendix A) will be used. It is anticipated that a resolution of 50 to 100m (per grid cell) can be achieved in the immediate spill area to account for near field effects with coarser resolution adopted for far field processes. The following will not be included in the model:

- Long-term (>1 year) water level variations
- Riverine inflows with the exception of the inflow from Lake Superior and the outflow to St. Clair river[2]

The wave model will be prepared using the spectral wave model software MIKE SW. Even though the wave conditions are considered to be mild in the area of interest, in the oil spill model wave data are used

[2] The riverine inflows are not, in general, expected to significantly affect the transport and dispersion of the oil compared to the regional (wind driven) flows. However, the available stream gauging data from all larger riverine inputs will be reviewed and, if they show to be of significance for the hydrodynamics in the Straits, they will be included in the model. The exclusion, herein, refers to the riverine inflows that have no relevance to the hydrodynamic in the Straits.

for determining the amount of oil dispersed into the water column. While this is an important process the wave data required do not need to be highly accurate. The existing forecast model calibration and validation is thus considered adequate, with extension of the model to include Lake Michigan. The wave model will be based on the following data:

- Wind data from Environment Canada and/or other publically available data sources
- Ice coverage from publically available data sources

The MIKE 21 SW spectral wave model will be applied using default model parameters and using a quasi-stationary mode with a time step of 3 or 6 hours.

In order to determine the oil drift and weathering under a variety of conditions data from Environment Canada and the wave model covering the area covering the following periods:

- 3-dimensional hydrodynamic model data covering 1 full year. The data will include velocity components U, V, W, density and temperature (all in 3D) and total water depth (in 2D)
- Wind speed and direction (or U and V) for the same year as hydrodynamic model data
- Wave height (Hs) and period (T02) for the same years as wind data (in 2D)

Selection of Scenarios

The selection of scenarios will be developed by the project team and include:

- Oil type
- Amount of oil spilled
- Instantaneous spill or spilled over a given period of time
- Location and depth
- Length of simulation after spill has stopped (for example 15 or 30 days)

The environmental conditions (currents, waves and wind) during and after the spill determines the area impacted by oil. Each spill is simulated for a large number of environmental conditions, which will enable a statistical analysis. If each spill is simulated for an estimated 120 different environmental conditions throughout the year [essentially one spill start time every 3 days for the 1 year of hydrodynamic data simulated], average and worst case impacts can be determined, plus the probability of exposure.

The following table gives the alternatives and associated suggested modelling scenarios.

ID	Alternative	Scenarios	Conditions investigated
1	Construction of new pipelines that do not cross water Decommissioning of existing pipeline	Qualitative assessment of land based oil spills taking into account different seasonal effects (rain, ice cover etc.) 4 spill scenarios along the new pipeline route 3 decommission scenario spills along the existing route	Matrix of environmental conditions from 1 year HD base, to base statistical analysis on. This includes different seasons and ice cover to determine probability of exposure. Decommissioning scenario will exclude ice cover.
2	Utilizing existing alternative pipeline infrastructure that does not cross the Straits Decommissioning of existing pipeline	Qualitative assessment of land based oil spills taking into account different seasonal effects (rain, ice cover etc.) Decommissioning same as alt. 1	Decommissioning same as alt. 1
3	Utilizing alternative transportation methods Decommissioning of existing pipeline	Qualitative assessment of rail and tanker truck (where deemed feasible) 4 spill scenarios based on vessel collision/grounding for vessel transport (if deemed feasible) Decommissioning same as alt. 1	For vessel transport Matrix of environmental conditions from 1 year HD base to base statistical analysis on. This includes different seasons and ice cover to determine probability of exposure. Decommissioning same as alt. 1

ID	Alternative	Scenarios	Conditions investigated
4	Replacing the existing Straits Pipelines with new pipelines	4 spill scenarios along the pipeline route	Matrix of environmental conditions from 1 year HD base to base statistical analysis on. This includes different seasons and ice cover to determine probability of exposure.
	Decommissioning of existing pipeline	Decommissioning same as alt. 1	Decommissioning same as alt. 1
5	Keeping existing pipeline	4 spill scenarios along the pipeline route [Magnitudes/probability will be different from Alt 4]	Matrix of environmental conditions from 1 year HD base to base statistical analysis on. This includes different seasons and ice cover to determine probability of exposure.
6	Eliminating all transportation of petroleum products and decommissioning of pipeline	Decommissioning same as alt. 1	Decommissioning same as alt. 1

Simulation of Oil Spills and Analysis of Simulation Results

Selected scenarios will be simulated using MIKE simulation model for the selected environmental conditions. The output provided at the end of each simulation will include 2D fields of:

- Maximum oil mass / thickness in each grid cell during the simulation
- Shortest drift time to each grid cell
- Stranded amount of oil in grid cells along land
- Oil mass remaining within model area at end of simulation

Many other parameters (e.g. amount of oil divided into oil fractions) may also be saved from each simulation.

Based on simulations performed for each scenario the following statistics can be prepared:

- Probability of occurrence of oil in each grid cell (in percent)
- Probability of tolerance limits for environmental receptors being exceeded
- Overall shortest / average drift time to environmental receptors
- Statistic of oil mass vs probability in each grid cell
- Statistics of stranded amount vs probability in each grid cell

The deliverables will include a graphical representation of the oil spill based on the trajectory simulations and statistical analysis. These graphical representations will include, but are not limited to:

- Probability of an area being exposed to spilled oil
- Minimum time of exposure after spill for a given area.
- Probability of a given key receptor being exposed
- Description of metocean forcing conditions typically associated with the exposure of key receptors
- Animations of select critical spill situations.

Examples of statistical maps are shown in Figure 4 and Figure 5 below.

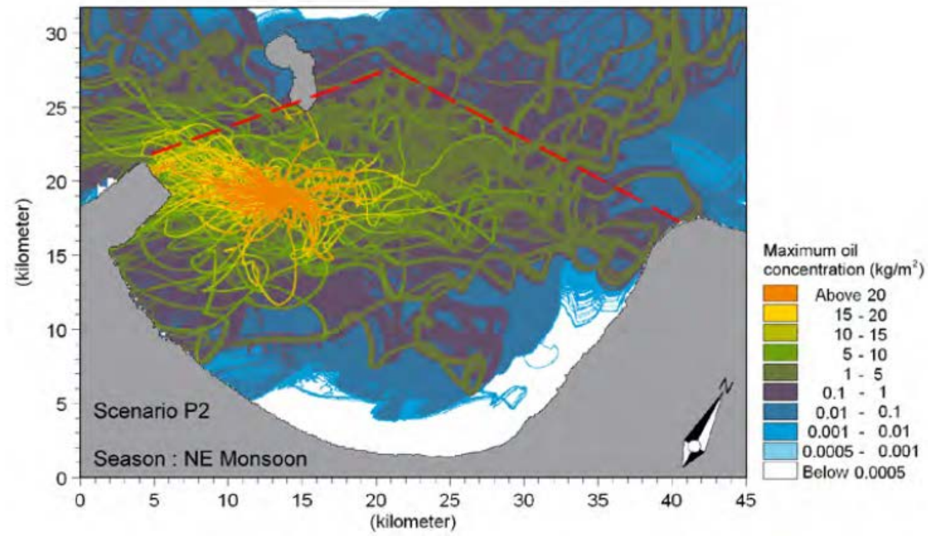


Figure 4 - Example of map of maximum oil concentration for a spill scenario

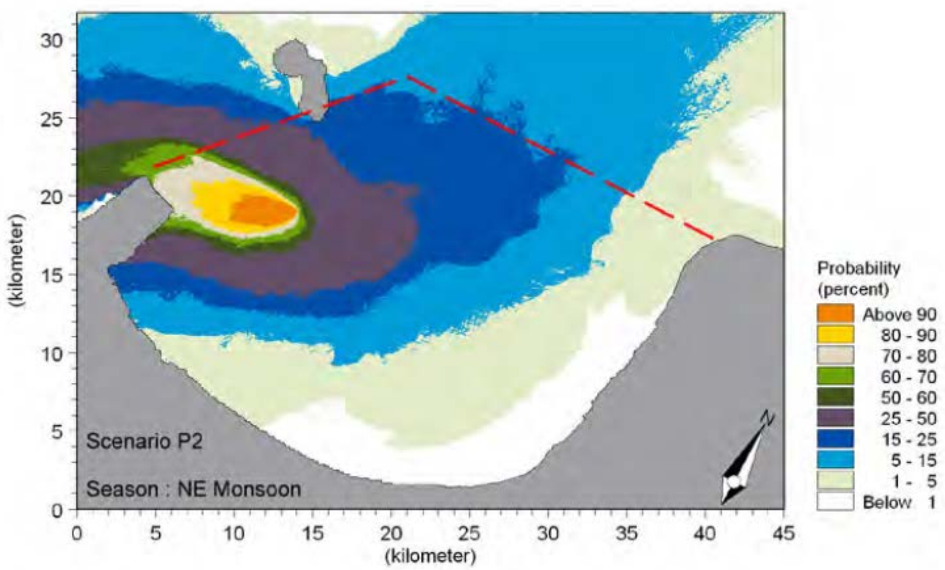


Figure 5 - Example of probability map for oil spill scenario

Environmental Habitats

The environment of the Great Lakes is unique and highly vulnerable to spills from petroleum products. A potential oil spill could heavily impact on fish, shoreline mammals, birds as well as vegetation and effects may range from direct contamination of the flora and fauna to prolonged impacts due to toxicity effects due to the oil characteristics.

Habitats and sensitive receptors within the project area will be mapped in order to allow a thorough assessment based on the results of the oil spill modelling.

The following steps will be undertaken as part of this task.

- Data collection and desk survey of available information on habitats within the project area including sensitivity to oiling where available
- Data collection of water quality parameters (from literature) or publically available research projects
- Establish any protected/endangered/vulnerable species within the project area (e.g. the piping plover and Kirtland's warbler)
- Consolidate and graphical represent all habitat information in ArcGIS and associated data bases.

Due to the large extent of the project area, no detailed field surveys will be carried out as part of this study. This should be included in the scope of an Environmental Impact Assessment of the chosen alternative in the future.

Environmental Impacts

An oil spill in the lake will be evaluated based on the probabilities maps and statistical analysis from the oil spill model that will highlight the areas impacted.

Key focus will be the fauna and flora present in and around the Great Lakes, including but not limited to fish, (shoreline) mammals, (water) birds as well as crustaceans.

There will be no quantification of the oil spill on terrestrial areas, but any impacts will be evaluated qualitatively. This will include again impacts on any flora and fauna, but will also include impacts on ground water, ground contamination and pathways into the lakes.

The identification for the oil spill within water and on land will follow these four steps:

- Description of the environment likely to be significantly affected by the spill (based on information collected on environmental habitats)
- Description of the potential environmental impacts of the oil spill (incl. impact to water quality, direct impact, toxicology impact etc.) and their significance
- A clear indication of predictive methods (e.g. oil spill modelling) and underlying assumptions
- Identification of gaps in knowledge and uncertainties encountered

The project team will be using an updated version of the well-established RIAM (Rapid Impact Assessment Matrix) methodology that will evaluate potential impact in their magnitude, significance (ecologically and economically) as well as the likelihood of such impacts. In that way, impacts can be compared fairly objectively not only within one alternative, but also across the different alternatives.

If apparent, high level recommendation for mitigation measures that may reduce the impact level significantly may be made, however, a full mitigation recommendation is considered to be outside of the scope.

The mapping of the environmental habitats and sensitive receptors will feed directly into the environmental assessment of the alternatives and associated spill scenarios.

Health and Safety Impacts

Failure of a hydrocarbon liquid pipeline or a storage container (e.g. rail car) has the potential to cause damage to the surrounding public, property and the environment. The consequences of failure are primarily due to the thermal radiation which is produced if the release ignites. The escaping fluid can ignite, resulting in a fireball, crater fire/surface fire or jet fire which generates thermal radiation.

Figure 6 shows a typical Event Tree (ET) used for releases from liquid pipelines on land.

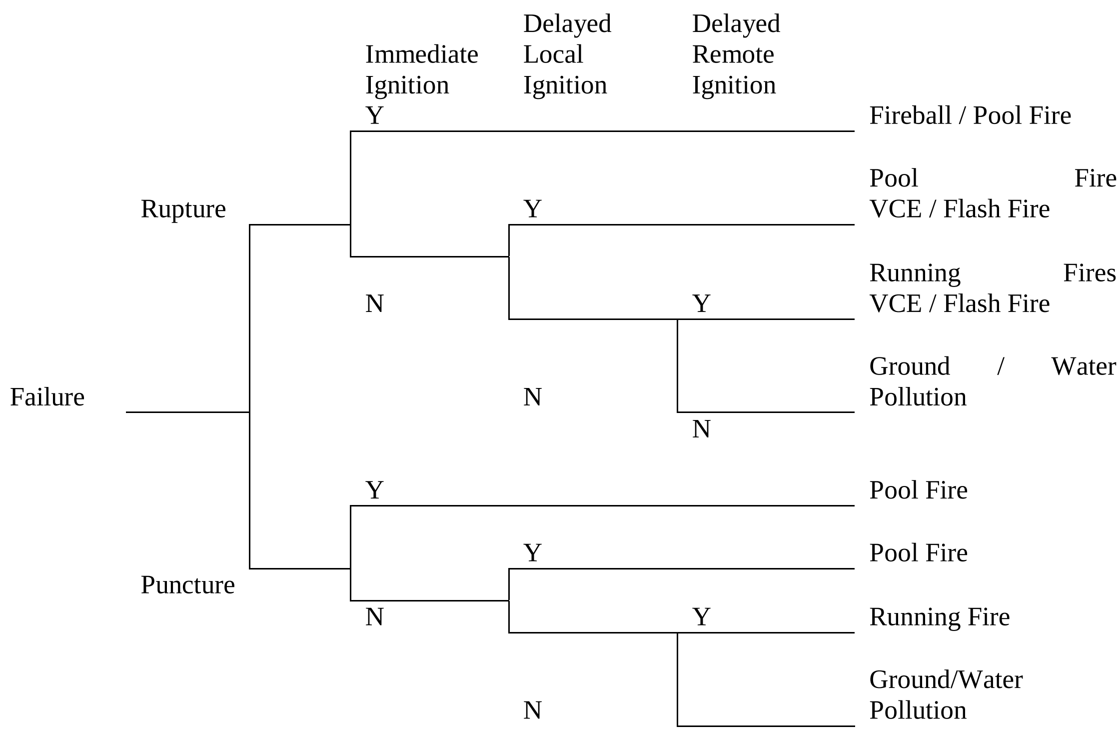


Figure 6 - Typical Event Tree Analysis for Releases from Liquid Pipeline on Land (ref. PD 8010 – 3 2009+A1: 2013)

In case of an underwater release, the main concern is surface and running fires, as well as the vapour cloud produced by evaporation from the hydrocarbon pool.

As part of this scope of work, for each alternative listed in Part II-A of the Request for Information and Proposals for an Independent Risk Analysis for the Straits Pipelines, the consequence scenarios are developed for the identified worst-case spill and release scenarios. These consequences and their potential impact on public health and safety is assessed using the PHAST consequence models, version 7.11 (DNV GL Software, Process Hazard Analysis Software Tool).

The modelling includes dispersion and fire calculations to obtain representative impact zones for the dispersing hydrocarbon liquid and the associated vapour cloud.

The analysis will examine the following consequences for each alternative as appropriate:

- **Pool Fire / Surface Fires**: Ignition of the released liquid which does not vaporize and forms a hydrocarbon pool over the surface of land or water.
- **Flash Fire:** Delayed ignition of a flammable vapour cloud (caused by evaporation from the pool) in an uncongested area.

- **Jet Fire:** Immediate ignition of a pressurized release of flammable material
- **Fireball:** Short-lived flames generally resulting from ignition and combustion of turbulent vapour/ two-phase fuels in air. A fireball is usually caused by near instantaneous releases and involves catastrophic failure of pressurized vessels / pipelines.
- **Unignited Hydrocarbon Cloud:** Extent of a hydrocarbon cloud at a concentration which can be harmful to the public.
- **BLEVE:** A BLEVE (Boiling Liquid Expanding Vapour Explosion) occurs when a jet or pool fire is located beside a vessel containing a pressurized liquid. The heat of the fire causes a rise in liquid temperature and pressure which can cause the vessel wall to weaken. Once the vessel walls fail, the pressurized liquid will flash, resulting in an overpressure and potential fireball. This scenario is only applicable to the pressurized vessels (i.e. tanker trucks, and rail cars).

Vapour Cloud Explosions (VCEs) occur when a flammable cloud is ignited in a congested area (such as areas with high density of piping and process equipment). The area surrounding pipelines are generally considered unobstructed, and do not provide the type of confinement that are required to cause vapour cloud explosions. Therefore, the VCEs are excluded from the scope of this analysis.

The following data are used as inputs to the consequence modelling:

- Pipeline/vessel operating conditions and composition of released material
- Magnitude of spill (i.e. outflow rate or release inventory) – see 'Failure Probability and Associated Magnitude of Release'
- Extent of overland / overwater pooling (i.e. hydrocarbon pool)
- Average weather conditions (i.e. average temperature and wind speeds for both Summer and Winter conditions)

The consequence modelling produces the following outputs which are used as inputs to the risk analysis along with the associated event frequency.

- Maximum distance to thermal radiation levels which are considered harmful and can cause fatality
- Maximum distance to LFL (Lower Flammability Limit) cloud which may cause a flash fire event
- Maximum distance travelled by an unignited hydrocarbon cloud at a concentration which is considered harmful to public

Figure 7 shows an example of output for radiation distances resulted from a pool fire event.

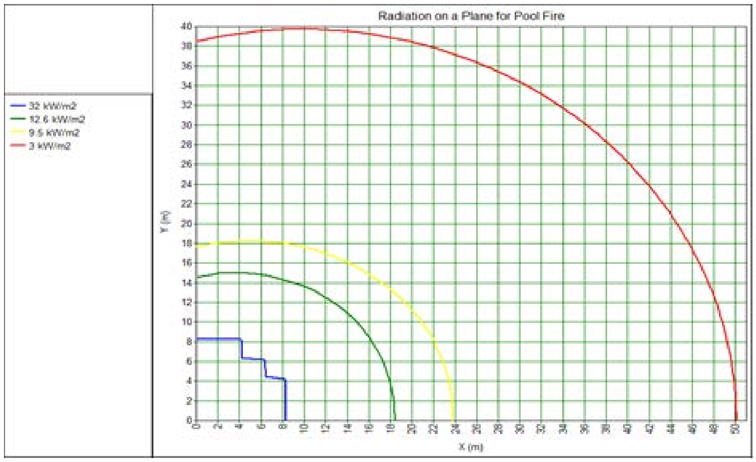


Figure 7 - Example of Thermal Radiation Contours From Pool Fire

<u>Economic Impact and Analysis</u>

Economic Analyses & Evaluations

The Study will include a number of economic analyses and evaluations at different stages. As a general principle, the approach undertaken will be to rely on methods that: (i) use publicly available information that is transparent and has withstood the scrutiny of peer review, regulatory processes, or independent quality assurance; (ii) permits application to the different alternatives in a consistent fashion; and, (iii) can be used or updated with little incremental cost at a future date if other alternatives are identified.

The economic analysis approach has further been streamlined to address Study requirements in four distinct modules and a final synthesis of these modules for reporting purposes. These are described in further detail below.

Module 1 – Economic Baseline Forecast

During the initial phase of the Study, a baseline forecast will be prepared that involves collecting basic historical economic information of relevance within the study area, and presenting that data in a manner consistent with other components of the Study. Specific tasks will include (but are not necessarily limited to) the following:

i. Define the spatial dimensions of the Study's primary Area of Interest (AOI) in the Michigan Great Lakes Region, as well as focal sub-areas within the primary AOI. The AOI will include all anticipated alternatives to be considered, and will include definitions at the sub-area level that correspond to county boundaries in the State. Use of the county boundaries will be consistently used across all analyses where relevant as this is the most detailed spatial unit on which demographic and economic information is collected and made available through the US Bureau of Economic Analysis.

ii. Obtain historical price and income deflators for Michigan and (where available) major urban areas within the AOI. These will be selected based on official Michigan statistical accounts made available during the Study. The deflators will be used for standardizing facility cost estimates and oil spill costs, as well as in the market impact analysis.

iii. Specify assumptions for future economic conditions that may impact any of the economic analyses (exchange rates, unemployment rates, growth rates, tax rates, inflation). Analytical assumptions (discount rates, rates of return on invested capital, analytical base year, length of analysis for discounting purposes [years]) will also be selected within this task, with sources and rationales clearly documented.

iv. Organize and document all information in a transparent fashion and make it available for use in cost estimating and in analytical models.

v. Summarize a Baseline Economic forecast (for analytical purposes) and one low-growth sensitivity forecast (for qualitative discussion purposes).

Module 2 – Financial Feasibility Analyses

The financial feasibility analyses will be developed for each alternative considered, and will be based on a cash flow profile of capital and operating costs needed to deliver a volume equivalent to that of the current pipeline infrastructure. This volume is selected as a benchmark to permit comparisons of alternatives independent of selected upstream and downstream impacts (which will be addressed elsewhere). Key metrics will include present value and cost-of-service (or levelized cost in $/bbl. terms). The levelized costs will be subsequently used in market analyses to determine the degree to which producers, refiners, major industrial customers, and other consumers of energy products may be impacted.

The financial analyses will also reflect potential co-benefits from any given alternative if there are potential cost savings or cost-sharing opportunities of new infrastructure. For example, tunnels (Alternative 4) permit the use of cost-saving and higher quality inspection tools; in some jurisdictions tunnels are also shared with other utilities. Such co-benefits are analytically treated as a reduction in cost of the Alternative, resulting also in a reduction in any cost-of-service calculation attributable to the Alternative in a market analysis.

Core results of this module will be provided in a Financial/Economic Feasibility Interim Report (to be integrated subsequently into project Draft and Final Report) showing results for each alternative and a comparison of all alternatives using transparent and consistent assumptions.

Module 3 – Spill Cost Analyses

Spill cost analyses are treated as two separate activities within the Study:

3.1 Scenario Independent Socio-economic Spill Vulnerability

The purpose of this activity is to identify and map those areas in the AOI that may have the highest negative socio-economic impacts in the event of a spill from any source. For this step we will use a simplified vulnerability index to identify a potential economically high consequence area (HCA). This reflects a notion that a worst-case spill from a technical perspective (in terms of water column or shoreline environmental impacts) may not be the highest consequence spill from an economic perspective. A vulnerability index will be constructed for the AOI and mapped similarly to environmental sensitivity. The variables used in the index will be sourced from public statistics and land-use/land-cover data. A heat map will be created and used to inform the selection of worst-case spills across all alternative scenarios.

3.2 Scenario Dependent Spill Costs

Spill costs will be estimated for up to three scenarios in each alternative. The three scenarios will be characterized as: (i) technical worst case spill to reflect an outflow and conditions associated with greatest volumes or environmental impacts; (ii) economic worst case spill to reflect an outflow of potentially lesser volume into a HCA as defined in 3.1 above; and, (iii) a most credible worst case scenario.

For each alternative and spill scenario, the spill costs will be disaggregated into two main components consistent with current literature: clean-up (including response) costs; and, damage costs. Each of these can also be disaggregated further to reflect: natural resource damages (including human uses) as defined in Natural Resource Damage Assessments which quantify public goods and services; government costs (which are also publicly borne but are not associated with direct damage to goods and services); and, private costs which include any privately borne costs that can be directly linked to an oil spill event (this could include changes in property values, lost business income, health impacts, or a range of other private impacts).

The approach to estimating the core spill costs will be to rely on spill cost statistics maintained by the consultants (including spill cost data in PHMSA, data documented in regulatory hearings in Canada and the

United States, data accessible through the International Oil Pollution Compensation Fund, in-house estimates of ecosystem values based on the international database of Environmental Valuation Reference Inventory [EVRI], and other sources). The spill data that will be used in this Study have also been vetted specifically by intervenor and regulator examination in recent hearings before Canada's National Energy Board for hypothetical spills from Northern Gateway and from the Trans Mountain Expansion.

In addition, where applicable, a spill that coincides with a service disruption (of delivered product) may result in a prolonged outage period. This may impact downstream refiners or customers, and/or upstream producers in the US and Canada. The economic consequences of this outage will be estimated using "worst case" assumptions whereby the entire product value is lost during a period of unmet demand for a specified length of time, after which partial value is lost until transportation services are re-established. It should be noted that in some instances – typically those involving unit shipments on barges or trucking – these economic consequences of unmet demand are negligible.

A final analytical step that will be taken in the Study will be to place the spill costs in the context of the probability of such a spill occurring. In theoretical welfare economics (which is the basis for cost benefit analysis) the "expected" cost of a spill is the probability of the spill occurring multiplied by the resultant costs and consequences of that spill; such a metric permits the comparison of spill costs against events with different likelihoods. It also permits comparison of hypothetical low-probability spill costs from a given transportation alternative to the certain (i.e., probability of unity) benefits associated with that alternative.

A spill cost summary will be presented in a stand-alone Spill Cost Interim Report which documents spill costs across all alternatives and scenarios. This Interim Report will also form part of the Draft Final Report, which will also document all sources and provide a qualitative discussion of any limitations of the spill cost estimates. It is important to note that each spill is different and that any spill cost estimation of a hypothetical event should be regarded as a best estimate; the methods that will be employed in this Study cannot be compared to those used after a spill event occurs. The methods are, however, regarded as reliable and appropriate for looking at a comparison of different alternatives that may have different risk profiles.

Module 4 – Socio-Economic Impact Analyses

Socio-economic impacts will be examined for each alternative, both from the development of the alternative transportation mode, and for the oil spill event that corresponds to that transportation mode. Three types of analyses will be provided: (i) qualitative discussion of unmeasurable socio-economic costs associated with oil spills and facility development; (ii) quantitative assessment of measurable job, income and taxation benefits associated with facility development for each alternative; and, (iii) quantitative assessment of market impacts of changes to supply and demand patterns arising from a shift in or elimination of a transportation mode for each alternative.

The Study will provide a stand-alone Socio-economic Impact Draft Report showing results for each alternative.

4.1 Qualitative socio-economic impacts

Many socio-economic impacts can be described but are not readily estimated. Cultural impacts, noise, congestion, traffic disruptions, and other negative consequences may all be associated with a given facility development (e.g., tunneling, pipeline construction, trucking traffic, rail cars). The precise monetary quantification of such impacts is not typically possible for hypothetical projects as they require public consultation at affected sites alongside original data collection to be meaningful in the context of a given project or alternative; each negative impact will also typically have an acceptable mitigation mechanism which can be internalized within a project's cost. The facility and operations cost estimates that will be prepared for this Study will generally include best available technologies that reduce such impacts. Nonetheless, residual impacts may still occur and the Study will document and assess these impacts using a simple screening tool that is used in social impact assessments. Such tools generally address five accepted categories of impacts (UN Public Administration Network, A Comprehensive Guide for Social Impact Assessment, 2006) categorized as: lifestyle impacts; cultural impacts; community impacts; quality of life impacts; and, health impacts. The tool will be adapted as appropriate for this Study and applied as a qualitative screening mechanism to compare alternatives. As the Study does not include primary data collection, the tool will be used based on consultant knowledge of the technologies and of impacts usually considered in projects before regulatory authorities in the US and Canada.

A qualitative discussion will also be provided of omitted socio-economic impacts arising from oil spills. Experience has shown that a spill event does lead to localized positive benefits in some industries for a short period after the spill due to cleanup activities. Simply put: a proportion of the cleanup costs would be injected into the local economy and generate income, job and taxation benefits just as any other outside economic stimulus might. For this Study, such an analysis will not be performed as experience elsewhere indicates that such analyses are not generally well received by the general public, which can perceive the analyses as down-playing the significant negative impacts that accompany oil spills. A quantitative analysis will not be undertaken, except to discuss the concept in more general terms and in the context of a different and more general investment in oil spill preparedness. It is more balanced to argue that certain types of oil spill preparedness can have positive impacts in terms of jobs and income generation: training of responders; equipping individuals, vessels and vehicles for oil spill response; exercising emergency procedures; and, public information sessions. All such activities can have direct socio-economic benefits and can also enhance preparedness for any emergency to greater social benefit. Again, the Study will address such benefits qualitatively through general discussions in the Draft and Final Reports.

4.2 Quantitative socio-economic impacts – direct, indirect and induced impacts

The Study will provide a quantitative assessment of the direct, indirect and induced impacts of the project based on standard multiplier techniques using a built-for-purpose model that relies primarily on the RIMS II November 2015 model (Bureau of Economic Analysis, US Department of Commerce; Regional Input-Output Modeling System). The structure of RIMS II provides an appropriate model for estimating impacts at a local and regional basis; it features 369 industries and provides multipliers on user-defined regions. The team has extensive experience with input-output (IO) accounts and the use of such models in other jurisdictions (CANSIM in Canada, various IO models internationally); the RIMS II IO structure readily permits simulation of demand shocks to determine the impacts on total gross output, value added, earnings, and employment in the region. The team regards the RIMS II structure as best in class for estimating impacts in Michigan: it permits user-defined regions; it permits isolation of local impacts at a county level; it is updated annually with high credibility and transparency; and, it can be cost-effectively applied for this purpose to permit comparative analyses of different alternatives.

This Study will define up to 14 different regions and sub-regions for analytical purposes including: Michigan as a whole; an AOI that includes the Michigan Great Lakes Region; and, up to 12 sub-areas within the AOI to permit investigation of more localized impacts. To initialize the model, the multipliers associated with the November 2015 release of RIMS II will be used; the model will be updated once if another update of the RIMS II regional data is released on a timely basis that permits its incorporation within the Draft Report (an update is expected in 2016 but the precise date is not available at time of writing). To complement the model, the Study will introduce a separate tax impact model based on current (2016) tax rates to generate tax multipliers that permit estimation of tax impacts from the RIMS II structure.

For each alternative, the impact model will be used to simulate spending shocks arising from two expenditure sources: (i) total capital expenditure; and, (ii) annual recurrent expenditure. The direct impacts of each of these will be identified by assigning the expenditures to appropriate industry classes in the appropriate region to determine the impacts throughout that region, the AOI, and Michigan. Resultant impacts will be reported for the following economic indicators: employment, income, and taxes. Discussion of these impacts will include standard caveats associated with IO models and multipliers; notably, the reader will be reminded that high cost projects will have high economic impacts because of their direct impacts on the economy, but they are rarely the least expensive means of achieving a given objective (which would have lower costs, for example, to deliver the same output or throughput). Model results will also be placed in the context of current income and employment information to show percentage changes from the status quo.

4.3 Quantitative socio-economic impacts – energy market adjustments

As described previously, changes in transportation mode can engender impacts beyond the direct and induced socio-economic impacts captured in a linear IO framework. Line 5 transports approximately 540,000 bpd of petroleum products; this volume represents approximately 15% of Canada's total current production of approximately 3.7 million bpd. Also, by comparison, Michigan is within the Midwest Petroleum Administration Defense District (PADD 2), which has refinery capacity of approximately 2.4 million bpd (Source: American Fuel & Petrochemical Manufacturers, 2015). A shift in transportation mode, and a change in the unit costs of such transportation, has the potential to impact both suppliers and consumers throughout North America.

It is beyond the scope of the present study to Model all of the supply and demand impacts of a change of this nature, but a partial analysis of energy market adjustments will be conducted that focuses on PADD 2 and Eastern Canada. Most of the alternatives being considered in this Study still propose shipping the same volume (540,000 bpd) over the same time frame. For other pipeline routings or for the tunneling alternative, all of the impacts will thus be price related: price impacts can be modeled over the long-term on the basis of changes to the applicable cost-of-service arising from the alternative transportation mode. The increase (or decrease) in costs will potentially have a demand impact on final users or on refiner margins in the Sarnia refinery complex in Canada. A first order estimate will be made of such impacts for this Study. The alternatives relating to a complete abandonment of all petroleum shipments would, at the extreme, result in shut-in production in selected areas. Although Michigan has some oil production (approximately 15,000 bpd [US Energy Information Administration]) most of the shut-in capacity would be outside of the State; the Study will, however, evaluate the likely impacts on producers, consumers, and refiners based on public information within PADD 2 in the United States, and on refiners in Eastern Canada. The analysis will also consider the possibility that exports from both Canada and the United States may drop if transportation capacity becomes constrained; any price and demand impacts of changes in transportation costs may be negligible or not discernible in the context of anticipated international oil price volatility.

<u>Synthesis of Economic Analyses</u>

The Draft Report and Final Report will include a synthesis of all economic analyses, including summaries of assumptions, methods, and results. Qualitative discussions will provide guidance on the interpretation of the results.

Project Deliverables

The following is the list of deliverables for the project:

- Draft engineering report analyzing the six alternatives for the Straits Pipelines
- Two public consultations reviewing the draft report of the alternatives
- Final engineering report analyzing the six alternatives for the Straits Pipelines

Project Assumptions

In the development of the project scope of work, there were a number of assumptions made which are outlined below. These assumptions form the boundary of engineering analysis to be performed in each alternative on the project.

- Alternative 1 - New Pipeline Route:
  - A high-level screening of general routing (northern route vs southern route) will be performed prior to selecting a preferred route and developing a corridor which will be used for analysis purposes. This corridor will not constitute a high-resolution alignment upon which detailed design will be performed, however it will be sufficient to perform the risk and economic analysis required.
  - As detailed information such as wall thickness changes, depths of cover, location of discrete geohazards, etc. will not be available, failure frequency estimates will rely largely on industry incident data. Similarly, estimates of consequence will be based on high-level analysis, commensurate with the resolution at which data is available (i.e., detailed site-specific consequence analysis that requires knowledge of discrete receptors such as structures, aquifers, etc. will not be possible).
  - Capital and operational cost estimates will be based on high-level analysis utilizing an approximate alignment, as well as known diameter, and throughput requirements
  - While no new pipeline infrastructure may cross the open waters of the Great Lakes, utilization of existing pipeline infrastructure at the crossing of the St. Clair River may be assumed.

- Alternative 2 – Other Pipeline Infrastructure:
  - The alternative infrastructure investigated will be that which is required to enable the abandonment of the existing Straits Pipelines.
  - Consistent with the approach described under Alternative 1, failure frequency estimates will rely largely on industry incident data. Similarly, estimates of consequence will be based on high-level analysis, and detailed site-specific consequence analysis based on discrete receptors such as structures, aquifers, etc. will not be performed.
  - Operational (and any required capital) cost estimates will be based on high-level analysis utilizing known alignments, design configuration and throughputs
  - Use of existing pipeline infrastructure that may involve river crossings (including the crossing of the St. Clair River) may be assumed as part of the pipeline routing.
  - This alternative may involve both existing transportation infrastructure and/or also new infrastructure to connect to and use the existing infrastructure (Alternative 1 / 2 hybrid)

- Alternative 3 - Utilization of alternative transportation methods:
  - The risk assessment for the alternative transportation methods will focus on the operational risks associated with the infrastructure required to replace the pipeline crossing at the Strait of Mackinac (e.g. storage facilities, rolling stock, etc.).

- Where the use of loading / storage facilities is required, new pipeline infrastructure may be required to carry products to these facilities. These new pipelines will be included within the scope of the risk assessment and cost analysis.
- A high level feasibility study will be conducted in the alternative for the use of barges, trucks and other transportation modes to deliver the product for the replacement of the Straits Pipelines. A detailed risk analysis and cost assessment for a given transportation mode will be performed only if the feasibility study indicates that it is viable.
- Where the feasible alternative(s) involves crossing the open waters of the Great Lakes the environmental risk assessment will quantitatively assess the transport and fate of released oil within the Great Lakes. Where the feasible alternative(s) does not involve crossing the open waters of the Great Lakes, environmental risk will be assessed qualitatively.

- Alternative 4 - Pipeline Replacement:
  - The project will look at conventional trenched pipeline and tunnel options to replace the existing Straits Pipelines utilizing current state-of-the art offshore technology to design, construct and install a pipeline.
  - The environmental risk assessment will quantitatively assess the transport and fate of released oil within the Great Lakes.

- Alternative 5 – Existing Pipeline:
  - The risk analysis will focus on the Straits Pipelines only (i.e., the risk analysis will not address the full-length of Line 5)
  - Enbridge will provide any additional data, not already in the public domain, that may be required to perform the risk analysis of the Straits Pipelines.
  - The environmental risk assessment will quantitatively assess the transport and fate of released oil within the Great Lakes.

- Alternative 6 – Decommissioning the Straits Pipelines:
  - A full risk assessment is not required for this alternative; only the potential economic impacts to the Great Lakes Region will be assessed

- All Alternatives:
  - For the purposes of the project, the Straits Pipelines are defined as the two 20-inch diameter segments of Enbridge Energy Limited Partners Line 5 pipeline system that transports oil and natural gas liquids that are submerged at the Straits of Mackinac bound by the valve sites upstream and downstream of the crossing,
  - Risk assessment performed will address operating risk and not risks incurred during construction.
  - Risk assessments will be performed to generate three different measures of risk, as follows:

    1. Health & Safety:

- There are a range of health and safety consequences, ranging from fatalities to lesser-effects, by convention with industry practice, health and safety risk will be characterized in units of fatalities per year of operation, and that by proxy, this characterization imputes less severe consequences. Other H&S consequences, including toxicity are accounted for in the environmental impact analysis.

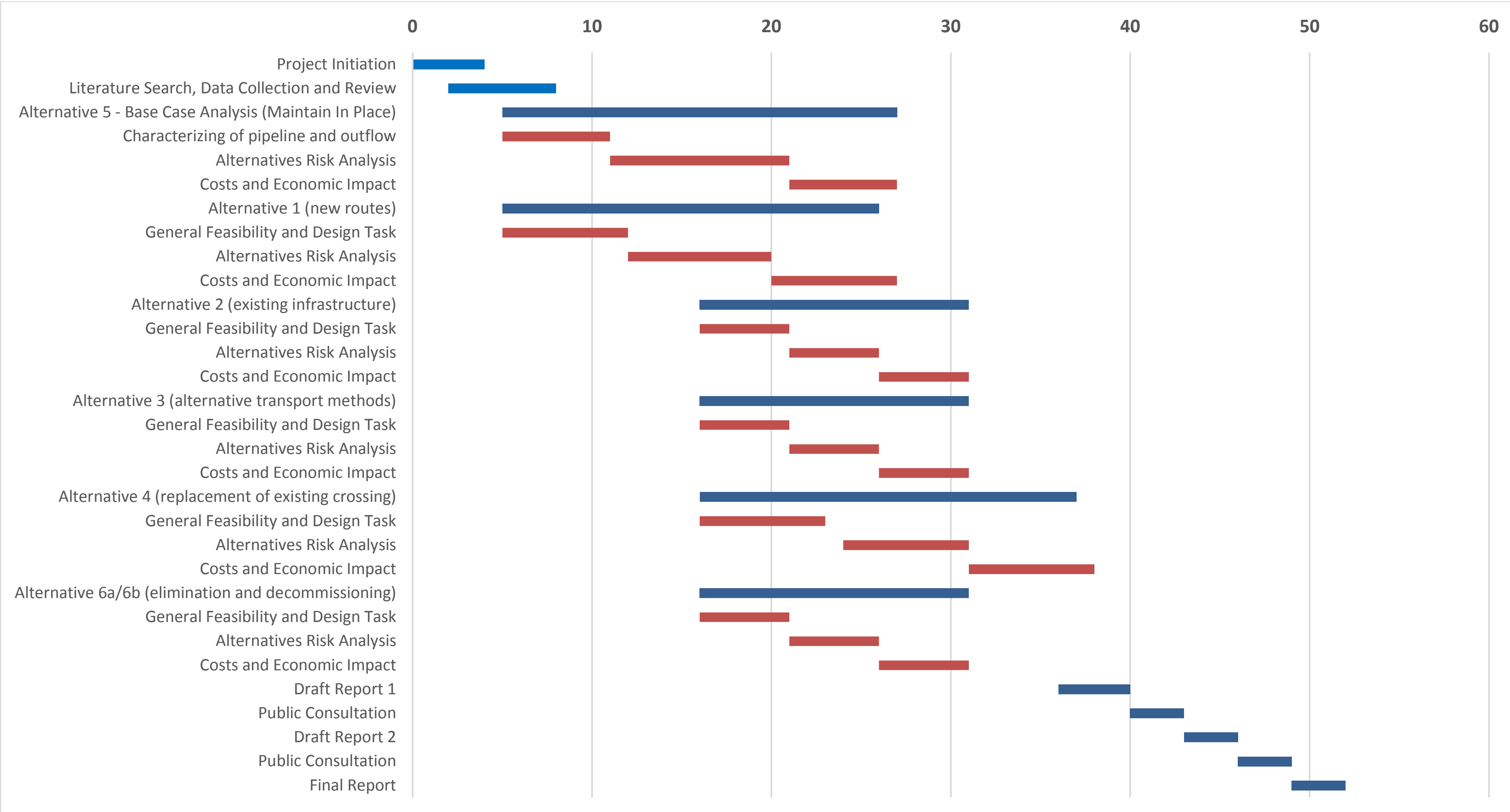
2. Environmental Impacts
    - As there are no standards or government regulation in existence that enables environmental impacts to be evaluated quantitatively, environmental consequences will be evaluated using a qualitative index scoring system. The evaluation of environmental risk will account for the frequencies of occurrence of a range of release magnitudes, and their associated consequences. It will also account for seasonal conditions; such as ice cover. The resulting risk evaluation will therefore represent the combined consideration of a range of release magnitudes and the probability of incurring those releases under a range of conditions.
3. Potential natural resources damages, including, but not limited to, damages to the Great Lakes; Potential response and clean-up costs; and Potential economic impacts to the Great Lakes Region.
    - Each of these measures of consequence will be expressed quantitatively in units of $ impact.

- Environmental, health and safety, social and unquantifiable economic impacts will not be described or analyzed outside of the State of Michigan.
- Economic impacts will not be quantified outside of the State of Michigan except for the potential market impacts on product prices, which are best described on a State-wide basis (see next bullet below). Other economic impacts (including spill costs, natural resource damage costs, and the employment/income impacts of construction and operations) will be quantified at the level of the Great Lakes Region within the State of Michigan. Quantifiable impacts outside of the Counties in the Great Lakes Region but still associated within the State of Michigan will be characterized as "Other Michigan Impacts".
- The incremental economic market impacts of all alternatives relative to the status quo could be distributed throughout North America impacting consumers, suppliers, and refiners through market pricing mechanisms. Such qualitative impacts will be described, with quantitative impacts summarized for the State of Michigan as a whole in terms of a single indicator reflecting unit pricing of a typical market commodity (e.g., $/gallon of product) to final Michigan consumers based on current (mid-2016) market conditions.
- Environmental Assessment will focus on the vulnerability of habitats exposed to potential oil spill in order to be able to differentiate the environmental risks between alternatives rather than a detail environmental impact assessment. The study will thus not be a substitute for an environmental impact assessment for any of the alternatives.

- The environmental assessment focuses on the aquatic and coastal environments in relation to the oil spill scenarios, including the Great Lakes and major water courses (rivers) that may be crossed. Only preliminary assessment will be carried out relating to terrestrial spills and effects on ground water etc.
- The process of obtaining regulatory approval and social license required for all alternatives, including timeframes required to obtain regulatory approval, permits, and land acquisition is not within the scope of work for the project.
- The project will only evaluate the engineering feasibility, risk, consequence and cost for these alternatives.
- The state will request that Enbridge will release data requested by the project in a timely fashion (i.e., within 10 business days or less from the date of request).
- Two public consultations will be held during the project in order to review the report developed.
- One formal project kick-off meeting in Lansing, Michigan.

Project Schedule

The preliminary project schedule is based on a project start date of August 19 2016 with a 52-week duration. A detailed project schedule will be developed as part of the project initiation task. The project schedule may change during the execution phase depending on project issues that might arise. The duration shown in the schedule below is in units of weeks.

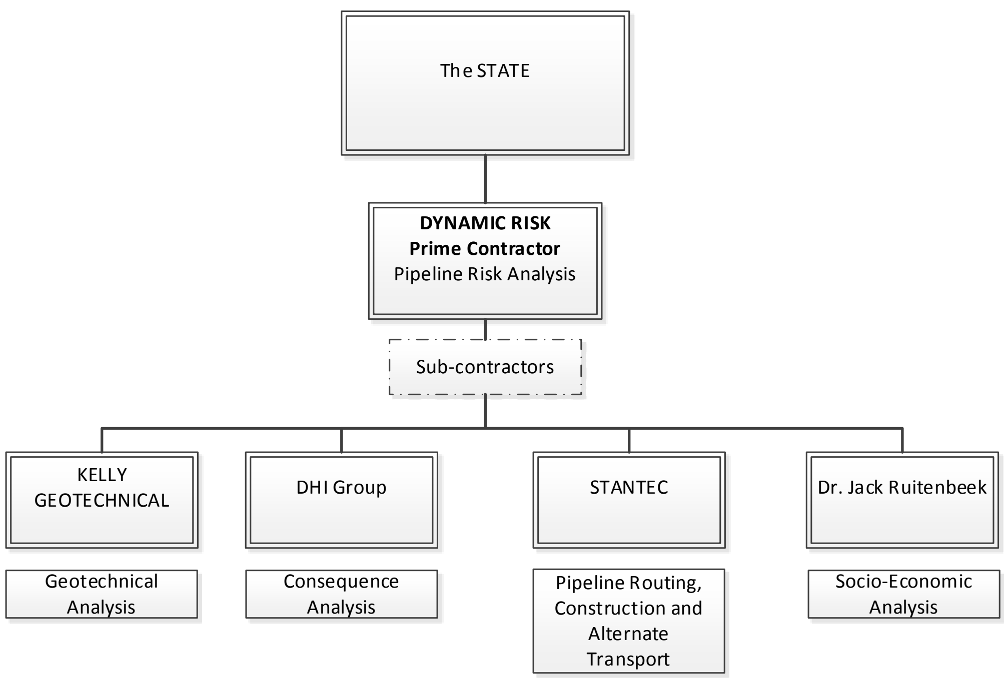


Project Organization

Dynamic Risk has assembled a multi-disciplinary team of world class expertise to complete the independent analysis of the alternatives to the Straits Pipelines.
The team consists of the following key members:

1. Dynamic Risk – overall program management and quantitative pipeline risk analysis;
2. DHI Group – industry leaders in oil spill fates and effects analysis in marine environments;
3. Dr. Jack Ruitenbeek – recognized global expert in socio-economic financial impact analysis of oil spill events;
4. Stantec Engineering – pipeline engineering and design firm with global expertise on multi-billion dollar projects; and,
5. Kelly Geotechnical – an experienced and recognized authority in assessing geotechnical (ground movement) threats to existing and new pipeline designs.

Dynamic Risk would act as the Prime Contractor with the State of Michigan and be responsible for all reporting, communication and project deliverables from the project team.



Project Team

The following table contains the key project team members and their primary roles on the Independent Alternatives Analysis for the Straits Pipelines project.

Company	Name	Project Role	Role Description/Responsibilities	Project Tasks
Dynamic Risk	Jim Mihell	Technical Lead / Chief Engineer	Technical Leader - project oversight, review and technical guidance. Senior technical resource assigned based on scope/requirements.	Alternatives 1, 2, 3, 4, 5
Dynamic Risk	Patrick Vieth	Project Sponsor / Sr. Technical Lead	Responsible for the strategic relationship between all parties. Works closely with the State and Project Manager on communications and progress reporting. Technical advisor and resource.	Alternatives 1, 2, 3, 4, 5
Dynamic Risk	Phillip Nidd	Senior Pipeline Risk Expert	Sr. Pipeline Risk and Integrity technical support	Alternatives 1, 2, 3, 4, 5
Dynamic Risk	Ben Mittelstadt	Sr. Engineer	Sr. Pipeline Risk and Integrity technical support	Alternatives 1, 2, 3, 4, 5
Dynamic Risk	Nasim Tehrany	Intermediate Engineer	Pipeline Risk and Integrity technical support	Alternatives 1, 2, 3, 4, 5
Dynamic Risk	Bill Ho	Sr. Project Manager	Single point of contact during project execution phase. All project management duties, including communication, scheduling and budget control.	Alternatives 1, 2, 3, 4, 5
DHI	Tom Foster	Technical Lead	Quality Control and overall technical oversight	Alternatives 1, 2, 3, 4, 5

Company	Name	Project Role	Role Description/Responsibilities	Project Tasks
DHI	Dale Kerper	Principal Coastal Engineer	Project Manager / Sr. Hydraulic Support and Analysis	Alternatives 1, 2, 3, 4, 5
DHI	Dr. Guillaume Drillet	Aquaculture	Sr. Aquaculture Support and Analysis	Alternatives 1, 2, 3, 4, 5
DHI	Henrik Skov	Seabird Monitoring	Impact assessment and baseline investigations on birds and marine mammals	Alternatives 1, 2, 3, 4, 5
DHI	Dr. Laura Johnson	Assistant Professor of Biology	Water Quality Analysis	Alternatives 1, 2, 3, 4, 5
DHI	Morten Rugbjerg	Senior Project Manager and Marine Forecasting Coordinator	Oil spills impact assessment, and forecasting	Alternatives 1, 2, 3, 4, 5
DHI	Sonja Pans	Senior Environmental Impact Specialist	Environmental Impact Assessments and Marine Feasibility Studies	Alternatives 1, 2, 3, 4, 5
H.J. Ruitenbeek Resource Consulting Ltd.	Dr. Jack Ruitenbeek	Sr. Economist	Sr. Economic and Societal Consequence Support and Analysis	Alternatives 1, 2, 3, 4, 5, 6a, 6b
H.J. Ruitenbeek Resource Consulting Ltd.	Cindy Cartier	Economist	Economic Forecasting and Consequence Modeling Support	Alternatives 1, 2, 3, 4, 5, 6a, 6b
Stantec	Ziad Saad	Stantec Executive Sponsor	Oversight of Stantec work	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Jim Kenny	Sr. Pipeline Engineer	Technical leader for new pipeline design routes	Alternatives 1, 2, 3, 4, 6a, 6b

Company	Name	Project Role	Role Description/Responsibilities	Project Tasks
Stantec	Dr. Erez Allouche	Sr. Technical Lead Underground Infrastructure	Technical leader for alternative pipeline options such as tunneling	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Andy Purves	Sr. Technical Support Pipeline Design and Construction	Pipeline design and construction for new pipeline routes	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Harold Henry	Sr. Technical Support Pipeline Construction	Pipeline design and construction for new pipeline routes	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Rick Ponti Jr.	Sr. Technical Support Pipeline Tunneling	Technical design and modeling for pipeline tunneling option	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Riyaz Shivji	Sr. Technical Support - Terminals and Overland Transportation	Technical design and modeling of Terminals and Overland Transportation	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Steven Pierce	Sr. Technical Support Rail	Technical design and modeling of Rail option	Alternatives 1, 2, 3, 4, 6a, 6b
Kelly Geotechnical	Shane Kelly	Sr. Geotechnical Engineer	Geotechnical failure probability analysis	Alternatives 4, 5
Kelly Geotechnical	Dr. Rodney Read	Sr. Geotechnical Engineer	Sr. Pipeline Geotechnical Support and Analysis	Alternatives 4, 5
Kelly Geotechnical	Mr. Clive MacKay	Sr. Geotechnical Engineer - Tunneling	Sr. Pipeline Geotechnical Support and Analysis – Tunnel Geohazards Specialist	Alternatives 4, 5

*Project members may be added and/or substituted during execution depending on the needs of the project. If a key member of the project is substituted, a person with similar experience and qualifications will be used and their resume will be submitted to the State of Michigan for review.

Payment Schedule

The fixed fee will commence on August 2016 for a period of 13 months with the proposed payment schedule as follows:

Date	Payment	Description
Aug-16	$ 282,529.40	Project Kick off
Sep-16	$ 205,475.93	
Oct-16	$ 205,475.93	
Nov-16	$ 205,475.93	
Dec-16	$ 205,475.93	
Jan-17	$ 205,475.93	
Feb-17	$ 205,475.93	
Mar-17	$ 205,475.93	
Apr-17	$ 205,475.93	
May-17	$ 205,475.93	
Jun-17	$ 205,475.93	
Jul-17	$ 205,475.93	
Aug-17	$ 282,529.40	Project Completion

The work performed in this Project Technical Execution Plan shall commence on August 19, 2016 and remain in effect until the work is completed, with an anticipated completion date of August 19, 2017, or until it is otherwise terminated as provided in the Agreement.

IN WITNESS WHEREOF, the parties represent and warrant that they have full corporate power and authority to execute and deliver this Statement of Work and to perform their obligations hereunder, and that the person whose signature appears below is duly authorized to enter into this agreement on behalf of the party of whom they represent, as of the date and year first above written.

AGREED TO BY:	AGREED TO BY:
Michigan Department of Environmental Quality and Natural Resources	Dynamic Risk Assessment Systems, Inc.
By: ______________________	By:
Name: ______________________	Name: Trevor MacFarlane
Title: ______________________	Title: President
Date: ______________________	Date: Aug. 24, 2016.

APPENDIX A DHI MIKE Suite of Marine Models

DHI's MIKE Suite of Marine Models is perhaps the most globally applied marine modelling system and is presently utilized by 19 of the world's top 20 consultants working in marine environmental consultancy. This substantial user base ensures that the models are rigorously peer reviewed and scientifically sound. In particular, the MIKE System being an integrated package provides the workflows necessary to undertake the required scope of work efficiently and reliably, which is a critical aspect of the present consulting project given the relatively short time frame that will be available from definition of the spill scenarios to completion of the study.

Therefore, far from being an In House Model, MIKE is the most prevalent and proven technology available globally for the application being considered for the present project.

Hydrodynamics

Most oil spill vendors are reliant on third party hydrodynamic data, such as that utilized in RPS-ASA's report on oil spill model simulations using Oil Map for the Enbridge Line 5 Mackinac crossing (2013). This study utilized NOAA's Great Lakes 2D current forecast data set. The more recent study carried out by University of Michigan on Statistical Analysis of Straits of Mackinac Line 5 Worst Case Spill Scenarios (2016) again utilizes an existing hydrodynamic model results to drive their oil spill model, in this case the 3D model results of Anderson and Schwab (2013).

It is, however, DHI's experience that for reliable oil spill modelling a bespoke integrated hydrodynamic and oil spill model is required which tailors the resolution of the hydrodynamics in the area of potential oil impact specifically for the oil spill modelling processes. If the hydrodynamics has poor resolution (and thus poor performance) in the area of impact, then the resulting Oil Spill impact assessment will have poor resolution and poor performance.

The requirement for a bespoke hydrodynamic model tailored for the purposes of the present oil spill assessment is particularly important given the complexity of the shoreline and bathymetry surrounding the existing Straits Pipelines. The 3D model results of Anderson and Schwab (2013), which, although offering a resolution in the order of 300ft in the Mackinac Strait area, demonstrate a decreasing resolution on moving away from the straits with a resolution lower than of 1000ft 5 miles from the Straits and lower than 5000ft 18 miles from the Straits. As much of the predicted oil spill impact occurs in this lower resolution area (and further afield) a higher resolution hydrodynamic base is clearly required for the present study, particularly given the fact that two of the alternatives to be investigated as part of this study (alternative pipeline routing and marine transport) will investigate marine spills at locations in Lake Michigan / Huron which are more than likely very poorly resolved in existing hydrodynamic models. It is noted that this is not a criticism of the Anderson and Schwab model. The purpose of the Anderson and Schwab model was a high resolution hydrodynamic model of the Mackinac Straits, which it reliably achieves, not a hydrodynamic base model for the purpose of a wider oil spill impact assessment, which requires finer resolution in the potential impact areas.

To be able to offer such a bespoke 3-dimensional hydrodynamic model for the present study, it is noted that MIKE 3 is the only commercially available integrated hydrodynamic-oil spill model which is high performance computing enabled with close to one to one scaling based upon the number of cores. For the long duration high resolution hydrodynamic simulations required for this project, the HPC capability of MIKE 3 will be utilized to allow the DHI team to provide a 3D hydrodynamic resolution similar to that of the Anderson and Schwab model in the Mackinac straits, but with the higher resolution areas extended along the various potentially impacted shorelines plus the (yet unknown) locations of potential spills from the alternative pipeline routing and marine transport alternatives.

Estimated simulation times for the bespoke hydrodynamic model are in the order of a 1600CPU-day simulation given a broad spatial resolution in the order of 300ft in the potential impact areas. Utilizing the HPC capability of MIKE, DHI will be able accomplished these extensive simulations in approximately 4 days utilizing 400 cores on one of the global HPC centres available to DHI for execution of MIKE models. This model refinement is we believe essential to the project and something that can only be provided by the MIKE modelling system.

Rather than commencing the development of the bespoke hydrodynamic base for the oil spill modelling from scratch, DHI have the opportunity to base the refined modelling required for the present study on the Great Lakes Operational Forecast system that was developed for the State of Ontario. This operational system is broadly similar to the NOAA Great Lakes Coastal Forecasting System, GLCFS. Although the operational purpose of the State of Ontario system is primarily coastal flooding, the processes include in the model are identical to GLCFS such that we believe the model will form an accurate and reliable base for the present study similar to that of GLCFS. As the State of Ontario model is developed in MIKE, it is DHI's opinion that it will be easier for us to introduce high resolution 3D coverage in the various area of interest into this system rather than refine other hydrodynamic base options, simply because the work flows in MIKE are specific tailored for such project specific refinement of existing models. Model outputs will of course be compared to those of Anderson and Schwab and the model will be validated based upon the available current and water level information in the area of interest. In this context we note that DHI has undertaken model studies for the International Tribunal for the Law of the Sea which have required the use of quantitative performance criteria for documenting the performance (and acceptability) of hydrodynamic models and similar quantitative performance criteria will be utilized to verify acceptability of the bespoke hydrodynamic models that will be developed for the resent oil spill study.

We have attached a short description of MIKE 21/3 HD and can provide additional scientific material as may be required.

Oil Spill

In terms of the proposed oil spill model. The status of MIKE 21/3 OS (here in after referred to as MIKE OS) as one of the globally leading oil spill models is confirmed by the Inter-comparison study of Oil Spill Prediction Models (Copy attached), which compared 3 of the leading commercial oil spill models (OSCAR, OILMAP and MIKE OS), DOE's public domain BLOSOM model and 2 US university codes, post Deep Water Horizon to improve understanding of the uncertainties associated with oil spill modelling arising from the choice of model. Although the focus of the inter-comparison was deep water blow outs (>500ft which is deeper than the present case), the paper serves as a suitable peer reviewed validation of the overall applicability of MIKE OS for sensitive environmental studies.

MIKE OS similar to the hydrodynamic code, has the advantage of being HPC enabled allowing the statistical simulations to be carried out with greater resolution (number of release cases, number of climatic scenarios etc.) than none HPC codes given time frame constraints common for consulting contracts. We note that the proposed statistical matrix for the present study involves in the order of 2520 simulations across the 6 alternatives compared to the 800 undertaken in the University of Michigan study.

One of the primary advantages of MIKE OS in terms of the present case is that MIKE OS is a template within DHI's EcoLab open environmental equation editor. This allows MIKE OS to mimic the process formulations of any alternative oil spill model (provided the formulations are known). Thus if results are challenged because of the model (The inter-comparison study quoted above demonstrates that there is fairly large variability based upon choice of model and environmental groups thus often chose to contest based on the model) the formulations can be adjusted (not just the set-up and calibration parameters as is the case with other proprietary tools) to match a specific desired technical approach (e.g. droplet formation equation) to demonstrate the differences. This ability is we believe unique to MIKE OS and is a tremendous advantage if results are to be used for selection and approval of alternatives.

We have attached a short description of MIKE 21/3 OS and can provide additional scientific material as may be required.

DHI has undertaken numerous oil spill studies around the world often in areas of intense public and institutional environmental scrutiny. Through this global experience we strongly believe an integrated hydrodynamic and oil spill modelling tool such as MIKE 3 HD/OS is the most efficient and reliable approach to oil spill impact assessment.

The integrated MIKE system provides significant benefits over the other tools that could have been chosen for the present study, not only in terms of the seamless workflows provided by an integrated system, but more importantly in terms of access to high performance computing resources which we believe are essential for the present study to provide the necessary high resolution in the potential impacts areas within the relatively short time frame from which the spill scenarios will be defined to the completion of the study.

References

Anderson, E.J., and D.J. Schwab, 2013. Predicting the oscillating bidirectional exchange flow in the Straits of Mackinac. Journal of Great Lakes Research 39:663-671. http://www.glerl.noaa.gov/pubs/fulltext/2013/20130038.pdf

RPS-ASA 2013 Results From Oil Spill Model Simulations in Lake Michigan. Prepared for Enbridge Pipeline http://www.michigan.gov/ag/0,4534,7-164-18157_76405_76409---,00.html

University Of Michigan, 2016. Statistical Analysis of Straits of Mackinac Line 5: Worst Case Spill Scenarios http://graham.umich.edu/media/pubs/Mackinac-Line-5-Worst-Case-Spill-Scenarios.pdf