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 Michigan Technological University ("**Contractor**"). This Contract is effective on January 12, 2018 ("**Effective Date**"), and unless terminated, expires on October 31, 2018 (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 14.**

"**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; and
d. 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. Contractor's responsibilities with regard to deficient/defective services or deliverables shall be limited to such defect being rectified by Contractor during a period of twelve (12) months following completion of the services or delivery of the deliverables, whichever is deficient/defective (the "Warranty Period"). State shall give Contractor verbal notice, confirmed in writing, within the Warranty Period, specifying, in reasonable detail, the defect in the Services and/or Deliverables, as soon as the defect becomes apparent. This warranty is EXCLUSIVE AND, EXCEPT AS STATED HEREIN, CONTRACTOR MAKES NO EXPRESS OR IMPLIED WARRANTIES AS TO ANY MATTER WHATSOEVER, INCLUDING WITHOUT LIMITATION, THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR USE WHICH EXCEED THE FOREGOING WARRANTY.

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, work-for-hire and intellectual property rights assignment 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

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

d. **Access to Information**. The State shall provide the Contractor, without undue delay, all relevant information and documentation requested by Contractor that is available to the State and shall request Enbridge to provide such relevant information and documentation requested by Contractor required for Contractor to carry out any Services as identified in the Statement of Work in accordance with the applicable requirements and Contractor's independent role.

e. **Deliverables.** Unless otherwise agreed to in writing by Contractor, the State shall only make available the Deliverables or parts thereof to third parties without altering the content, context or original language of the Deliverable.

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	Kim Codere Manager, Sponsored Programs Office 1400 Townsend Drive, Houghton, MI 49931 kmcodere@mtu.edu Phone: 906-487-2226

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	Kim Codere Manager, Sponsored Programs Office 1400 Townsend Drive, Houghton, MI 49931 kmcodere@mtu.edu Phone: 906-487-2226

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; and (b) be primary and non-contributing to any comparable liability insurance (including self-insurance) carried by the State.

Insurance Type	Additional Requirements
Commercial General Liability Insurance	
Minimal Limits: $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 Deductible Maximum: $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 insurance. Failure to maintain the required insurance does not limit this waiver.

This Section is not intended to and is not 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. As an independent contractor, Contractor has complete control, supervision and direction over its equipment and personnel and over the manner and method of the performance of the Services. Contractor shall have the sole right to control, and shall be solely responsible for controlling, the means and details of the Services to be performed by Contractor and/or other individuals designated by Contractor under the terms of this Agreement. Subject to the requirements of the State, as specified in the relevant Statement of Work, Contractor shall be responsible for establishing the dates, times, hours, sequence, and manner in which Contractor performs its services hereunder. 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. 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 any improvements thereto remain the property of the

party who developed them and that Contractor shall have a perpetual, irrevocable license to use the Services and Deliverables

9. **Assignment.** Except with regard to its affiliated entities, 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 terms of 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 $ 749,110.00 for its Services as specified in this Contract and the Statement of Work. The state will make payments under this Contract 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. 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 reasonably disputed amounts, under this Contract, until the parties agree as to the validity of the disputed amount. The State will notify Contractor of any dispute within a reasonable time. 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.

11. **Termination for Cause.** The State may terminate this Contract, in whole or in part if Contractor, as determined by the State breaches any of its material duties or obligations under this Contract or the Statement of Work and fails to cure a breach within the time stated in a notice of breach. 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 delivered to 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. The Contractor may, upon sixty (60) days' notice to State, terminate this Contract in whole or in part without penalty and for any reason. If this Contract is terminated 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. **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 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; and, (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 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.

15. **Warranties and Representations.** Contractor represents and warrants to the State that: (a) It will perform all Services in a professional manner in accordance with generally accepted industry standards for the performance of such services and the terms of this Contract, 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 knowingly 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) to the best of Contractor's knowledge and belief at

the time of execution of this Contract that, all information furnished and representations made in connection with the award of this Contract are true, accurate, and complete, and contain no intentional misrepresentations or omit any material 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.

16. **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.

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

18. **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.

19. **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.

20. **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.

21. **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.

22. **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 or Project Managers. 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 while a dispute is being resolved, unless the dispute precludes performance. A dispute involving payment does not preclude performance, unless the dispute remains unresolved more than ninety (90) days from the date the parties Contract Administrators or Project Managers are notified.

    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.

23. **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.

24. **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.

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

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

27. **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 PROVIDED 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.

28. **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.

MICHIGAN DEPARTMENT OF ATTORNEY GENERAL

By: _____

Title: DIVISION CHIEF

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

By: C. Heidi Grether

Title: Director

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

By: _____

Title: _____

MICHIGAN AGENCY FOR ENERGY

By: _____

Title: _____

MICHIGAN TECHNOLOGICAL UNIVERSITY

By:_____

Title:_____

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

By: _____

Title: _____

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

By: _____

Title: Director

MICHIGAN AGENCY FOR ENERGY

By: _____

Title: _____

MICHIGAN TECHNOLOGICAL UNIVERSITY

By: _____

Title: _____

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

By: _____

Title: _____

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

By: _____

Title: _____

MICHIGAN AGENCY FOR ENERGY

By: Valerie Brader

Title: Executive Director

MICHIGAN TECHNOLOGICAL UNIVERSITY

By: _____

Title: _____

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

By: _____

Title: _____

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

By: _____

Title: _____

MICHIGAN AGENCY FOR ENERGY

By: _____

Title: _____

MICHIGAN TECHNOLOGICAL UNIVERSITY

By: Kim Codere

Title: Manager, Sponsored Programs Office

EXHIBIT A

STATEMENT OF WORK

Statement of Work
Independent Risk Analysis for the Straits Pipelines

A Team Proposal to the State of Michigan
Led by Michigan Technological University

PI: Dr. Guy Meadows, Great Lakes Research Center
Michigan Technological University

January 4, 2018

Contents

List of Acronyms	
AWRI	Annis Water Resources Institute
CFR	Code of Federal Regulations
CS	Chief Scientist
GIS	Geographic Information System
GLAHF	Great Lakes Aquatic Habitat Framework
GLERL	(NOAA) Great Lakes Environmental Research Laboratory
GLRC	Great Lakes Research Center (Michigan Tech University)
GVSU	Grand Valley State University
IC	Independent Consultant
ITAR	International Traffic in Arms Regulations
LUC	Loyola University Chicago
MSU	Michigan State University
MTRI	Michigan Tech Research Institute (Michigan Tech University)
MTU	Michigan Technological University
NDSU	North Dakota State University
NGL	Natural gas liquids
NOAA	National Oceanic and Atmospheric Administration
O&M	Operations and Maintenance
OU	Oakland University
PASS	Powell & Associates Science Services
PSAB	Pipeline Safety Advisory Board
SA	Section Author
SL	Section Lead

List of Acronyms	
SOW	Scope of Work
SPO	Sponsored Programs Office
T&E	Threatened and Endangered
UM	University of Michigan
WMU	Western Michigan University
WSU	Wayne State University

1. Background & Introduction

Michigan Tech proposes to assemble a team of recognized experts from across Michigan and beyond in subjects including engineering, hydrodynamics, public health, ecology/environmental science, economics, resource management, and social science to perform an independent risk analysis of the Straits section of Enbridge's Line 5 pipelines for the State of Michigan. This analysis will estimate the total potential liability for a worst-case spill scenario at this site, including the direct costs of containment/cleanup and restoration as well as the total value of economic losses including public health, cultural and natural resources, commercial, and real estate damages.

In 2010, Michigan experienced one of the largest inland oil spills in US history when a pipeline known as Line 6B burst and spilled in excess of 1 million gallons of heavy crude into a tributary of the Kalamazoo River. To prevent future accidents of this nature, the State formed a multi-agency task force called the Michigan Petroleum Pipeline Task Force. The task force issued a report in 2015 that made 13 recommendations, including the establishment of the Pipeline Safety Advisory Board (PSAB) and the commissioning of two studies of the Mackinac Straits portion of Enbridge, Inc.'s Line 5 pipelines: a risk analysis and an alternatives analysis.

A final report on the alternatives analysis was published on November 20, 2017. The risk analysis, however, was halted in June 2017 when the State of Michigan became aware of a Conflict of Interest with the firm contracted to perform the analysis and consequently terminated its contract. The State subsequently identified Michigan Technological University (Michigan Tech, MTU) as a potential project lead for a multi-institution team to take over the risk analysis. Michigan Tech was identified because of the faculty's extensive knowledge of the complex flows in the Straits of Mackinac region. The director of Michigan Tech's Great Lakes Research Center, Dr. Guy Meadows, served on the PSAB at that time as the representative of state universities and therefore he recused himself of voting on the matter. The other members of the

PSAB voted unanimously to recommend that the State of Michigan contract with Michigan Tech. Dr. Meadows subsequently resigned from the PSAB to lead the new risk analysis proposal development and avoid any appearance of conflict of interest during the project.

2. Business Organization

Lead Organization

Name:	Michigan Technological University
Participating Units:	Great Lakes Research Center Michigan Tech Research Institute Sustainable Futures Institute School of Forest Resources and Environmental Science School of Business and Economics College of Engineering College of Sciences and Arts
Address:	1400 Townsend Drive Houghton, MI 49931-1295
Legal Form:	Public University
Project Lead and POC:	Dr. Guy Meadows, Director, Great Lakes Research Center gmeadows@mtu.edu 906-487-1106
Administrative Lead:	Ms. Lisa Jukkala, Director, Sponsored Programs Office lajukkala@mtu.edu 906-487-2226

Supporting Organizations (alphabetically)

Name:	Alice Lippert
Participating in Tasks:	X, consulting as-needed across project
Address:	4188 Culpeper Lane Fairfax, VA 22030
Legal Form:	Sole Proprietor
Institution POC:	Ms. Alice Lippert
Name:	Ariaratnam Enterprises, Inc.
Participating in Tasks:	A
Address:	13663 East Geronimo Road Scottsdale, AZ 85259
Legal Form:	Corporation
Institution POC:	Dr. Samuel Ariaratnam dr.s.ariaratnam@gmail.com 480-236-5085

Name:	Grand Valley State University (GVSU)
Participating Units:	Robert B. Annis Water Resources Institute (AWRI)
Participating in Tasks:	E
Address:	1 Campus Drive Allendale, MI 49401
Legal Form:	Public University
Institution POC:	Dr. Kevin B. Strychar, Professor, AWRI strychak@gvsu.edu 616-331-8796

Name:	Great Lakes Environmental Research Laboratory – NOAA
Participating Task:	B
Address:	4840 South State Rd. Ann Arbor, MI 48108-9719
Legal Form:	US Government
Institution POC:	Dr. Philip Chu philip.chu@noaa.gov 734-741-2120

Name:	Joanne Shore
Participating in Tasks:	X, consulting as-needed across project
Address:	400 Madison Street, #1607 Alexandria, VA 22314
Legal Form:	Sole Proprietor
Institution POC:	Ms. Joanne Shore

Name:	LimnoTech
Participating in Tasks:	H
Address:	501 Avis Drive Ann Arbor, MI 48108
Legal Form:	Corporation
Institution POC:	Dr. John Bratton, Senior Scientist jbratton@limno.com 734-332-1200

Name:	Loyola University Chicago (LUC)
Participating Units:	Institute of Environmental Sustainability
Participating in Tasks:	G, I
Address:	1032 W Sheridan Rd Chicago, IL 60660
Legal Form:	Private University
Institution POC:	Dr. Richard (Max) Melstrom, Assistant Professor rmelstrom@luc.edu 773-508-2948

Name:	Michigan State University (MSU)
Participating Units:	Department of Agricultural, Food and Resource Economics
Participating in Tasks:	G, I
Address:	220 Trowbridge Rd East Lansing, MI 48824
Legal Form:	Public University
Institution POC:	Dr. Frank Lupi, Professor mailto:lupi@anr.msu.edu 517-432-3883

Name:	North Dakota State University (NDSU)
Participating Units:	Department of Civil and Environmental Engineering
Participating in Tasks:	A
Address:	1340 Administration Ave. Fargo, ND 58102
Legal Form:	Public University
Institution POC:	Dr. Ying Huang, Assistant Professor Ying.Huang@ndsu.edu 701-231-7651

Name:	Oakland University (OU)
Participating Units:	School of Health Sciences
Participating in Tasks:	D
Address:	201 Meadow Brook Rd. Rochester, MI 48309-4401
Legal Form:	Public University
Institution POC:	Dr. Richard Olawoyin, Assistant Professor olawoyin@oakland.edu 248-364-8653

Name:	Powell & Associates Science Services (PASS)
Participating in Tasks:	E
Address:	PO Box 210-145 Auburn Hills, MI 48321-0145
Legal Form:	Sole Proprietorship
Institution POC:	Mr. Robert M. Powell rpowell@powellassociates.com 248-977-0317

Name:	University of Michigan (UM)
Participating Units:	Civil and Environmental Engineering
Participating in Tasks:	B, C, F
Address:	500 S State St. Ann Arbor, MI 48109
Legal Form:	Public University
Institution POC:	Dr. Aline Cotel, Associate Professor, Civil & Environmental Engineering acotel@umich.edu 734-763-1463

Name:	Wayne State University (WSU)
Participating Units:	College of Engineering
Participating in Tasks:	F, G
Address:	42 W Warren Ave. Detroit, MI 48202
Legal Form:	Public University
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Name:	Western Michigan University (WMU)
Participating Units:	College of Arts and Sciences
Participating in Tasks:	D, E, H
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Legal Form:	Public University
Institution POC:	Dr. Charles Ide, Professor of Biological Sciences charles.ide@wmich.edu 269-387-5951

3. Qualifications and Relevant Experience

Michigan Tech has assembled a team of 41 subject matter experts in relevant areas of engineering, hydrodynamic modeling, risk assessment, public health, ecology, social sciences and economics. The project team comprises faculty and technical staff from nine universities as well as three consulting organizations, two independent contractors (advisory capacity, former DoE and AFPM staff) and assistance from the NOAA Great Lakes Environmental Research Laboratory (GLERL) as an unfunded contributor. Michigan Tech staff and student interns will provide needed support with project management and data management/sharing. Table 1 presents the full project team and each member's role (details follow below).

Table 1. Proposed risk analysis project team members and roles.

SECTION	TASK	LEAD	SCIENTIST	AUTHOR(S)	OTHER(S)
A	Worst Case	Amanda Grimm (MTU)	Ying Huang (NDSU)	Guy Meadows (MTU)	
				Mir Sadri-Sabet (MTU)	
				Samuel Ariaratnam (Ariaratnam Enterprise, Inc.)	
B	Fate & Transport	Gord Paterson (MTU)	Pengfei Xue (MTU)	Dave Schwab (UM)	Eric Anderson (NOAA)
				David Shonnard (MTU)	Philip Chu (NOAA)
C	Clean-up	Daisuke Minakata (MTU)	Aline Cotel (UM)	Amlan Mukherjee (MTU)	
				Stephen Techtmann (MTU)	
D	Public Health	Kelly Kamm (MTU)	Richard Olawoyin (OU)	Charles Ide (WMU)	
				Gord Paterson (MTU)	
E	Ecological Impacts	Jill Olin (MTU)	Charles Ide (WMU)	Marla Fisher (WMU)	
				Robert Powell (PASS)	
				Kevin Strychar (GVSU)	
				David Flaspohler (MTU)	
F	Restoration	Steve Techtmann (MTU)	Avery Demond (UM)	Aline Cotel (UM)	
				Timothy Scarlett (MTU)	
				Jill Olin (MTU)	
G	Nat Res Damage	Latika Gupta (MTU)	Frank Lupi (MSU)	Yongli Zhang (WSU)	
				Carson Reeling (WMU)	
				Max Melstrom (LUC)	
				Steve Miller (MSU)	
H	Gov Costs	Adam Wellstead (MTU)	John Bratton (LimnoTech)	David Shonnard (MTU)	
				Amlan Mukherjee (MTU)	
I	Public & Private Costs	Latika Gupta (MTU)	Frank Lupi (MSU)	Yongli Zhang (WSU)	
				Carson Reeling (WMU)	
				Max Melstrom (LUC)	
				Steve Miller (MSU)	
J	Final Report	Amanda Grimm (MTU)	Guy Meadows (MTU)	Sarah Green (MTU)	
SECTION	**TASK**	**LEAD**	**RESOURCE TEAM**		**DESCRIPTION**
X	Broader Impacts	Roman Sidortsov (MTU)	Alice Lipert (former DoE)	Nancy Langston (MTU)	Public Engagement, Qualitiative Considerations, and Native Community Interests
			Joanne Shore (former AFPM)	Chelsea Schelly (MTU)	
				Mark Rouleau (MTU)	

To develop the generation of a cohesive, integrated assessment of risk possible for this group on a short timeline, the team has been structured with defined roles for each task (Figure 1, below).

Each section (II-A through II-I, plus II-X) of the analysis will include a Chief Scientist (CS), whose role includes identification of data needs, ensuring validity of data used in the section analysis, contributing to the section writing, and leadership in public outreach and addressing public comments; multiple Section Authors (SA), who will apply subject area expertise to identify

the section outline as it relates to the overall Risk Analysis and support the section's development; and a Section Lead (SL), a Michigan Tech faculty/technical staff member who will form the Project Coordination Team with PI Meadows and project coordinator Grimm, facilitating the exchange of information and overall analysis development across section teams. Some individuals will hold multiple roles in one or more sections. Biographical sketches for Dr. Meadows and each of the Chief Scientists are provided below; two-page curriculum vitae for all team members are included as Appendix A.

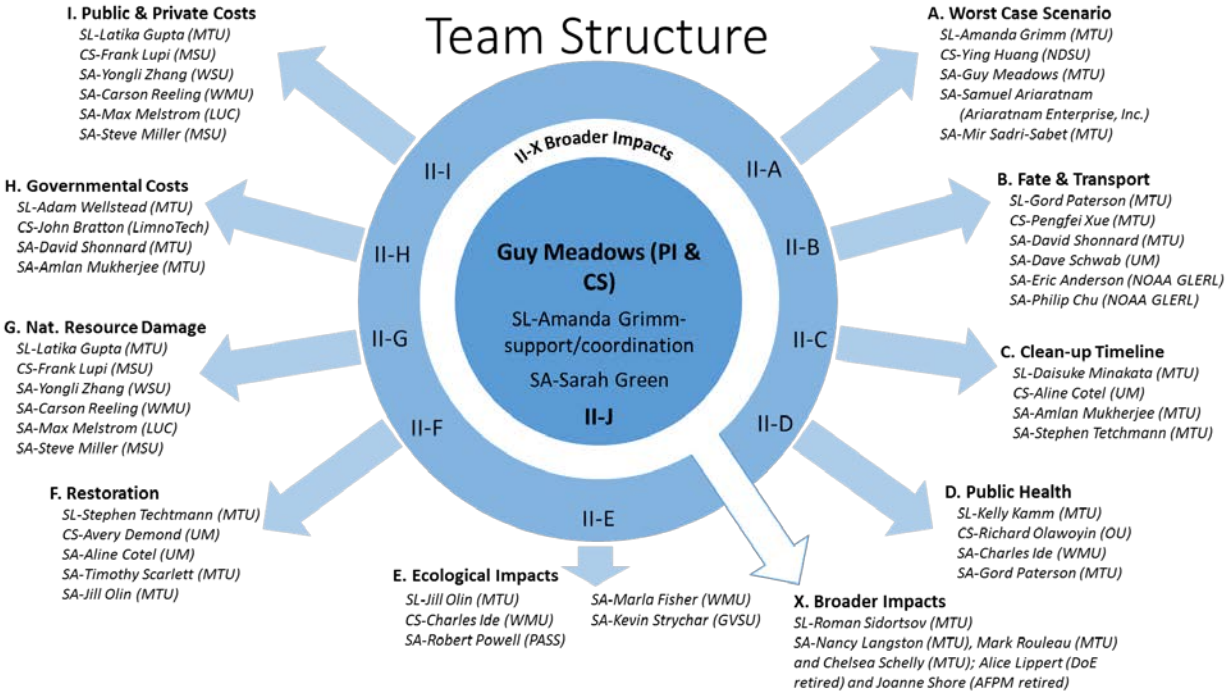

Figure 1: Structure of the multi-institution project team. The team is illustrated as a "clock" because the results of early tasks serve as inputs to later sections of the analysis.

Project PI: Dr. Guy Meadows

Upon graduation from Purdue University in 1977, Guy Meadows joined the faculty of the University of Michigan, College of Engineering, where he served as Professor of Physical Oceanography for 35 years. During his tenure, he served the College and University as Director of the Ocean Engineering Laboratory, Director of the Cooperative Institute for Limnology and Ecosystems Research (NOAA Joint Institute), Director of the Marine Hydrodynamics Laboratories and founding Academic Director of the M-STEM Academy. He joined Michigan Tech in June of 2012 to help establish the new Great Lakes Research Center where he holds the Robbins Professorship of Sustainable Marine Engineering. His primary goal is to blend scientific understanding and technological advancements into environmentally sound engineering solutions for the marine environment through teaching, research and service.

His teaching reaches beyond the University setting to less formal environments and includes

five nationally televised documentaries for the History and Discovery Channels. His primary research interests are in geophysical fluid dynamics with emphasis on environmental forecasting and full-scale, Great Lakes and coastal ocean experimental hydrodynamics. In this arena, he has influenced policy and explored societal impacts of environmental forecasting for coastal management, recreational health and safety, and regional climate change.

Task A. Chief Scientist: Dr. Ying Huang (NDSU)

Dr. Ying Huang has more than ten years of research background in structural health monitoring and pipeline risk analysis and corrosion assessment. She has coauthored over 70 high quality peer reviewed publications that include one book chapter, 30 journals articles, and 40 conference papers, which have been cited 345 times with an i10-index of 9. She holds a PhD in Civil Engineering from Missouri University of Science and Technology, and is currently an Assistant Professor in the Department of Civil and Environmental Engineering at North Dakota State University.

Task B. Chief Scientist: Dr. Pengfei Xue (MTU)

Dr. Pengfei Xue, one of the original developers of the unstructured grid Finite Volume Community Ocean Model (FVCOM) with his major professor, Dr. Changsheng Chen, School for Marine Science and Technology, University of Massachusetts-Dartmouth, joined the Tech faculty in 2013. Since his arrival, he has worked closely with NOAA-GLERL in jointly developing FVCOM based hydrodynamic and climate models for the Great Lakes, including the combined Lakes Michigan-Huron coupled model to assess flow through the Straits of Mackinac. He has made Michigan Tech's supercomputing cluster available for joint model development and testing. Dr. Xue's areas of expertise include hydrodynamic modeling, coupled physical-biological modeling, dynamics of coupled ocean-atmosphere models, ocean data assimilation, and bio-physical processes in the Great Lakes.

Task C. Chief Scientist: Dr. Aline Cotel (UM)

University of Michigan Associate Professor Dr. Aline Cotel researches fluid dynamics, studying topics ranging from the impact of biofuel spills on aquatic environments to the impact of turbulence on fish swimming and aquaculture systems. Her expertise includes turbulent mixing and stratified flows, which would be essential physical processes at play during a worst case scenario event. Dr. Cotel also teaches a course on Aquatic Ecosystem Restoration at UM and has been involved in research in that area as well.

Task D. Chief Scientist: Dr. Richard Olawoyin (OU)

Dr. Richard Olawoyin worked in the petroleum industry as a geologist, geophysicist, petroleum engineer, safety and environmental health scientist, both in the upstream and downstream oil & gas sectors. His research interests include human health exposure risk assessment, environmental quality assessment and sustainability, fire engineering, statistical techniques in Environmental Health and Safety Engineering, risk management and solution innovations, hazard management and systems safety, and occupational decision-making aspects of EHS.

Dr. Olawoyin is certified by the Academy of Board Certified Environmental Professionals (CEP) and by the Board of Certified Safety Professionals as a Certified Safety Professional (CSP) and Associate Safety Professional (ASP). He is a book chief editor and has authored numerous publications (16 as first author) on environmental health and safety, energy & mining engineering, petroleum engineering, environmental engineering, drilling innovation and environmental health sciences.

Task E. Chief Scientist: Dr. Charles Ide (WMU)

Dr. Charles Ide, a professor in the Biology Department at Western Michigan University as well as the director of the Great Lakes Environmental and Molecular Sciences Center (GLEAMS), was involved in evaluating the effects of the 2010 Enbridge spill in Kalamazoo. Dr. Ide's research focuses are environmental risk assessment and neuroscience. Specific projects examine how industrial contaminants and pesticides found in the Great Lakes Basin alter ecosystem health.

Task F. Chief Scientist: Dr. Avery Demond (UM)

Dr. Avery Demond is an environmental engineer by training and has been on the faculty in the Department of Civil and Environmental Engineering at the University of Michigan for nearly 30 years. Her research focuses on the fate of organic contaminants in the environment, including work on the impact of biofuel spills on the fate of regulated organic compounds in surface waters. She served as a coordinator of DOE's Subsurface Science Program's Multiphase Fluid Flow Subprogram for five years. Furthermore, she has served on a number of National Research Council boards and committees, including the Committee for the Review of DOE's Environmental Restoration Priority System. Dr. Demond is a Professional Engineer, registered in the State of Michigan.

Tasks G, I. Chief Scientist: Dr. Frank Lupi (MSU)

Dr. Frank Lupi has a joint tenure system appointment in the Agricultural, Food, and Resource Economics and Fisheries and Wildlife Departments. He is a member of the Partnership for Ecosystem Research and Management, the Center for Systems Integration and Sustainability, the Water Science Network, and the Environmental Science and Policy Program. His research addresses the economics of ecosystem services, conservation, agriculture, fisheries, wildlife, and water.

Task H. Chief Scientist: Dr. John Bratton (LimnoTech)

Dr. John Bratton is a Senior Scientist at LimnoTech with broad expertise in earth and environmental sciences, including successful leadership of projects involving remedial investigation/remedial design for contaminated sites, large ecosystem restoration, and litigation support. He has worked as a consultant, researcher, educator, and science manager for over 30 years, especially in the Great Lakes and Northeast regions, and has contributed to over 40 scientific publications and 75 research presentations since 2000. His specialties include coastal geology and groundwater, freshwater and ocean sediment geochemistry, glacial geology,

environmental history, and environmental law and policy. Dr. Bratton previously served as Deputy Director and Acting Director of NOAA's Great Lakes Environmental Research Laboratory in Ann Arbor, Michigan and as a research group leader with the Coastal and Marine Geology Program of the US Geological Survey in Woods Hole, Massachusetts.

Qualifications of Lead Institution:

Michigan Tech has significant experience in the administration of multi-subcontractor, collaborative awards, including large multi-university collaborative projects. Michigan Tech's Sponsored Programs Office (SPO) staff includes dedicated pre- and post-award processing specialists, including research accountants, subcontract negotiation and oversight analysts, as well as individuals whose positions include intellectual property, research integrity and compliance, and data analysis for project reporting. Experienced staff from SPO will be available to assist the leadership team in management of the lead contract with the State of Michigan, subcontracts, billing, etc., and other contract requirements. Michigan Tech is a member of the Federal Demonstration Partnership to reduce administrative burden and streamline contracting between academic institutions. This partnership also provides tools and templates that Michigan Tech will make available to sub-awardees for greater contract processing and oversight throughout the life of the project.

The leadership team is also very experienced in the use of communication tools for web conferencing and data sharing and will develop convenient avenues of communication for use among the section teams and between the leadership team and the State. Recent relevant experience of the lead institution in projects of this scope includes the following:

- Acting as lead institution for the Midwestern Regional Center of the Department of Energy's National Institute for Climate Change Research
- Acting as lead in a multi-university industry/university collaborative research center in Advanced Sustainable Iron and Steel Technologies, sponsored by the National Science Foundation
- Serving as the home of US EPA's Region 5 Environmental Finance Center
- Hosting the US DOT's Eastern Tribal Technical Assistance Program
- Partnering with the US Forest Service, the Trust for Public Land, the Council for Air and Stream Improvement and the University of Minnesota in the Northern Institute of Applied Climate Science

Michigan Tech is a STEM-dominated university with strong research capabilities that support a solid foundation of expertise as the lead institution in this integrated multi-institution risk assessment. Since 2012, the University has opened a 50,000 square foot waterfront facility, centrally located on its main campus on Lake Superior ($25M capital investment partnership with the State of Michigan); funded the addition of six new faculty lines to support Great Lakes research; added high-performance computing capabilities to run large scale hydrodynamic models; and equipped a fleet of surface and sub-surface, science vessels/vehicles with state-of-the art technology to enhance education, public outreach and research. The National Science Foundation's 2015 survey of higher education research and development expenditures placed

Michigan Tech as the highest ranked institution in the State of Michigan in Atmospheric Science, Oceanography, and Environmental Science. Additionally, Michigan Tech's dual locations in Houghton (Upper Peninsula) and Ann Arbor (centrally located in Lower Michigan) provide geographic reach across the region that will help facilitate the coordination of the analysis. Michigan Tech brings a commitment from its faculty and university leadership to support this important, independent risk assessment at the highest level.

4. Conflicts of Interest

Lead Institution

Michigan Tech, through the Great Lakes Research Center (GLRC), has conducted research for Enbridge on a contract basis, four contracts in total. Funding was used exclusively for environmental monitoring and establishment of increased pipeline safety. The funded projects include the annual operations and maintenance (O&M) of the environmental monitoring buoy in the Straits of Mackinac, NDBC # 45175 (two, O&M consecutive contracts); collection of environmental monitoring data during the recent hydrostatic testing of the Line 5 pipelines; and the development of advanced underwater acoustic sensing and measurement techniques, utilizing an autonomous underwater vehicle, to provide observational data of the pipelines and lake floor. Guy Meadows served as lead on three of the four contracts. The hydrostatic test monitoring was led by Director of GLRC Operations Michael Abbott.

The State of Michigan is aware of Michigan Tech's contractual relationships with Enbridge. Before his appointment to the Pipeline Safety Advisory Board (PSAB), Guy Meadows disclosed to the PSAB his roles in relation to Enbridge contracts. The State found them to be of no concern. The Enbridge projects have contributed 5.23 percent of the GLRC's overall sponsored awards portfolio:

- Total GLRC award value (2012 to current): $14,172,154
- Enbridge award value: $740,963

In addition, between 1974 and 2002, Michigan Tech students were beneficiaries of scholarships funded by Enbridge. The sum of these scholarships totaled $79,250.

As a step in identifying the team of experts to support this important project, Michigan Tech implemented a number of assurances to identify and disclosure in advance of a contract any known or potential conflicts of interest. The information provided by the individual members of the project team was vetted by Michigan Tech's Office of Compliance, Integrity and Safety that oversees the ethical conduct or research. All potential conflicts of interest, known or perceived, have been disclosed to the State.

Team Members

At the individual level, each member of the proposal team is providing Michigan Tech with a signed statement that either confirms that they do not have any known, potential or apparent conflicts of interest, or discloses the details of any such potential conflicts. Team members have also provided a summary of their current and pending support. This documentation will be provided to the State.

5. Proposed Methodology and Design for the Analysis

Project Management

Section Teams

As described in Section 3, each task (II-A through II-I, plus II-X) of the analysis will include a Chief Scientist, multiple Section Authors, and a Michigan Tech-affiliated Section Lead. The Project Coordination Team, composed of Primary Investigator Meadows, project coordinator Grimm, and all Section Leads, will be ultimately responsible for the timely delivery of the draft and final reports. Some individuals will hold multiple roles in one or more sections. In Figure 2 below, teams are grouped into three "sub-sections" that will work together most closely: sections A-C, who will define the worst-case scenario releases, model scenarios of their fate/transport, and analyze the consequences in terms of cleanup/containment requirements and times; sections D-F, responsible for identifying and analyzing the living costs of a worst-case spill in terms of public health, ecological damage, and restoration/mitigation needs and costs; and sections G-I, who will estimate the total costs of a worst-case spill in economic terms. The teams for sections C and H, as the groups responsible for estimating cleanup timelines and costs, respectively, will also work together closely.

Broader Impacts Team

The Broader Impacts team, or "Section X", will provide cross-cutting support across the analysis sections by collecting and applying documentary data to ensure that qualitative risks and the perceptions of risk by potentially affected communities are adequately represented in the assessment. Section X will also engage in legal analysis to identify risks arising out of legal rights and obligations by various parties as well as play a role in planning and organizing the public information presentation and listening sessions following the release of the draft report.

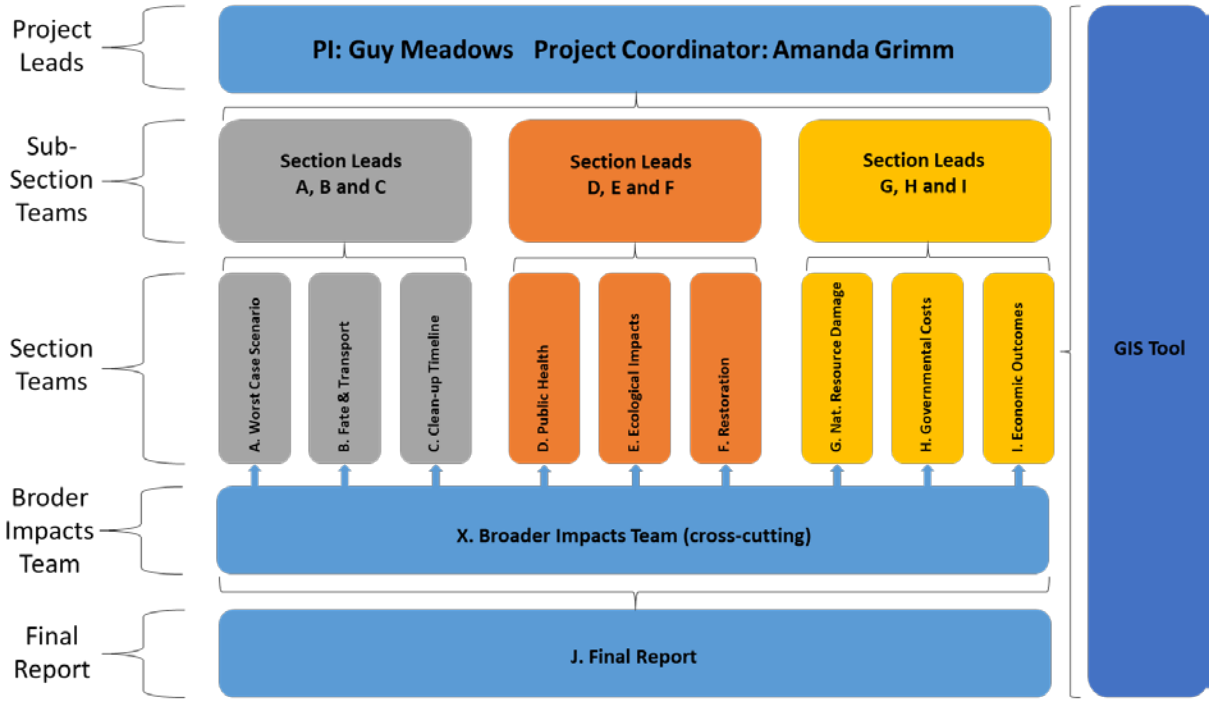

Figure 2: Project organization, including management and support structures.

Data Management and Sharing Support

For a consistent analysis, it will be important for all section teams to work from the same source data. Project data coordination will be handled by the Michigan Tech Research Institute (MTRI), a multi-disciplinary education, research and technology center located in Ann Arbor with a full suite of resources for geospatial projects, including advanced image and data processing software and a large and scalable storage system. Using the spill effect areas generated by the fate and transport modeling in Task II-B, the data team will gather spatial data on affected populations, natural & cultural resources, and other assets, including but not limited to coastal wetland and submerged aquatic vegetation maps, Great Lakes Aquatic Habitat Framework (GLAHF) biological datasets, existing species distribution and environmental sensitivity maps, locations of designated Critical Habitat and Important Bird areas, shoreline type classifications, census data, and potentially affected cultural features and fisheries resources. The MTRI data team will work with the section teams to identify their data needs and retrieve, organize and provide that data. Data access and delivery will be based on a user-friendly ArcGIS online based framework (represented by the blue “GIS tool” in Figure 2). MTRI has previously developed several web map interfaces for data hosting and sharing, including the Portal and Dynamic Decision Support System (DDSS) for the Great Lakes and Molecular Sciences (GLEAMS) Center, which was developed in collaboration with proposal team member Dr. Charles Ide and focused on the US EPA designated Superfund site in Michigan’s Kalamazoo River watershed (Figure 3).

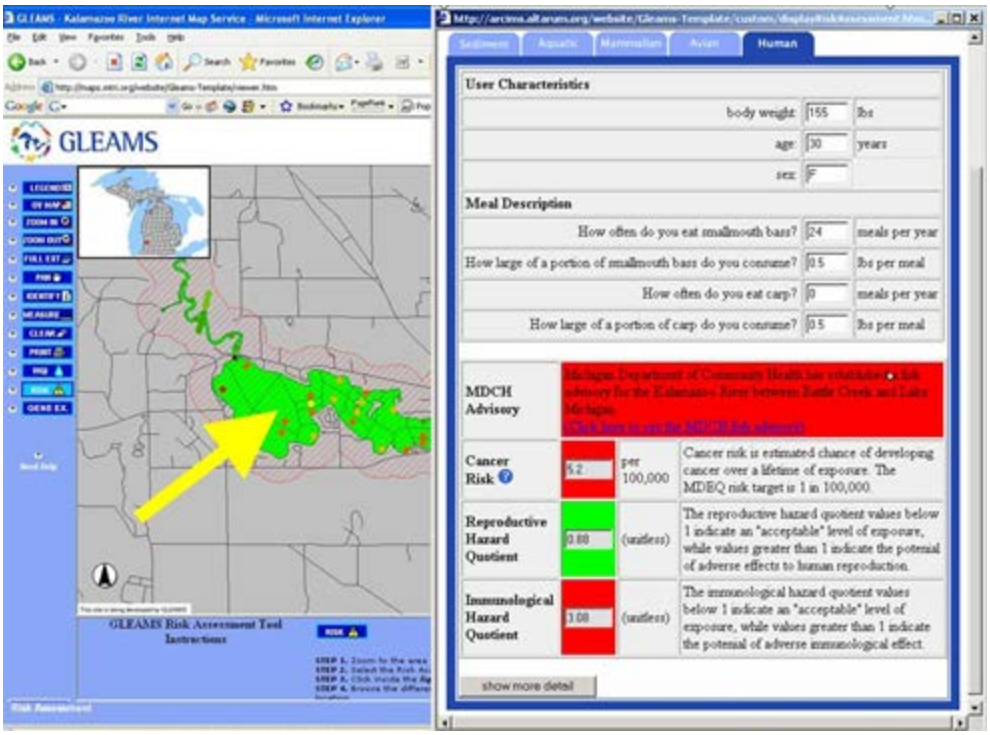

Figure 3: The GLEAMS map-based web portal and risk assessment tool for health risk assessment related to consumption of fish from the Kalamazoo River.

Data security: MTRI staff will develop a project-specific data management plan that meets State requirements and professional standards for documentation, ethics and legal compliance, storage, preservation and sharing. All Michigan Tech project team members will follow University IT policies for Data Custodians, who are required to regularly safeguard, backup, and maintain digital information that has been entrusted to the University. Data generated by subcontractors may also be stored at the user's home institutions/organization and may be governed by their data management policy. Whenever possible, data of potential scientific value generated or provided by subcontractors will be incorporated into Michigan Tech's data storage and made available to internal and external researchers.

The project team recognizes that successful development of the proposed Risk Analysis will require the secure sharing and protection of sensitive data, e.g. those related to pipeline specifications and threatened and endangered species. MTRI regularly handles sensitive data, including meeting all requirements for government classified information, and maintains secure data storage areas where access can be controlled to specific approved users, such as a designated folder structure for International Traffic in Arms Regulations (ITAR) information. This experience and demonstrated capabilities to handle sensitive information would be applicable to this project.

Government Roles

The proposed leadership team expects to work closely with the State's 6-person project coordination team and the larger technical team assembled by the State of Michigan. We

anticipate a set biweekly web/phone conference with screen-sharing capability, where the State's personnel would take on the following roles:

- Provide clear guidance for framing the task
- Facilitate drawing on state information/data resources
- Answer questions regarding the scope of work and goals
- Facilitate communication with Enbridge
- Provide previous requests and responses for information from Enbridge and the state
- Provide what information the State has available on the attendees and materials from the workshop on spill response costs convened as part of the previous effort
- Periodically review progress on the analysis and give input on possible gaps
- Lead communication/consultation with tribal entities

Separately from the State of Michigan's technical team, Drs. Philip Chu and Eric Anderson at NOAA-GLERL will contribute their hydrodynamic modeling expertise as unfunded contributors to Task B of the Scope of Work.

Detailed Methods

The subsections below describe the methods that would be used to perform each of the requested elements of the Scope of Work (SOW).

Scope of Work Recommendations

The proposal team has combined tasks G and I into one larger analysis conducted by a single team because the work of these tasks is so closely related. The analyses requested for both sections would still be included in the project reports. This suggestion is reflected in the use of "Task G/I" throughout this proposal.

SOW II-A: Identifying and analyzing the duration and magnitude of a "worst-case" spill or release of oil or other products from the Straits Pipelines into the environment.

Section Team:
Chief Scientist: Ying Huang (NDSU)
Section Authors: Guy Meadows (MTU), Mir Sadri-Sabet (MTU) and Samuel Ariaratnam (Ariaratnam Enterprise, Inc.)
Section Lead: Amanda Grimm (MTU)

Task Overview: The team for Section A of the analysis will identify multiple specific "worst-case" spill scenarios for the Straits pipelines that will form the basis for the work of all other section teams. Beginning from the 40 CFR 194.5 definition of worst-case as "the largest foreseeable discharge of oil, including a discharge from fire or explosion, in adverse weather conditions", Team A will also consider the maximum plausible potential release assuming failures of various

engineering and procedural controls, differences in worst-case release scenarios for the different products transported through the pipelines, seasonal differences (including ice cover) in both the environmental impact and the detectability of a release, and assessment of both sudden, “catastrophic” worst-case releases and longer-term “pinhole” leaks that could result in a large total release volume over time if undetected. These scenarios will be organized based on tiers of potential system failure, beginning with the first level of safeguards and progressing to higher tiers of failure.

Methods: The regulatory “worst case discharge” defined by 40 CFR 194.5 include the situations with three hole size failures with differing volume/release duration, three different materials transported in the pipelines, and two seasons (summer/winter) including consideration of storm events. The most critical situations are the combinations with unique impact sets. To determine the critical combinations to be investigated for worst case, some critical pipeline data will need to be supplied by Enbridge and/or the State of Michigan. A visit by this technical team to the Enbridge Control Facility, may be required. The data to be reviewed and used in the analysis will include:

1) The structural features of the existing pipelines (design drawings and parameters such as high resolution horizontal alignment and vertical profile of the pipe, thickness and diameter of the pipe, construction methods used, etc.),
2) The operational and control system logic and functioning (such as types of product transported historically, currently, and planned, product transport schedule, and product transportation temperature variations),
3) The leak detection methods and response philosophies, inspection schedules and intervals, inspection data if any such as thickness and diameter profile,
4) The types, accurate locations, and operational schedules of valves used in the line including shut-off valves, manual valves, and check valves, etc.,
5) If any system is rated higher than Safety Integrity Level 3, more specific information concerning assurance of the rating will be requested, and
6) All other needed data is already in hand, has already been requested from Enbridge, or will be obtained from public sources.

Considering the location, the structural feature, and product transport schedules of the pipe, it may require multiple scenarios to be evaluated as “worst case” scenarios with the considerations of sudden and long-term releases in the different failure sizes. Sudden release, occurs when there is a large hole or catastrophic failure of the pipeline. Long-term release occurs when smaller holes develop in the pipeline and persist without detection. Due to the limitations of the detection tools, smaller holes may have a much longer leak duration and actually can release more products to the environment. The impact of these two types of release may be significantly different and will be investigated in this study. The potential worst-case discharge volume will be estimated as a time-based discharge curve. The detail calculations include but are not limited to, the maximum design flow rate, the maximum leak rate, the responding time to isolate the section, the quantity of products that could be released, and the quantity of products remaining in the affected pipeline.

Detailed Subtasks and Time Management: Task II-A is scheduled to be conducted within one and one-half months from contract initiation. During Task II-A, bi-weekly phone meetings will be performed between all the team members of this Task to make sure the Task is proceeded on track. Below is the detail scope of work and timeline for the seven subtasks in the Task II-A of the proposed project:

Subtask II-A 1 (Jan 15 – Jan 26, 2018): This subtask is intended to obtain all the required materials and documents from Enbridge and the State of Michigan with all the design and placement of the pipelines, control systems, leak detection methods, and valves listed above.

Subtask II-A 2 (Jan 22 – Feb 9, 2018): Based on the obtained materials and documents from agencies, this subtask will determine the various types of physical or operational failures or other potential hazards (over 20 scenarios) that could result in releases of oil or other products, including both sudden releases and longer-term releases that could be undetected using the existing systems.

Subtask II-A 3 (Feb 9 – Feb 16, 2018): In this subtask, the maximum design flow rate based on the maximum allowable operating pressure (MAOP) will be calculated with consideration of the types of products being transported.

Subtask II-A 4 (Feb 16 – Feb 23, 2018): This subtask will determine the potential failure of release detection methods, control systems, or shut-off valves to operate as intended, and calculate the maximum leak rate with the hole size being considered at the pipeline design and maximum design flow rate.

Subtask II-A 5 (Feb 23 – Mar 9, 2018): This subtask will analyze multiple logical tiers of failure and the associated minimum response times to isolate the failed section and quantities of oil or other products that could be released at the maximum leak rate before the flow was cut off. Maximum detection times will be based on the assumption that high-reliability engineered equipment is available. The volume of product that could leak out of the hole over time after the section is isolated will vary by product and is highly dependent on elevation changes in the pipeline and the hole locations.

Subtask II-A 6 (Mar 12 – Mar 16, 2018): With the quantity of oil or other product released, in this subtask, the investigators will determine the quantity and fate of oil or other products remaining in the affected pipeline(s) at the maximum design flow rate after the flow is cut off, with the assumption that no volume reduction will be calculated for response efforts to reduce the spill volume by removing product trapped in the line.

Subtask II-A 7 (Mar 19 – Mar 30, 2018): In this subtask, a report will be drafted and submitted to the lead engineer at Michigan Tech for evaluation and for the State of Michigan for review. With approval, Task II-A is completed and the results from Task II-A will be shared with other Task groups for other tasks of this project.

Deliverables: Team A will generate several scenarios for fate-and-transport modeling that specify released product(s), release rate, duration, location and weather conditions (including ice cover).

SOW II-B: Analyzing the likely environmental fate and transport of oil or other products released from the Straits Pipeline under a worst-case scenario.

Section Team:
Chief Scientist: Pengfei Xue (MTU)
Section Authors: David Shonnard (MTU), David Schwab (UM), Philip Chu (NOAA-GLERL) and Eric Anderson (NOAA-GLERL)
Section Lead: Gordon Paterson (MTU)

Task Overview: Accurate estimation of the movement and fate of pipeline products released under worst-case spill scenarios is critical to the assessment of possible damage to human and environmental health and socio-economic impacts. The team for Task II-B of the analysis will employ the oil spill scenarios provided by Task II-A as inputs for hydrodynamic modeling exercises that will generate a comprehensive analysis of the transport and fate of pipeline products released under worst-case scenarios. In combination with established information quantifying water current strength and direction in the Straits region, pipeline product chemical and physical characteristics, hydrodynamic modeling efforts will predict the fate of discharged products with respect to open water transport and evaporation/weathering and the extent of shoreline oiling and deposition.

Methods: A hydrodynamic model (Combined Lakes Michigan-Huron coupled model) developed by Anderson and Schwab (2013) will serve as the foundation to describe water currents that will affect pipeline product fate and dispersal under worst-case oil spill scenarios in the Straits of Mackinac region. This three dimensional model extends across the areas of Lakes Michigan and Huron encompassed by the Straits region and is based on the Finite Volume Community Ocean Model (FVCOM) that has been previously used to predict open water and coastal circulation patterns throughout the Great Lakes basin. Hydrodynamic model predictions will be used to develop geographic information system (GIS) maps of offshore and onshore oil concentrations that result from the spill scenarios and volumes identified by Task II-A. Evaporation model predictions will provide accurate estimates of the loss of oil-spill volatile components and resultant changes in oil slick characteristics with time (density, viscosity, propensity to form emulsions with water). Atmospheric fate of volatile components in the liquid oil, including the natural gas liquids (NGL) fraction of the pipeline contents, will be modeled to assess fate and risks to human and ecological health. Life-cycle assessment modeling will also be completed to estimate the mass balance environmental fate(s) of released pipeline petroleum products. Baseline data required for the oil spill fate and transport modeling and life-cycle assessment efforts include but are not limited to;

1) Meteorological data describing regional weather conditions (air temperatures, wind direction and velocities, relative humidity), ice cover, water temperatures, currents and wave action at the predicted times/seasonality of worst case spill events,
2) Physical and chemical information (density, evaporation rates, weathering) and constituent characteristics (volatile- and semi-volatile organic compounds, polycyclic aromatic hydrocarbon) of the three pipeline products (Light crude, light synthetic crude, and natural gas liquids),
3) Location of pipeline rupture and product release (Task II-A),
4) Volume(s) of pipeline products released under worst-case scenario oil spills (Task II-A),
5) Duration of pipeline product release under worst-case scenario oil spills (Task II-A), and
6) Regional GIS base maps describing the bathymetry and shoreline topology for Lakes Michigan and Huron and the Straits of Mackinac region.

Given the range of environmental variables that can contribute to the transport and fate of petroleum products released during oil-spill events, multiple simulations will be required for each worst-case scenario identified by Task II-A. Specifically, regional climate considerations including wind speed and direction, air and water temperatures, wave action will be included into model predictions for understanding the fate and transport of pipeline products under worst-case release conditions.

Detailed Subtasks and Time Management: Task II-B is scheduled to be conducted in cooperation with the progress of Task II-A (Worst-case scenario evaluations) and completed within three months of the initiation of the project contract. The section leader of Task II-B will coordinate a teleconference with the Task II-A section leader within two weeks of project initiation to establish initial progress of the identification of worst-case scenarios and establish benchmarks for preliminary hydrodynamic modeling exercises. The Task II-B section team members will hold bi-weekly teleconference meetings to discuss data requirements and availability, preliminary model results and progress, and Task specific deliverables.

Subtask II-B 1 (Feb 15 – Feb 28, 2018). Section team members will discuss and identify necessary data and input requirements for hydrodynamic and other fate model operations. This information will be communicated to Task II-B section lead as associated with hydrodynamic model exercises for worst-case oil-spill scenarios.

Subtask II-B 2 (Mar 1 – Mar 23, 2018). Begin hydrodynamic model simulations to predict oil spill fate and transport as associated with worst-case scenarios identified by Task II-A including:

1) Location of pipeline product release (e.g. north shore, central channel, south shore),
2) Duration of pipeline product release,
3) Pipeline specific product released (e.g. Light crude, light synthetic crude, natural gas liquids),
4) Seasonality of pipeline rupture and product release, and
5) Combinations of the above.

Subtask II-B 3 (Mar 26 – Apr 2, 2018). Complete volatiles evaporation modeling as well as atmospheric fate modeling of volatile components as well as NGL. Complete life-cycle emissions and release inventory of pipeline products based on fate and transport modeling results from the worst-case oil-spill scenarios.

Subtask II-B 4 (Apr 2 – Apr 13, 2018). Compile hydrodynamic model predictions and life-cycle emissions and release inventory results into draft report for dissemination to project lead engineer and other section leads for evaluation and subsequent project specific tasks.

Deliverables: Team II-B will provide probability maps describing the relative risk of oiling in open water areas of Lakes Michigan, Huron and the Straits of Mackinac and also the relative risk of oiling along shoreline regions in coastal areas of these three waterbodies. GIS based maps will be developed to predict temporal changes in the degree of oiling in both open waters and along impacted shorelines. Model predictions will also provide estimates of oil deposition (density – g/m^2) along coastal shorelines within impacted Lake Michigan, Huron and Straits of Mackinac regions. The life cycle-assessment approach will provide the mass balance fate (open water vs shoreline deposit vs sedimentation vs. volatilization) of pipeline products released into the environment under the worst-case scenario releases.

SOW II-C: Analyzing how long it would take to contain and clean up the worst-case release.

Section Team:
Chief Scientist: Aline Cotel (UM)
Section Authors: Amlan Mukherjee (MTU) and Stephen Techtmann (MTU)
Section Lead: Daisuke Minakata (MTU)

Task Overview: This team will be responsible for collecting relevant data on private and public response plans and resources to determine the following for each of the worst-case scenarios:

- Personnel and resources required for spill containment;
- Estimated time needed for containment based on the capabilities and limitations of existing emergency response resources;
- Cleanup resources needed for different spill products and scenarios;
- Time required for both short- and long-term cleanup actions; and
- Effects of adverse weather conditions on containment and cleanup effort requirements.

The assessment will include the identification and assessment of all federal, state, local, and private Enbridge emergency resources that are available for spill response in the Straits, including both physical (booms, skimmers), chemical (solidifiers, dispersants, shoreline pretreatment agents), and biological (bioremediation) countermeasures; consideration of recent emergency response exercises conducted in the Straits; and where necessary, interviews with relevant authorities and response personnel.

Methods: Team C will review all available documentation and literature relevant to previous similar oil spills as well as current Enbridge documentation to evaluate the following. Physical modeling and possible numerical simulations will be used to estimate the time for containment and clean-up based on the data provided by Team A.

1) The capabilities and limitations of existing spill response plans and resources, which will be assessed by evaluating the following plans in terms of regulatory criteria and lessons learned from multi-agency pollution response exercises conducted in the Straits of Mackinac:
    a. the Area Contingency Plan (ACP)
    b. relevant Spill Prevention, Control and Counter (SPCC) Measures Plans
    c. Enbridge-specific response plans
2) The capabilities and limitations of the available resources;
    a. identification of all response resources (i.e., physical, chemical, and biological, and short and long term) that can be brought to bear on a worst case discharge
    b. a tiered, response time-based categorization of available resources
3) The capabilities and limitations of the available personnel;
    a. evaluation of state, federal, and local response agencies billeted
    b. available personnel
    c. training criteria
    d. exercise participation
4) The duration of activities to contain and cleanup a worst-case spill;
    a. review of exercise and incident After Action Reports
    b. lessons learned from resources identified from the item 1
    c. other relevant documents
5) The limitations of spill response measures and available resources and personnel under adverse weather and seasonal conditions, including winter ice cover.

Cooperating agencies for the acquisition of relevant information will include US Coast Guard; US Fish & Wildlife Agency; US EPA; Michigan Department of Environmental Quality; Michigan Department of Natural Resources; and Michigan State Police. Adequate representation of the oil spill response community will be identified through potential interviews and by referral from the Michigan Petroleum Pipeline Task Force.

Timeline:
Jan 15 – Jan 19, 2018 Virtual team meeting. Identify team members' specific tasks.
Jan 15 – Mar 15, 2018 Obtain all relevant documentation from Enbridge and publications related to other similar studies.
Mar 15 – Apr 30, 2018 Analyze data provided by Team A and make necessary calculations for cleanup and containment time periods.
May 1 – Jun 15, 2018 Evaluate current resources and personnel to meet the requirements defined by calculations.
Jun 15 – July 15, 2018 Write initial report for State and public comments.
July 30 – Sep 15, 2018 Respond to public comments, revisions and final report write-up.

Deliverables: Team C will ultimately produce informed estimates of the timeline of response activities that would be expected for containment and cleanup in the event of each of the worst-case scenarios identified from Task A.

SOW II-D: Analyzing the short and long term public health and safety impacts.

Section Team:
Chief Scientist: Richard Olawoyin (OU)
Section Authors: Charles Ide (WMU) and Gord Paterson (MTU)
Section Lead: Kelly Kamm (MTU)

Task Overview: The team for Task D will be responsible for assessing the scope and magnitude of impacts to public health and safety that could potentially occur in the event of a worst-case Line 5 spill, including contact or airborne exposure to waterborne and atmospheric contaminants, effects on drinking water sources, fire or explosion hazards, and associated disruptions to public health and safety systems. The team will assess the modeled pollutant concentrations generated in the Task B simulations via comparison with existing data on exposure effects and thresholds.

Methods: Fate and transport modeling results from Task II-B will be used to characterize the risk to local and regional communities based on exposure to petroleum related products, during a line 5 pipeline worst-case release scenario. Local population demographics will be used to characterize individual groups and communities and identify potential susceptible populations within the petroleum product release areas. The potential hazards associated with the Line 5 pipeline products will be identified and the contaminant concentrations predicted from Task II-B modeling efforts will be evaluated against human health benchmarks for chemicals in environmental media to estimate increased level of risk posed by pipeline products dispersed into the environment. Risk-based modeling approaches will be used to estimate potential short- and long-term increases in adverse health effects associated with exposure to oil-spill products, their constituents, and agents used for cleanup/containment. Information required to evaluate risks to public health and safety associated with potential Line 5 release events include but are not limited to:

1) Geographic areas at risk of exposure during worst case scenarios as identified by Task II-B's hydrodynamic modeling efforts describing pipeline product fate and transport;
2) Local coastal communities and populations at risk of exposure within geographic areas susceptible to shoreline deposition/beaching of pipeline petroleum products;
3) Magnitude, frequency and duration of potential human exposure associated with predicted fate and transport of pipeline petroleum products;
4) Population demographics (age distribution, occupation, race, sex) of at-risk communities;
5) Chemical composition and physical and chemical properties of petroleum products transported within Line 5 pipeline;
6) Baseline health status of at risk communities and populations;

7) Reference concentrations or human health benchmarks for exposures to petroleum constituents through inhalation, ingestion and/or dermal exposure pathways;
8) Acute and chronic adverse health effects associated with short- and long-term exposures to Line 5 pipeline products and their constituents released in a worst case scenario; and
9) Sources and likely mechanisms of ignition that could trigger combustion or explosion of petroleum products released in an oil-spill event.

Task II-A will provide the worst-case oil spill scenarios for the three products transported by the Line 5 pipelines, in addition to location and duration specific considerations of pipeline product releases, and seasonal effects (e.g. ice-cover, temperature, wind and wave action). Consequently, multiple modeling simulations are anticipated for Task II-B that will predict the fate and transport of pipeline related products released into the Michigan waters of Lakes Huron and Michigan and the Straits of Mackinac during an oil spill event. Thus, the evaluation of public health and safety impacts associated with a Line 5 pipeline release will require assessment across a range of spatial and temporal scales.

Detailed Subtasks and Time Management: Task II-D is dependent on the outcomes of Tasks II-A and II-B and will coordinate assessment efforts in cooperation with the progress of these task groups. It is anticipated that the analysis of short- and long-term public health and safety impacts will require approximately three months to complete. The Task II-D section leader will communicate or coordinate teleconferences with the Task II-A and II-B section leaders within the first month of the project to determine initial progress for identifying geographic areas at risk and extent of oiling predicted during worst-case oil spills. Task II-D section team members will hold bi-weekly teleconference meetings to discuss Task II-A and II-B results, data availability, compilation and requirements, preliminary assessment results and outcomes, and Task specific deliverables.

Subtask II-D 1 (Apr 2 – Apr 6, 2018): Section team members will discuss, identify and assign individual tasks and responsibilities and identify any data gaps and information required for project Task completion. This information will be communicated by the section lead to the Task II-A and II-B section leads to identify any Task II-D data specific needs for the assessment of short- and long-term public health and safety impacts associated with Line 5 worst-case oil spill scenarios.

Subtask II-D 2 (Apr 9 – Apr 20, 2018): Compile data including:

a. Geographic areas at risk of oiling under worst-case scenarios (Tasks II-A & II-B)
b. Sources of combustion and/or explosion risk (Task II-A)
c. US Census Bureau population demographics for State of Michigan communities at risk of exposure following worst-case scenario Line 5 pipeline rupture (Task II-B)
d. Oil concentration information for open water regions and oiled shorelines (Task II-B)
e. Hazard constituents of pipeline products as outlined in Environmental Protection Agency's guidance document for the characterization of spilled oils, fuels and petroleum products (EPA/600/R-03/072).

f. Human health benchmarks for pipeline product constituents in water, food, and air.
g. Acute and chronic health adverse health effects associated with short- and long-term exposures to oil spill products and their constituents.

Subtask II-D 3 (Apr 23 – May 31, 2018): Complete exposure evaluations for at risk populations including, for example, chronic daily intake estimates through inhalation, ingestion and dermal absorption pathways.

Subtask II-D 4 (May 15 – June 30, 2018): Model the risks of short- and long-term health impacts in affected populations using metrics including hazard indices, quotients, and incremental lifetime cancer risks. Correlate information on exposure doses and health outcomes that will help improve environmental health surveillance and public safety.

Deliverables: The outcomes of the analysis for Task D will consist of the delineation of areas where estimated contaminant concentrations could be expected to cause certain acute or chronic illness; quantification of the likely public exposure based on the time of year; and the likely extent of the fire/explosion hazard in an ignition scenario.

SOW II-E: Analyzing the short and long term ecological impacts.

Section Team:
Chief Scientist: Charles Ide (WMU)
Section Authors: Marla Fisher (WMU), Robert Powell (PASS), Kevin B. Strychar (GVSU) and David Flaspohler (MTU)
Section Lead: Jill Olin (MTU)

Task Overview: The effect areas generated in Task B for the several worst-case scenarios will be overlaid with relevant existing datasets on, e.g., species distributions, migration timing, wetland maps, locations of designated Critical Habitat, Essential Fish Habitat and Important Bird Areas, fisheries resources, and other sensitive ecosystems and features. The team will identify and produce expert-informed estimates of the magnitude and duration of impacts on potentially affected natural resources, including effects on air and water quality, on fish and wildlife, and on aquatic, benthic, and coastal habitats. The team will also evaluate the ecological impacts to natural resources that may result from proposed mitigation and restoration alternatives identified in Task F. Gaps in data, knowledge or any uncertainties will be identified.

Methods: The project team will assess the ecological effects of a worst case scenario oil spill and potential mitigation and restoration alternatives (identified in Task F), based on the overlap between the affected area (identified by the spill modelling in Task B) and the natural resources, including the sensitivity of those resources, to the scenario and mitigation. The project team will conduct a comprehensive literature review to identify the resources of concern, specific to critical and sensitive habitats and organisms, in and adjacent to the affected area for this assessment. For the different natural resources, we will draw on existing data provided in habitat and wetland designation maps, species distribution maps for both plants and animals,

fisheries data, Threatened and Endangered (T&E) listings, and published/grey literature to determine exposure potential and ecological effects, with key focus as follows.

1. Ecological effects on habitats (short- and long-term) will include quantification of habitat loss and contamination for the following:
    a. Wetland, Upland
    b. Shoreline
    c. Intertidal shorelines (including surface waters 0–1 meter)
    d. Mid-water (0–2 meters from the surface, but above the bottom 2 meters)
    e. Benthic (bottom + 2 meters)
2. Ecological effects on organisms will include evaluation of the acute effects (direct mortality),chronic effects (compromised health and reduced survival and reproduction) and probable effects using Probable Effects Concentrations, when available, in addition to short- and long-term biological responses to altered or decreased habitat availability for the following:
    a. Mammals (aquatic and non-aquatic dependent)
    b. Birds (aquatic and non-aquatic dependent)
    c. Reptiles and amphibians (aquatic and non-aquatic dependent)
    d. Macroinvertebrates (aquatic and non-aquatic dependent)
    e. Aquatic vertebrates
    f. T & E species—Animals
    g. T & E species—Plants
    h. Plants (wetland, upland, submerged and floating aquatic vegetation)
3. Air and water quality will be evaluated using predictive models for parameters such as evaporation, given the outcome of Task B for specific pipeline products, under varying seasonal release scenarios with respect to the following:
    a. Volatility
    b. Concentration
    c. Dispersal
    d. Contaminant Dissolution
    e. Contaminant Degradation

Team E will define the affected area for the natural resource assessment based on outputs from Task B, where predicted environmental concentrations are above the predicted no-effect concentration levels for direct or acute and chronic effects. We will evaluate indirect effects on a species and habitat basis. Data from historical oil spill events, for example, the 2010 Enbridge spill into the Kalamazoo River, will be used as a reference for estimating the magnitude of impacts and the recovery rates of species and habitats under worst-case scenario seasonal and spatial constraints of the spill.

Deliverables: Estimates of effects on natural resources, including the areas of affected habitats, ecological services that could be impacted, and effects on important species. Both short- and long-term, as well as direct and indirect effects will be summarized.

Detailed Subtasks and Time Management: During the course of accomplishing these above tasks, monthly phone meetings will be held. Completion of Subtask II-E will follow the schedule below:

Subtask II-E 1 (Jan 15 – Mar 15, 2018): Obtain and compile relevant data, documents and literature.

Subtask II-E 2 (Mar 15 – Apr 15, 2018): Identify the natural resource considerations resulting from the worst-case spill scenarios and possible mitigation and restoration alternatives.

Subtask II-E 3 (Apr 15 – Jun 15, 2018): Evaluate the worst-case scenario effects and potential mitigation alternatives.

Subtask II-E 4 (Jun 1 – Jun 30, 2018): Draft the initial report section.

Subtask II-E 5 (Aug 1 – Sep 15, 2018): Respond to public comment, revisions, and draft the final report.

SOW II-F: Analyzing potential measures to restore the affected natural resources and mitigate adverse impacts upon ecological and cultural resources.

Section Team:
Chief Scientist: Avery Demond (UM)
Section Authors: Aline Cotel (UM), Jill Olin (MTU) and Tim Scarlett (MTU)
Section Lead: Stephen Techtmann (MTU)

Task Overview: This task will identify the potential measures that could be applied to restore the systems affected by the potential worst case spills identified in earlier tasks. The team for Task F will identify and assess alternative options for restoring natural and cultural resources and/or mitigating the ecological damages quantified in Task E in terms of the availability, effectiveness, requirements, and costs of each countermeasure. This section of the assessment will focus on alternatives and costs of restoring coastal and nearshore habitats, protecting drinking water and restoring water quality, protecting and restoring living coastal and aquatic resources, mitigating damages to cultural resources, and restoring and enhancing recreational use opportunities.

Methods: Team F will review all available documentation and literature relevant to similar oil spills as well as current Enbridge documentation. Physical modeling and possible numerical simulations will be used to estimate consequences and effects of spills in the framework of ecosystem services lost due to the spill. The team will also identify the type and extent of restoration needed to compensate for the anticipated damage to natural and cultural resources for the different arenas (coastal and nearshore habitats, drinking water and water quality, living coastal and aquatic resources, underwater and coastal archaeological sites, etc.). This approach will allow for the identification of measures that can be employed to mitigate potential risk and the measures best suited for protection and/or restoration of affected resources.

The team will start by identifying available measures and those best suited for addressing the damaged resources for the different arenas. This will be accomplished through virtual meetings with the Task F team and review of relevant documents and publications. Once these measures have been identified, each measure will be evaluated by the following criteria:

1) Evidence for effectiveness at reducing risk, restoring damaged resources, or mitigating ecological impact of the worst-case spill;
2) Timeframe for best application – Some measures are better suited for early application while others may be employed as longer-term response measures;
3) Challenges to the implementation of these measures – The ideal measures should be ready to implement and can be done rapidly to mitigate the long-term impacts of a worst-case spill; and
4) Costs – A thorough evaluation of potential response measures must take into account the costs for direct comparison of effective measures.

Deliverables: An evaluation of alternative options and costs for mitigating impacts to, and/or restoring, the vulnerable ecological and cultural resources and services identified in Task E. This includes both early/acute actions and longer-term projects.

Detailed Subtasks and Time Management: During the course of accomplishing this task, regular monthly phone meetings will be performed to make sure that tasks are completed in a timely manner.

Subtask II-F 1 (Jan 15 – Mar 1, 2018): Obtain relevant documents and publications.
Subtask II-F 2 (Mar 1 – Apr 15, 2018): Identify the relevant measures for mitigation of ecological and cultural impacts from the worst-case spill.
Subtask II-F 3 (Apr 15 – May 30, 2018): Evaluate the identified measures for effectiveness, timeframe of use, challenges to implementation and costs.
Subtask II-F 4 (Jun 1 – July 15, 2018): Write initial report.
Subtask II-F 5 (Aug 1 – Sep 15, 2018): Response to public comments, revisions, and writing of final report.

SOW II-G/I: Estimating the amount of natural resource & other economic damages, public and private, that would result from a worst-case release.

Section Team:
Chief Scientist: Frank Lupi (MSU)
Section Authors: Yongli Zhang (WSU), Carson Reeling (WMU), Richard (Max) Melstrom (LUC) and Steve Miller (MSU)
Section Lead: Latika Gupta (MTU)

Section Objectives: Team G/I will contribute to two sections identified in the SOW:

Task II-G: Estimating the amount of natural resource damages that would result from a worst-case release. This would include, but not be limited to, analyzing:

1) Available information regarding the baseline ecological, natural resource and economic conditions in the areas potentially affected by a worst-case release;
2) The economic value of the natural resources destroyed or impaired;
3) The economic value of the public uses and ecological services provided by the affected resources that would be lost until a final cleanup and restoration is complete; and
4) The economic value of any residual damages to natural resources that could not be cleaned up or restored.

Task II-I: Estimating all other economic damages, public and private, that would result from a worst-case release. This would include, but not be limited to, identifying and estimating the scope and magnitude of damages not otherwise accounted for in Task II-G, above, to:

Subtask II-I 1 - Subsistence, sport, and commercial fishing and hunting;
Subtask II-I 2 - Commercial navigation;
Subtask II-I 3 - Recreational boating;
Subtask II-I 4 - Tourism and recreation-related businesses in the Great Lakes region;
Subtask II-I 5 - Property values in areas affected by the release; and
SubtaskII- I 6 - Losses of tax revenues.

Methods: We will estimate the dollar value of natural resource damages by calculating the monetary cost of injuries to natural resources that would result from a worst-case release. Damages to natural resources are evaluated by identifying the functions or "services" provided by the resources, determining the baseline level of the services provided by the injured resources, and quantifying the reduction in service levels as a result of the contamination. We will use several methods to quantify damages, including market-based and non-market resource valuation and economic impact analysis (BLM, 2008; Haab and McConnell, 2002). We describe our procedure for addressing each objective for section G below, making note of how we will measure the additional outcomes listed in section I where appropriate.

Detailed Subtasks and Time Management:
Subtask II-G 1 Analysis of Baseline Ecological, Natural Resource, and Economic Conditions - Team G/I will collaborate with other scientists on the project team to predict damage scenarios for a worst-case spill. Key outcomes include (1) physical fates and transport pathways to determine injury, including oil floating on water, current driven transport, stranding on shorelines, sinking, and evaporation; and (2) biological exposure and effects pathways to quantify injury, including dermal contact, ingestion of water, prey consumption, inhalation. Specific data required include information on the characteristics of the release (e.g., substance and quantity), parameters related to the release and the resources likely to be affected (e.g., the location of the spill, the type of environment affected, wind speed at the time of the spill) and information regarding lost services (e.g., length of beach closure, area of hunting closure).

Subtask II-G 2 Analysis of the Economic Value of Natural Resources Destroyed or Impaired - The value of a natural resource stock is derived from the present value of its flow benefits, or the value of the ecosystem services it provides (Costanza et al. 1997). These include provisioning, regulating, supporting, and cultural ecosystem services. The process by which we will estimate the value of these ecosystem service flows is described in detail below for Subtask II-G 3.

Subtask II-G 3-4 Economic Value of Public Uses and Ecological Services Lost Until Restoration is Complete or that Could Not be Cleaned Up or Restored - The economic value of public uses will be determined from demand models. These models measure the demand for ecological services as a function of costs, service attributes and user characteristics. Economists have developed revealed preference and stated preference approaches to value natural resources. Revealed preference approaches, like the travel cost method, are a preferred method for measuring the value of natural resource-based recreational activities (Farber et al. 2006; English et al. 2017). The travel cost method uses the measurable effect of travel cost on recreation demand to determine the maximum value or willingness to pay that visitors have for a recreation site or experience. Several existing demand models can be used to measure the value of ecological services in the Straits region, including beach visits (Subtask II-I 4; Weicksel, 2012; Chen, 2013; Cheng 2016), sport fishing (Subtask II-I 1; Melstrom and Lupi, 2013; Knoche 2014), and sport hunting (Subtask II-I 1; Knoche, 2014). These models will be used to predict the loss of economic value from a worst-case release. Damage estimates will include the value of uses lost until a final cleanup and any residual damages that could not be cleaned up.

The economic value of public uses with no existing model of Michigan users (e.g., recreational boating [Subtask II-I 3], visits to cultural or historic sites [Subtask II-I 4]) will be measured using benefit transfer. Benefit transfer methods provide economic value estimates for non-priced natural resources based on existing studies and are useful in ex ante estimates of risks posed by unobserved events. Secondary studies are selected based on similarity of conditions and environment to the study event and may entail clustering estimates across multiple studies. The secondary study estimates are used as a basis for demand estimates but are modified based on local demographics and geography to better reflect the primary study region. There are two benefits transfer methods—value transfer and function transfer (Palm-Foster et al., 2013). Value transfer assigns a value measured in the secondary study to the good or activity in the primary study. Function transfer applies the demand model developed in the secondary study to demand for the good or activity in the primary study. Benefits function transfer will be employed when practicable. Benefits function transfer is preferable in valuing recreational activities because it can measure the economic loss from the closure of several recreation areas more accurately than value transfer (Rosenberger and Loomis, 2017; Palm-Foster et al., 2016). Public use of natural resources will be measured by existing data. Sources include but are not limited to: state fee and license records, visitor records maintained by state and federal organizations, the MSU Michigan Recreational Angler survey, the MSU Great Lakes Beaches web survey, Michigan Department of Natural Resource Game Harvest surveys, and the US Fish and Wildlife National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

A worst-case release may affect the value of lakefront and some inland property sold during the event and subsequent cleanup and restoration (Subtask II-I 5). Hedonic regression analysis is the most common method used to estimate damage to real property from changes in environmental amenity values (Haab and McConnell, 2002). This method involves estimating the price of real property as a function of its characteristics (e.g., lot size, square footage of the building, neighborhood characteristics). Prior work estimates the effect of oil spills on surrounding property values, albeit for a regions outside of Michigan (Simons et al., 2001). Team G/I will therefore use benefit function transfer methods to estimate the effect of an oil spill on affected properties as a fractional response on property values of baseline property values. Baseline property values of affected properties will be obtained from county assessor's offices and/or via data-sharing agreements with commercial sources such as Zillow for coastal housing up to a to-be-determined distance from the coast, as suggested by the existing literature.
We will use an input-output model of economic activity in the affected region to estimate the economic impacts of a release. Changes in economic activity in a given sector of the economy (including the composition of tourism-related industries and impacted commercial shipping and fisheries [Subtask II-I 1,2,4]) gives rise to larger economic contributions once accounting for the circular flow of transactions throughout the economy. Impact estimates will be modeled to account for secondary impacts using the economic simulation software IMPLAN, calibrated for the affected region, the state and for the nation. The economic loss of commercial activities (Subtask II-I 1,4) will be measured using market data on workers' wages and salaries. This data is collected by the US Bureau of Labor Statistics (BLS) ES202 data. The ES202 is derived from required employer establishment reports on employment and wages for fulfilling unemployment insurance mandates and provides region-specific earnings profiles by industry classification down to the county level. Other data relating to production, output and value added will be collected by the Bureau of Economic Analysis for estimating relationships between employment changes and production changes, including proprietor's income

Changes in economic activity and property values will impact two dominant channels of public tax revenues, personal income taxes and property taxes. Personal income taxes will be based on average state and local personal tax revenues (Census of Government) and state personal income (Bureau of Economic Analysis), capturing the estimated changes in wage and proprietors' incomes. These will be statewide estimates for affected states and will be reported as both direct tax revenue impacts and total tax revenue impacts that account for all secondary effects. Property tax impacts will be assessed based on regional (as small as the county level), average millage rates applied to estimated change in assessed property values (Subtask II-I 6).

Team G/I will adhere to the following timeline:

Jan 15 – Jan 19, 2018: Team meeting, identify individual tasks
Jan 22 – Feb 16, 2018: Develop economic models
Feb 19 – Mar 16, 2018: Obtain data
Mar 16 – Mar 31, 2018: Obtain worst-case release scenario
Apr 2 – May 25, 2018: Estimate damages
May 28 – July 15, 2018: Compile draft of sections I and G

July 15 – Sep 15, 2018: Participate in public presentation, respond to public comments, make necessary revisions and prepare the final report section

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SOW II-H: Estimating the governmental costs that would be incurred as a result of a worst-case release.

Chief Scientist: John F. Bratton (LimnoTech)

Section Authors: Amlan Mukherjee (MTU) and David Shonnard
Section Lead: Adam Wellstead (MTU)

Task Overview: The task of this team will be to estimate the costs to federal, state, local, and tribal governments of responding to the spill emergency, conducting damage assessments, monitoring cleanup activities, overseeing restoration efforts, and negotiating a settlement with responsible parties in the event of a worst-case spill. These estimates will utilize available and State-provided cost information, such as the Coast Guard's reimbursable standard rates, Federal pay and per diem tables, and comparisons with government costs and claims from other spill responses as a cost basis, using the cleanup time estimates from Task C to guide the assessment.

Methods: The team will employ a range of methods to estimate costs of government oversight of oil spill response and recovery. We will rely on published reports and government settlement details from past oil spills in locations with comparable geographic and ecological characteristics, including marine settings, and with oil properties and volumes that are similar or can be scaled or adjusted proportionally to the worst-case spill parameters. We will also consider the particular response roles and responsibilities of various government agencies. Federal roles are outlined in the 2016 revision of the Great Lakes Geographic Annex (CANUSLAK Plan) to the bilateral Joint Marine Pollution Contingency Plan; Canadian government response costs, if any, will not be estimated under this task. Government roles for 16 federal agencies, 8 states, tribes (12 in Michigan), and first responders are described in the coastal operational area sections of the 2015 Region 5 Regional Contingency Plan / Area Contingency Plan.

One of the most important factors in estimating oil spill response costs for the government is the length of shoreline and types of habitats impacted by the spill. Because a worst-case release into the waters of the Straits is likely to affect long stretches of shoreline on the Upper and Lower Peninsulas, as well as islands on either side of the Straits, information from Task B will be needed. We will base estimates on available data on government oversight costs for response to and recovery from past oil spills, adjusted to the particulars of the estimated worst-case spill scenario for the Straits, with methods and assumptions clearly stated. In addition to this statistical approach, we will also employ unit process cost factors (e.g., hourly or day rates for government or chartered support ships and aircraft, hourly pay and overhead rates for various labor categories of government oversight employees and contractors, rental rates for temporary command post and meeting space). Longer-term post-response costs associated with damage assessment, monitoring, restoration oversight by trustees, and litigation or negotiation with responsible parties will also be considered.

Deliverables: The team will prepare a best-estimate summary of costs to federal, state, local, and tribal governments in the event of a worst-case oil spill response and recovery scenario, including a description of methods and assumptions applied, estimates of the uncertainty range in the calculated costs, and consideration of how costs are likely to change over time due to inflation and other factors.

SOW II-X: Qualitative considerations and broader impacts

Section Team:[1]
Section Scientists and Authors: Alice Lippert (DoE retired), Joanne Shore (AFPM retired), Mark Rouleau (MTU), Chelsea Schelly (MTU), Nancy Langston (MTU) and Roman Sidortsov (MTU)
Section Lead: Roman Sidortsov (MTU)

Task Overview: The Section X team will engage in a qualitative risk identification to provide a comprehensive overview of risks that various affected communities perceive to arise in connections with the Straits Pipelines. Understanding perceived risks will provide qualitative guidance for the risk analysis frameworks carried out by the other Sections thereby strengthening their analysis. The Section X team will identify key actors likely to be impacted by a potential spill, including Indigenous communities, state and U.S. and Canadian local government officials, environmental and historic preservation groups, as well as tourism, fishing, and recreation industries. The team will first identify a range of risks and perspectives regarding the valuation of risk severity, and then explore the range of risk avoidance, tolerability, and acceptance concerns expressed by key actors. The Section X team will work closely with other sections to ensure that the identified risks, severity valuation perspectives, and other qualitative risk findings receive due consideration in the full risk analysis.

Methods: The Section X team will rely on documentary analysis, focus groups, and qualitative semi-structured interviews to obtain relevant data. The team will employ complementary and corroborative discourse and content analyses to evaluate and assess the obtained data. To the extent necessary, team members will also engage in legal analysis to identify risks arising out of legal rights and obligations by various parties in case of transboundary pollution, fishing rights impingement, etc.

The Section X team will apply the aforementioned methods as follows:
1) Team members will identify all applicable sources of secondary documentary data such as public comments received in the process of the alternatives analysis.
2) The relevant data will be analyzed in Nvivo or Atlas.ti software.
3) Focus groups will be designed based upon the initial documentary analysis. Between one and three focus groups will be conducted.
4) Semi-structured interviews (15-25) with key actors will be designed, scheduled, and conducted based upon the results of the initial document review and/or focus group(s).
5) Legal analysis will be conducted simultaneously with the documentary analysis, focus group(s), and qualitative interviews.
6) The results of the focus group(s), semi-structured interviews, and legal analysis will be added to Nvivo or Atlas.ti; team members will be assigned to specific topical areas in which they will conduct discourse and content analyses.

[1] Due to the cross-cutting nature of the task, section team members will share responsibilities of section scientist and section authors.

Team members will ensure that all relevant project activities have received approval by Michigan Tech's Institutional Review Board.

Detailed Subtasks and Time management: Because of the cross-cutting nature of this Task, the team will carry out its research activities in close collaboration with other section teams for the duration of the analysis. To facilitate collaboration, the team will establish an internal platform to provide qualitative guidance and receive input from other teams.

Below is the detailed scope of work and timeline for the seven subtasks in the Task II-X of the proposed project:

Subtask II-X 1 (Jan 15 – Jan 31, 2018): Team members will gather, organize, categorize, and upload all relevant documents into Nvivo or Atlas.ti software.

Subtask II-X 2 (Jan 15 – Jan 31, 2018): Team members will establish the internal collaboration platform and will develop the collaboration protocol to other teams.

Subtask II-X 3 (Feb 1 – Mar 15, 2018): Team members will conduct content and discourse analyses of the documentary data.

Subtask II-X 4 (Feb 15 – Mar 31, 2018): Team members will organize and conduct focus groups and will systematize the obtained data.

Subtask II-X 5 (Mar 15 – Apr 15, 2018): Team members will prepare and present an internal interim qualitative risk identification report to other project teams.

Subtask II-X 6 (Apr 15 – Aug 2, 2018): Upon the internal interim report presentation, team members will provide qualitative guidance to other section teams as necessary.

Subtask II-X 7 (Feb 1 – Apr 1, 2018) Team members will develop, schedule, and conduct qualitative interviews using the results of prior analysis for guidance.

Subtask II-X 8 (Feb 1 – Apr 1, 2018) Team members will conduct the aforementioned legal analysis.

Subtask II-X 9 (Mar 1 – May 1, 2018) Team members will merge all the relevant data in Nvivo or Atlas.ti software and will conduct complementary and corroborative content and discourse analysis.

Subtask II-X 10 (May 1 – July 15, 2018) Team members will prepare a section of the draft report and will assist other section teams with incorporating qualitative data into the part for which they are responsible.

Subtask II-X 11 (July 15 – Sept 15, 2018) Team members will respond to public comments, make necessary revisions and contribute to the final report.

Deliverables: The Section X will prepare an internal interim report to inform other section teams regarding the qualitative picture of risks in connection with the operation of the Straits Pipelines. The team will also contribute to the final report by presenting its qualitative assessment of the identified risks, severity valuation perspectives, and other qualitative risk findings.

6. Proposed Schedule and Deliverables

The project team will, according to a schedule agreed on with the State:

1) Prepare a draft report of the analysis, with periodic input/review from the State's project technical team as the drafting progresses;
2) Prepare and conduct a public information presentation on the draft analysis;
3) Conduct up to three public "listening sessions" to gather critical feedback;
4) Consider and respond to listening session and written comments on the draft report; and
5) Prepare the final report.

The proposed project schedule for completing task activities, communicating with the State and the public, and delivering draft and final reports is presented in the form of a Gantt chart (Table 2 below). Because the analysis is designed in such a way that later tasks depend on the results of earlier tasks as inputs, the analysis will be drafted in stages.

Table 2: Timeline of project communications, tasks and deliverables.

	Activity/Deliverable	Jan		Feb		Mar		Apr		May		June		July		August		September	
Comm	Weekly meeting of core team and section leads																		
	Biweekly web conference w/SoM technical team																		
Analysis & Drafting	Task A																		
	Task B																		
	Task C																		
	Task D																		
	Task E																		
	Task F																		
	Task G/I																		
	Task H																		
	Task X																		
Input Gathering & Revision	Synthesis of draft report																		
	Delivery of draft to State																		
	Draft report public release																		
	Public presentations & listening sessions																		
	Public comment period																		
	Comments on comments period																		
	Consider and respond to comments																		
	Delivery of final report																		

More work-intensive period of drafting the analysis for this team's task

Team will still be active planning and gathering data (before analysis) or helping other teams integrate the results into their own tasks (after analysis)

Draft and final report development

7. Proposed Budget

Budget

Michigan Tech will issue and administer subaward contracts to the eight institutional academic partners and three consulting organizations supporting this effort. Additionally, two consultant agreements will be issued to provide as-needed expertise across all tasks outlined in the SOW. The project budget includes personnel costs for 21 Michigan Tech faculty and technical staff involved in the project and additional administrative support to support project delivery at 10% effort as an administrative cost in accordance with 2 CFR 200.413. The budget also includes travel and supply costs to facilitate team member attendance at project specific meetings, to provide the required public outreach, and to gather place-based observational data. In compliance with the Office of Management and Budget Uniform Guidance, Michigan Tech will collect indirect costs at the institution's federally approved rate for Other Sponsored Activities including Public Service. These costs are calculated based on modified total direct costs and only collected on the first $25,000 of any subaward issued on this project. The following outlines the project budget:

Michigan Tech Personnel	$292,028.00
Supplies and Travel	$ 50,500.00
Project Partners (subawards/contracts)	$214,800.00
Indirect Costs	$191,782.00
Total Project Cost	**$749,110.00**

Michigan Tech will invoice the State of Michigan monthly for services provided and actual costs incurred towards progress made and completion of project deliverables.