INDEPENDENT RISK ANALYSIS for the Straits Pipelines

APPENDICES

September 15, 2018

A Multi-organizational Initiative Led by Michigan Technological University for the State of Michigan – Project ID: 1801011

Michigan Technological University

Independent Risk Analysis for the Straits Pipelines

Final Report

September 15, 2018

Appendices

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Appendix A-1

Detailed Calculations of Leakage after Valves Closed for Base Case of Rupture/Pin-hole:

As indicated in Section 3.3 in Equation A-E1, the leakage after the valves closed can be calculated using Equation (A1-E3) for either a rupture or a pinhole leakage as below:

Leakage after Valves Closed = Pipeline Cross-section Area × Distance from the Lowest Elevation Point (A1-E1)

The pipeline to be investigated in this analysis is 20" in outer diameter with a nominal wall thickness of 0.812". Thus, the inner diameter of the pipe is 18.376" as also shown in Table A2. The pipeline cross-section area then can be calculated as below:

$$Pipeline\ cross\ section\ area = \frac{\pi \times (18.376)^2}{4} = 265.077\ in^2 \quad \text{(A1-E2)}$$

Also, Table A-A1-3 (replication of Table A3 in Section 2.3) shows detailed information for the twelve locations which need to be investigated. The distance to the lowest elevation point is the parameter to be used in Equation (A1-E3) for calculations which also repeated as below.

Table A-A1-3. Line 5 Straits Crossing Critical Locations

Location Name and Elevation	**Distance to the lowest elevation point (mile)**	**Location Name and Elevation**	**Distance to the lowest elevation point (mile)**
East Seg. Loc. 1 (586.38 ft)	1.56	West Seg. Loc. 1 (586.84 ft)	1.63
East Seg. Loc. 2 (491.34 ft)	0.42	West Seg. Loc. 2 (484.09 ft)	0.39
East Seg. Loc. 3 (339.40 ft)	0.00	West Seg. Loc. 3 (330.68 ft)	0.00
East Seg. Loc. 4 (443.11 ft)	0.17	West Seg. Loc. 4 (454.72 ft)	0.47
East Seg. Loc. 5 (504.49 ft)	1.45	West Seg. Loc. 5 (506.17 ft)	1.54
East Seg. Loc. 6 (651.71 ft)	2.32	West Seg. Loc. 6 (651.15 ft)	2.25

East Strait Segment

ERLoc1 & E3Loc1: If the rupture or pin-hole occurs at East Seg. Loc. 1, the crude oil exists in the pipeline from this location to the lowest elevation point is 1.56 miles (1 mile=63,360 in., 1 bbl= 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (1.56 \times 63360) in = 2.62 \times 10^7\ \text{in}^3 = 2{,}700\ \text{bbl}$$

ERLoc2 & E3Loc2: If the rupture or pin-hole occurs at East Seg. Loc. 1, the crude oil exists in the pipeline from this location to the lowest elevation point is 0.42 miles (1 mile=63,360 in., 1 bbl= 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (0.42 \times 63360) in = 7.05 \times 10^6\ \text{in}^3 = 727\ \text{bbl}$$

To be conservative, we assume a minimum 15% of crude oil existing in the current pipeline would release post valve shutdown. The release volume of 15% is

$$265.077\ in^2 \times 3.8865 \times 63360\ \text{in}\ \times 15\% = 9.8 \times 10^6\ \text{in}^3 = 1{,}009\ \text{bbl}$$

Since 727 bbl is less than minimum (15%), the minimum release of 1,009 bbl is used at ERLoc3.

ERLoc3 & E3Loc3: If the rupture or pin-hole occurs at East Seg. Loc. 1, the crude oil exists in the pipeline from this location to the lowest elevation point is 0 miles (1 mile=63,360 in., 1 bbl= 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (0 \times 63360) in = 0\ bbl$$

Since zero bbl is less than 15% of minimum, the minimum release of 1,009 bbl is used at ERLoc3.

ERLoc4 & E3Loc4: If the rupture or pin-hole occurs at East Seg. Loc. 1, the crude oil exists in the pipeline from this location to the lowest elevation point is 0.17 miles (1 mile=63,360 in., 1 bbl= 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (0.17 \times 63360) in = 2.85 \times 10^6\ \text{in}^3 = 294\ \text{bbl}$$

Since 294 bbl is less than 15% of minimum, the minimum release of 1,009 bbl is used at ERLoc4.

ERLoc5 & E3Loc5: If the rupture or pin-hole occurs at East Seg. Loc. 1, the crude oil exists in the pipeline from this location to the lowest elevation point is 1.45 miles (1 mile=63,360 in., 1 bbl= 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (1.45 \times 63360) in = 2.44 \times 10^7\ in^3 = 2{,}510\ bbl$$

ERLoc6 & E3Loc6: If the rupture or pin-hole occurs at East Seg. Loc. 1, the crude oil exists in the pipeline from this location to the lowest elevation point is 2.32 miles (1 mile=63,360 in., 1 bbl= 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (2.32 \times 63360) in = 3.896 \times 10^7\ in^3 = 4{,}016\ bbl$$

West Strait Segment

WRLoc1 & W3Loc1: If the rupture or pin-hole occurs at West Seg. Loc. 1, the crude oil exists in the pipeline from this location to the lowest elevation point is 1.63 miles (1 mile=63,360 in., 1 bbl= 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (1.63 \times 63360) in = 2.74 \times 10^7\ \text{in}^3 = 2{,}822\ \text{bbl}$$

WRLoc2 & W3Loc2: If the rupture or pin-hole occurs at West Seg. Loc. 2, the crude oil exists in the pipeline from this location to the lowest elevation point is 0.39 miles (1 mile=63,360 in., 1 bbl= 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (0.39 \times 63360) in = 6.55 \times 10^6\ in^3 = 675\ bbl$$

To be conservative, we assume a minimum 15% of crude oil existing in the current pipeline would release post valve shutdown. The release volume of 15% is

$$265.077\ in^2 \times (3.8865 \times 63360) in \times 15\% = 9.8 \times 10^6\ \text{in}^3 = 1{,}009\ \text{bbl}$$

Since 675 bbl is less than the minimum (15%), the minimum release of 1,009 bbl is used at WRLoc3.

WRLoc3 & W3Loc3: If the rupture or pin-hole occurs at West Seg. Loc. 3, the crude oil exists in the pipeline from this location to the lowest elevation point is 0 miles (1 mile = 63,360 in., 1 bbl = 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (0 \times 63360) in = 0\ bbl$$

Since 0 bbl is less than 15% of minimum, the minimum release of 1,009 bbl is used at ERLoc3.

WRLoc4 & W3Loc4: If the rupture or pin-hole occurs at West Seg. Loc. 4, the crude oil exists in the pipeline from this location to the lowest elevation point is 0.47 miles (1 mile=63,360 in., 1 bbl= 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (0.47 \times 63360) in = 8.0 \times 10^6\ \text{in}^3 = 824\ \text{bbl}$$

Since 824 bbl is less than 15% of minimum, the minimum release of 1,009 bbl is used at ERLoc3.

WRLoc5 & W3Loc5: If the rupture or pin-hole occurs at West Seg. Loc. 5, the crude oil exists in the pipeline from this location to the lowest elevation point is 1.54 miles (1 mile=63,360 in., 1 bbl= 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (1.54 \times 63360) in = 2.59 \times 10^7\ in^3 = 2{,}666\ bbl$$

WRLoc6 & W3Loc6: If the rupture or pin-hole occurs at West Seg. Loc. 1, the crude oil exists in the pipeline from this location to the lowest elevation point is 2.25 miles (1 mile=63,360 in., 1 bbl= 9,702 in^3). Thus, the leakage volume after valves closed is

$$265.077\ in^2 \times (2.25 \times 63360) in = 3.7903 \times 10^7\ in^3 = 3{,}907\ bbl$$

Table A-A1-13 below summarizes the leakage after the valves closed can be calculated using the Equation (A1-E3) for either a rupture or a pinhole leakage. Grayed rows indicate that Locations 1 and 6, the endpoints of the Straits pipelines, are on land and outside of the scope of this assessment, so analysis of these locations was not included in the report.

Table A-A1-13. Summary of Leakage After Valve Closure

Rupture Case Name East	Total Leak Amount (Barrels)	Rupture Case Name West	Total Leak Amount (Barrels)
ERLoc1 or E3Loc1	2700	WRLoc1 or W3Loc1	2822
ERLoc2 or E3Loc2	1009*	WRLoc2 or W3Loc2	1009*
ERLoc3 or E3Loc3	1009*	WRLoc3 or W3Loc3	1009*
ERLoc4 or E3Loc4	1009*	WRLoc4 or W3Loc4	1009*
ERLoc5 or E3Loc5	2510	WRLoc5 or W3Loc5	2666
ERLoc6 or E3Loc6	4016	WRLoc6 or W3Loc5	3907

** Conservative assumption of minimum 15% leakage post-shutdown applies.*

Detailed Calculations of Leakage before Valve Closure for Base Case of Rupture:

For Tier 1, the rupture detection time is 0 minutes and the valve isolation time, which is the response time, is 3.5 minutes. Thus, the rupture leakage before valve closure can be calculated based on Equation (A1-E3), repeated below:

$$\text{Rupture Leakage before Closing Valve} = \text{Response Time} \times \text{Flow Rate} \qquad \text{(A1-E3)}$$

The maximum flow rate is 25,591 bbl/h. Thus the leakage after valve closure is:

$$\frac{3.5min}{60min./hr.} \times 25{,}591 \text{ bbl/h.} = 1{,}493 \text{ bbl}$$

Thus, the total leakage for Tier 1 will be:

$$\text{Total Leak Amount} = \text{Leakage before Closing Valve} + \text{Leakage after Valves Closed} \qquad \text{(A1-E4)}$$

As also shown in Table A-A1-8 (replication of Table A8 in Section 3.1), the total leak amount will be as follows:

Table A-A1-8. Tier 1 Total Leak Amount

Rupture Case Name	Total Leak Amount	Rupture Case Name	Total Leak Amount

East	(Barrels)	West	(Barrels)
ERLoc1	4200	WRLoc1	4400
ERLoc2	2500*	WRLoc2	2500*
ERLoc3	2500*	WRLoc3	2500*
ERLoc4	2500*	WRLoc4	2500*
ERLoc5	4000	WRLoc5	4200
ERLoc6	5500	WRLoc6	5400

** Conservative assumption of minimum 15% leakage post-shutdown applies.*

For a Tier 2 rupture, the detection time is 0 minutes and decision time is 10 minutes in addition to a valve isolation time of 3.5 minutes, for a total response time of 13.5 minutes. Thus, with the maximum flow rate is 25,591 bbl/h, the rupture leakage before valve closure can be calculated based on Equation (A1-E3):

$$\frac{13.5min}{60min/hr.} \times 25{,}591 \text{ bbl/h.} = 5{,}758 \text{ bbl}$$

Thus, based on Equation (A1-E4) the total leakage for Tier 2 will be:

Total Leak Amount = Leakage before Closing Valve + Leakage after Valves Closed

As also shown in Table A-A1-9 (replication of Table A9 in Section 3.1), the total leak amount will be as follows:

Table A-A1-9. Tier 2 Total Leak Amount

Rupture Case Name East	Total Leak Amount (Barrels)	Rupture Case Name West	Total Leak Amount (Barrels)
ERLoc1	8500	WRLoc1	8600
ERLoc2	6800*	WRLoc2	6800*
ERLoc3	6800*	WRLoc3	6800*
ERLoc4	6800*	WRLoc4	6800*
ERLoc5	8300	WRLoc5	8500
ERLoc6	9800	WRLoc6	9700

** Conservative assumption of minimum 15% leakage post-shutdown applies.*

Appendix A-2 Historical Data

Table A-2.1: Hazardous Liquid Pipeline Accident Ranking by Release Volume from 2010 - Present

Accident Time	Identified Time	Responding Time (minutes)	Responding Time (hours)	Company Name	Discharged Crude Oil (barrels)	Incident Location
7/29/13 00:00	9/29/13 21:36	90576	1509	Tesoro High Plains Pipeline Company LLC	20600	Bicker, ND
7/25/10 17:58	7/26/10 11:17	1039	17	Enbridge Energy, L.P.	20082	Marshall, MI
12/5/16 10:15	12/5/16 10:30	15	0	Belle Fourche Pipeline Co	12615	North Billings, ND
6/4/11 07:30	6/4/11 07:30	0	0	Enterprise Crude Pipeline LLC	12229	Wise County, TX
10/11/10 07:45	10/11/10 07:45	0	0	Centurion Pipeline L.P.	10200	Levelland, TX
1/19/17 07:14	1/19/17 07:14	0	0	Tallgrass Pony Express Pipeline, LLC	10009	Logan County, CO
4/13/11 18:58	4/13/11 18:58	0	0	Marathon Pipe Line LLC	9000	Stockbridge, MI
12/8/14 16:08	12/8/14 16:05	0	0	Plantation Pipe Line Co	8800	Belton, SC

8/29/16 02:00	9/10/16 17:15	18195	303	Sunoco Pipeline L.P.	8600	Sweetwater, TX
10/23/16 21:51	10/23/16 21:51	0	0	Enterprise Crude Pipeline LLC	7603	Cushing, OK

Table A-2.2: Hazardous Liquid Pipeline Accident Ranking by Responding Time from 2010 - Present

Accident Time	Operator Identified Time	Responding Time (minutes)	Responding Time (hours)	Company Name	Discharged Crude Oil (barrels)
1/14/12 07:10	1/31/12 11:45	24755	412.6	SHELL PIPELINE CO., L.P.	215
7/25/10 17:58	7/26/10 11:17	1039	17.3	ENBRIDGE ENERGY, L.P.	20082
3/26/14 05:18	3/26/14 10:30	312	5.2	ENBRIDGE ENERGY, L.P.	7
5/12/11 11:05	5/12/11 13:45	160	2.7	BUCKEYE GULF COAST PIPELINE LP	5
4/12/11 08:15	4/12/11 10:25	130	2.2	WEST SHORE PIPELINE CO	11.9
6/28/14 20:53	6/28/14 22:30	97	1.6	ENBRIDGE ENERGY, L.P.	3

3/21/12 18:00	3/21/12 19:17	77	1.3	MAGELLAN PIPELINE COMPANY, LP	12
6/2/16 14:20	6/2/16 14:29	9	0.2	WEST SHORE PIPELINE CO	0.48
5/18/15 05:58	5/18/15 06:05	7	0.1	WEST SHORE PIPELINE CO	2
7/27/12 14:41	7/27/12 14:45	4	0.1	ENBRIDGE ENERGY, L.P.	1729
5/29/10 12:34	5/29/10 12:37	3	0.1	AMOCO OIL CO	2121
2/8/17 11:13	2/8/17 11:14	1	0.0	WEST SHORE PIPELINE CO	0.17

Table A-2.3: *Enbridge Owned* Hazardous Liquid Pipeline Accident Ranking by Responding Time from 2010 – Present

Accident Time	**Operator Identified Time**	**Responding Time (minutes)**	**Responding Time (hours)**	**Location**	**Discharged Crude Oil (barrels)**
2/22/13 10:30	3/22/13 14:00	40530	675.5	Cushing, OK	0.36
11/2/13 17:47	11/3/13 14:08	1221	20.4	Berthold, ND	9
7/25/10 17:58	7/26/10 11:17	1039	17.3	Marshall, MI	20082
3/26/14 5:18	3/26/14 10:30	312	5.2	Between Friendship, MI and Grand Marsh, MI	7

5/2/13 8:12	5/2/13 11:27	195	3.3	Between Knox, ND and York, ND	1.5
5/7/13 9:44	5/7/13 11:30	106	1.8	Grand Forks, ND	1
6/28/14 20:53	6/28/14 22:30	97	1.6	Hampshire, IL	3
3/3/12 2:04	3/3/12 3:05	61	1.0	New Lenox, IL	1500
9/9/10 11:30	9/9/10 12:28	58	1.0	Romeoville, IL	7538
12/22/12 15:09	12/22/12 15:57	48	0.8	Rolling Fork, MS	10
4/16/14 23:45	4/17/14 0:18	33	0.6	Deer River, MN	0.36
7/22/13 6:58	7/22/13 7:18	20	0.3	Deer River, MN (Same facility as the one above)	3.33
2/25/14 10:30	2/25/14 10:40	10	0.2	Griffith, IN	747.7
1/21/15 6:38	1/21/15 6:45	7	0.1	Superior, WI	2
10/2/14 8:49	10/2/14 8:55	6	0.1	Cushing, OK	8.9
2/6/14 18:20	2/6/14 18:25	5	0.1	Griffith, IN	5
7/27/12 14:41	7/27/12 14:45	4	0.1	Lincoln, WI	1729
11/7/14 7:12	11/7/14 7:13	1	0.0	Lockport, IL	0.36

Appendix B-1 Oil Dispersal and Proportional Oil Fate

Included within this appendix are representative figures describing oil dispersal and proportional oil fate figures for oil spill simulations conducted for a worst case scenario for the submerged Line 5 pipeline that transits the Straits of Mackinac between the State of Michigan's Upper and Lower Peninsulas. A summary of the figures is provided below.

Figures A-B1-1 through A-B1-12: Maximum shoreline oiled shoreline distances (km) GIS overlay figures describing oil distribution along the Straits of Mackinac shorelines and also adjacent Lake Michigan and Lake Huron coastal and island shorelines for January–December 2016. Specific time, date and release locations for oil release are provided in each figure caption in addition to the time of oil dispersal that resulted in the maximum oiling scenario.

Figures A-B1-13 through A-B1-24: Maximum extent of surface area oiling (km^2) GIS overlay figures describing simulated oil dispersal across the surface waters of the Straits of Mackinac shorelines and also adjacent Lake Michigan and Lake Huron surface waters for January–December 2016. Specific time, date and release locations for oil release are provided in each figure caption in addition to the time of oil dispersal that resulted in the maximum oiling scenario.

Figures A-B1-25 through A-B1-36: Proportional fate distribution figures describing the percent of the total released oil that becomes beached remains afloat on the water surface or is lost to evaporation over a 60-day dispersal period of January–December 2016. Specific time and date for oil release are provided in each figure caption.

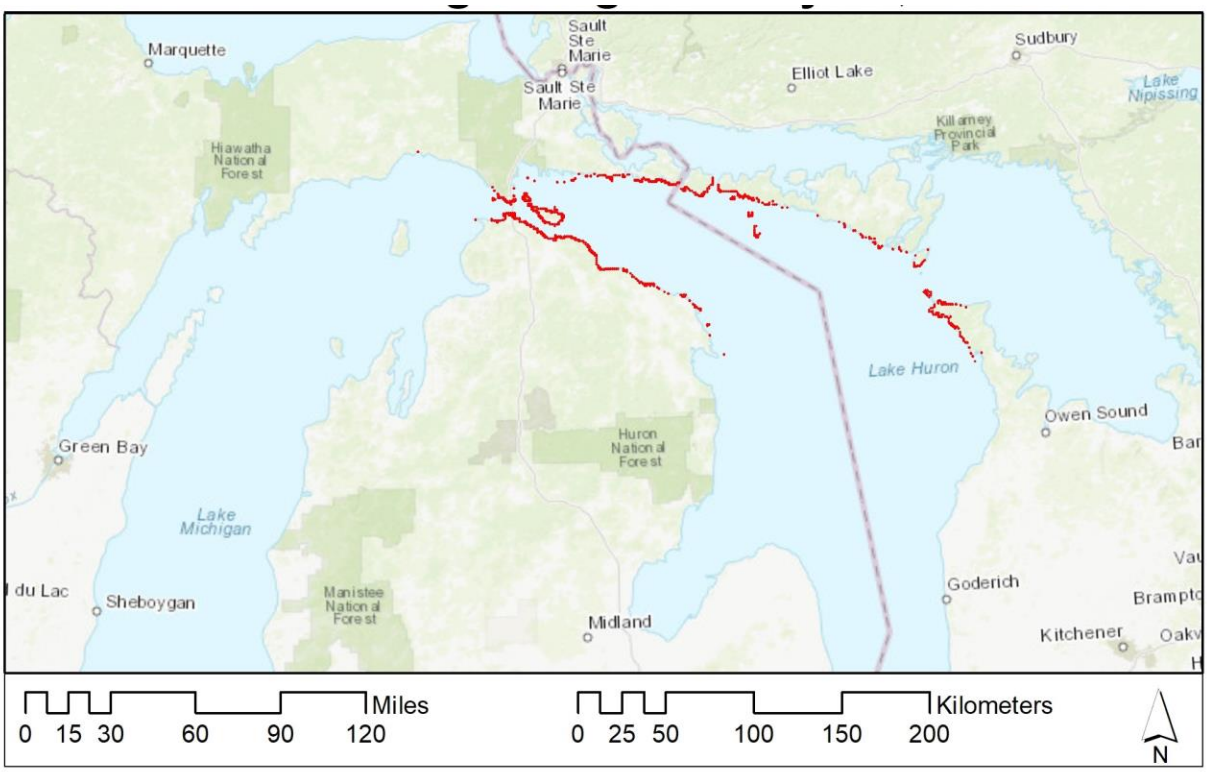


Figure A-B1-1. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for January

Results depicted above represent a total oiled shoreline distance of 1146 km following an oil release date and time of 01/17/2016 at 1800 hrs from the northern pipeline release point and a total dispersal simulation time of 60 days. The red particles represent dispersed oil.

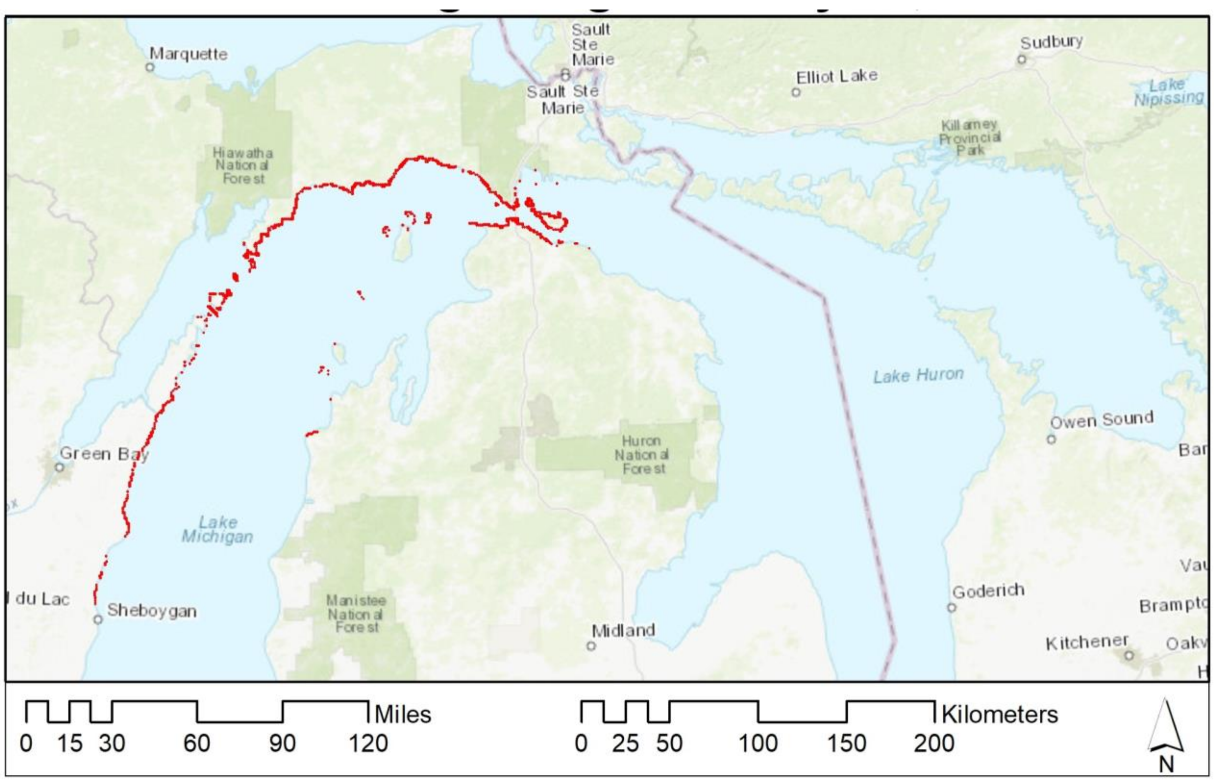


Figure A-B1-2. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for February.

Results depicted above represent a total oiled shoreline distance of 1021 km following an oil release date and time of 02/28/2016 at 1200 hrs from the central pipeline release point and a total dispersal simulation time of 60 days. The red particles represent dispersed oil.

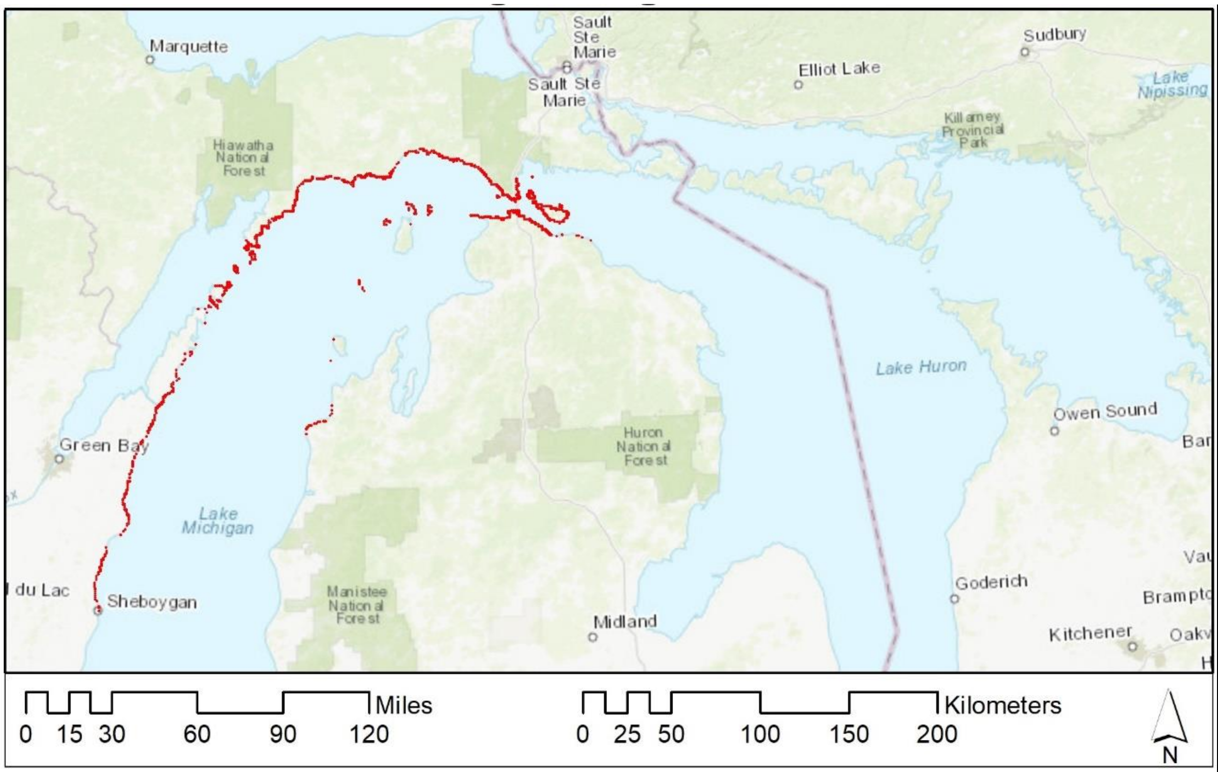


Figure A-B1-3. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for March

Results depicted above represent a total oiled shoreline distance of 996 km following an oil release date and time of 03/01/2016 at 1800 hrs from the central pipeline release point and a total dispersal simulation time of 60 days. The red particles represent dispersed oil.

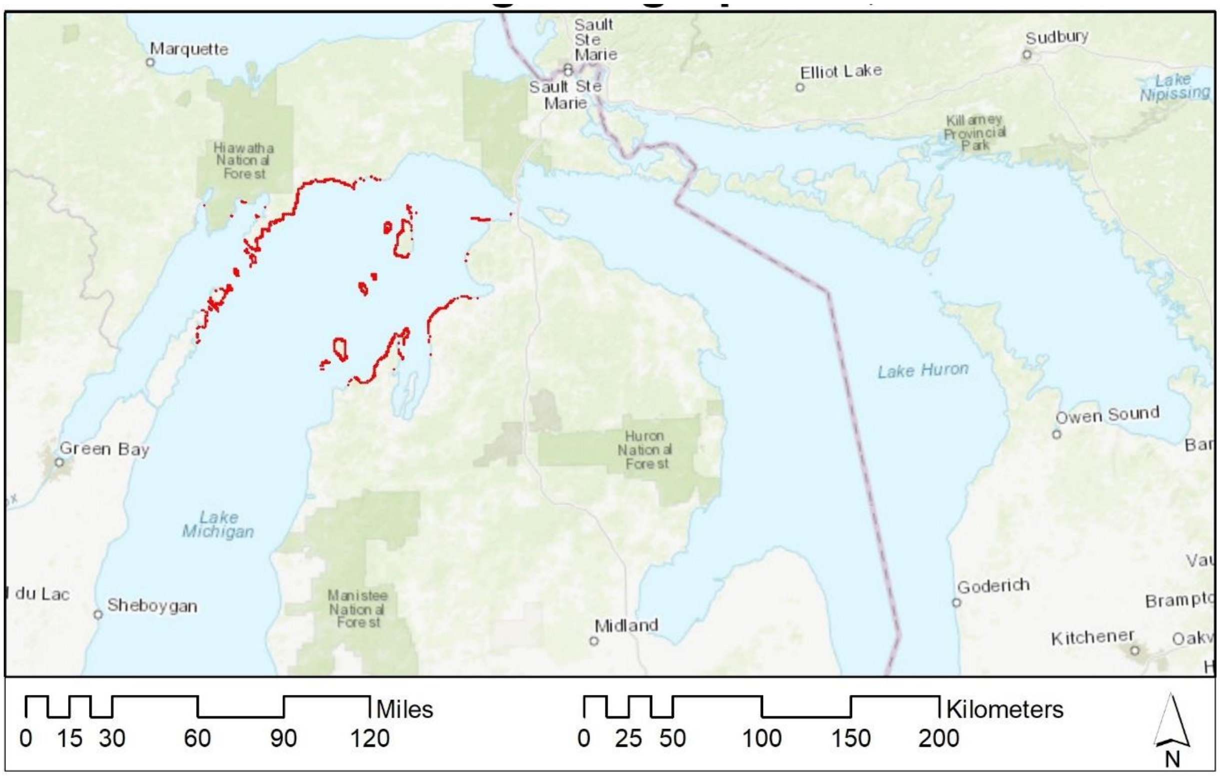


Figure A-B1-4. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for April

Results depicted above represent a total oiled shoreline distance of 794 km following an oil release date and time of 04/24/2016 at 1800 hrs from the southern pipeline release point and a total dispersal simulation time of 60 days. The red particles represent dispersed oil.

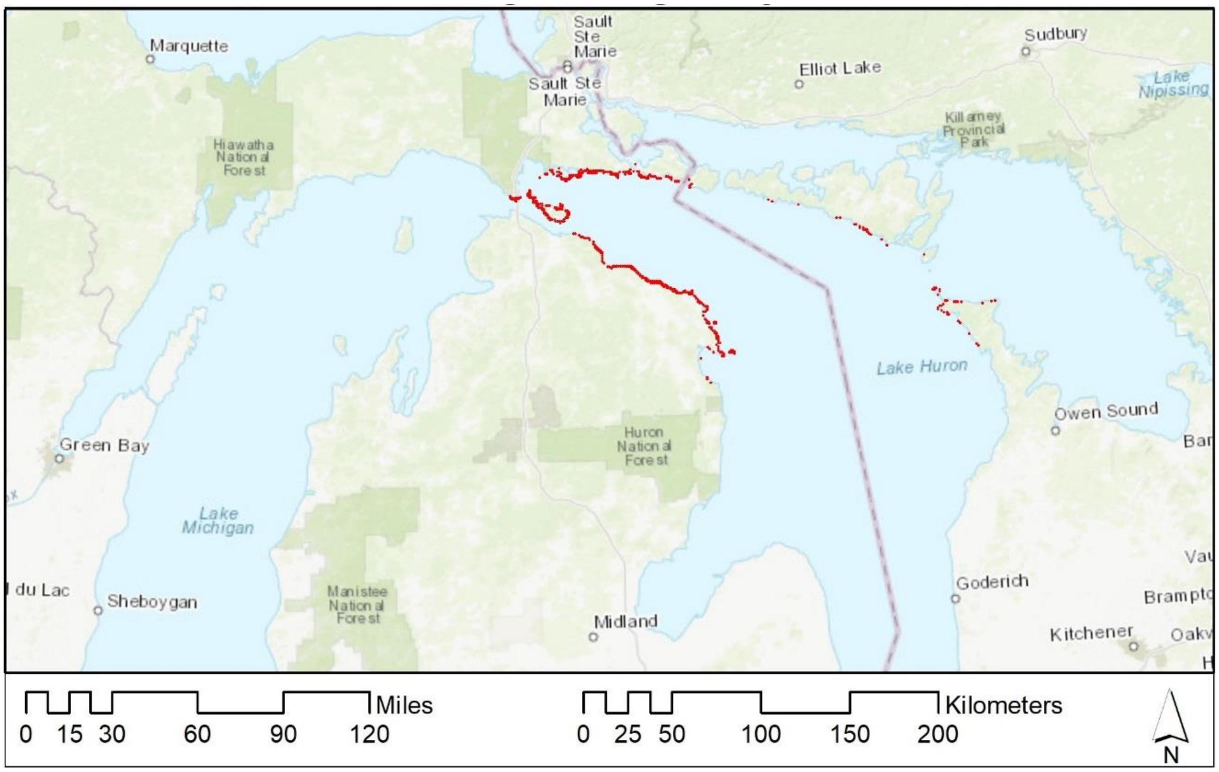


Figure A-B1-5. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for May

Results depicted above represent a total oiled shoreline distance of 847 km following an oil release date and time of 05/12/2016 at 1200 hrs from the central pipeline release point and a total dispersal simulation time of 60 days. The red particles represent dispersed oil.

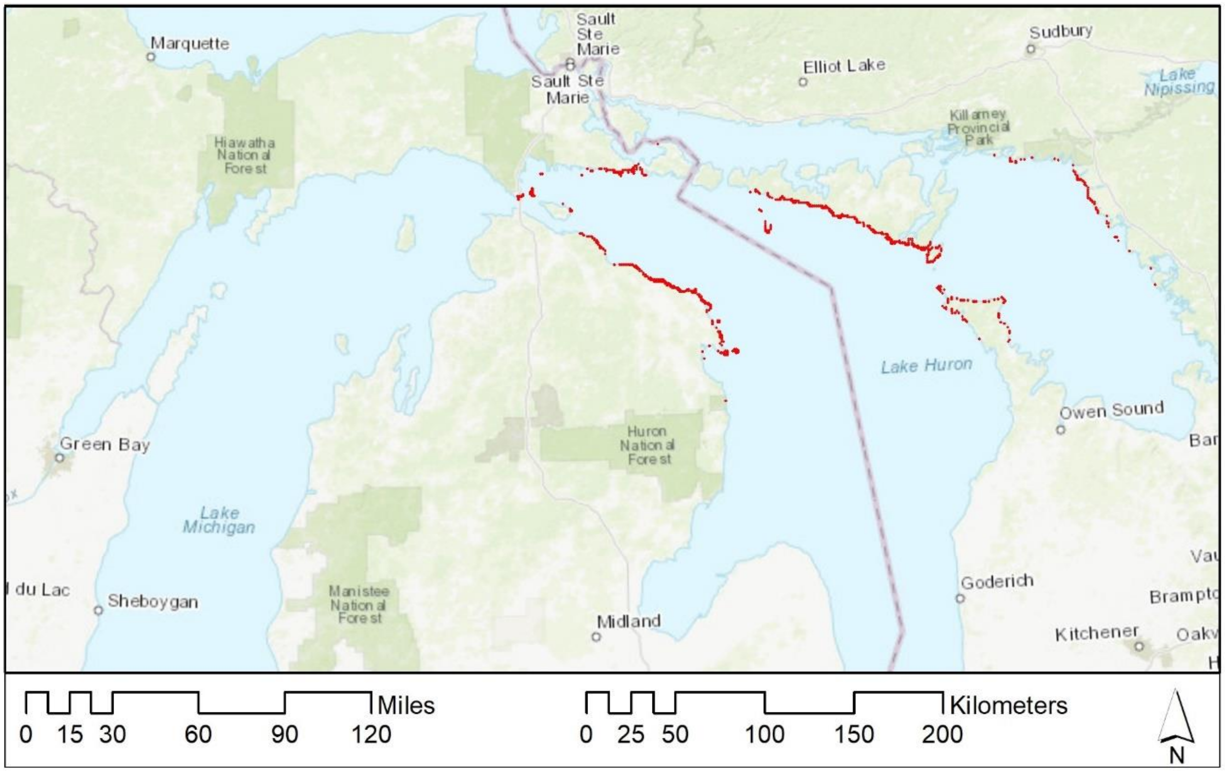


Figure A-B1-6. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for June

Results depicted above represent a total oiled shoreline distance of 2,006 km following an oil release date and time of 06/20/2016 at 0000 hrs from the central pipeline release point and a total dispersal simulation time of 60 days. The red particles represent dispersed oil.

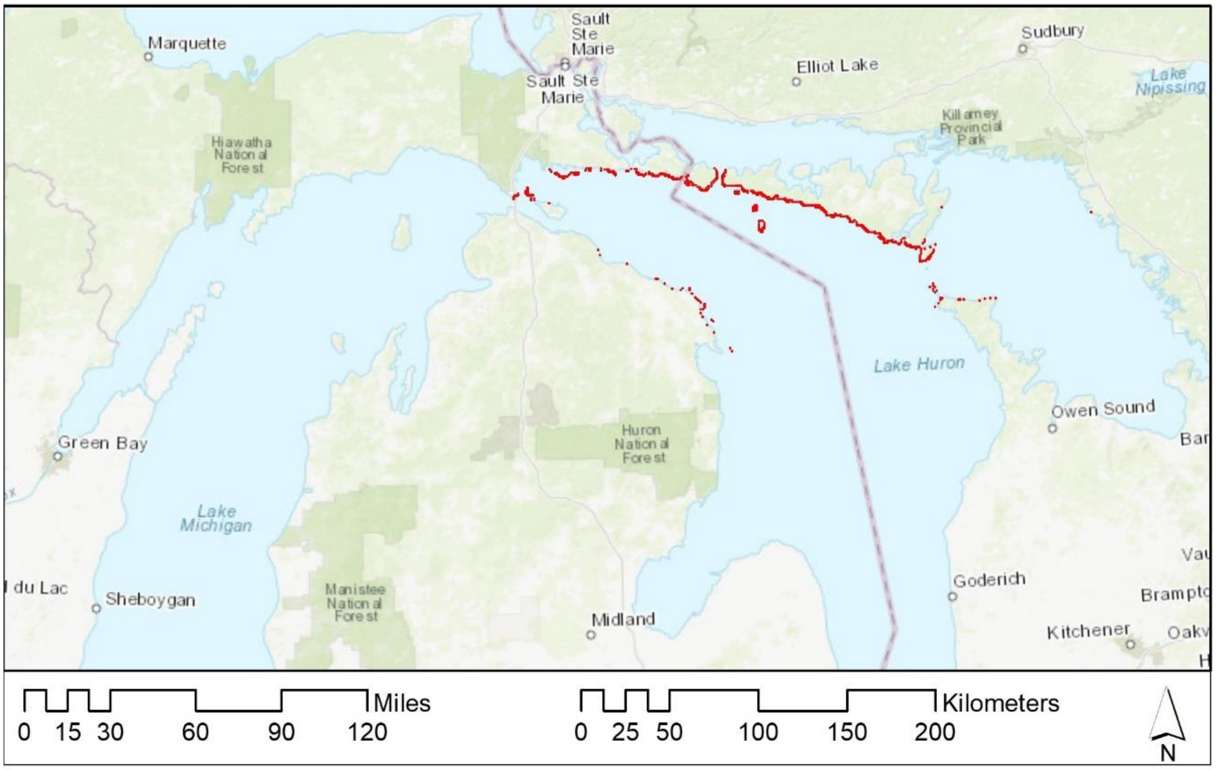


Figure A-B1-7. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for July

Results depicted above represent a total oiled shoreline distance of 927 km following an oil release date and time of 07/13/2016 at 0000 hrs from the northern pipeline release point and a total dispersal simulation time of 60 days. The red particles represent dispersed oil.

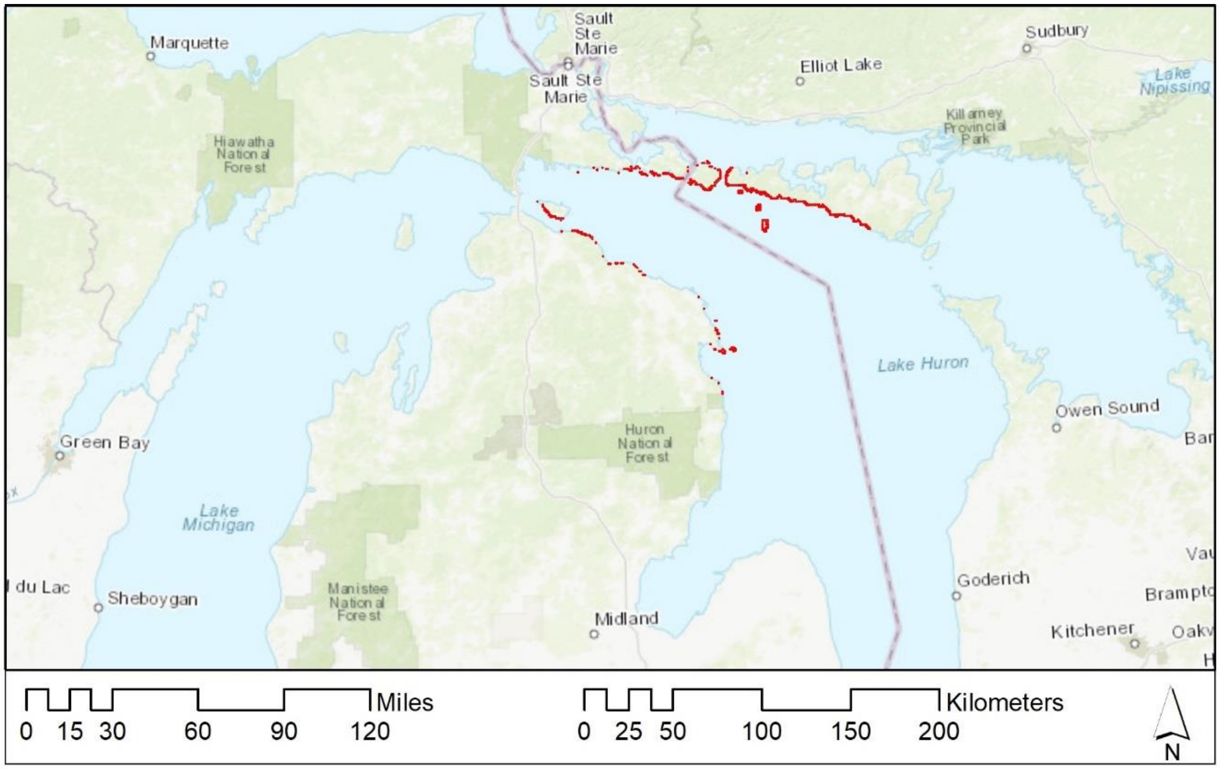


Figure A-B1-8. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for August.

Results depicted above represent a total oiled shoreline distance of 650 km following an oil release date and time of 08/21/2016 at 0600 hrs from the southern pipeline release point and a total dispersal simulation time of 30 days. The red particles represent dispersed oil.

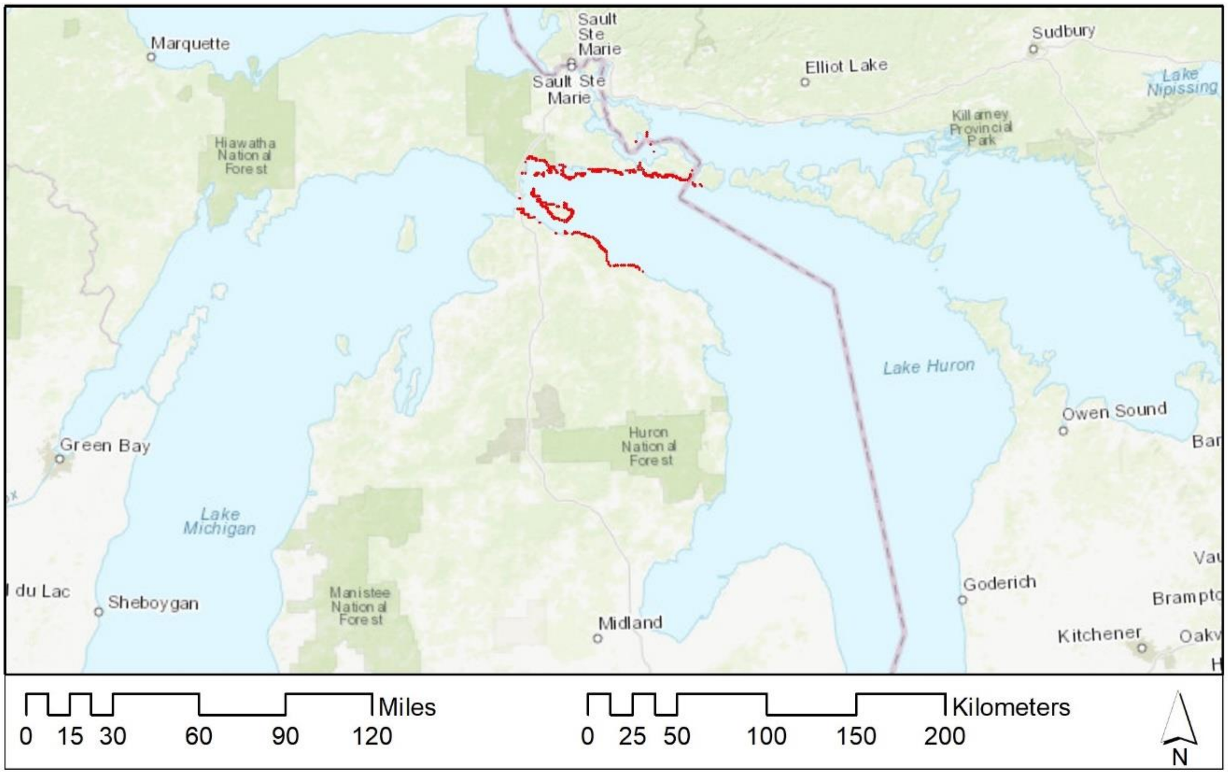


Figure A-B1-9. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for September.

Results depicted above represent a total oiled shoreline distance of 572 km following an oil release date and time of 09/17/2016 at 0000 hrs from the southern pipeline release point and a total dispersal simulation time of 20 days. The red particles represent dispersed oil.

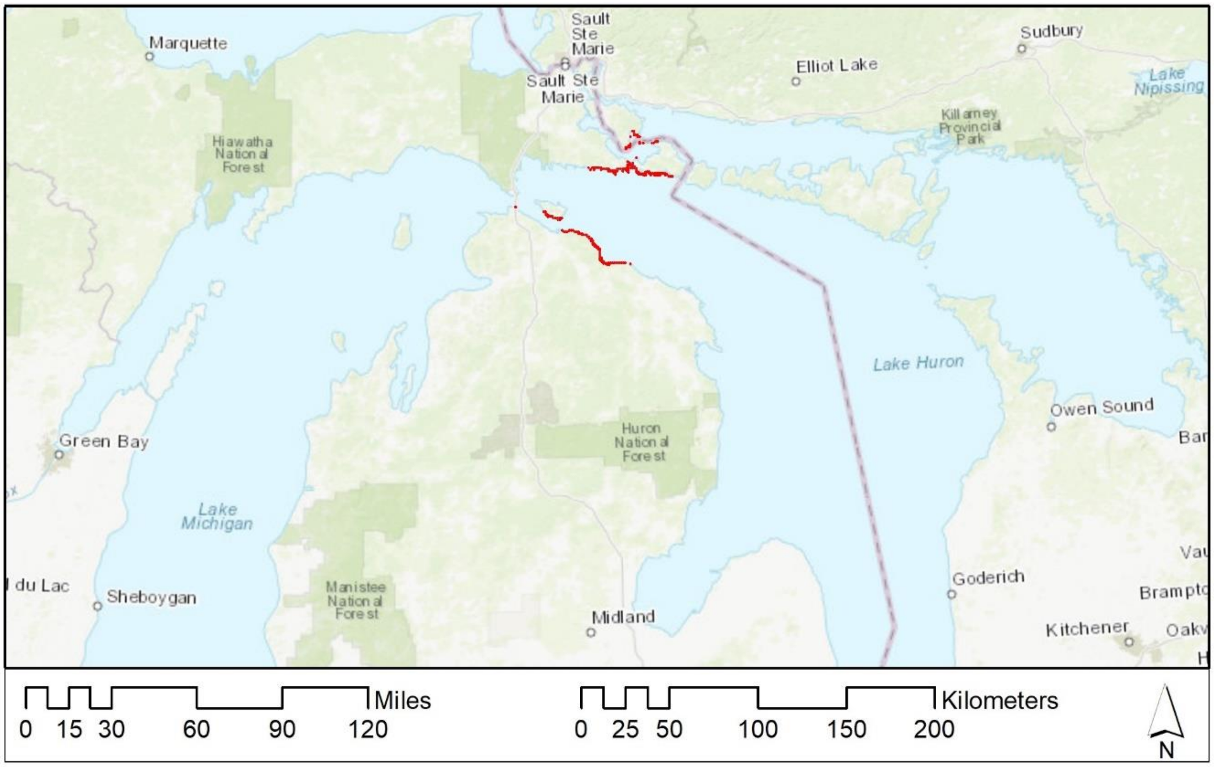


Figure A-B1-10. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for October.

Results depicted above represent a total oiled shoreline distance of 348 km following an oil release date and time of 10/08/2016 at 0000 hrs from the southern pipeline release point and a total dispersal simulation time of 10 days. The red particles represent dispersed oil.

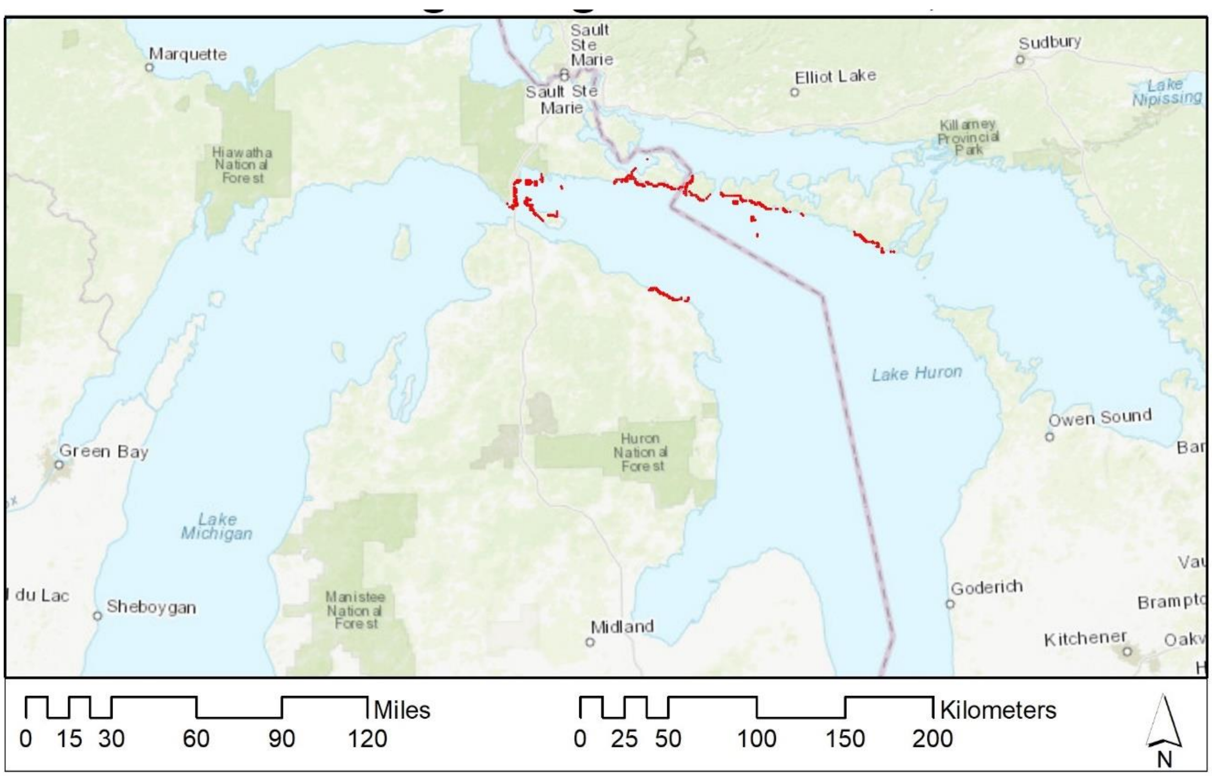


Figure A-B1-11. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for November.

Results depicted above represent a total oiled shoreline distance of 587 km following an oil release date and time of 11/30/2016 at 0000 hrs from the southern pipeline release point and a total dispersal simulation time of 15 days. The red particles represent dispersed oil.

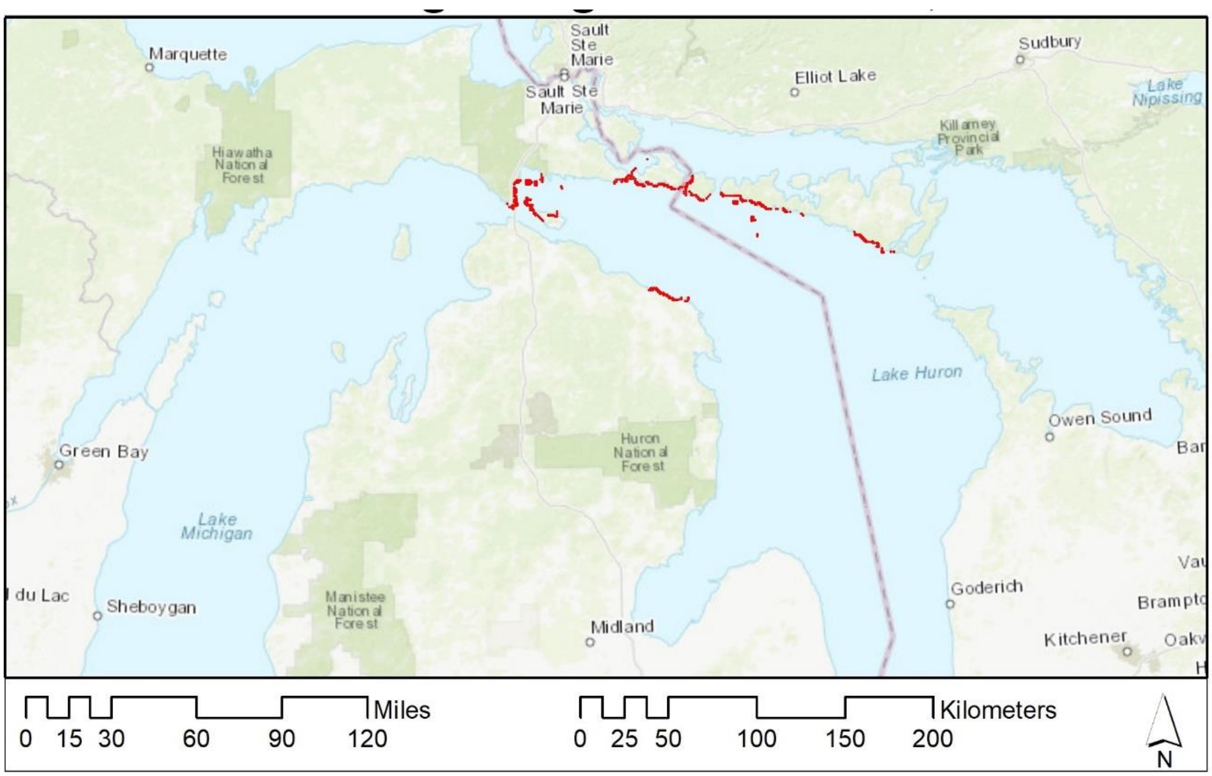


Figure A-B1-12. Maximum Extent of Shoreline Oiling (Km) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for December.

Results depicted above represent a total oiled shoreline distance of 414 km following an oil release date and time of 12/27/2016 at 1800 hrs from the central pipeline release point and a total dispersal simulation time of 15 days. The red particles represent dispersed oil.

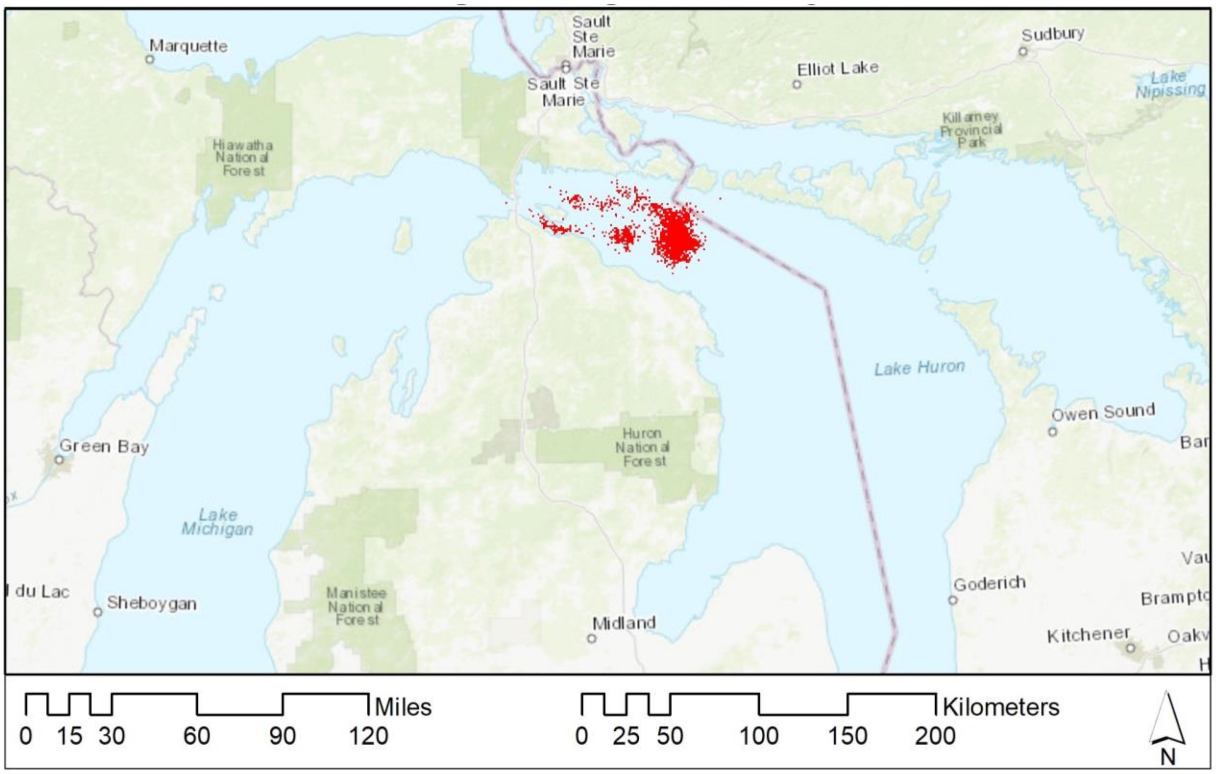


Figure A-B1-13. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for January.

Results depicted above represent a total surface area of 921 km^2 following an oil release date and time of 01/18/2016 at 1800 hrs from the northern pipeline release point and a total dispersal simulation time of 15 days. The red particles represent dispersed oil.

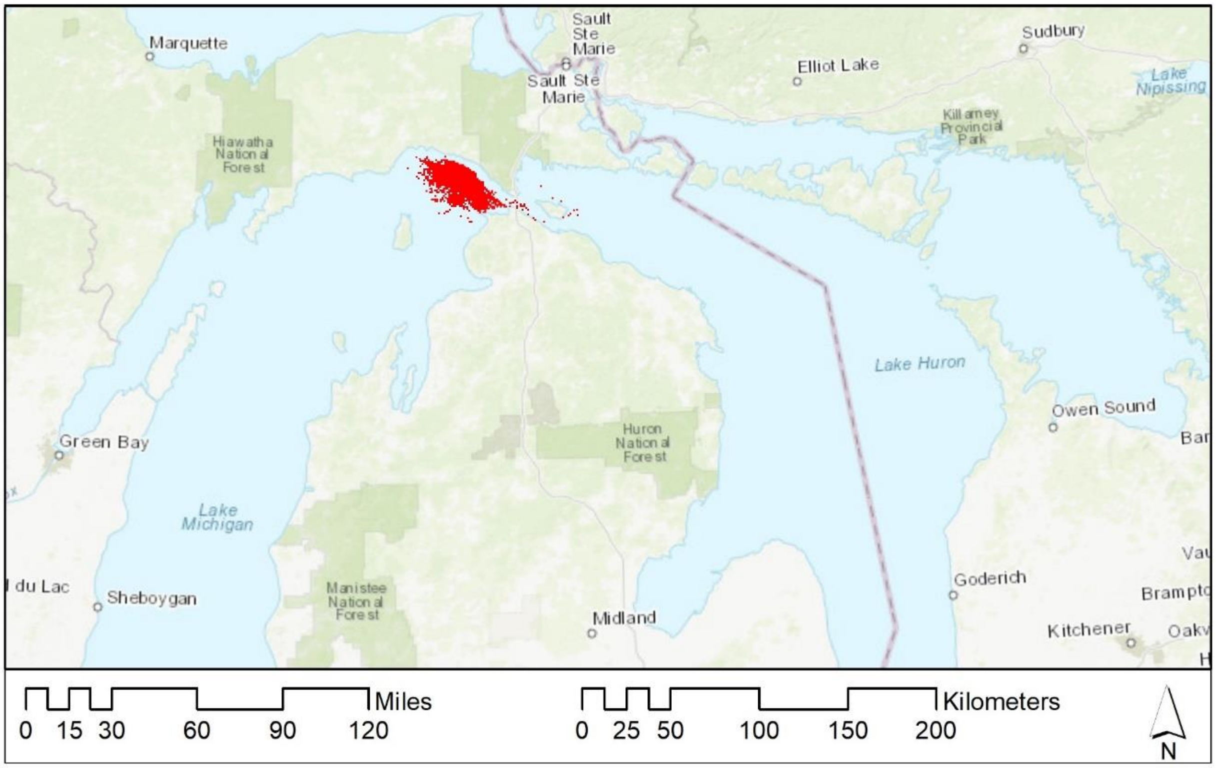


Figure A-B1-14. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for February.

Results depicted above represent a total surface area of 783 km^2 following an oil release date and time of 02/28/2016 at 0000hrs from the central pipeline release point and a total dispersal simulation time of 15 days. The red particles represent dispersed oil.

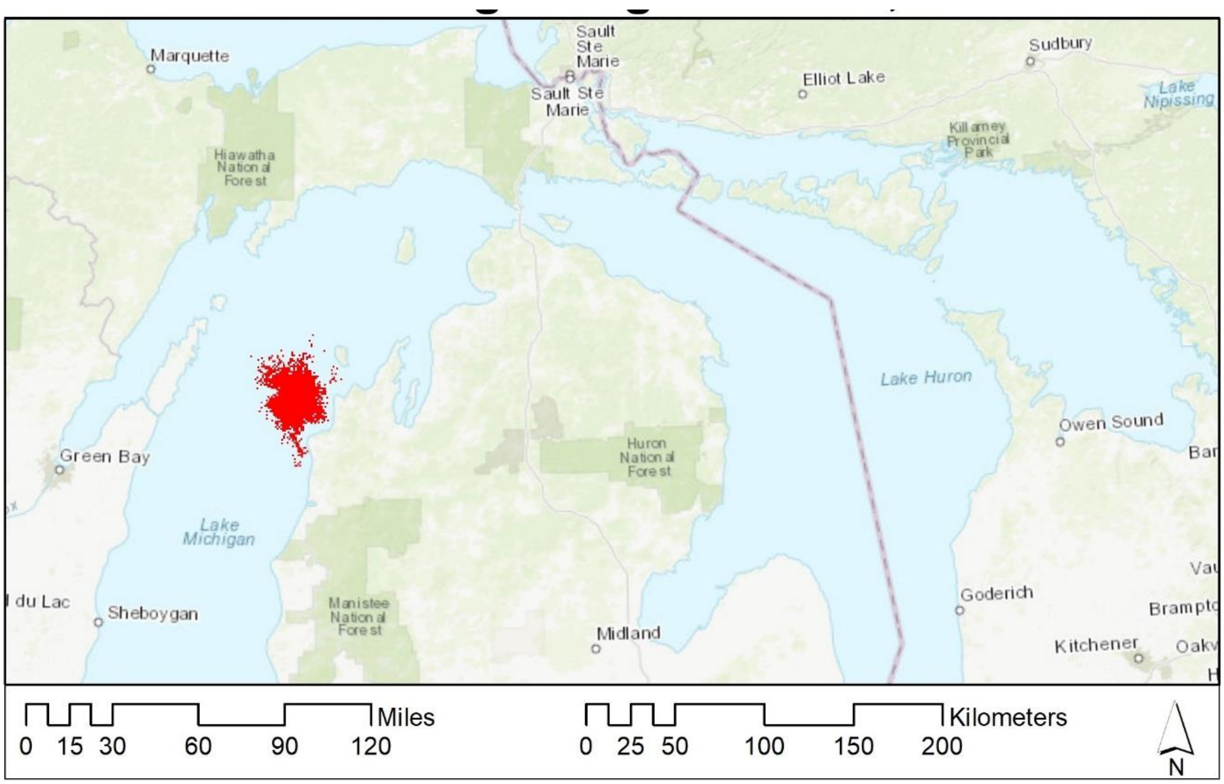


Figure A-B1-15. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for March.

Results depicted above represent a total surface area of 1102 km^2 following an oil release date and time of 03/15/2016 at 1800hrs from the southern pipeline release point and a total dispersal simulation time of 30 days. The red particles represent dispersed oil.

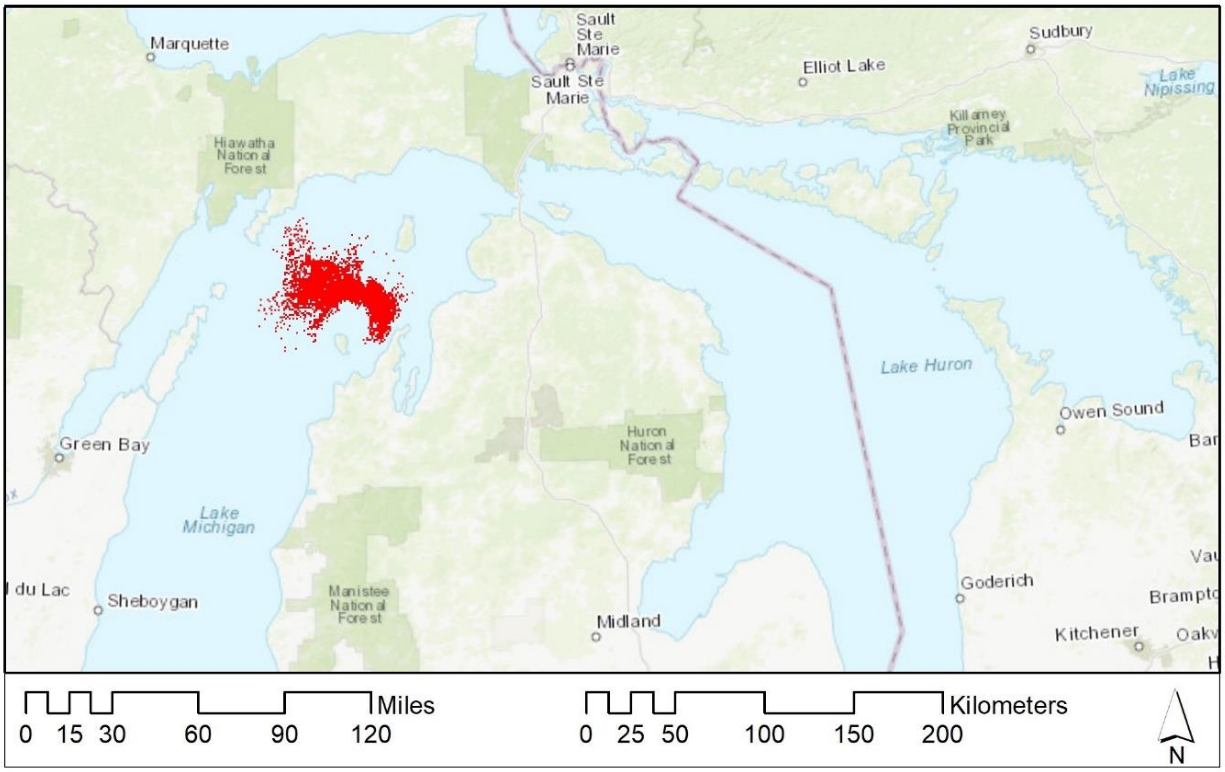


Figure A-B1-16. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for April.

Results depicted above represent a total surface area of 1745 km^2 following an oil release date and time of 04/24/2016 at 1200hrs from the northern pipeline release point and a total dispersal simulation time of 30 days. The red particles represent dispersed oil.

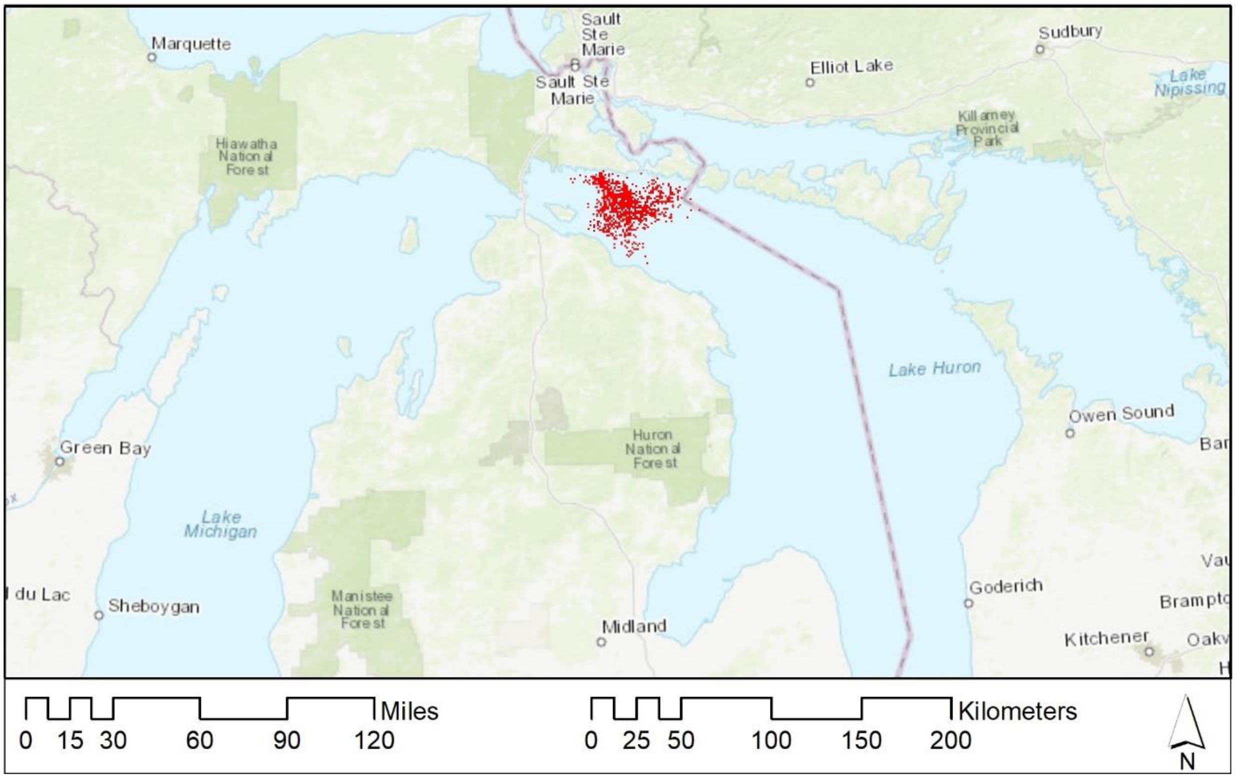


Figure A-B1-17. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for May.

Results depicted above represent a total surface area of 712 km^2 following an oil release date and time of 05/12/2016 at 1800 hrs from the northern pipeline release point and a total dispersal simulation time of 20 days. The red particles represent dispersed oil.

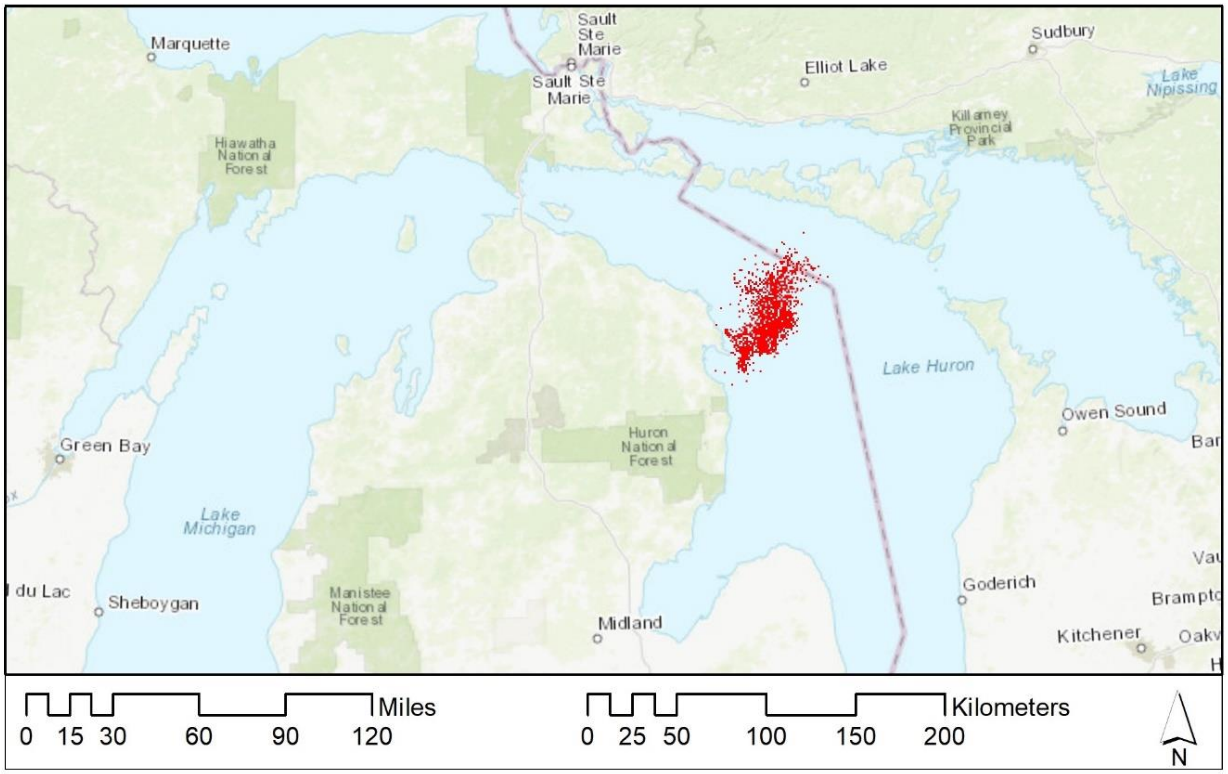


Figure A-B1-18. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed forJune.

Results depicted above represent a total surface area of 1033 km^2 following an oil release date and time of 06/20/2016 at 0000 hrs from the central pipeline release point and a total dispersal simulation time of 20 days. The red particles represent dispersed oil.

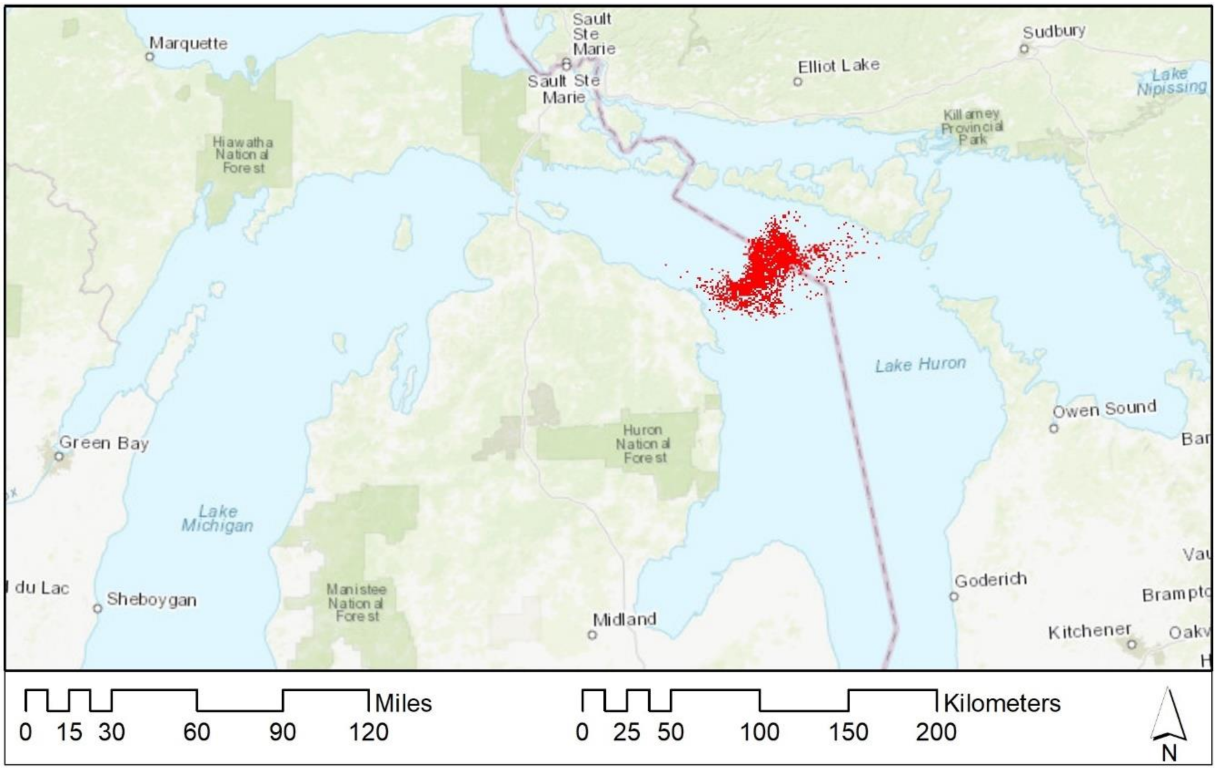


Figure A-B1-19. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for July.

Results depicted above represent a total surface area of 1288 km^2 following an oil release date and time of 07/14/2016 at 0000 hrs from the central pipeline release point and a total dispersal simulation time of 20 days. The red particles represent dispersed oil.

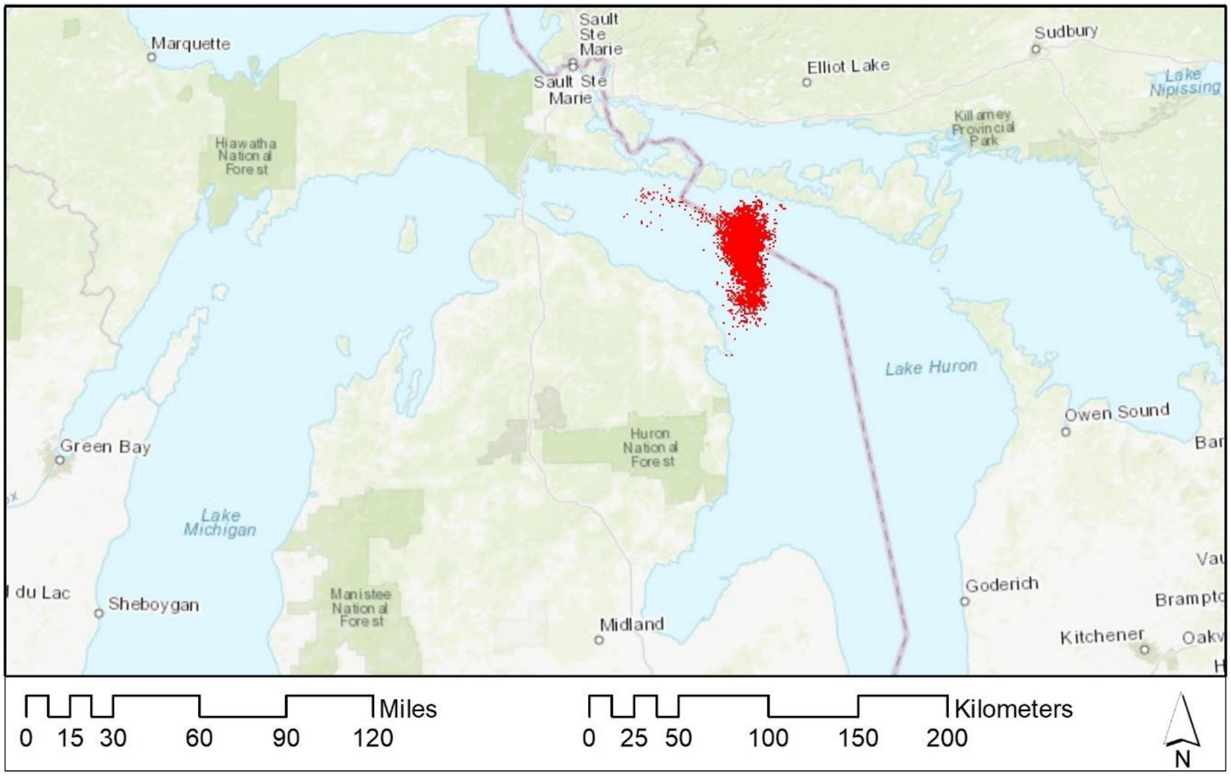


Figure A-B1-20. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for August.

Results depicted above represent a total surface area of 1317 km^2 following an oil release date and time of 08/21/2016 at 0600 hrs from the southern pipeline release point and a total dispersal simulation time of 15 days. The red particles represent dispersed oil.

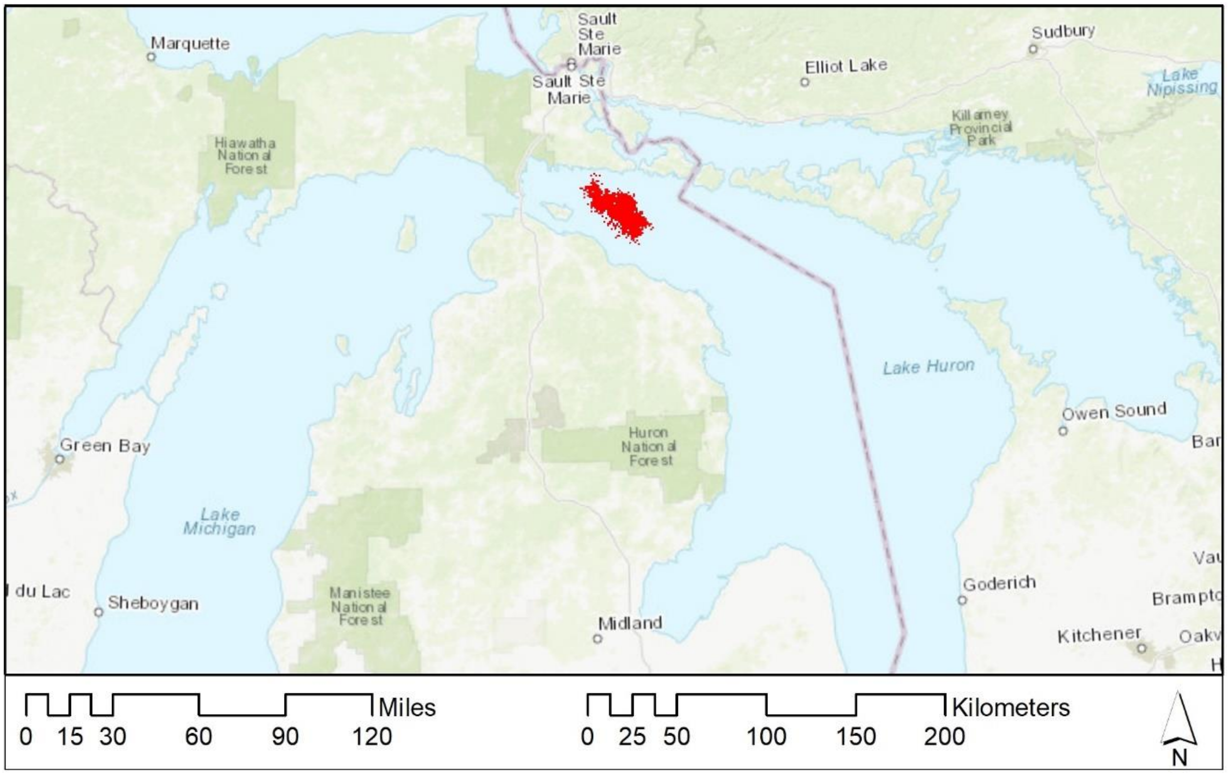


Figure A-B1-21. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for September.

Results depicted above represent a total surface area of 563 km^2 following an oil release date and time of 09/17/2016 at 0000 hrs from the southern pipeline release point and a total dispersal simulation time of 6 days. The red particles represent dispersed oil.

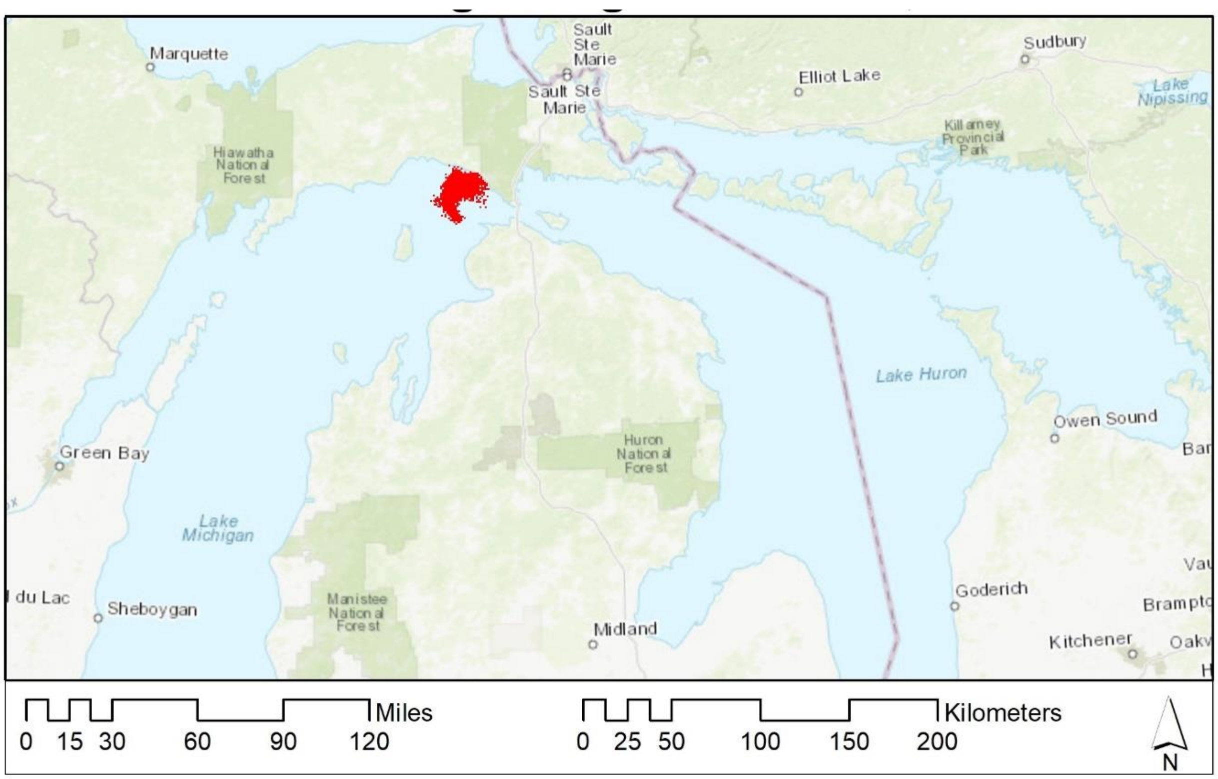


Figure A-B1-22. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for October.

Results depicted above represent a total surface area of 494 km^2 following an oil release date and time of 10/26/2016 at 0000 hrs from the central pipeline release point and a total dispersal simulation time of 6 days. The red particles represent dispersed oil.

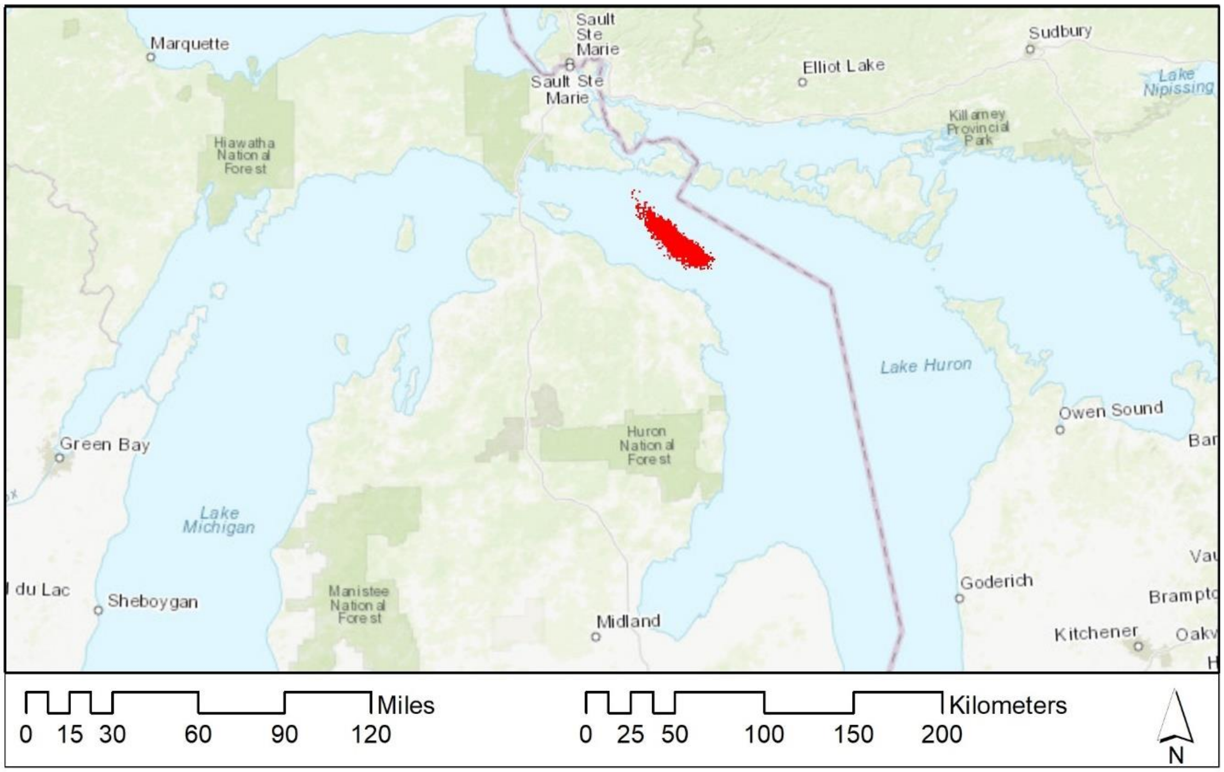


Figure A-B1-23. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for November.

Results depicted above represent a total surface area of 572 km^2 following an oil release date and time of 11/29/2016 at 1800 hrs from the central pipeline release point and a total dispersal simulation time of 6 days. The red particles represent dispersed oil.

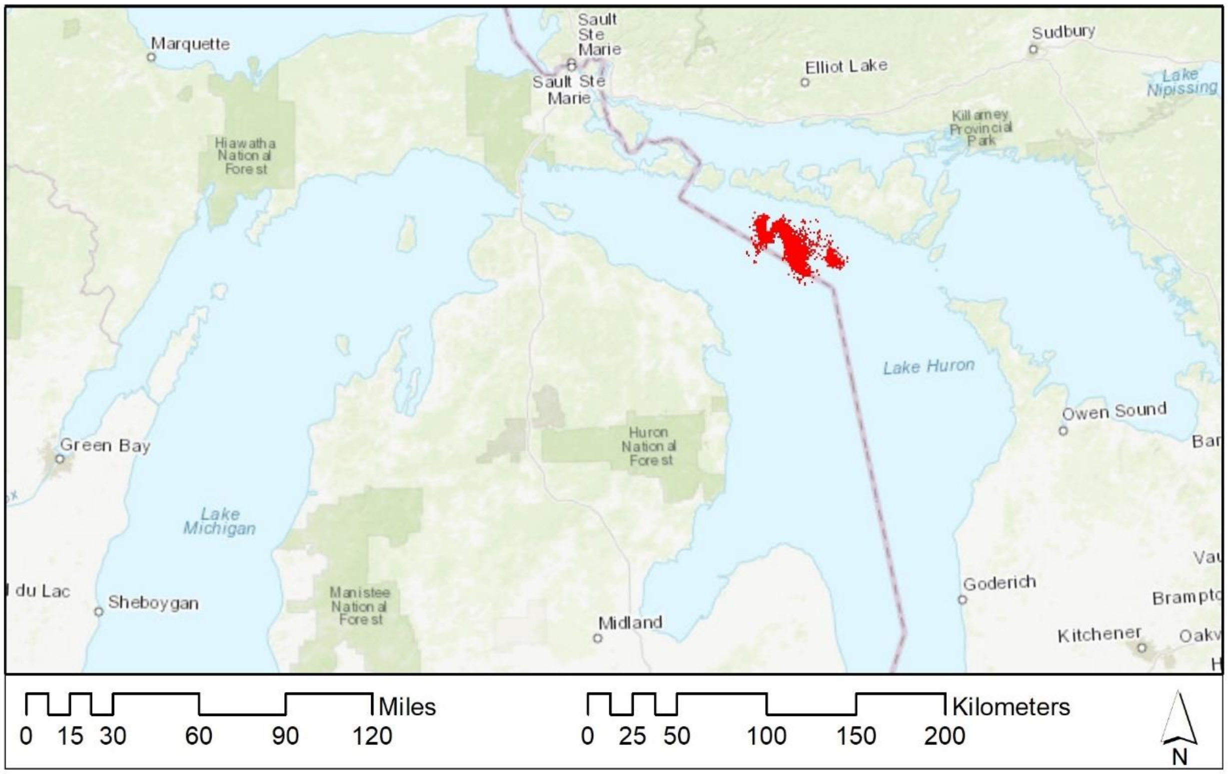


Figure A-B1-24. Maximum Extent of Surface Area Oiling (km^2) Predicted for the Straits of Mackinac and Adjacent Lake Michigan and Huron Regions as Associated with the Meteorological, Ice Cover and Water Current Conditions Observed for December.

Results depicted above represent a total surface area of 723 km^2 following an oil release date and time of 12/13/2016 at 1800 hrs from the northern pipeline release point and a total dispersal simulation time of six days. The red particles represent dispersed oil.

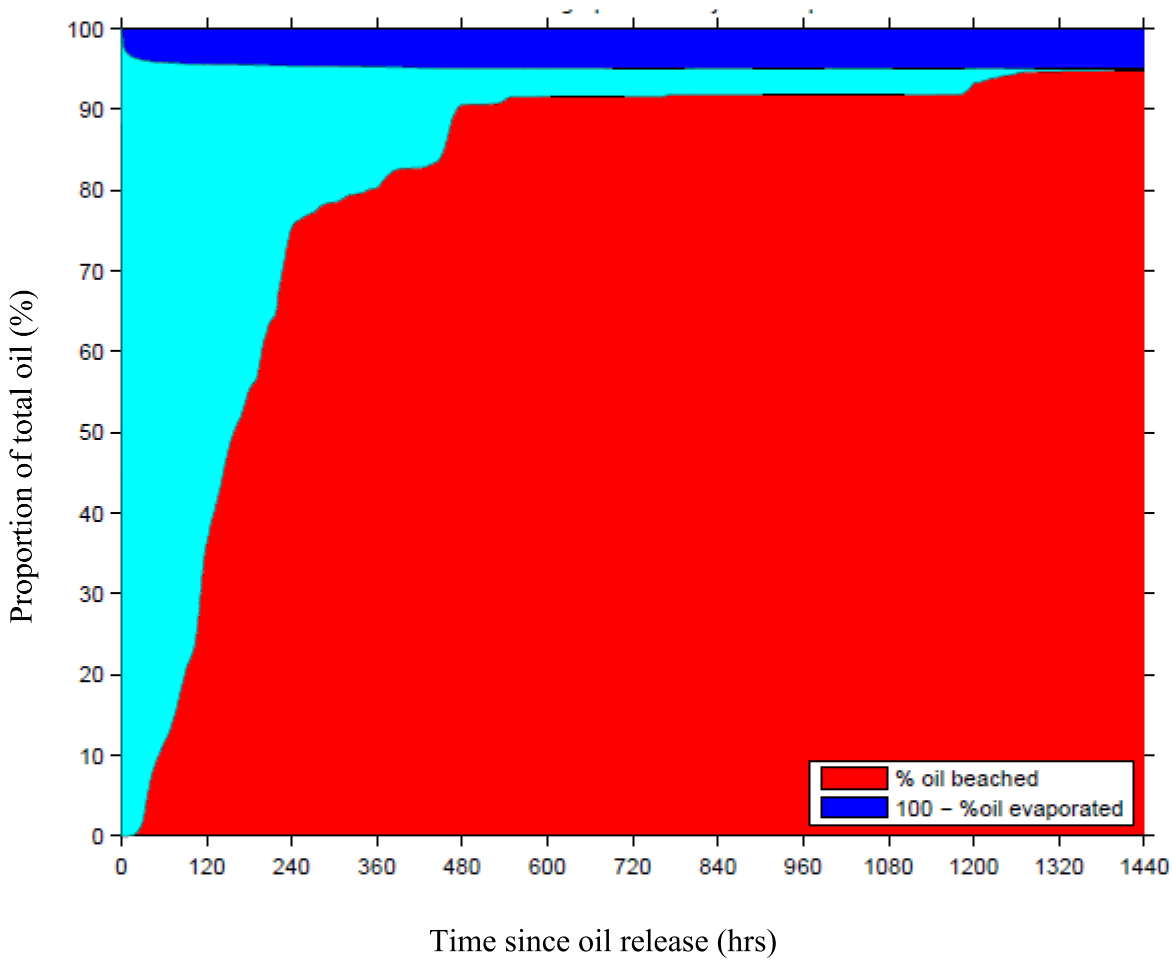


Figure A-B1-25. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for January

The shaded red area represents the proportion (%) of oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on January 20, 2016, at 12:00 am.

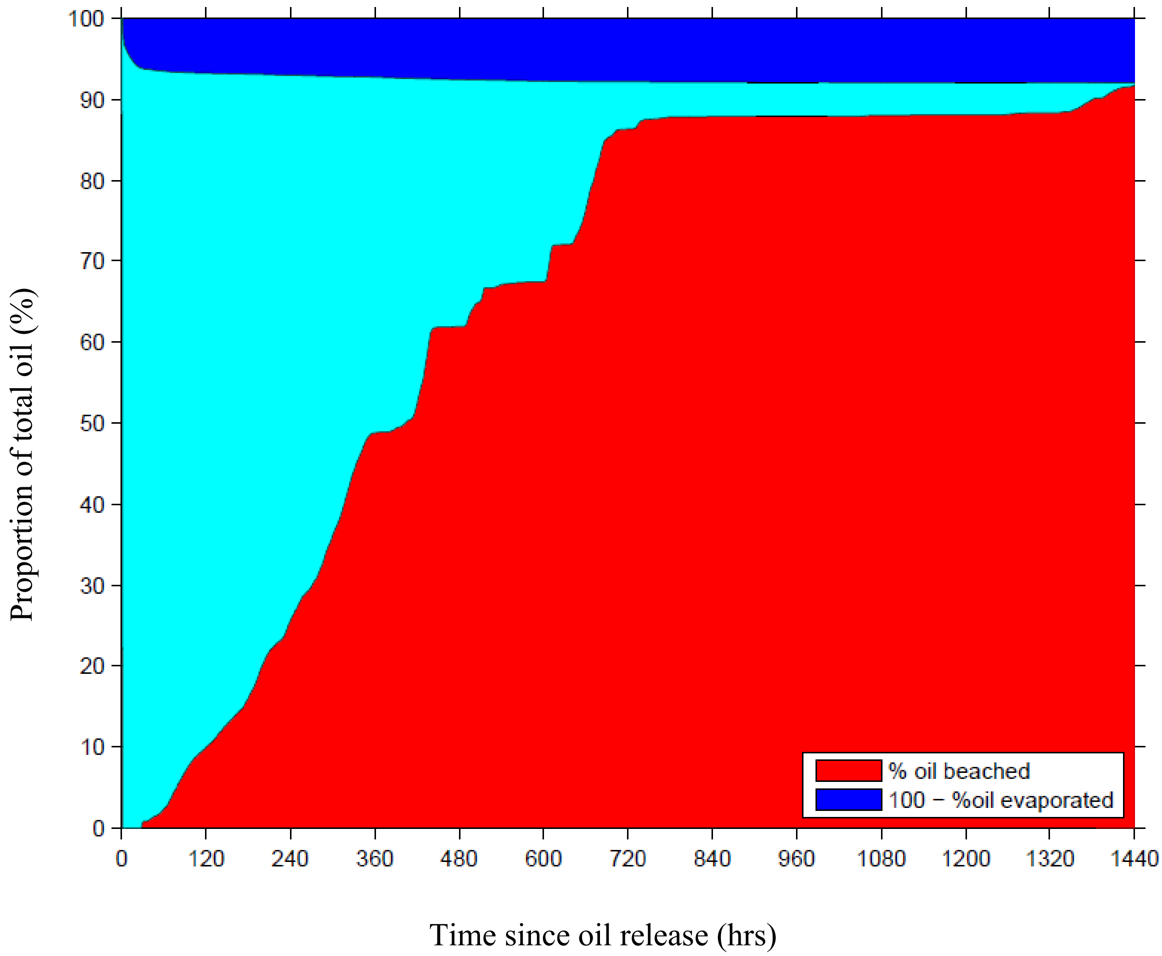


Figure A-B1-26. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for February

The shaded red area represents the proportion (%) of total released oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on February 28, 2016, at 12:00 pm.

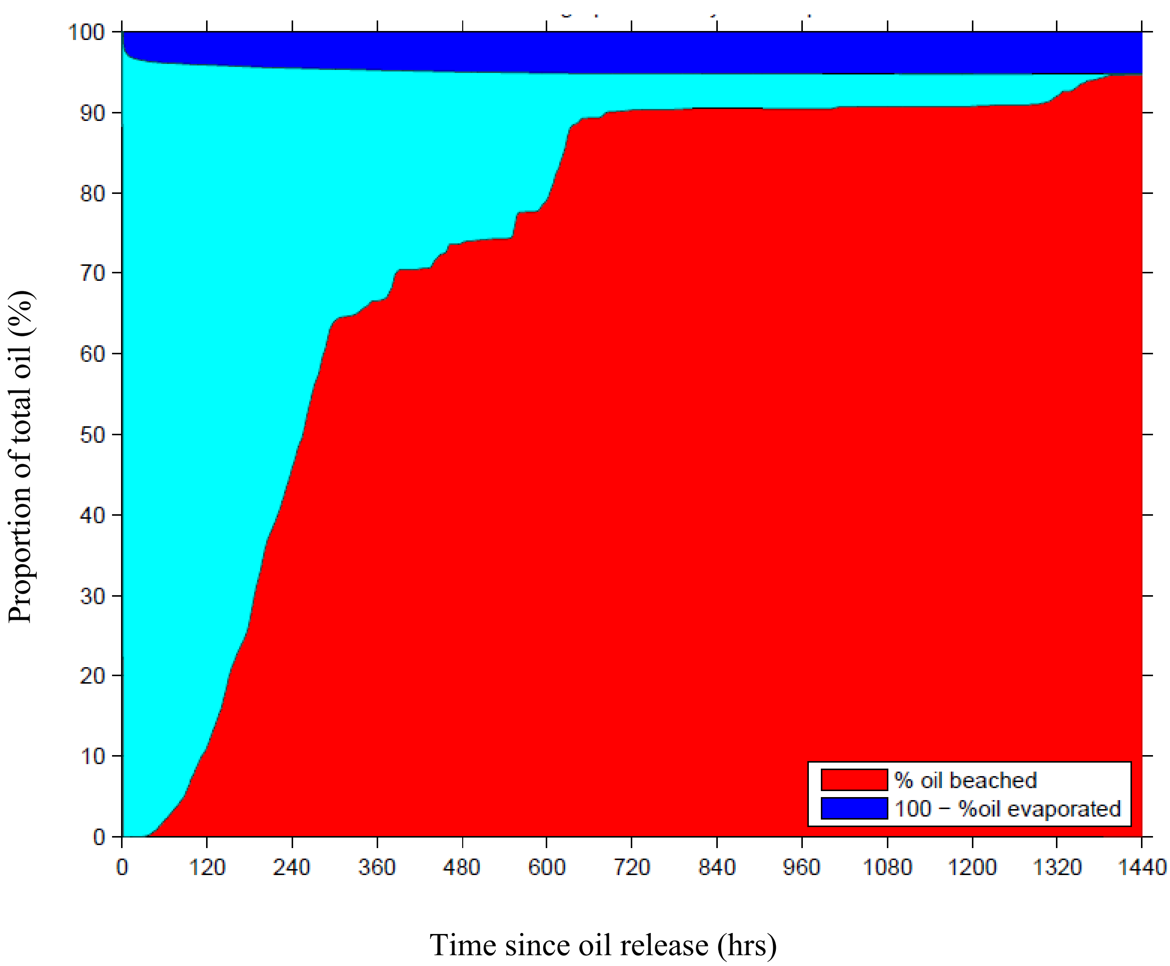


Figure A-B1-27. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for March

The shaded red area represents the proportion (%) of total released oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of total released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on March 1, 2016, at 6:00 pm.

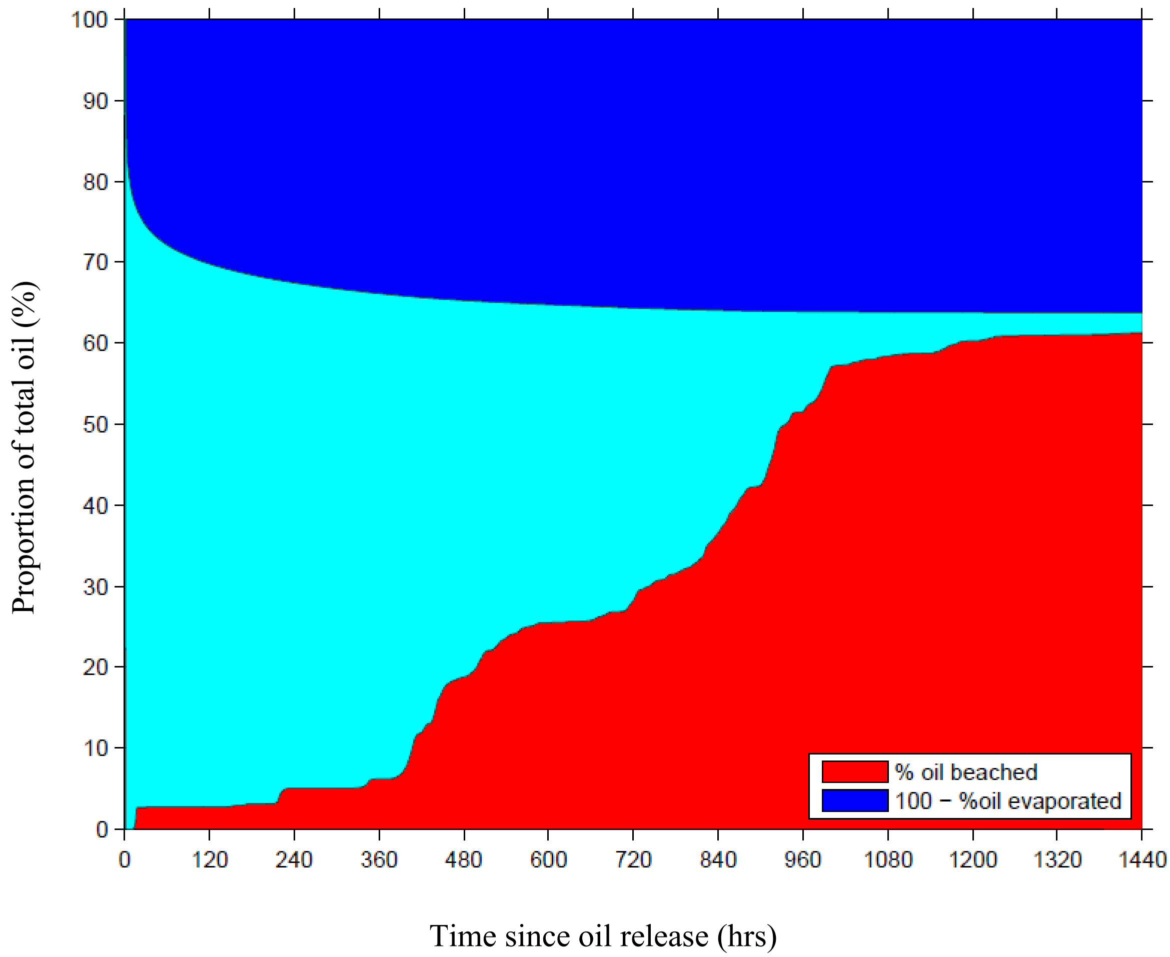


Figure A-B1-28. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for April

The shaded red area represents the proportion (%) of total released oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of total released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on April 24, 2016, at 6:00 pm.

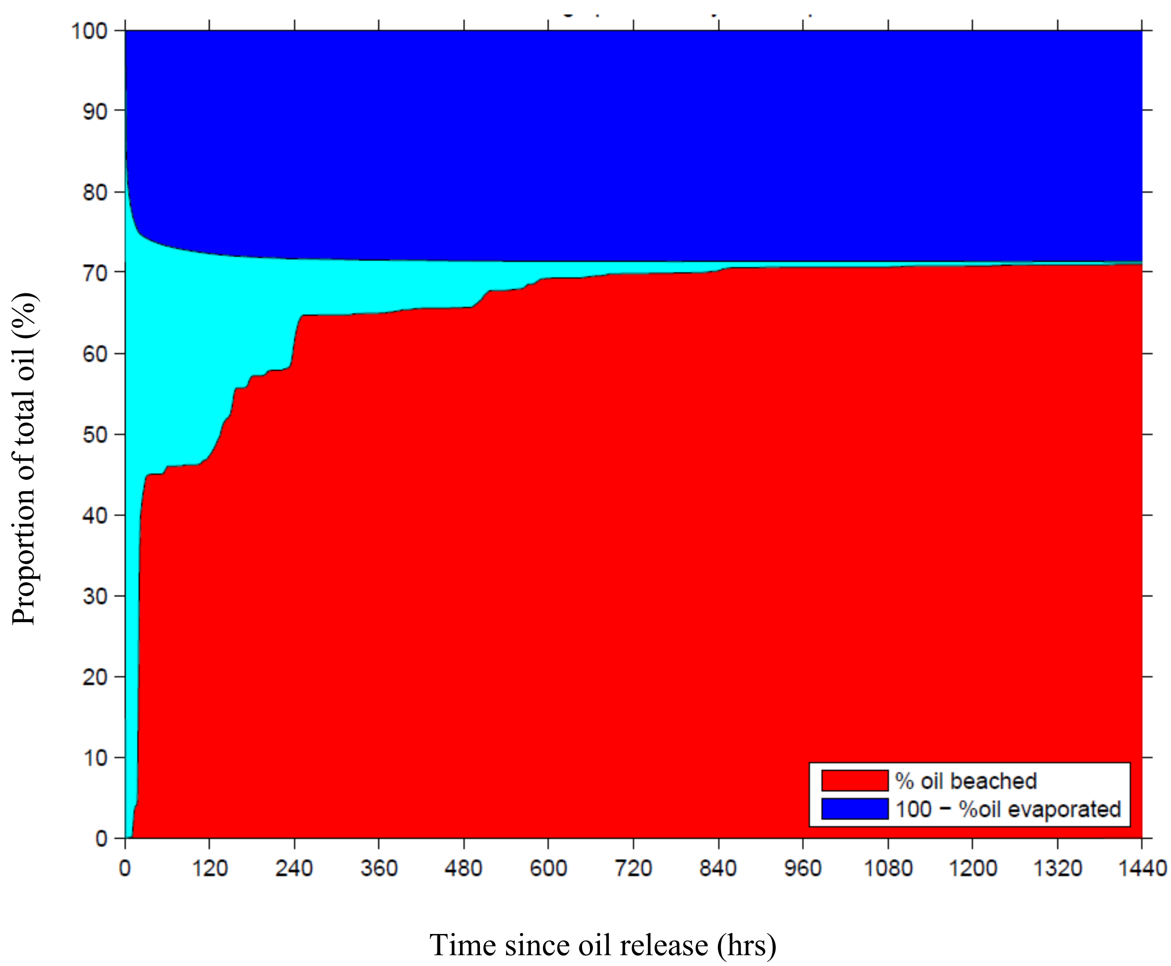


Figure A-B1-29. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for May

The shaded red area represents the proportion (%) of total released oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of total released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on May 12, 2016, at 12:00 pm.

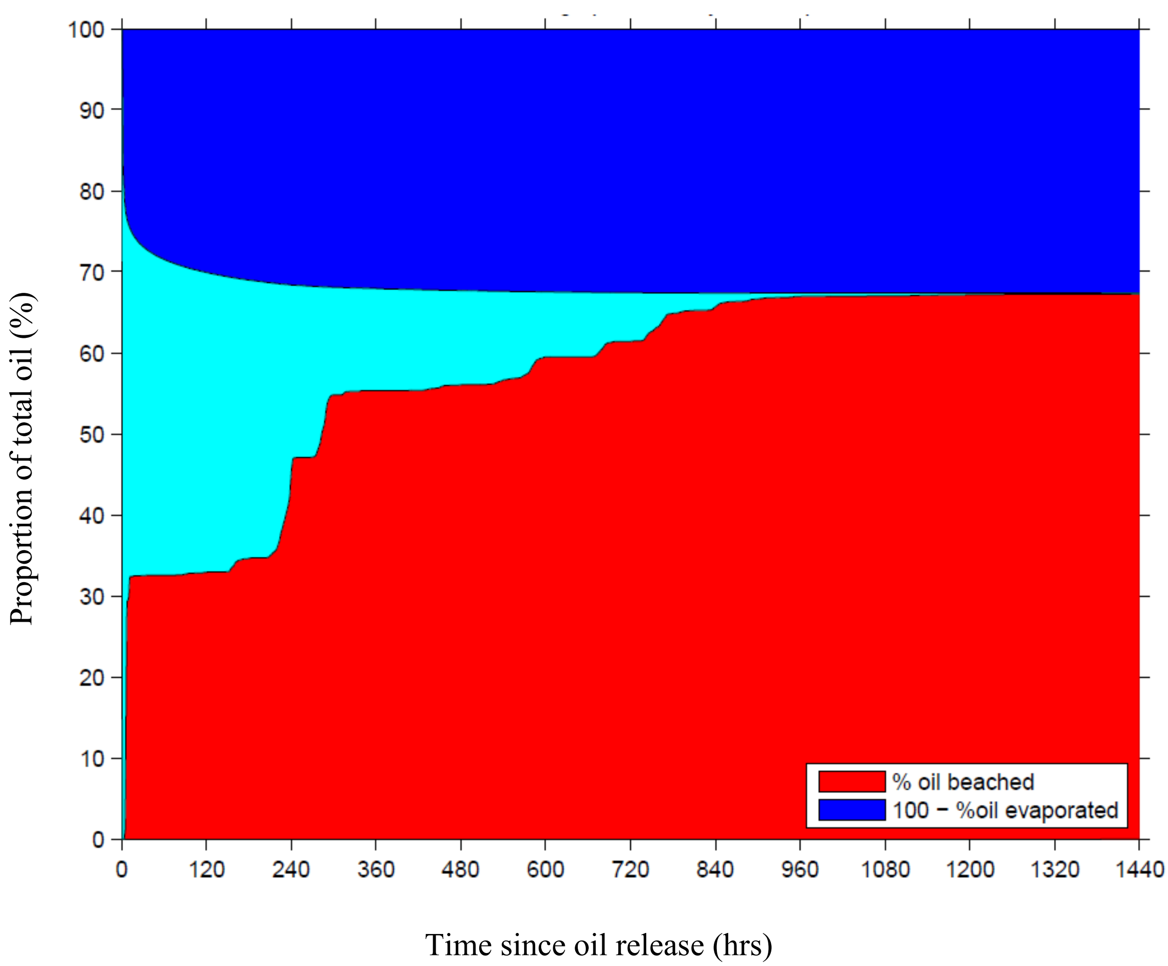


Figure A-B1-30. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for June

The shaded red area represents the proportion (%) of total released oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of total released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on June 20, 2016, at 12:00 am.

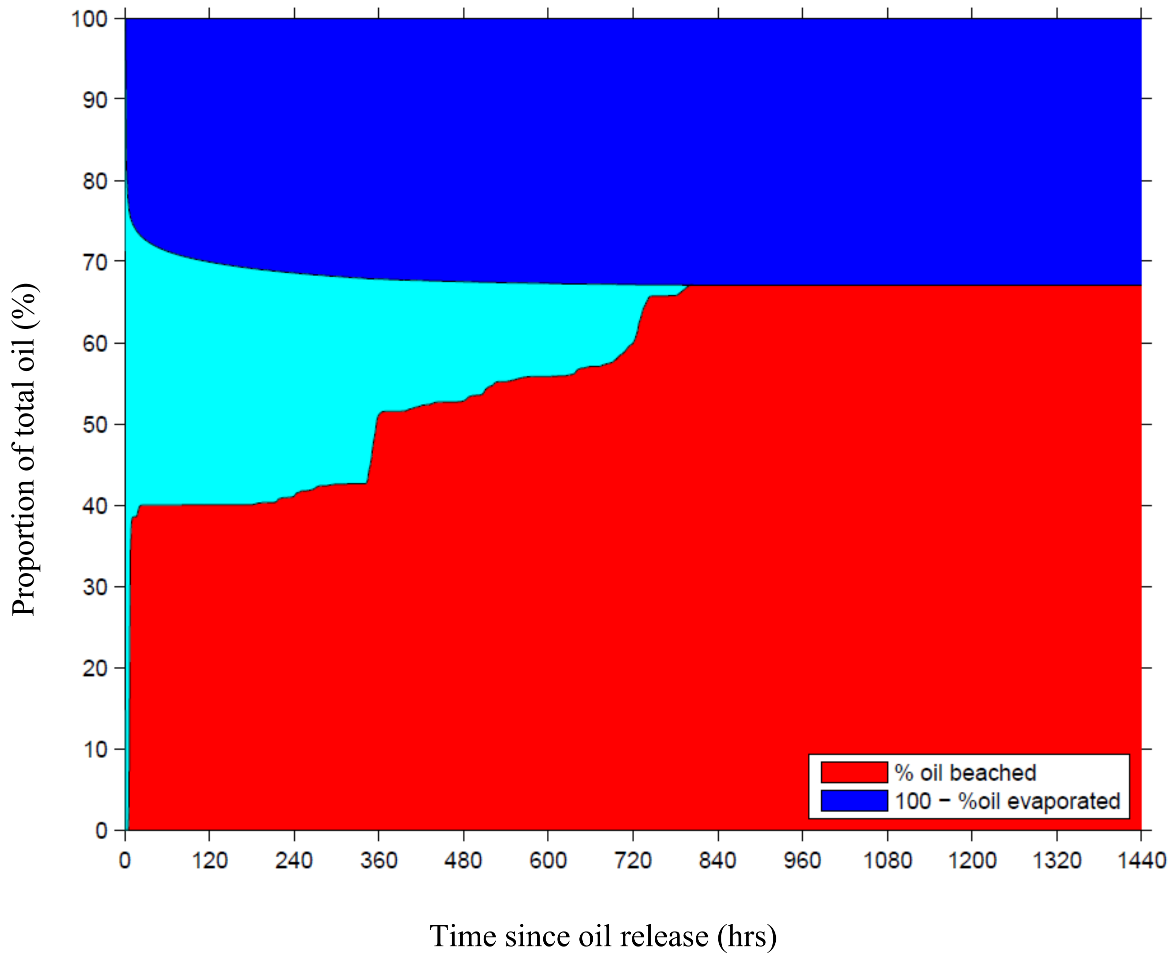


Figure A-B1-31. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for July

The shaded red area represents the proportion (%) of total released oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of total released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on July 21, 2016, at 6:00 pm.

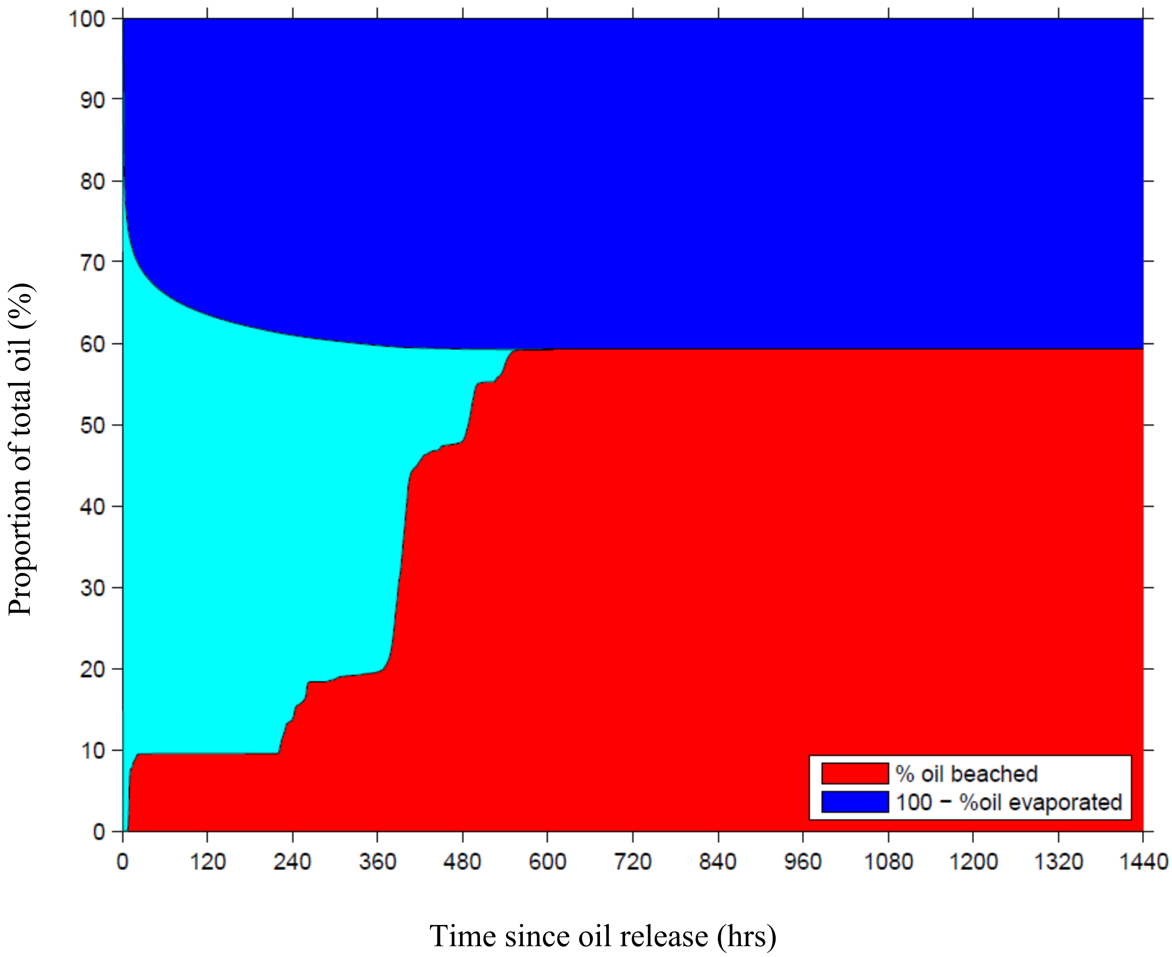


Figure A-B1-32. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for August

The shaded red area represents the proportion (%) of total released oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of total released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on August 21, 2016, at 6:00 am.

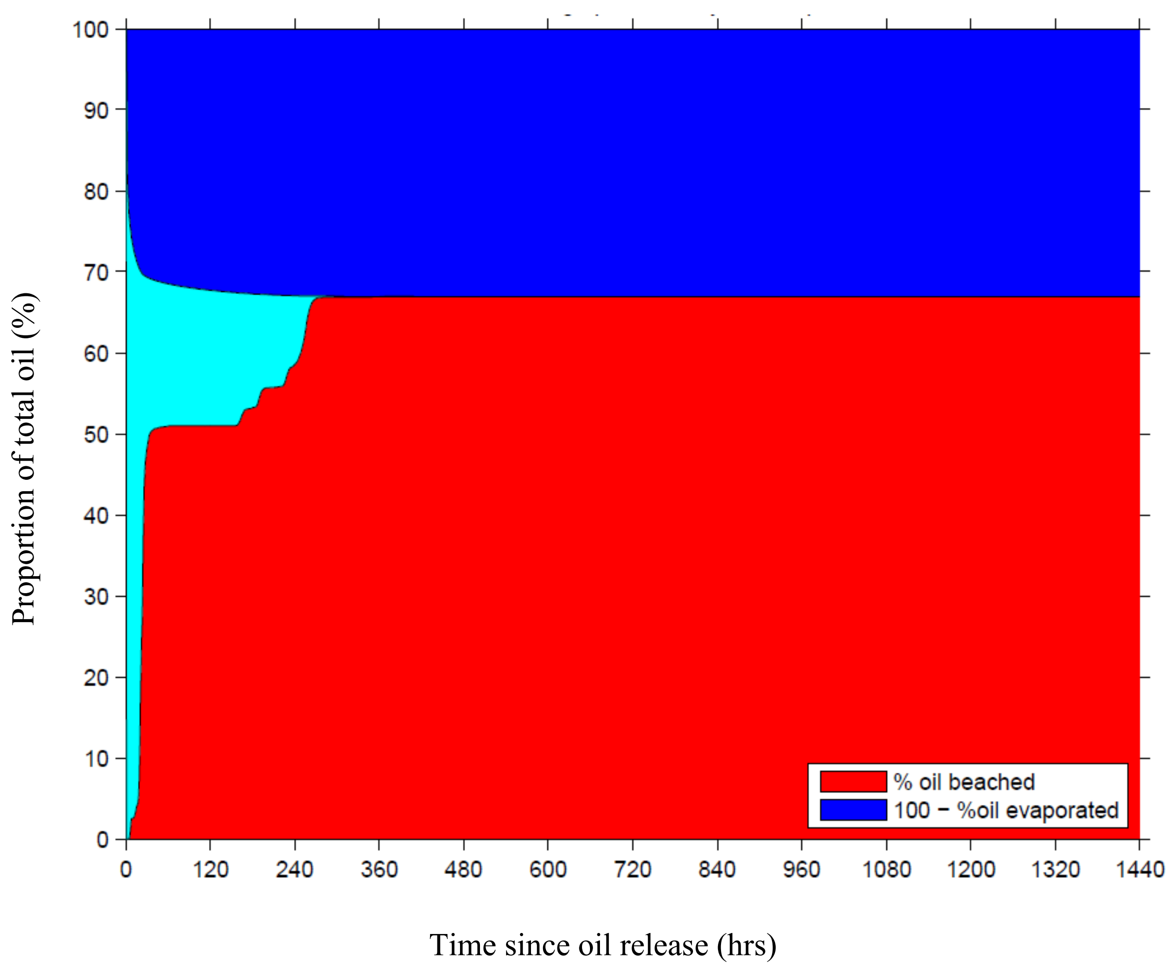


Figure A-B1-33. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for September

The shaded red area represents the proportion (%) of total released oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of total released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on September 17, 2016, at 12:00 am.

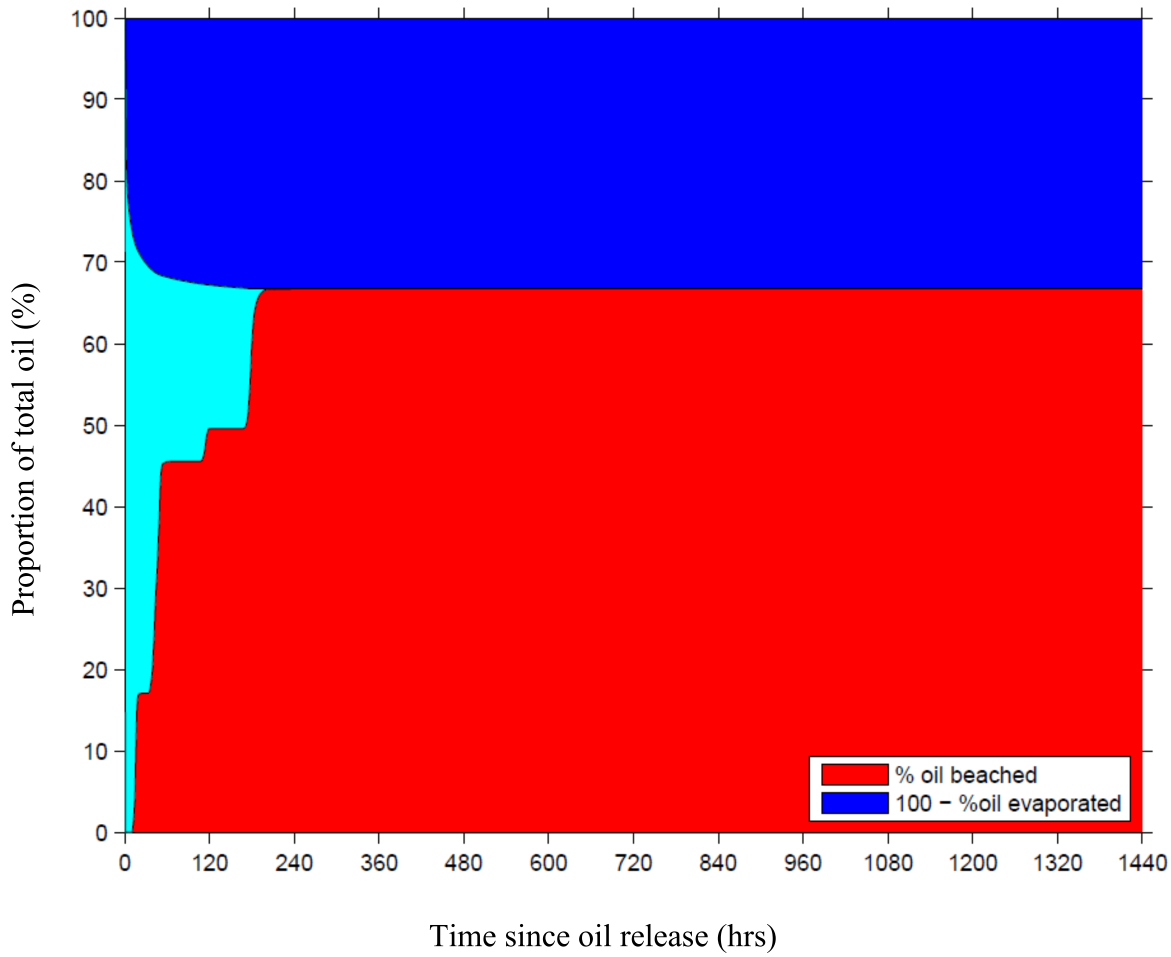


Figure A-B1-34. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for October

The shaded red area represents the proportion (%) of total released oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of total released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on October 8, 2016, at 12:00 am.

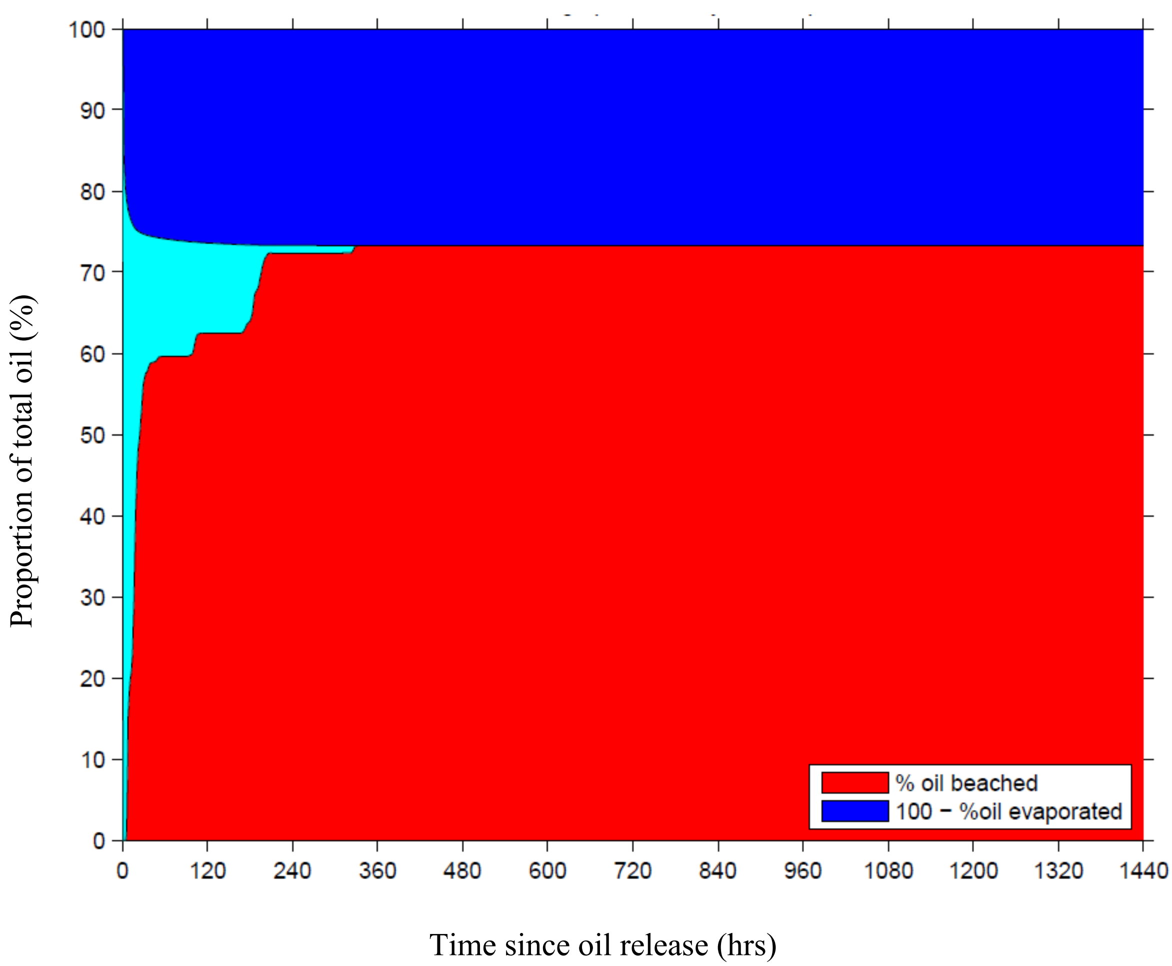


Figure A-B1-35. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for November

The shaded red area represents the proportion (%) of total released oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of total released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on November 30, 2016, at 12:00 am.

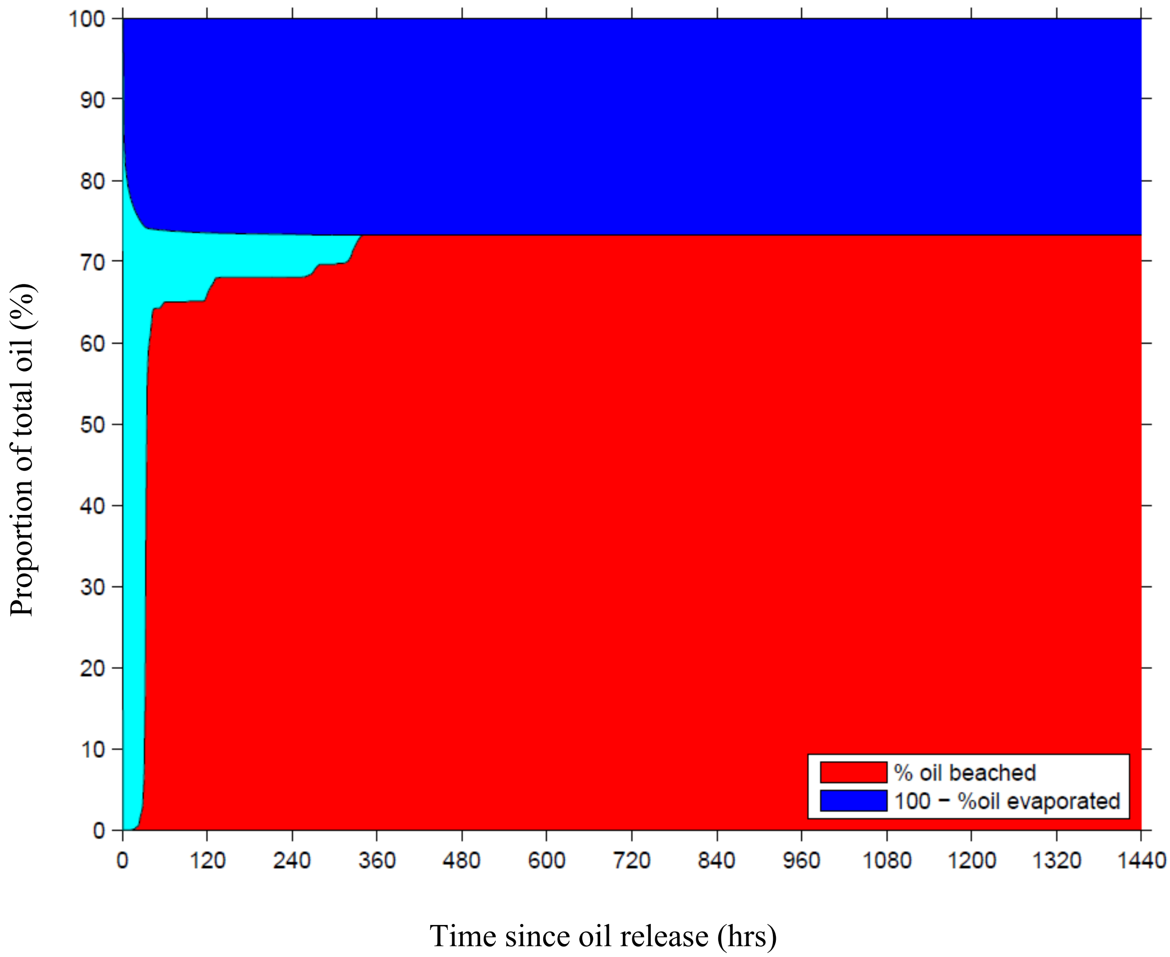


Figure A-B1-36. Temporal Fate of Worst Case (58,000 bbl) Oil Dispersal Simulation for December

The shaded red area represents the proportion (%) of total released oil that has become beached along coastal shorelines with the light blue shading indicating the proportion (%) of total released oil that remains afloat on the water surface. The dark blue shaded area at the top of the panel represents the proportion (%) of the total released oil that has evaporated since the time of release. The time since release represents a maximum dispersal time of 1440 hours (60 days). This scenario represents oil released on December 27, 2016, at 6:00 pm.

Appendix B-2 GIS Processing of FVCOM Modeling Results for Further Analysis

The Finite Volume Community Ocean Model (FVCOM) predictions of oiled shorelines and lake surface areas are output from the model as 1 x 1 km resolution gridded plots. These model outputs, described in Task B and summarized in Tables B3 and B4, were utilized directly for analyses focused on the amount and distribution of floating oil. They were also used to approximate relative severity for shoreline oiling, using the assumption that a 1 km grid cell that overlaps the shoreline contains approximately 1 km of shoreline, which helped in efficiently identifying the longest oiled shorelines for each month out of thousands of model runs.

For accurate analyses of oiled shoreline length, however, it was necessary to translate the fate and transport results from those 1 km gridded results to a high-resolution shoreline. As an example, Figure A-B2.1 below shows a closer view of the model results for the March worst-case scenario presented in Figure A-B1.3 in Appendix B1. The red points represent the centroids of 1 km grid cells where the model predicts shoreline oiling. The values in Table B3 of the main text represent shoreline length estimates in km corresponding to the total number of 1 km^2 grid cells in which the model predicts shoreline oiling. Figure A-B2.2 shows the same scenario, but with the points colored to represent the volume of oil that the model calculates would be beached in that area. These volumes account for evaporation.

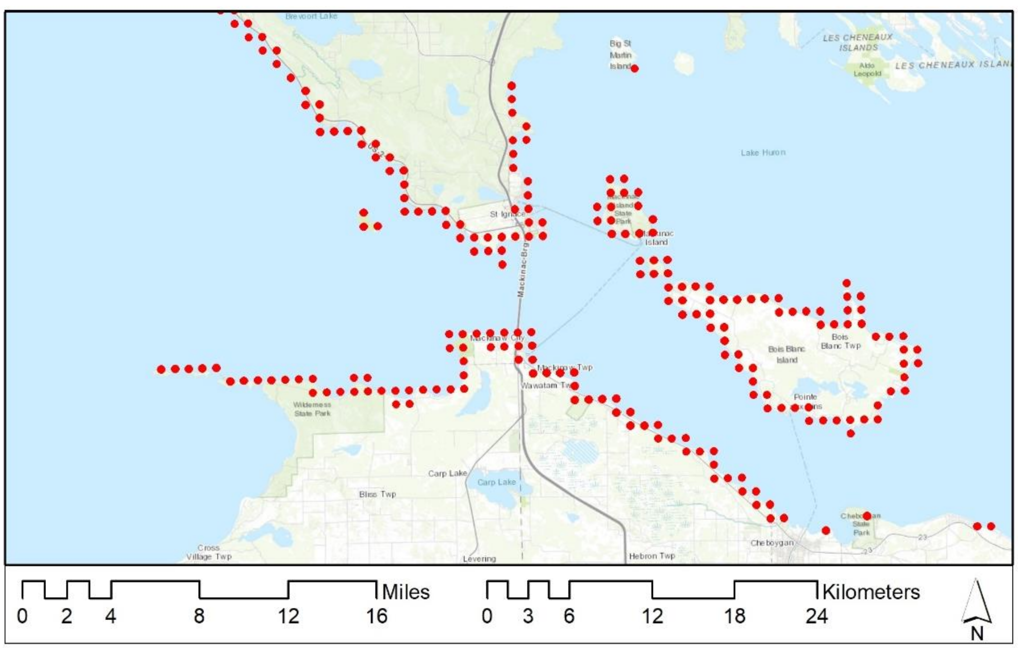


Figure A-B2.1. Zoomed Maximum Extent of Shoreline Oiling (km) Predicted for the Straits of Mackinac for the Meteorological, Ice Cover and Water Current Conditions Observed for March 2016

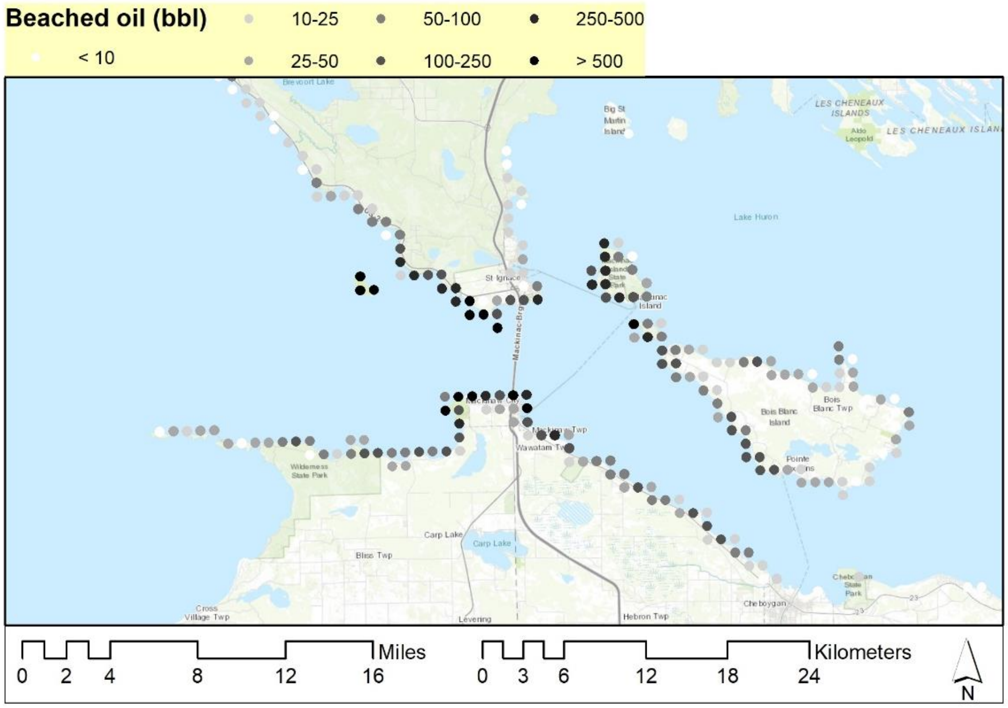


Figure A-B2.2. March Worst-case Model Output (same as Figure A-B2-1) Symbolizing Model Volume Estimation of Beached Oil

For more accurate estimations of damages, it was necessary to translate the grid to a high-resolution shoreline while conserving the total volume and spatial distribution of oil in the model results. The Great Lakes shoreline shapefile produced by the Great Lakes Aquatic Habitat Framework (GLAHF) harmonizes existing shoreline classifications from the National Oceanic and Atmospheric Administration's Environmental Sensitivity Index and the Environment Canada's Environment Sensitivity Atlas. This shapefile was used as the high-resolution shoreline classification layer because it consistently identifies broad shoreline types (Artificial, Coarse-grain flat coast, Coastal wetland / riparian, Mixed beach, Rocky cliffs, Sand beach, and Sediment Scarp) across both the US and Canadian Great Lakes shorelines. Figure A-B2.3 shows the classified GLAHF shoreline for the Straits area.

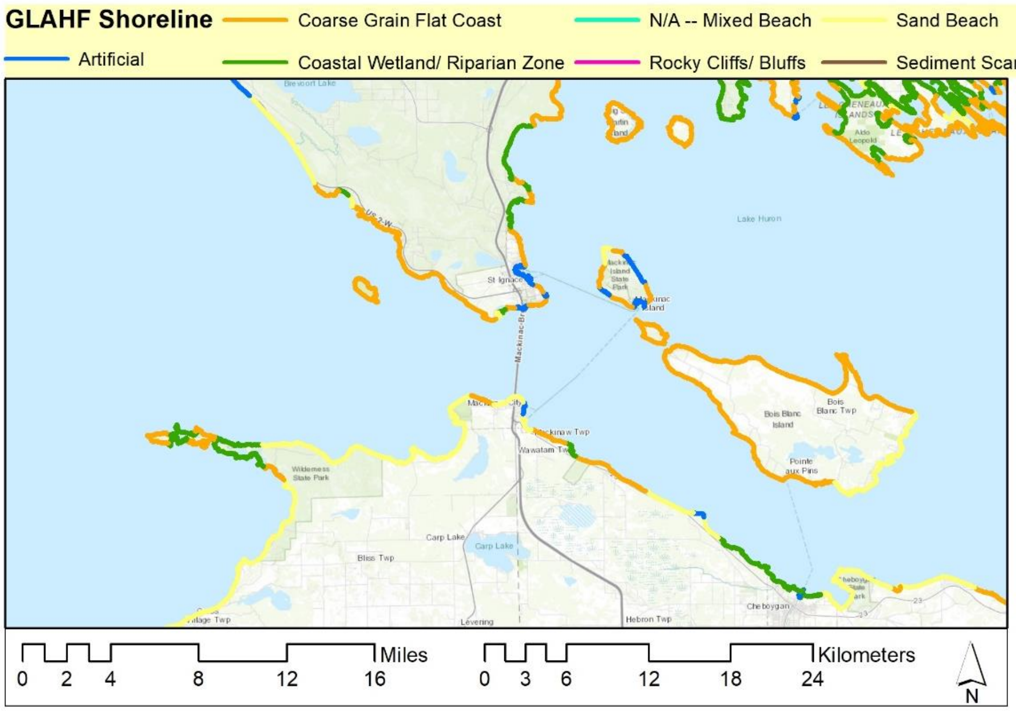


Figure A-B2.3. GLAHF's Harmonized GIS Layer of Shoreline Classes for the Straits Area Along US and Canadian Great Lakes Shorelines

Geographic Information System (GIS) software was used to shift each grid centroid to the nearest point on the shoreline. Then, each centroid was associated with the length of shoreline that was closer to that centroid than to any other centroid using Thiessen polygons. GIS software can generate Thiessen polygons for a point layer; any location within a Thiessen polygon is closer to its associated point than to any other point feature. Mathematically, they are defined by the perpendicular bisectors of the lines between all points. Finally, the volume of oil provided by the FVCOM model for each centroid was divided by the length of the shoreline associated with the centroid (i.e., the length of the shoreline that falls within the Thiessen polygon) to obtain shoreline oiling severity in bbl/km. Figure A-B2.4 shows the output for the March worst-case scenario example, overlaid with the Thiessen polygons for visualization purposes. For the March scenario, the 704 1-km grid cells for which the model predicted shoreline oiling correspond to 995.9 km of actual shoreline. Thus, the shoreline estimates used by Tasks C-H are generally higher than the values given in Table B3 due to shoreline sinuosity and the accurate inclusion of island shorelines.

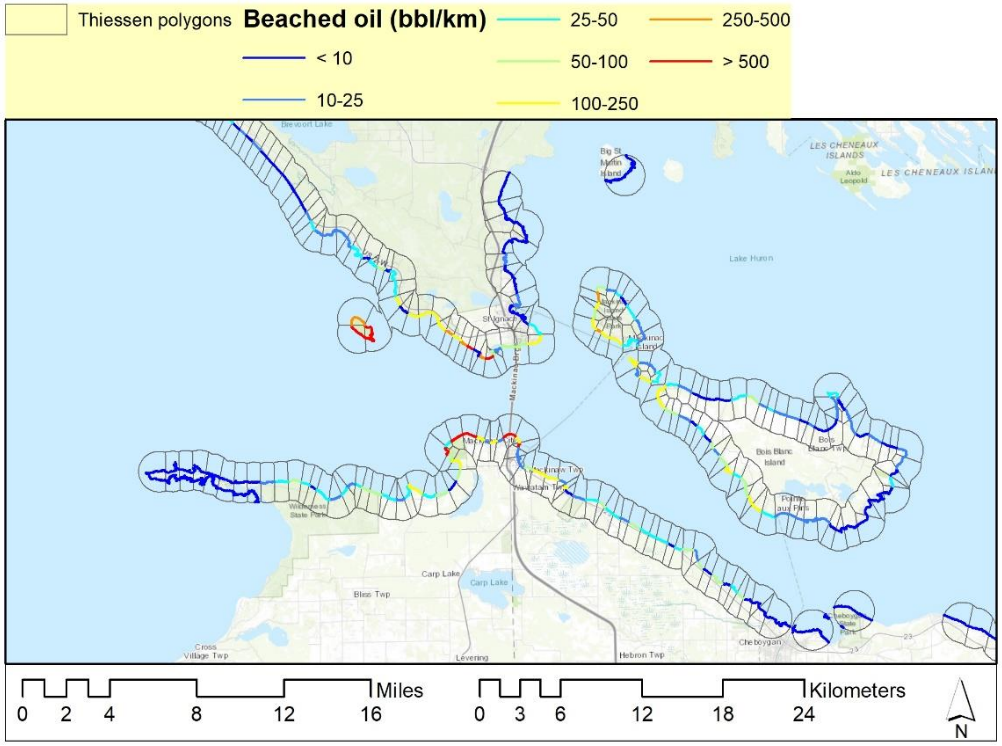


Figure A-B2.4. Beached Oil bbl/km Shoreline Estimates for the March Worst-Case Scenario Example

Derived by translating the FVCOM model results to the high-resolution great lakes shoreline. The Thiessen polygons (black outlines) represent the areas over which the modeled oil volumes associated with grid centroids, shown in Figure A-B2.2 were distributed.

For some analysis tasks, estimates of the thickness or concentration of beached oil on the shoreline were needed. To estimate beached oil thickness, an assumed shoreline width was defined for each type of shoreline in the GLAHF classification. These shore width values are consistent with assumptions that have been used for other oil transport modeling efforts (e.g., Farrar et al. 2005, Horn et al. 2015) and are presented in Table A-B2-1. To convert thickness to a concentration in units of g/m^2, a specific gravity of 0.86 was assumed based on information provided by Enbridge regarding the characteristics of the products transported in Line 5.

Table A-B2-1. Shoreline widths assumed for different Great Lakes shoreline classes in order to convert beached oil estimates from bbl/km to thickness and grams per square meter.

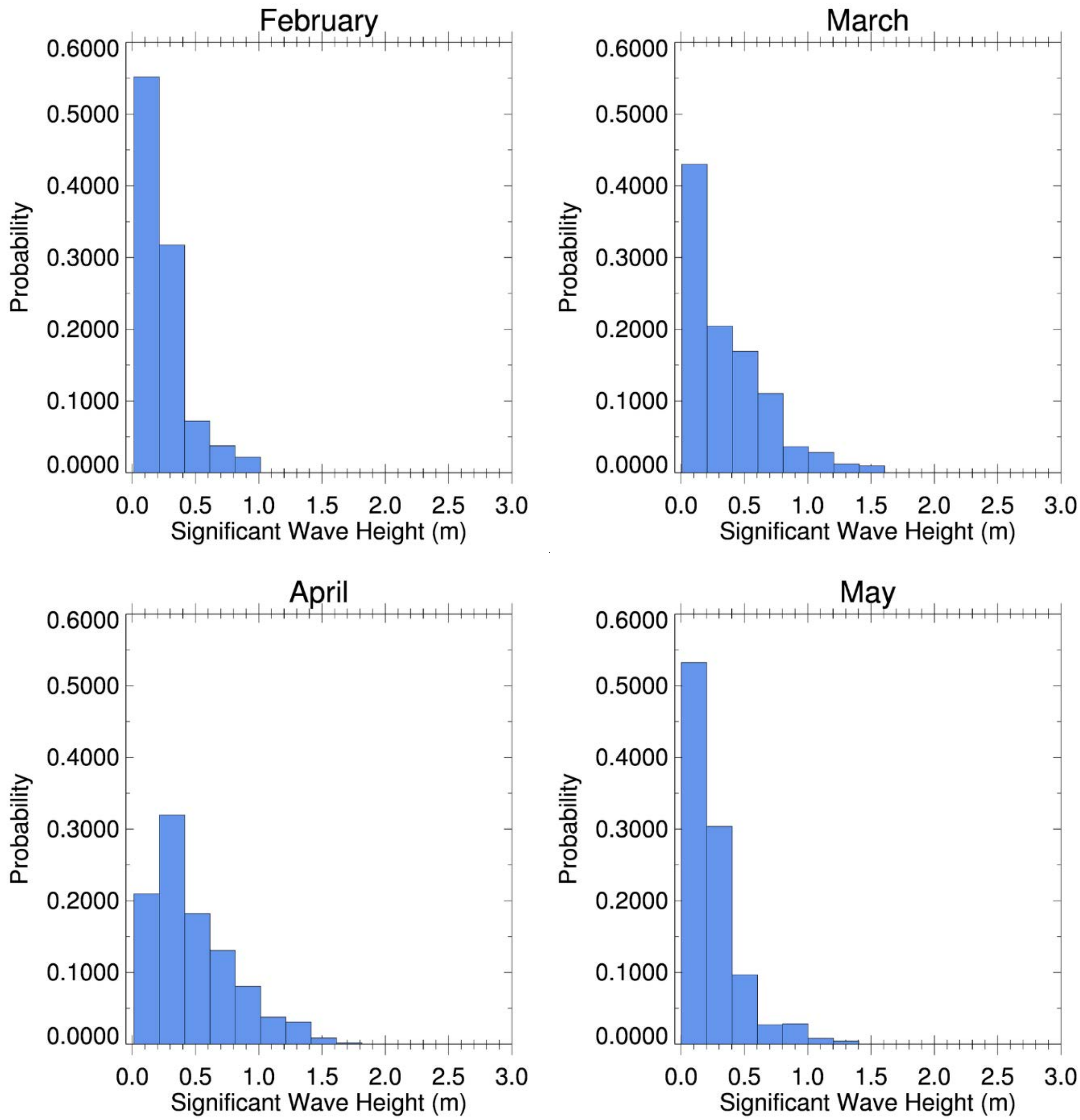
GLAHF Shoreline Class	Shore Width (m)
Artificial	0.5
Coarse Grain Flat Coast	1
Coastal Wetland/Riparian Zone	20
Mixed Beach	2
Rocky Cliffs/Bluffs	0.5
Sand Beach	5
Sediment Scarp	2

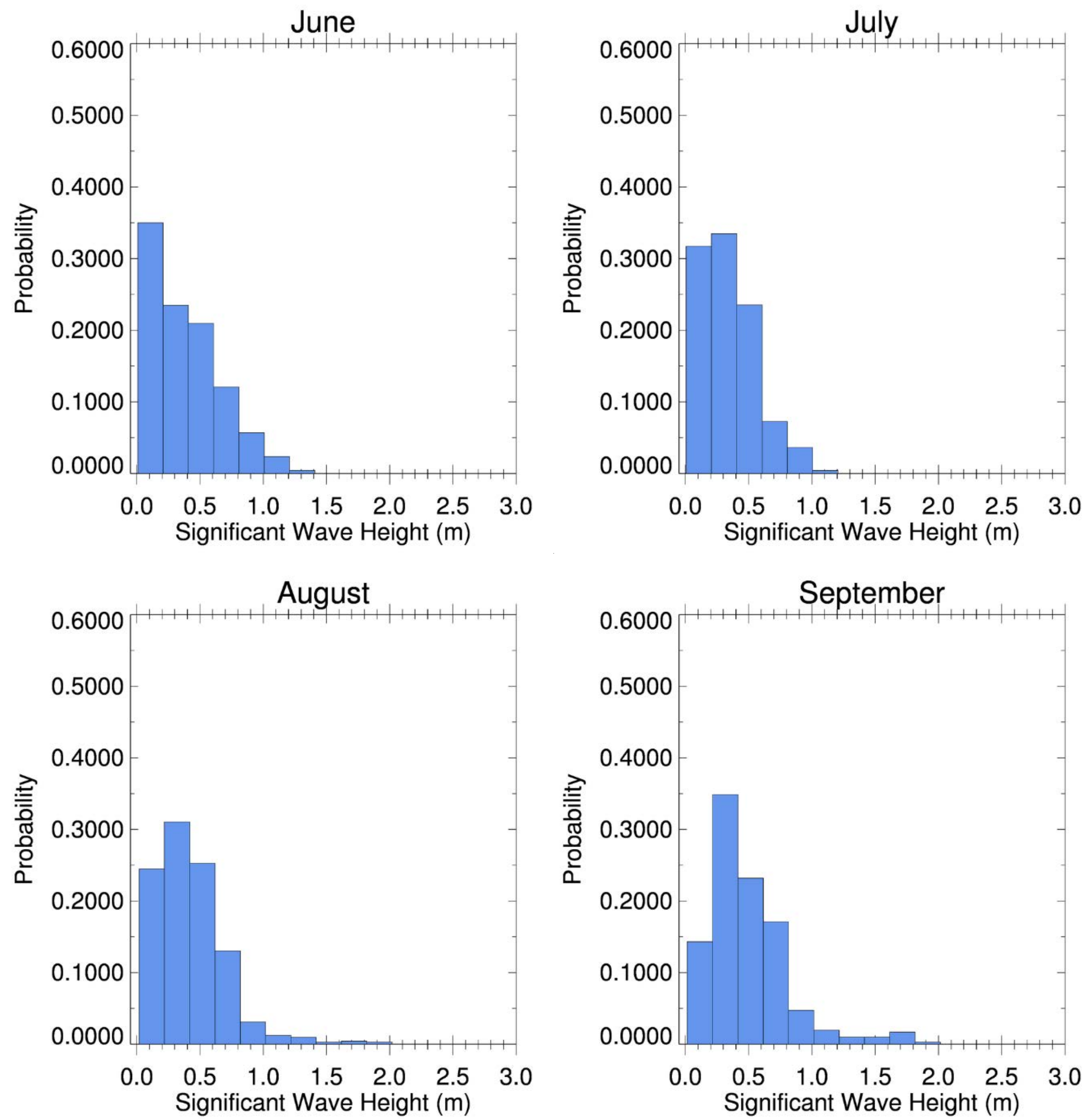
References

Farrar, W., Galagan, C., Isaji, T., & Knee, K. (2005). GIS technology applied to modeling oil spills on land. In *25th Annual Esri International User Conference. San Diego, California: http://proceedings. esri. com/library/userconf/proc05* (Vol. 20).

Horn, M., Fontenault, J., & Ducharme, J. (2015). *Evaluation of the Fate and Effects of Pipeline Releases Along the Enbridge Line 3 Replacement Program for the Ecological and Human Health Risk Assessment. Final Report.* Sourth Kingstown, RI: RPS ASA.

Appendix C-1 Wave and Current Data




June
July
August
September
Probability
Significant Wave Height (m)
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
0.0
0.5
1.0
1.5
2.0
2.5
3.0

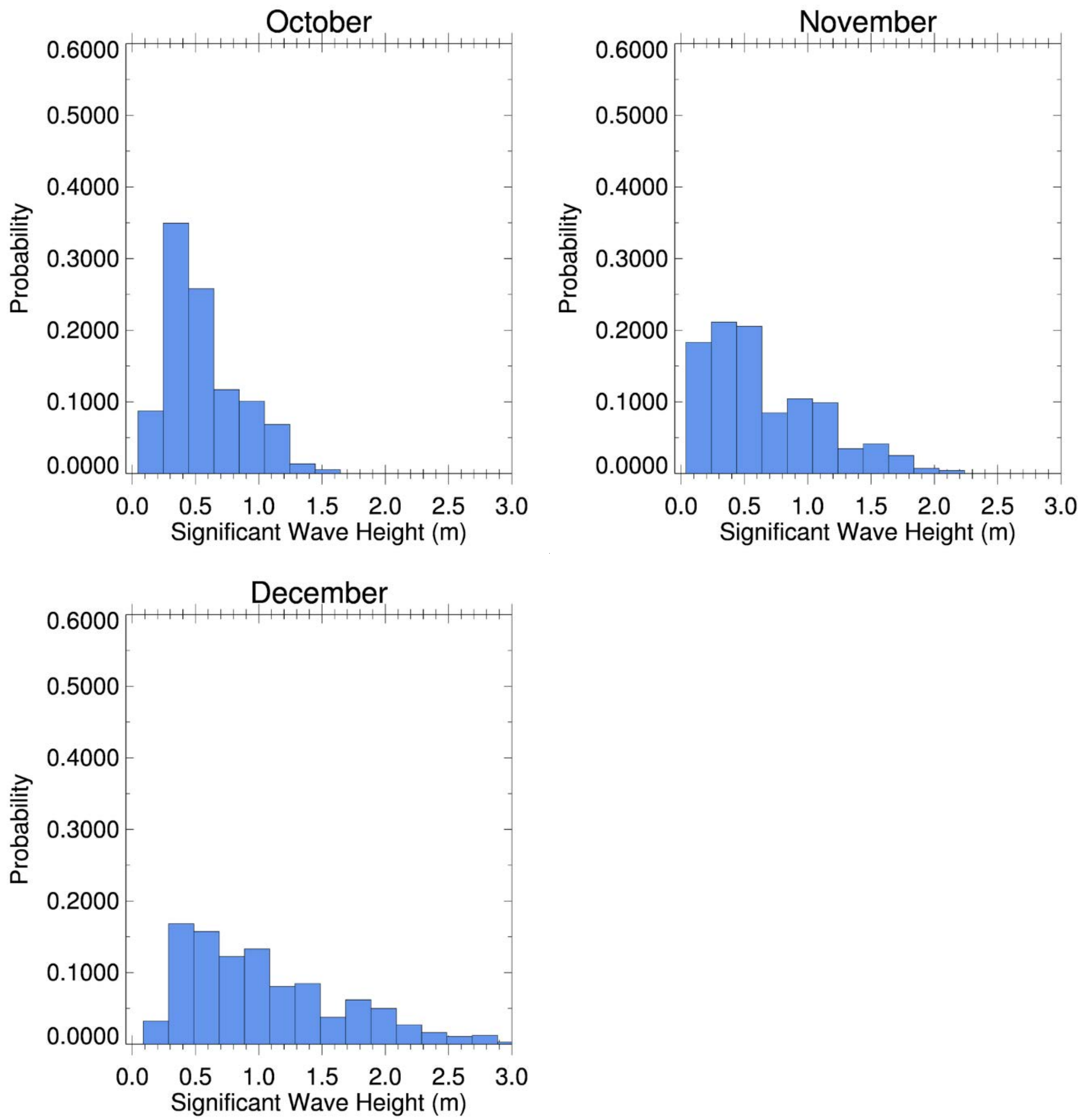
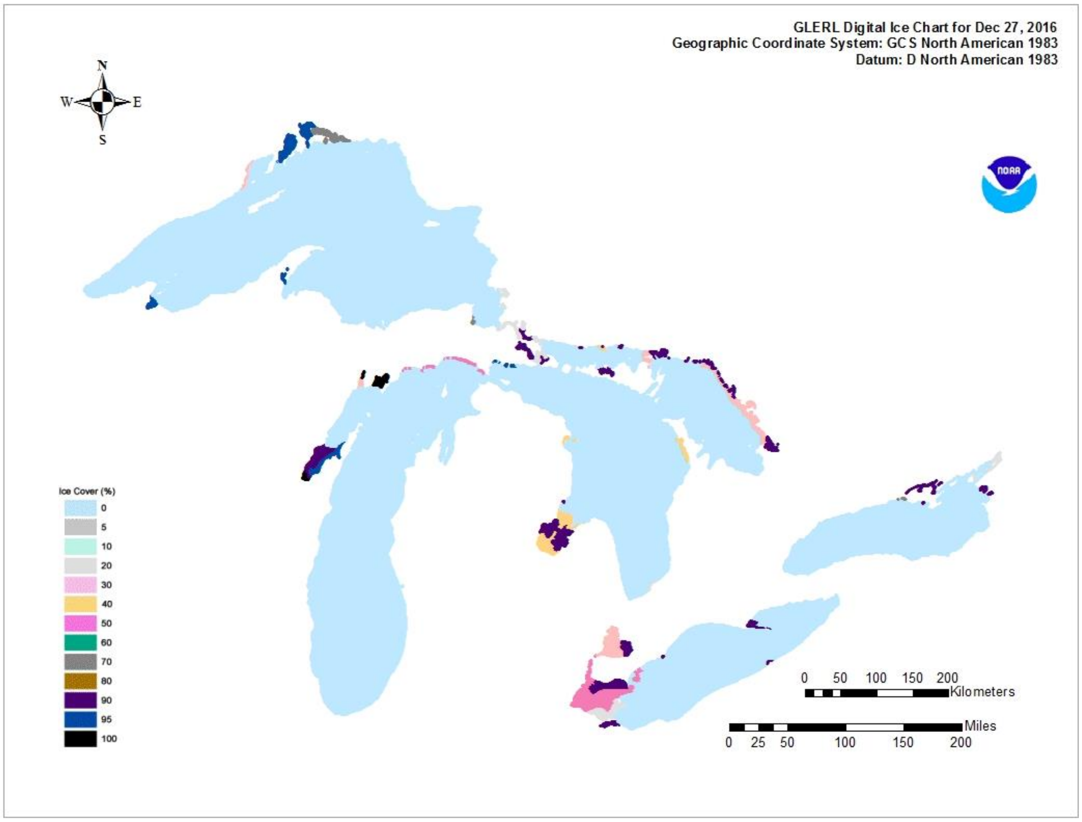
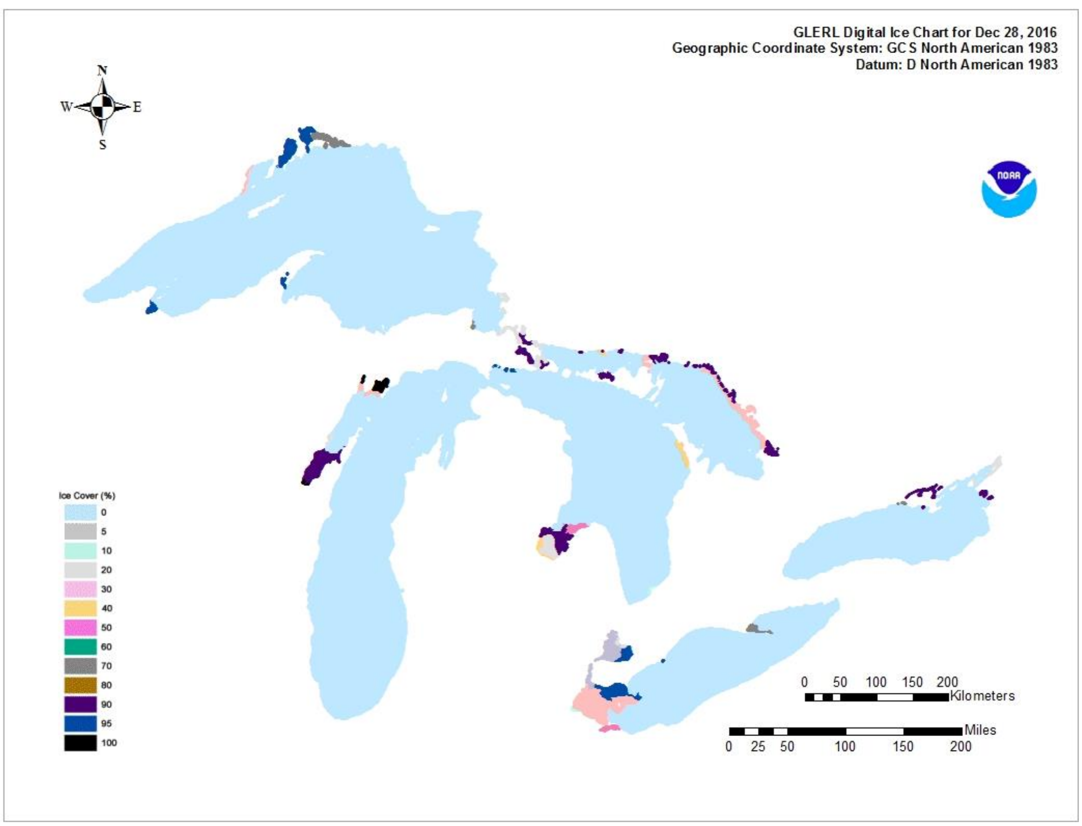
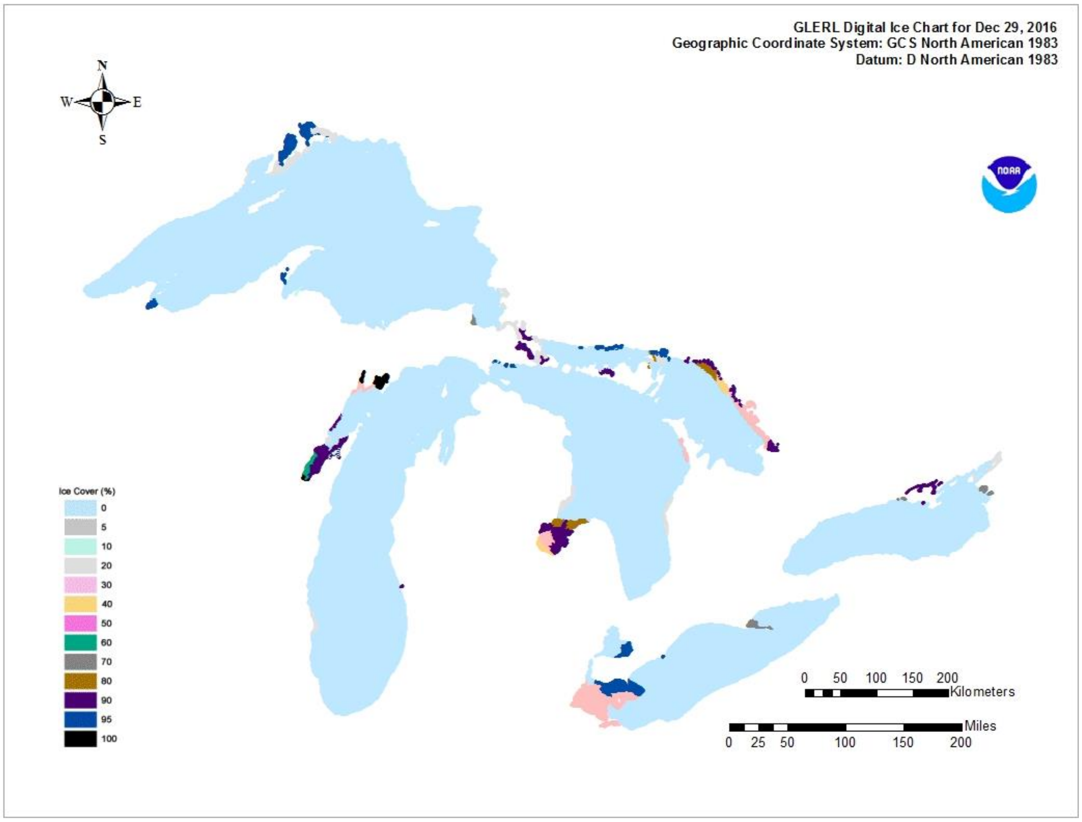
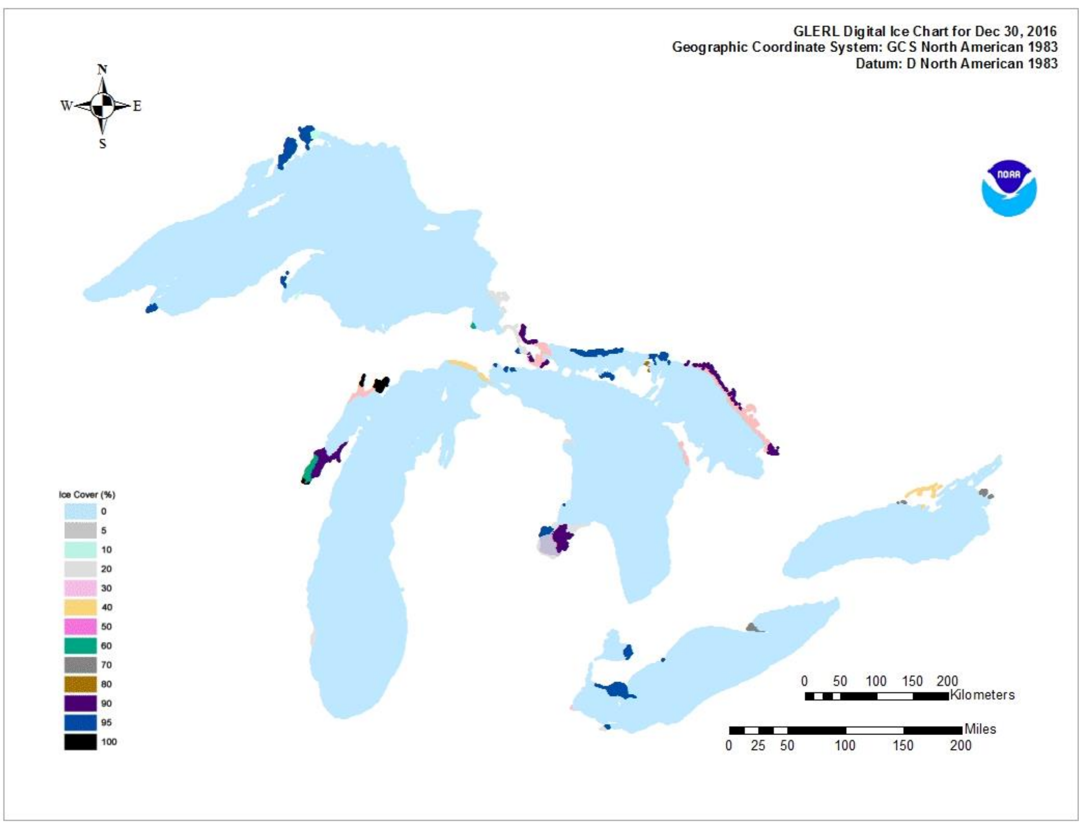


Figure A-C1-1. Monthly Histograms of 2016 Wave Heights for the Straits of Mackinac


GLERL Digital Ice Chart for Dec 27, 2016
Geographic Coordinate System: GCS North American 1983
Datum: D North American 1983
N
W
E
S
Ice Cover (%)
0
5
10
20
30
40
50
60
70
80
90
95
100
0 50 100 150 200
Kilometers
Miles
0 25 50 100 150 200


GLERL Digital Ice Chart for Dec 28, 2016
Geographic Coordinate System: GCS North American 1983
Datum: D North American 1983
N
W
E
S
Ice Cover (%)
0
5
10
20
30
40
50
60
70
80
90
95
100
0 50 100 150 200
Kilometers
Miles
0 25 50 100 150 200


GLERL Digital Ice Chart for Dec 29, 2016
Geographic Coordinate System: GCS North American 1983
Datum: D North American 1983
N
W
E
S
Ice Cover (%)
0
5
10
20
30
40
50
60
70
80
90
95
100
0 50 100 150 200
Kilometers
Miles
0 25 50 100 150 200


GLERL Digital Ice Chart for Dec 30, 2016
Geographic Coordinate System: GCS North American 1983
Datum: D North American 1983
N
W
E
S
Ice Cover (%)
0
5
10
20
30
40
50
60
70
80
90
95
100
0 50 100 150 200
Kilometers
Miles
0 25 50 100 150 200

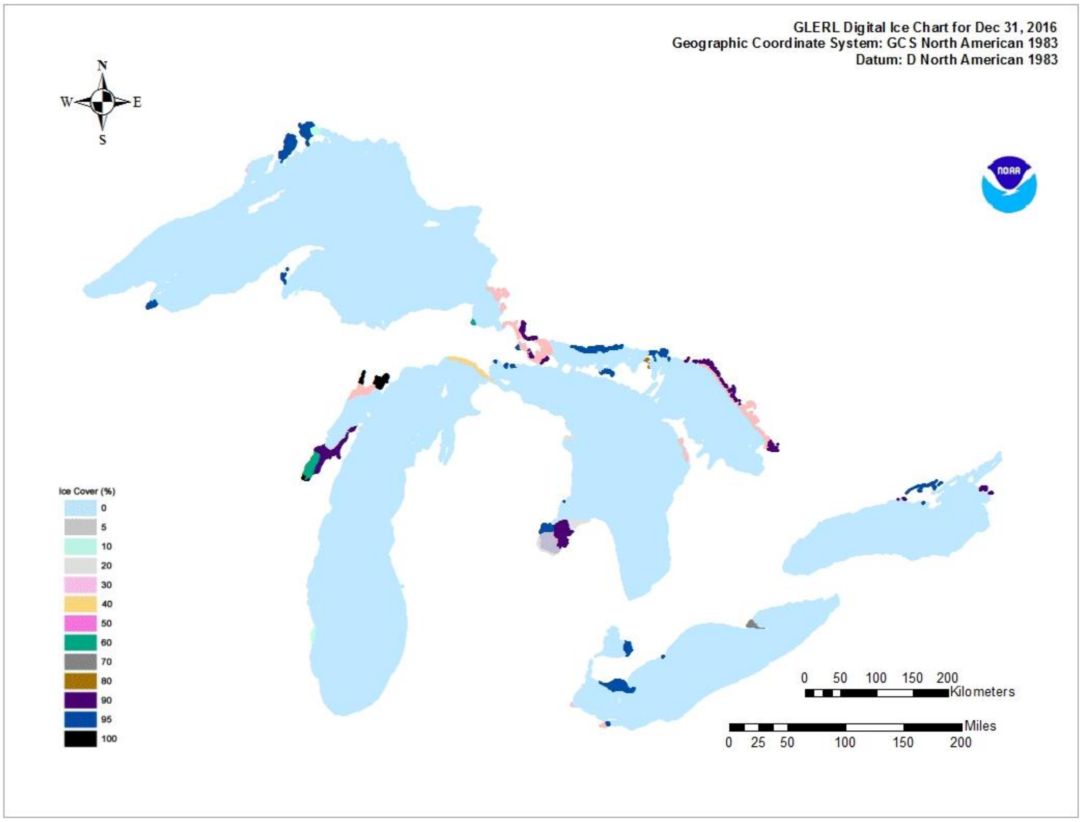


Figure A-C1-2. Great Lakes Daily Ice Cover Charts for Dates Modeled Using ROC Software for Task C

Source: Retrieved from the NOAA Great Lakes Environmental Research Laboratory Ice Atlas, https://www.glerl.noaa.gov/data/ice/#historical

Table A-C1-1. Wave and Current Data for the Studied Worst-case Scenario Time Frame (December 27-28, 2016)

Source: NOAA GLERL Great Lakes Coastal Forecasting System (Nowcast). The requested longitude is -84.7664 degrees and latitude 45.8134 degrees. All velocities are in knots and wave heights in feet.

Lake:Michigan						
Date/Time(GMT-0400)	Eastward Water Velocity at Surface	Northward Water Velocity at Surface	Water Velocity at Surface	Water Velocity at Surface Direction(Degrees 0=toward North)	Significant Wave Height	Wave Direction(Degrees 0=toward North)
2016-12-27 00:00:00 -0400	0.4564	-0.0396	0.4581	94.955	9.0459	86.0501
2016-12-27 01:00:00 -0400	0.4636	-0.073	0.4693	98.9433	9.065	86.3987
2016-12-27 02:00:00 -0400	0.4559	-0.0764	0.4622	99.5114	8.9938	85.4197
2016-12-27 03:00:00 -0400	0.2355	-0.0885	0.2515	110.6008	8.0569	85.5629
2016-12-27 04:00:00 -0400	0.3078	-0.0918	0.3212	106.6143	7.6015	87.4515
2016-12-27 05:00:00 -0400	0.2787	-0.1503	0.3166	118.3395	7.4417	89.3412
2016-12-27 06:00:00 -0400	0.2202	-0.1963	0.295	131.7116	6.9555	89.5787
2016-12-27 07:00:00 -0400	0.1292	-0.174	0.2167	143.4015	6.2335	88.7122
2016-12-27 08:00:00 -0400	0.1038	-0.1254	0.1628	140.3773	5.5425	88.019
2016-12-27 09:00:00 -0400	0.0513	-0.0925	0.1058	150.9897	4.7582	89.6773
2016-12-27 10:00:00 -0400	0.0525	-0.0593	0.0792	138.4447	4.3405	92.5174
2016-12-27 11:00:00 -0400	0.104	-0.0815	0.1321	128.0761	4.3465	93.9207
2016-12-27 12:00:00 -0400	0.1265	-0.0857	0.1528	124.1335	4.6244	94.1196
2016-12-27 13:00:00 -0400	0.1323	-0.1207	0.1791	132.3617	4.7487	95.3333
2016-12-27 14:00:00 -0400	0.1197	-0.1344	0.18	138.3161	4.6399	93.5916

2016-12-27 15:00:00 -0400	0.0533	-0.0989	0.1124	151.6834	4.2934	94.2218
2016-12-27 16:00:00 -0400	0.0626	-0.0774	0.0996	141.0257	4.2277	100.5011
2016-12-27 17:00:00 -0400	0.0252	-0.0741	0.0782	161.238	3.841	106.1652
2016-12-27 18:00:00 -0400	0.0305	-0.069	0.0755	156.1809	3.4816	109.7515
2016-12-27 19:00:00 -0400	0.0139	-0.0726	0.0739	169.1391	3.5161	111.4669
2016-12-27 20:00:00 -0400	0.0258	-0.0857	0.0895	163.2291	3.5812	112.8359
2016-12-27 21:00:00 -0400	0.0439	-0.089	0.0992	153.7172	3.689	113.8143
2016-12-27 22:00:00 -0400	0.0486	-0.0874	0.1	150.9543	3.7859	112.1595
2016-12-27 23:00:00 -0400	0.0508	-0.108	0.1194	154.8261	3.728	110.8412
2016-12-28 00:00:00 -0400	0.0316	-0.0908	0.0961	160.7798	3.5845	110.1716
2016-12-28 01:00:00 -0400	0.0129	-0.0866	0.0876	171.5334	3.2868	110.0615
2016-12-28 02:00:00 -0400	0.0014	-0.0842	0.0842	179.0782	3.0783	110.5549
2016-12-28 03:00:00 -0400	-0.0083	-0.0618	0.0623	187.6434	2.8533	109.4669
2016-12-28 04:00:00 -0400	-0.0045	-0.0649	0.0651	183.9598	2.6927	107.7418
2016-12-28 05:00:00 -0400	-0.0067	-0.0635	0.0639	185.9912	2.5732	105.1108
2016-12-28 06:00:00 -0400	-0.0062	-0.063	0.0634	185.6484	2.2969	104.0794
2016-12-28 07:00:00 -0400	-0.015	-0.0454	0.0478	198.2692	2.0093	103.0416
2016-12-28 08:00:00 -0400	-0.0316	-0.0369	0.0485	220.5403	1.5817	105.5701
2016-12-28 09:00:00 -0400	-0.0228	0.0308	0.0383	323.4978	1.225	99.1797
2016-12-28 10:00:00 -0400	-0.0059	0.097	0.0972	356.4932	1.0371	66.6782

2016-12-28 11:00:00 -0400	0.0178	0.1627	0.1637	6.2537	1.1465	44.5574
2016-12-28 12:00:00 -0400	0.0449	0.2393	0.2435	10.6183	1.6367	33.5367
2016-12-28 13:00:00 -0400	0.056	0.2534	0.2595	12.4531	1.6943	31.3394
2016-12-28 14:00:00 -0400	0.0534	0.2381	0.244	12.6409	1.3861	22.3199
2016-12-28 15:00:00 -0400	0.0482	0.2139	0.2193	12.6911	1.5681	7.3327
2016-12-28 16:00:00 -0400	0.0307	0.2601	0.2619	6.7362	1.6564	346.0948
2016-12-28 17:00:00 -0400	0.0187	0.2865	0.2871	3.7297	1.7082	337.3329
2016-12-28 18:00:00 -0400	0.0153	0.2767	0.2771	3.1729	1.6132	332.1065
2016-12-28 19:00:00 -0400	0.0362	0.2647	0.2672	7.7968	1.4474	331.8664
2016-12-28 20:00:00 -0400	0.0499	0.2364	0.2416	11.9255	1.3771	337.744
2016-12-28 21:00:00 -0400	0.064	0.257	0.2649	13.9883	1.8054	352.1775
2016-12-28 22:00:00 -0400	0.0912	0.2806	0.295	17.998	1.7564	349.1506
2016-12-28 23:00:00 -0400	0.1114	0.2268	0.2526	26.1673	1.6303	2.42
2016-12-29 00:00:00 -0400	0.1212	0.1736	0.2118	34.9193	1.581	31.7309
2016-12-29 01:00:00 -0400	0.1154	0.126	0.1709	42.4856	1.671	53.0858
2016-12-29 02:00:00 -0400	0.1137	0.086	0.1426	52.8802	2.3442	77.2393

Appendix C-2 Total USCG inventories (provided by USCG Sector Sault Ste Marie, May 2018)

Total Inventories	
Item	**Quantity**
18" hard boom (100' section)	31
8" hard boom (100' section)	2
8" absorbent boom (40' section)	3
6" absorbent boom (10' section)	16
4" absorbent boom (5' section)	1
absorbent pads	18.5
bag of pom poms	1
bag of skimming sweeps	1
anchors (small)	18
anchors (medium)	25
anchors (large)	7
anchor lights	8
towing bridles/lines (various lengths)	115
anchor line	2 spools and 1 box
fence post	20
fence post driver	1
Shackles	18
buoy markers	45
spanner wrench	2
hatchet	1
augers	15
shovel	8
extension cord	1
mallet	2
rake	11
oil sample kit	1
tool kit	7
first aid kit	7

fire extinguisher	6
tyvec suits	9 bags, 1 box
rain gear	31
tarps	6
rescue heaving line	2
Type III PFD	3
safety glasses	16
hard hat	15
mango helmet	2
box of ear plugs	1
nitrile glove box	8
garden gloves	20 pair (+ a bag full)
rubber gloves	24 pair
rubber boots	26 pair
hip waders	17
trash bag box	11
hazmat bags	6
step stool	2
flashlight	2
spotlight	5
light bar	1
safety tape	1 roll
spare tire	5
hydraulic jack	3
tire iron	3
2 and 5/16th" ball hitch	1
air pump	1
generator	1
sea foam motor treatment	1
CHRIS manual	5
box of paint markers	1
box of dry erase markers	1

The detailed equipment for each USCG trailer is provided below.

Trailer #1

Tag# DHS-60832T	Expires:
Vin# 1WC200E18A1126156	Inspected: 08AUG17
Location: Sault Ste Marie, MI	
CBP Lot	
Item	**Quantity**
18" hard boom (100' section)	4
8" hard boom (100' section)	0
4" absorbent boom (5' section)	1
8" absorbent boom (10' section)	7
absorbent pads	2 bales
anchors (small)	0
anchors (medium)	4
anchors (large)	1
anchor lights	0
towing bridles/lines (various lengths)	17
Shackles	0
buoy markers	7
fence posts	12
augers	2
shovel	1
mallet	0
rake	2
tool kit	1
first aid kit	2
fire extinguisher	2
Tyvek suits	4 Bags
rain gear	4
type III PFD	0
safety glasses	4
hard hat	4
mango helmet	0
nitrile glove box	1
garden gloves	4 pair
rubber gloves	18
rubber boots	18
hip waders	3

Trash bag box	3
safety tape	1 roll
flashlight	0
spot light	0
spare tire	1
hydraulic jack	0
tire iron	1

Trailer #2

Tag# DHS-4877T	Expires: unknown
VIN# 1WC200E27Y1090883	Inspected: 06JUN17
Location: Marquette, MI	
USCG Station Marquette	
Item	**Quantity**
18" hard boom (100' section)	4
8" hard boom (100' section)	0
8" absorbent boom (40' section)	0
6" absorbent boom (10' section)	0
absorbent pads	4.5 bales
anchors (small)	5
anchors (medium)	5
anchors (large)	1
anchor lights	3
towing bridles/lines (various lengths)	17
Shackles	6
bouy markers	9
boat hook	0
augers	0
shovel	2
mallet	0
rake	5
tool kit	2
first aid kit	0
fire extinguisher	1
Tyvek suits	2 bags
rain gear	8
type III PFD	3
safety glasses	2
hard hat	0
mango helmet	2
nitrile glove box	1
garden gloves	4 pair
rubber gloves	2 pair
rubber boots	2 pair
hip waders	1
Trash bag box	1
step stool	1
flashlight	1
spotlight	0
spare tire	1
hydraulic jack	1
tire iron	0

Trailer #3

Tag# DHS-60833T	Expires: JULY 2018
VIN# 1WC200E16A1126155	Inspected: 24MAY17
Location: Manistique, MI	
Water Treatment facility	
Item	**Quantity**
18" hard boom (100' section)	4
8" hard boom (100' section)	0
8" absorbent boom (40' section)	1
6" absorbent boom (10' section)	4
absorbent pads	2 bales
anchors (small)	4
anchors (medium)	0
anchors (large)	2
anchor lights	0
towing bridles/lines (various lengths)	15
Shackles	2
buoy markers	6
boat hook	0
augers	3
shovel	1
mallet	1
rake	0
tool kit	1
first aid kit	1
fire extinguisher	0
Tyvek suits	0
rain gear	0
type III PFD	0
safety glasses	0
hard hat	0
mango helment	0
nitrile glove box	0
garden gloves	0
rubber gloves	0
rubber boots	0
hip waders	0
Trash bag box	0
step stool	0
flashlight	0
spot light	0
spare tire	0
hydraulic jack	0
tire iron	0

Trailer #4

Tag# DHS-2858T	Expires: None
VIN# 1WC200E2111094997	Inspected: 22MAY17
Location: Cheboygan, MI	
USCGC MACKINAW mooring	
Item	**Quantity**
18" hard boom (100' section)	4
8" hard boom (100' section)	1
8" absorbent boom (40' section)	1
6" absorbent boom (10' section)	6
absorbent pads	3 bales
anchors (small)	7
anchors (medium)	0
anchors (large)	3
anchor lights	0
towing bridles/lines (various lengths)	17
Shackles	0
bouy markers	6
boat hook	1
augers	3
shovel	1
mallet	1
rake	1
tool kit	0
first aid kit	1
fire extinguisher	1
Tyvek suits	0
rain gear	0
type III PFD	0
safety glasses	0
hard hat	0
mango helment	0
nitrile glove box	0
garden gloves	0
rubber gloves	0
rubber boots	0
hip waders	0
Trash bag box	0
step stool	0
flashlight	0
spotlight	2
spare tire	0
hydraulic jack	1
tire iron	0

Trailer #5

Tag# DHS-61661T	Expires JAN 2020
VIN: 1WC200E24W1080020	Inspected: 19SEP17
Location: Charlevoix, MI	
USCG Station Charlevoix	
Item	**Quantity**
18" hard boom (100' section)	4
8" hard boom (100' section)	0
8" absorbent boom (40' section)	1
bag of skimming sweeps	2
absorbent pads	2 bales
anchors (small)	0
anchors (medium)	6
anchors (large)	0
fence post	4
towing bridles/lines (various lengths)	9
Shackles	0
bouy markers	5
boat hook	0
augers	0
shovel	1
mallet	0
rake	1
tool kit	1
first aid kit	1
fire extinguisher	0
Tyvek suits	1 bag
rain gear	2
type III PFD	0
safety glasses	0
hard hat	3
mango helment	0
nitrile glove box	1
garden gloves	4
rubber gloves	0
rubber boots	2
hip waders	1
Trash bag box	3
step stool	0
flashlight	0
spotlight	0
spare tire	1
hydraulic jack	0
tire iron	0

Trailer #6

Tag# DHS-0165T	Expires: None
Vin# 4X4TEXZ293N033690	Inspected: 08SEP17
Location: Traverse City, MI	
USCG AIRSTA Traverse City	
Item	**Quantity**
18" hard boom (100' section)	7
8" hard boom (100' section)	1
8" absorbent boom (40' section)	0
6" absorbent boom (10' section)	4
absorbent pads	2 bales
bag of pom poms	1
anchors (small)	2
anchors (medium)	4
anchors (large)	0
anchor lights	5
towing bridles/lines (various lengths)	25
anchor line	2 spools and 1 box
fence post	2
fence post driver	1
Shackles	5
bouy markers	4
spanner wrench	2
hatchet	1
augers	1
shovel	1
extentsion cord	1
rake	1
oil sample kit	1
tool kit	2
first aid kit	1
fire extinguisher	1
tyvec suits	4
rain gear	9
tarps	6
rescue heaving line	2
safety glasses	6
hard hat	4
box of ear plugs	1
nitrile glove box	1
garden gloves	4 (plus a bag full)
rubber gloves	4
rubber boots	0
hip waders	8
trash bag box	3
hazmat bags	6
step stool	1
spot light	3
light bar	1
spare tire	1
hydraulic jack	1
tire iron	1
2 and 5/16th" ball hitch	1
air pump	1
generator	1
sea foam motor treatment	1
CHRIS manual	5
box of paint markers	1
box of dry erase markers	1

Trailer #7

Tag# DHS-0177T	Expires: none
VIN# 1WC200E22Y1092816	Inspected: 11JUL17
Location: Alpena, MI	
USCG AUXOP Alpena	
Item	**Quantity**
18" hard boom (100' section)	4
8" hard boom (100' section)	0
8" absorbent boom (40' section)	0
6" absorbent boom (10' section)	2
absorbent pads	3 bales
anchors (small)	0
anchors (medium)	6
anchors (large)	0
anchor lights	0
towing bridles/lines (various lengths)	15
Shackles	5
bouy markers	8
fence post	2
augers	6
shovel	1
mallet	0
rake	1
tool kit	0
first aid kit	1
fire extinguisher	1
Tyvek suits	1 box , 2 bags
rain gear	8
type III PFD	0
safety glasses	4
hard hat	4
mango helment	0
nitrile glove box	4
garden gloves	4 pair
rubber gloves	0
rubber boots	4 pair
hip waders	4
Trash bag box	1
step stool	0
flashlight	1
spotlight	0
spare tire	1
hydraulic jack	0
tire iron	1

Appendix C-3 USCG Boom Trailer Locations

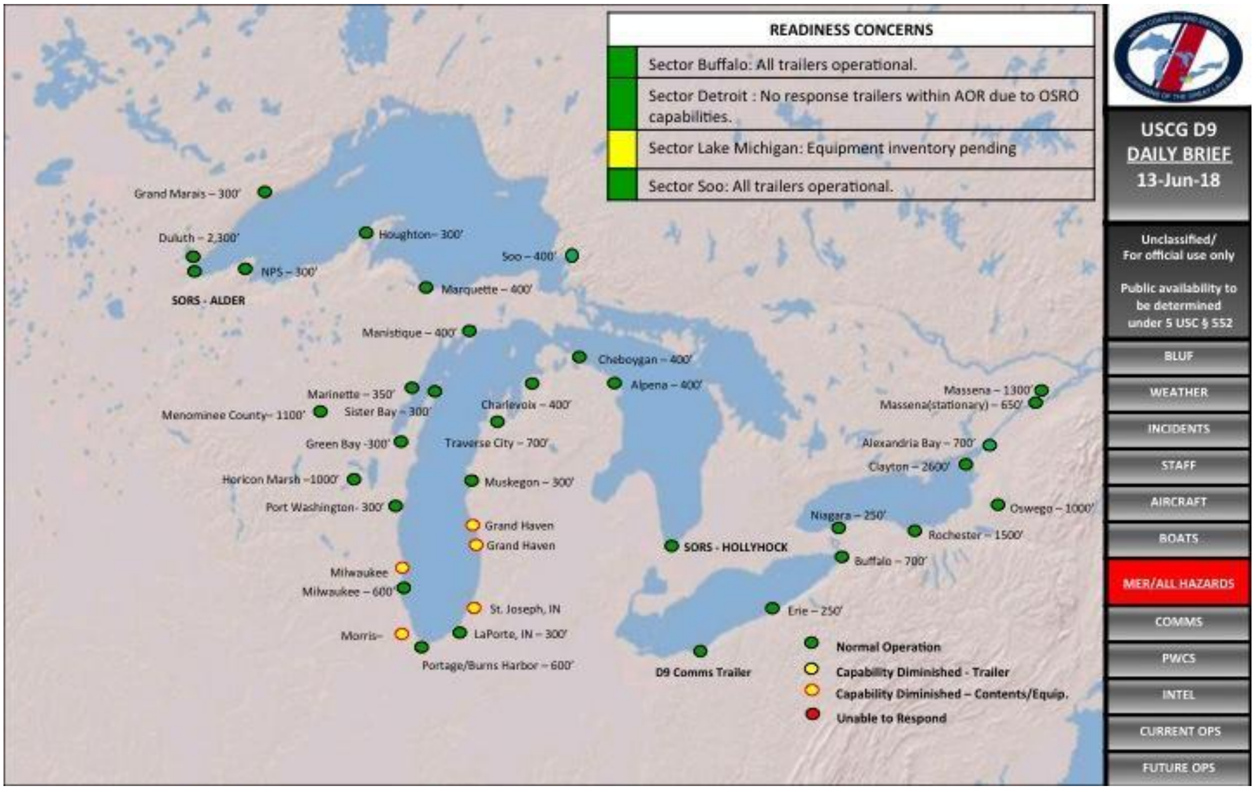


Figure A-C3-1. USCG Boom Trailer Locations

Appendix C-4 Three-year Average Wind Conditions (2015-2018) for the Straits Region

This summary of wind conditions at the Straits was generated from observational data collected by two C-MAN stations on either side of the Straits, the White Shoal Light Station (WSLM4) to the west and Spectacle Reed Light Station (SRLM4) to the east (Figure A-C15-1). Both stations began collecting data in April 2015, and all data through May 2018 were downloaded directly from the National Data Buoy Center (ndbc.noaa.gov).

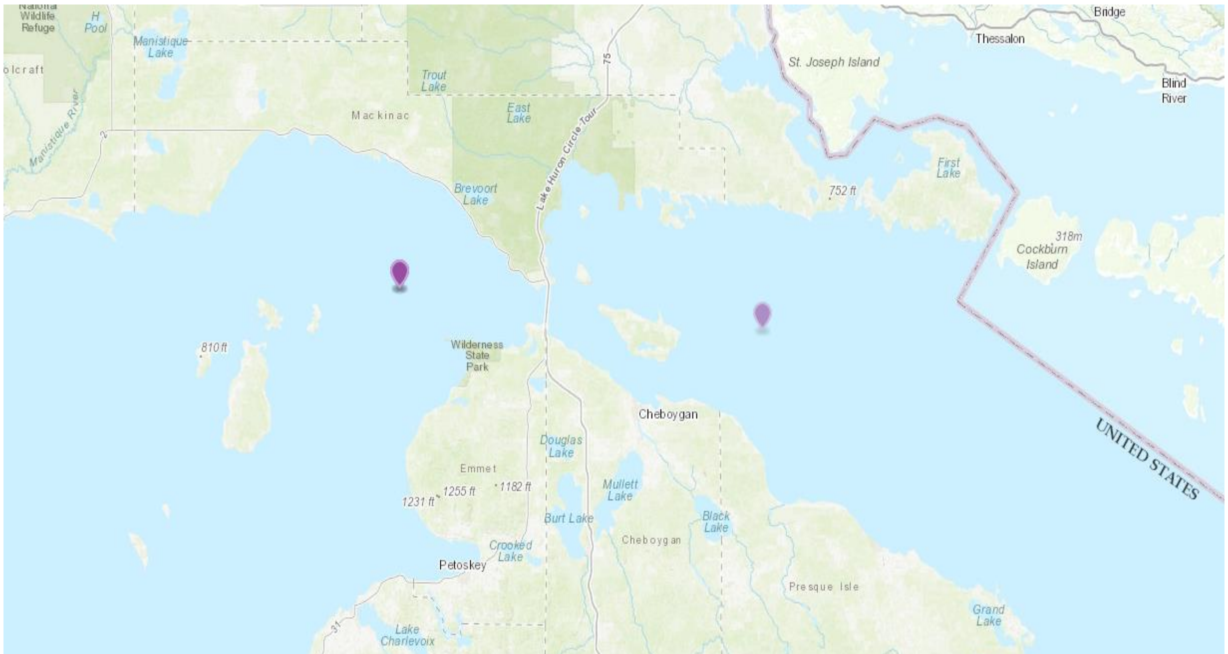


Figure A-C4-1. Locations of Stations WSLM4 (left) and SRLM4 (right)

Source: Screen capture from the GLOS Data Portal, portal.glos.us.

A summary of monthly wind conditions across the approximately three years of data is provided in Figures. A-C4-2 and A-C4-3.

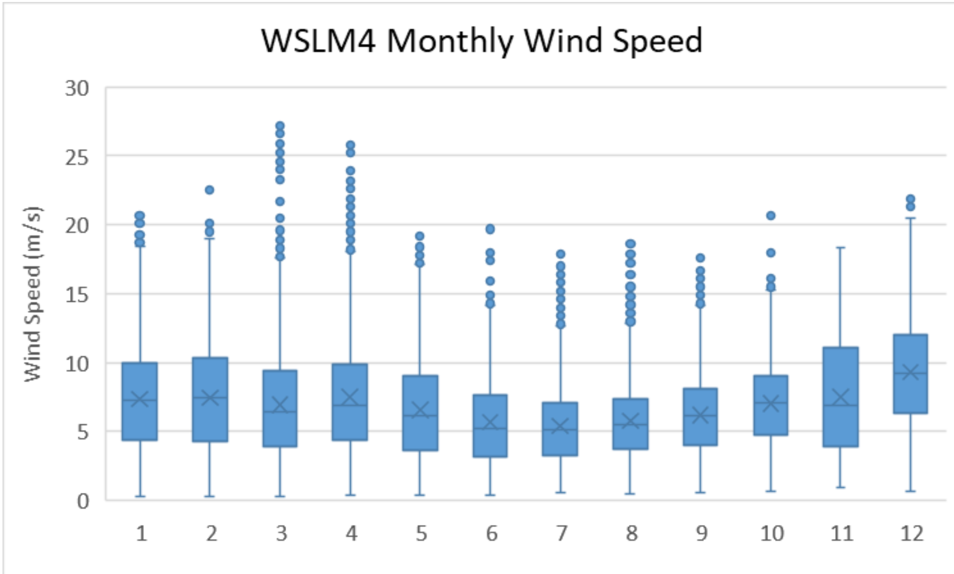


Figure A-C4-2. Monthly Wind Recordings for Station WSLM4 (West of Straits) April 2015-May 2018

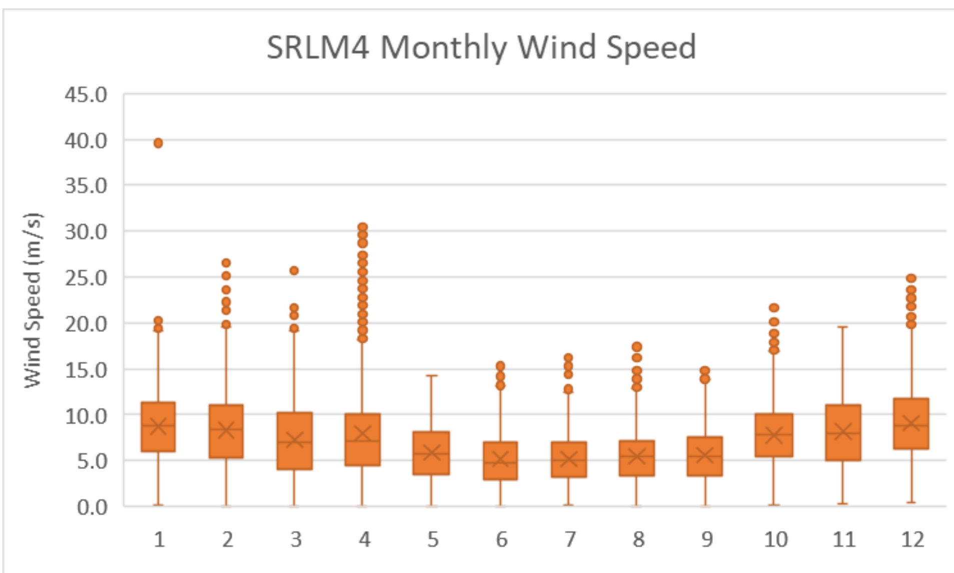


Figure A-C4-3. Monthly Wind Recordings for Station SRLM4 (East of Straits) April 2015-May 2018

Wind speeds were also thresholded into four classes based on the figure below (Spiltec 2009):

- ‘Low’ winds correspond to wind speeds of up to seven knots where all skimmer groups could function well
- ‘Medium’ winds of 7-11 knots would limit response to skimmer groups A and B
- ‘High’ winds of 11-19 knots would limit response to skimmer group A

- ‘Very High’ winds greater than 19 knots would be too high to operate any mechanical system.

This ‘Very High’ wind class also corresponds to approximate wave heights over six feet, which agencies responsible for spill response in the Straits have identified as conditions under which it would be unsafe for on-the-water response efforts.

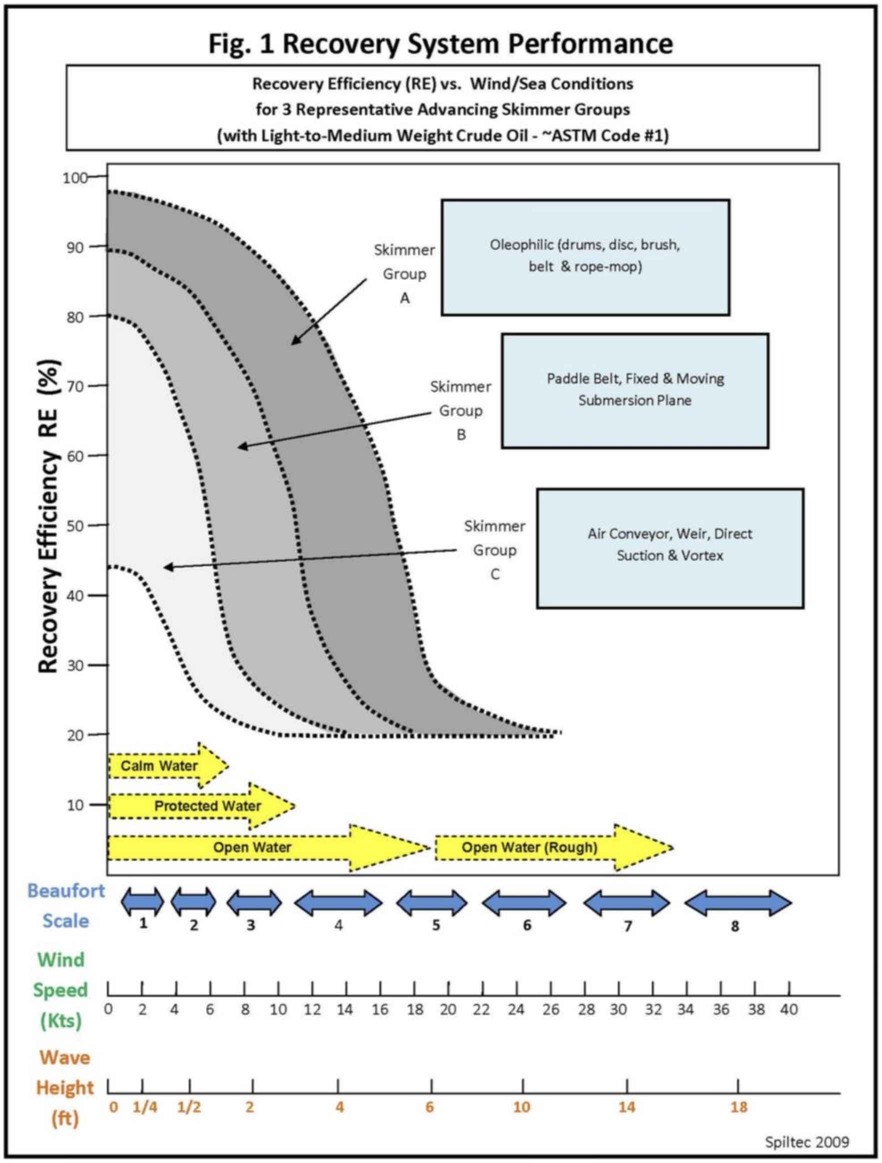


Figure A-C4-4. Recovery Systems Performance Over a Gradient of Wind/Sea Conditions

Source: Reprinted from the Genwest Response Options Calculator (ROC) Technical Documentation.

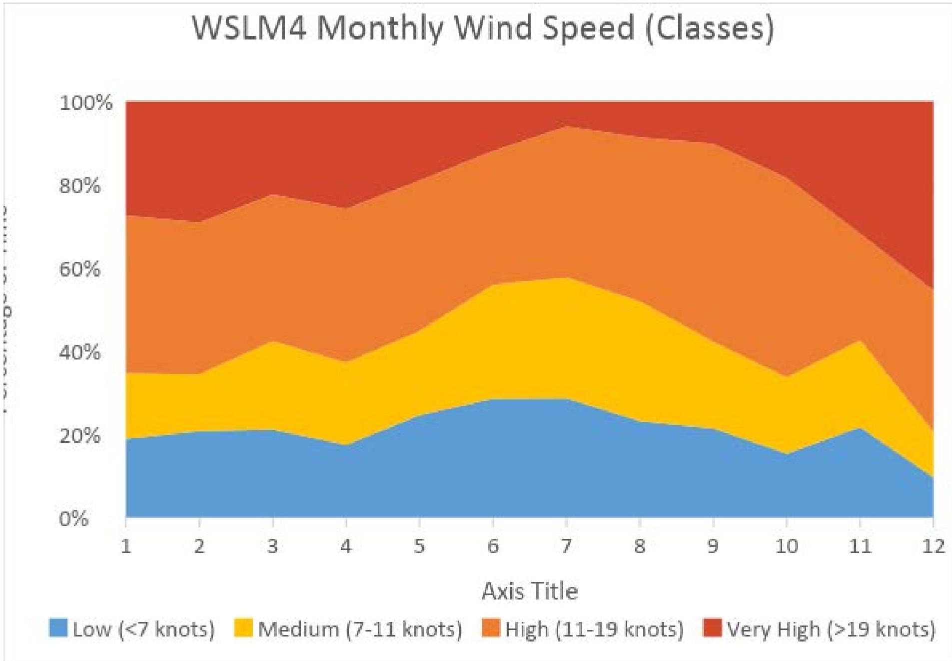


Figure A-C4-5. Seasonal Wind Speed Classes in Context of Oil Spill Response Activities for Station WSLM4 (West of Straits)

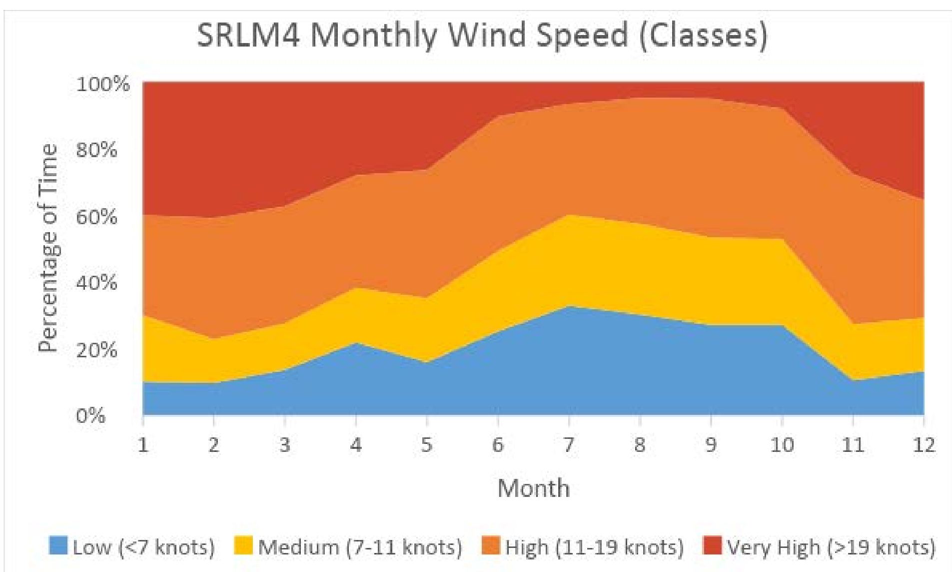


Figure A-C4-6. Seasonal Wind Speed Classes in Context of Oil Spill Response Activities for Station SRLM4 (East of Straits)

Appendix D-1 Population Characteristics

Table A-D1-1. Demographics by County, Z=value Greater Than Zero but Less Than Half Unit of Measure Shown

Fact	Emmet County	Cheboygan County	Mackinac County
Population estimates, July 1, 2016, (V2016)	33,182	25,401	10,820
Age & Sex			
Persons under 5 years, percent, July 1, 2016, (V2016)	4.80%	4.10%	3.80%
Persons under 18 years, percent, July 1, 2016, (V2016)	19.80%	17.10%	16.10%
Persons 65 years and over, percent, July 1, 2016, (V2016)	21.40%	26.00%	27.50%
Female persons, percent, July 1, 2016, (V2016)	50.50%	50.00%	48.90%
Race & Hispanic Origin			
White alone, percent, July 1, 2016, (V2016)	92.70%	93.20%	74.90%
Black or African American alone, percent, July 1, 2016, (V2016)	0.80%	0.60%	2.60%
American Indian and Alaska Native alone, percent, July 1, 2016, (V2016)	3.80%	2.90%	16.70%
Asian alone, percent, July 1, 2016, (V2016)	0.50%	0.40%	0.70%
Native Hawaiian and Other Pacific Islander alone, percent, July 1, 2016, (V2016)	0.10%	Z	Z
Two or More Races, percent, July 1, 2016, (V2016)	2.20%	2.90%	5.10%
Hispanic or Latino, percent, July 1, 2016, (V2016)	1.60%	1.40%	1.60%
White alone, not Hispanic or Latino, percent, July 1, 2016, (V2016)	91.40%	92.10%	73.70%
Population Characteristics			

Veterans, 2012-2016	2,790	2,330	1,096
Foreign born persons, percent, 2012-2016	2.00%	1.30%	2.50%
Housing			
Housing units, July 1, 2016, (V2016)	21,424	18,326	11,038
Owner-occupied housing unit rate, 2012-2016	74.50%	81.80%	73.30%
Median value of owner-occupied housing units, 2012-2016	$166,100	$113,300	$124,100
Families & Living Arrangements			
Households, 2012-2016	14,144	11,185	5,230
Persons per household, 2012-2016	2.3	2.26	2.05
Education			
High school graduate or higher, percent of persons age 25 years+, 2012-2016	94.00%	88.80%	89.10%
Bachelor's degree or higher, percent of persons age 25 years+, 2012-2016	32.90%	18.30%	19.10%
Health			
With a disability, under age 65 years, percent, 2012-2016	10.60%	14.80%	12.50%
Persons without health insurance, under age 65 years, percent	8.10%	9.80%	12.30%
Income & Poverty			
Median household income (in 2016 dollars), 2012-2016	$51,096	$41,023	$40,747
Persons in poverty, percent	11.80%	18.00%	13.70%
Geography			
Population per square mile, 2010	69.9	36.6	10.9
Land area in square miles, 2010	467.49	715.26	1,021.57

Source: (U.S. Census Bureau, n.d.).

Table A-D1-2. Unemployment Rates by County

Area	Labor Force	Employed	Unemployed	Rate (as of Dec. 2017)
Cheboygan County	10,531	8,889	1,642	15.6
Emmet County	17,324	15,906	1,418	8.2
Mackinac County	4,595	3,722	873	19
Michigan	4,876,000	4,659,000	217,000	4.4

Reference: (Michigan Department of Technology, Management, and Budget, Local Area Unemployment Statistics, & Bureau of Labor Market Information and Strategic Initiatives, 2018).

Table A-D1-3. Population and Other Information

Location	Coordinate	Wind Direction	Wind Speed	Area mi^2 (water)	Population [a]	Housing Units	Tourist *
City of St Ignace	45°51′57″N 84°43′33″W	SW	16 mph	2.68 (0.01)	2452	1,299	
St Ignace Twp	45°59′33″N 84°42′11″W	NNE	17 mph	97.1 (45.1)	939	601	
Big St. Martin Island	45°58′41″N 84°55′33″W			127 (6.9)	1080	739	
St. Martin Island	45°29′52″N 86°46′13″W	WSW	8.5 mph				
Round Island	45°49′47″N 84°36′05″W	SW	7.9 mph		uninhabited		
Marquette Twp Island	45°57′37″N 84°23′37″W	NNW	8.5 mph				
Clark Twp					2056		

City of Mackinac Island	45°51′40″N84°37′50″W	SSW	12.6 mph	4.35 (14.49)	492	1002	15,000
Mackinaw City	45°47′02″N 84°43′40″W	SSW	9.4 mph	3.36 (4.22)	801	814	
DeTour Village	45°59′26″N 83°54′18″W	SSE	16 mph	8.38 (4.83)	325	307	
Cheboygan	45°38′49″N 84°28′28″W	SW	8.2 mph	6.80 (0.20)	4867	2415	
Rogers City	45°25′8″N 83°49′6″W	SSW	8.2 mph	4.52 (3.82)	2827	1628	
Charlevoix	45°19′5″N 85°15′30″W	W	9.2 mph	2.05 (0.12)	2513	2201	
Petoskey	45°22′24″N 84°57′19″W	SSW	7.4 mph	5.09 (0.20)	5670	1,113	
Cross Village	45°38′56″N 85°1′10″W	SW	8.8 mph	10.0 (0.2)	294	280	
Good Hart	45°34′34″N 85°2′9″W	SSW	7.4 mph	31.0 (0.0)	493	411	
Naubinway	46.075552 -85.4453736	SSW	8.7 mph		580		
Port Inland	45.9708 -85.8723						
Leland Twp	45°0′54″N 85°44′11″W	W	7.8 mph	45.6 (100.9)	2,033	1550	
Manistique	45°57′28″N 86°14′59″W	NNW	8.5 mph	3.19 (0.32)	3097	1617	
Eastport	45°6′26″N 85°21′0″W	SSE	6.3 mph	2.00 (0.008)	218	-	

Traverse City	44°46′05″N 85°37′20″W	W	7.8 mph	8.33 (0.33)	14,674	7358	
Calcite Harbor							
Rockport	45°11′59″N 83°23′42″W						
Stoneport							
Alpena							
Presque Isle Township	45°17′14″N 83°28′26″W	NW	8.4 mph	35.6 (11.6)	1691	1595	
Beaver Island	45°40′N 85° 32′W	WSW	9 mph	55.8	657		
High Island	45°43′30″N 85°41′00″W			5.46	uninhabited		
Hog Island				3.24	uninhabited		
Garden Island				7.8	uninhabited		

Appendix D-2 Safety Risk and Consequence Detailed Methodology

A-D2.1 Methodology for the Carcinogenic and Non-carcinogenic Risk Analysis

Risk of adverse effects due to incidental ingestion of contaminated soils, inhalation of toxic compounds and absorption of chemicals through the human skin were calculated by combining the intake (dose) with an appropriate oral reference dose or slope factor, using equations D2-E1 through D2-E13 (US EPA, 1991; US EPA, 1996). See Table A-D2-1 for parameters in the equations used for the risk calculation.

A-D2.1.1 Carcinogenic Risk Assessment

A-D2.1.1.1 Exposure Route Health Impact Assessment

a) *Ingestion Risks:* The risk of adverse effects due to accidental ingestion of contaminated soils or water (surface water or during swimming related activities) was calculated by combining the intake (dose) with an appropriate oral reference dose or slope factor, as follows (US EPA, 1996).

$$ADD_{ing(c)} = \frac{C_s * CF_{km} * EF * IFS_{adj}}{AT_c} \quad \text{(D2-E1)}$$

$$ADD_{ing\ (n)} = \frac{C_s * CF_{km} * EF * IFS_{adj}}{AT_n} \quad \text{(D2-E2)}$$

$$IFS_{adj} = \left(\frac{IRS_c * ED_c}{BW_c}\right) + \left(\frac{IRS_a * ED_a}{BW_a}\right) \quad \text{(D2-E3)}$$

b) *Dermal Absorption Risks***:** The carcinogenic risk of chemicals entering the body through the skin surface area was modeled using the dermal absorption equations D2-E4 through D2-E6;

$$ADD_{derm(c)} = \frac{C_s * CF_{km} * EF * SFS_{adj} * ABS}{AT_c} \quad \text{(D2-E4)}$$

$$ADD_{derm(n)} = \frac{C_s * CF_{km} * EF * SFS_{adj} * ABS}{AT_n} \quad \text{(D2-E5)}$$

$$SFS_{adj} = \left(\frac{AF * SA_c * ED_c}{BW_c}\right) + \left(\frac{AF * SA_a * ED_a}{BW_a}\right) \quad \text{(D2-E6)}$$

c) *Vapor Inhalation Risks:* Risk of adverse effects due to inhalation of vapors released from the worst-case release of products was calculated by combining intake from (dose) with the appropriate inhalation reference dose or slope factor, equations D2-E7 through D2-E9 (US EPA, 1992):

$$ADD_{air(c)} = \frac{C_S * (\frac{1}{VF_S}) * EF * InhF_{adj}}{AT_c} \quad \text{(D2-E7)}$$

$$ADD_{air(n)} = \frac{C_S * (\frac{1}{VF_S}) * EF * InhF_{adj}}{AT_n} \quad \text{(D2-E8)}$$

$$InhF_{adj} = \left(\frac{IRA_c * ED_c}{BW_c}\right) + \left(\frac{IRA_a * ED_a}{BW_a}\right) \quad \text{(D2-E9)}$$

A-D2.1.1.2 Incremental Lifetime Cancer Risk (ILCR) Model

The additional cancer risks in adults (subscript a) and children (subscript c) were evaluated by applying the incremental lifetime cancer risk (ILCR) model (US EPA, 2004). The model assumes that exposure to carcinogenic CoPC will increase the risk of cancer induction in exposed individuals, this means that there is no safe or threshold dosage for a known carcinogenic substance such as benzo(a)pyrene or benzene. A cancer slope factor multiplied by the absorbed average daily intake gives a worst-case likelihood that an individual will develop cancer from exposure to the CoPC over a lifetime (US EPA, 2004). The ILCR were calculated using equations D2-E10 through D2-E13. The total risks are assumed to be additive from multiple CoPC and exposure routes; this is described further under risk characterization.

$$ILCR_{ing} = ADD_{ing\ (c)} * CSF_o \quad \text{(D2-E10)}$$

$$ILCR_{derm} = ADD_{derm(c)} * CSF_o \quad \text{(D2-E11)}$$

$$CR_{inh} = Cs * IUR_i \quad \text{(D2-E12)}$$

$$ILCR_{air} = ADD_{air(c)} * CSF_i \quad \text{(D2-E13)}$$

A-D2.1.1.3 Toxicity Equivalence Factors (TEQ)

The toxicity equivalent (TEQ) method was used to evaluate the eco-toxicological risk. The carcinogenic risk from multiple Polycyclic Aromatic Hydrocarbon (PAH) compounds was estimated by converting the carcinogenic potency of each individual PAH relative to B[a]P, which is the most potent carcinogenic PAH. The carcinogenic toxicity of mixtures of PAHs ($B[a]P_{eq}$) was calculated as the sum of the products of ($B[a]P_{eq}$ TEQ concentrations of individual PAHs. The total $B[a]P_{eq}$ was calculated by summing the

$B[a]P_{eq}$ for the 7 carcinogenic PAH (class B on Table A-D2-1) using the TEQ. The total $B[a]P_{eq}$ was calculated as shown in equation D2-E14;

$$Total\ B[a]P_{eq} = \sum C_{si} * TEQ_i \qquad \text{(D2-E14)}$$

Where C_{si} is the concentration of individual 16 PAHs and TEQ_i is the corresponding TEQ.

A-D2.1.2 Hazard Ratio or Quotient (HQ)

The ratio of exposure to the estimated daily exposure level at which no adverse health effects are likely to occur is *g*. Non-carcinogenic risk assessment of the CoPC was conducted, and the *HQ* of the individual exposure was determined. When the *HQ* > 1, the individual is at risk of non-carcinogenic effects.

$$HQ_{ing} = \left(\frac{ADD_{ing(n)}}{RfD_o}\right) \qquad \text{(D2-E15)}$$

$$HQ_{derm} = \left(\frac{ADD_{derm(n)}}{RfD_o}\right) \qquad \text{(D2-E16)}$$

$$HQ_{air} = \left(\frac{ADD_{air(n)}}{RfD_i}\right) \qquad \text{(D2-E17)}$$

A-D2.1.3 Chemicals of Potential Concern (CoPC) to Human Health

A-D2.1.3.1. Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons are a group of organic compounds containing two or more conjugated aromatic rings (Figure A-D2-1).

The US Environmental Protection Agency (US EPA) listed 16 PAHs as priority pollutants and 7 of which are carcinogenic. These PAHs have been determined to pose a risk to the public through inhalation, ingestion and dermal absorption.

The concentrations of the prioritized 16 PAHs have been analyzed in 48 crude oils from around the world in (Kerr et al., 1999, Pampanin and Sydnes, 2013). The results of the analyses are summarized in Table A-D2-1, which shows wide PAH concentration variation in crude oil from different locations.

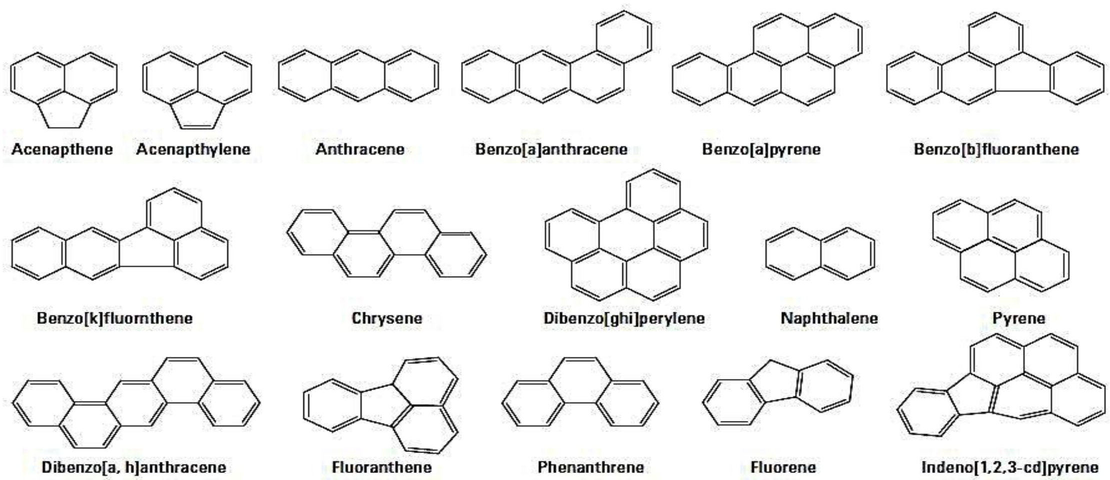


Figure A-D2-1. US. EPA 16 Priority Polycyclic Aromatic Hydrocarbons (PAHs) Chemical Structures

The PAH values in the line 5 crude oil were not available for use in this analysis. Therefore, the Monte Carlo method was used to simulate the most likely values for the PAHs. Toxicological profile of the PAH compounds and their respective cancer and non-cancer in Table A-D2-4.

A-D2.1.4 Risk Assessment of PAHs

A-D2.1.4.1 Monte Carlo Simulation for PAH Concentration

The Monte Carlo method (MCM) was based on the generation of multiple trials to determine the expected PAH concentrations from random variables. The basis of this method is provided in equation D2-E18.

$$\Pr\left\{\left|\frac{1}{N}\sum_N \xi - \mu\right| < \frac{3\sigma}{\sqrt{N}}\right\} \approx 99.8\% \qquad \text{(D2-E18)}$$

Where;

N = Total number of iterations

ξ = Maximum value from Table A-D2-1

μ = Mean Value from Table A-D2-1

σ = Standard Deviation of the normalized distribution

Each of these variables has a unique distribution; a uniform distribution was safely assumed without compromising the result. Another assumption was that each of these variables is independent of the others.

The general outline of the Monte Carlo method is as follows:

- Random values are generated for each of the PAH values.
- Add each series of random values to arrive at a total concentration.
- The expected PAH total concentration is the average of these values.

The RAND function was used to generate random numbers in the interval (0, 1) and multiplied by the range of each variable (i.e., maximum and minimum concentrations).

The MCM gave an estimate of the expected concentration value of a random variable and predicted the error estimate, which is proportional to the number of iterations/runs. The total error from equation D2-E18 is given as; $\varepsilon = \frac{3\sigma}{\sqrt{N}}$; The standard deviation from the distribution was determined as 609, therefore for an error of less than 2%, the number of iterations needed was calculated. The random variable was grossly estimated as the average of the maximum value and the minimum value; $\varepsilon = 65$.

Therefore, the number of iterations to generate a result with an error < 2% is:

$$N = \left(\frac{3 * 609}{65}\right)^2 = 784$$

The expected values of the random variable determined by the model are shown in Table A-D2-1.

Table A-D2-1. Simulated PAH Values from Concentrations in 49 Different Crude Oil Spill Samples and the Monte Carlo Simulation

Crude oil	TEQ [a]	49 different crude oils [b]		Monte Carlo Simulation (C_s) [c]	BaP eq mg/kg TEQ
PAH Compound		Maximum mg/kg oil	Mean mg/kg oil	mg/kg oil	
Naphthalene	0.001	3700	427	2946.5	2.9
Acenaphthene	0.001	58	11.1	43.9	0.04
Acenaphthylene	0.001	11 [38]	0	5.0	0.005
Fluorene	0.001	380	70.34	333.5	0.3
Anthracene	0.01	17	4.3	7.6	0.08
Phenanthrene	0.001	400	146	349.4	0.3
Fluoranthene	0.001	15	1.98	13.4	0.01
Pyrene	0.001	20	9.2	14.7	0.01
Benzo[g,h,j]perylene	0.001	1.7	0.08	1.3	0.001
Benzo[a]anthracene	0.1	16	2.88	12.2	1.2
Chrysene	0.01	120	30.36	42.1	0.4
Benzo[b]fluoranthene	0.1	14	4.08	11.2	1.1
Benzo[k]fluoranthene	0.1	1.3	0.07	0.9	0.09
Benzo[a]pyrene	1	7.7	1.5	1.6	1.6
Dibenz[a,h]anthracene	1	7.7	1.25	5.7	5.7
Indeno[1,2,3-cd] pyrene	0. 1	1.7	0.08	0.2	0.02

$\sum Total\ PAHs$		3789.21	13.8
	$\sum Total\ Carcinogenic\ PAHs$	73.9	10.0

[a] Potency equivalence factors (PEFs) for individual PAHs relative to B[a]P (Nisbet and Lagoy 1992)
[b] Maximum, and mean PAH content in 48 different crude oils (Kerr et al., 1999)
[c] Results generated in this analysis

A-D2.1.4.2 Risk Characterization of Potential Human Health Effects of PAHs

The risk characterization process involved using the data obtained from the worst-case oil spill analysis and related exposure parameters to evaluate human health risks. Several assumptions were made in the model calculation, and the Monte Carlo model was applied to evaluate the concentration distribution and exposure risk of the population. The most important assumption is the use of PAH concentration values obtained from the review of 49 different studies/cases, to establish the average concentrations of the compounds in the Line 5 products.

Totals from all three exposure pathways are computed to estimate the total cancer risk and total hazard index for each contaminant.

Table A-D2-2. Potential Incremental Lifetime Cancer Risks (ILCRs) and Hazard Quotients (HQ) May Affect the Population Along the Straits of Mackinac

Population	$ADD_{ing\ (}$	$ADD_{ing\ (}$	$ADD_{derm\ (}$	ADD_{derm}	$ADD_{inh\ (}$	$ADD_{inh\ (n)}$	$ILCR_{ing}$	$ILCR_{der}$	$ILCR_{inh}$	$Total\ ILC$	HQ_{ing}	HQ_{derm}	HQ_{inh}	$Total\ HQ$
Occupational	1.3E-05	1.2E-02	6.3E-10	5.6E-07	6.3E-10	5.6E-07	9.8E-05	1.6E-08	2.4E-09	9.8E-05	3.0E+00	1.4E-04	1.4E-04	3.0E+00
Permanent Resident	1.6E-05	1.4E-02	7.4E-10	6.5E-07	7.3E-10	6.5E-07	1.1E-04	1.8E-08	2.9E-09	1.1E-04	3.5E+00	1.6E-04	1.6E-04	3.5E+00
Seasonal Resident	1.1E-05	9.5E-03	5.0E-10	1.6E-08	5.0E-10	4.4E-07	7.8E-05	1.3E-08	2.0E-09	7.8E-05	2.4E+00	1.1E-04	1.1E-04	2.4E+00
Transient Resident	1.3E-06	1.2E-03	6.3E-11	5.6E-08	6.3E-11	5.6E-08	9.8E-06	1.6E-09	2.4E-10	9.8E-06	3.0E-01	1.4E-05	1.4E-05	3.0E-01

Totals for each pathway for all contaminants are also computed and summed to estimate the $ILCR$. The total ILCR to an individual over a lifetime, is accumulative across dermal, ingestion, and inhalation exposures (equation D2-E22). The risk range values for the ILCR are presented in Table A-D2-2.

$$Total\ ILCR = ILCR_{ing} + ILCR_{derm} + ILCR_{air} \qquad \text{(D2-E22)}$$

Hazard Quotient is the ratio of exposure to the estimated daily exposure level at which no adverse health effects are likely to occur. Non-carcinogenic risk assessment of the CoPC was conducted, and the HQ of the individual exposure was determined when the HQ > 1 the individual is at risk of non-carcinogenic effects. When the total HQ for the various CoPC (equation D2-E23), is greater than 1, the risk of non-carcinogenic can result in adverse health damages in the human body. The HQs were calculated for non-carcinogenic parameters for ingestion, dermal, and inhalation pathways.

$$Total\ HQ = HQ_{ing} + HQ_{derm} + HQ_{air} \qquad \text{(D2-E23)}$$

The risk values for each of the CoPC were calculated, and the total risk value provided the estimates of the total health risks that exposed individuals may be facing a possible worst-case event along the Line 5 pipeline in the Straits of Mackinac. The total risk represents the cumulative health risks for all toxic PAHs in the Line 5 product. If the ILCR of the CoPC is more than $1 * 10^{-4}$ it is considered as "definite risk," other risk levels are described in Table A-D2-3.

Table A-D2-3 Risk Range of ILCR

ILCRs	Risk Level Description
$< 1 * 10^{-6}$	Acceptable/negligible human health risk
$(1 * 10^{-6}) - (1 * 10^{-4})$	Potential human health risk
$> 1 * 10^{-3}$	Serious human health risk

Figures D5 and D6 of the main report illustrate the potential risk levels for carcinogenic and non-carcinogenic effects. From the results, there will be human health impacts from a worst-case pipeline product release, under the scenarios considered in this analysis. However, the level of risk to cleanup workers and all categories of seasonal residents are low, compared to the potential risks to permanent residents. If the assumptions for the concentrations of chemical compounds and the individual dose hold true, therefore, adults living permanently around 500 m (0.3 miles) from the shoreline around Mackinaw City are susceptible to both carcinogenic and non-carcinogenic risks. The ILCR level for permanent residents around this defined radius could be up to 114 times higher than the acceptable human health risk level of $1.0E - 06$. This is due to the combined effects of chemicals and the potential for exposure for a longer period. While the HQ level is 3.5 times higher than the risk threshold for non-carcinogenic effects.

It is expected that people directly exposed to the CoPC, immediately following a worst-case release in Mackinaw City, will experience varying degrees of health complications, from circulatory system complications to central nervous system issues, depending on the dose and duration of exposure of the persons. The cleanup workers and seasonal residents were shown in the analysis to have very low HQ; therefore, these groups may not have any significant health effects (chronic or acute). Nevertheless, the ILCR values for these groups, especially the cleanup workers ($9.8E - 05$), showed that there is potential for adverse health risks to occupational residents which may include the development of cancer. The value suggests that at least one in 10,000 workers may develop one form of cancer due to the exposure. This level of risk for permanent residents and workers pose a public concern and adequate measures should be put in place to properly protect the public in the event of a worst-case accident along the line 5 pipeline.

A-D2.2 Volatile Organic Compounds (VOCs)

There are numerous volatile organic compounds (VOCs) that are hazardous in air. In this independent risk analysis, the consequent health risks to the public (cleanup workers, residents, and visitors along the Straits, with potential for exposure) from VOCs emission were assessed in two ways: health risk evaluation including non-cancer and cancer risks (US EPA method) and occupational VOCs were evaluated using the exposure risk assessment (ACGIH method) for workers.

A-D2.2.1 Risk assessment of VOCs

A-D2.2.1.1 Estimation of VOC Concentration Using the Land's Method

The US EPA recommended using the Land's method to compute the upper confidence limit (UCL) at 95% on the mean for log-normally distributed data (Land, 1975; Gilbert, 1987). The Land's method requires the use of the H-statistic tables available at Gilbert (1987, Table A12, pg. 265). The concentrations of the VOCs were determined by computing the UCL for the mean of the log-normally distributed VOC concentrations generation from the air dispersion model. The steps for the calculation are described as follows:

Let $X1, X2, \ldots, Xn$ represent the n randomly sampled concentrations around the Straits of Mackinac, downwind from the release point.

STEP 1: Compute the arithmetic mean of the log-transformed data using equation D2-E24

$$\overline{\ln X} = \frac{1}{n}\sum_{i=1}^{n} \ln(X_i) \qquad \text{(D2-E24)}$$

STEP 2: Compute the associated standard deviation using equation D2-E25

$$S_{\ln X} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n} (\ln(X_i) - \overline{\ln X})^2} \qquad \text{(D2-E25)}$$

STEP 3: Look up the $H_{1-\alpha}$ statistic for sample size n and the observed standard deviation of the log-transformed data.

STEP 4: Compute the one-sided (95%) upper confidence limit on the mean using equation D2-E26

$$UCL_{95\%} = \exp\left(\frac{\overline{\ln X} + S_{\ln X}^2}{\frac{2 + H_{1-\alpha} S_{\ln X}}{\sqrt{n-1}}}\right) \qquad \text{(D2-E26)}$$

The calculation parameters and assumptions used for the VOC risk modeling are presented in Table D6 of the main report, and the calculated VOC concentrations are presented in Tables A-D2-5 and A-D2-6.

A-D2.2.1.2 Cancer and non-cancer risk exposure assessment using the US EPA method
The non-cancer and cancer risk assessments of exposure to VOCs through inhalation were evaluated based on the US EPA method (US EPA, 2009). The non-cancer risk was assessed by comparing the daily ambient concentrations with their respective chronic non-cancer inhalation reference levels. The adverse effects contributions from the individual VOCs were also evaluated. The non-cancer risk indicator, usually expressed by the hazard quotient (HQ), refers to all other adverse health risks, excluding cancer. The HQ for compound i can be calculated using equation D2-E27;

$$HQ_i = \frac{C_i}{RfC_i} \quad \text{(D2-E27)}$$

where C_i is the VOC concentration at the location ($\frac{mg}{m^3}$), and RfC_i is the reference concentration for compound $i \frac{mg}{m^3}$ (). For a given airborne toxic chemical, exposure below the reference level (HQ < 1) is unlikely to be related to adverse health effects. When the non-carcinogenic risk HQ > 1, long-term exposure can potentially result to non-carcinogenic health diseases.

The VOCs from the Line 5 pipeline considered in this analysis for human health effects, following a worst-case release are included in Table A-D2-4. However, only the benzene, toluene, ethylbenzene and xylene (BTEX) compounds were analyzed further because of their toxicity and potential effects on humans. The RfC_i values of individual VOCs used in this study and their sources are listed in Table A-D2-4.

Table A-D2-4. Inhalation Cancer Potency Factor, Unit Risks, Non-cancer Reference Concentrations of VOCs Found in this Study and their Carcinogenic Classifications in the IARC

	Non-cancer		Cancer					
VOCs	RfC ($\mu g m^{-3}$)	Source	Group	Unit risk ($m^3/\mu g$)	Source	PF $(mg/kg/day)^{-1}$	Source
Pentane	1000	IRIS					
Hexane	700	IRIS					
Heptane	400	PPRTV					
Nonane	20	PPRTV					
Benzene	9.6	ATSDR	1	6.0×10^{-6}	WHO	0.029	IRIS
Toluene	5000	IRIS	3	-	-	-	
Ethylbenzene	260	ATSDR	2B	2.5×10^{-6}	OEHHA	-	

m-Xylenes	217	ATSDR		-	-	-
o-Xylenes	217	ATSDR	3	-	-	-
p-Xylenes	217	ATSDR		-	-	-

ATSDR (Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention (US CDC)); IRIS (Integrated Risk Information System, US EPA); PPRTV (Provisional Peer Reviewed Toxicity Values of IRIS, US EPA); HEAST (Health Effects Assessment Summary Tables, US EPA); OEHHA (Office of Environmental Health Hazard Assessment); WHO (World Health Organization).

Also, the lifetime cancer risk associated with compound i ($ILCR_i$) with known unit risk (URi) was determined using the following equation D2-E28 (US EPA, 2009)

$$ILCR_i = C_i * UR_i \qquad \text{(D2-E28)}$$

where C_i is the mass concentration of compound i ($\frac{mg}{m^3}$), URi (unit:$\frac{mg}{m^3}$) is an estimation of the increased cancer risk from inhalation exposure to a 1 $\frac{mg}{m^3}$ of compound i for a lifetime. For compounds with URi values that cannot be directly obtained from the official agencies, the $ILCR$ attributable to inhalation exposures was estimated using equations D2--E29 and D2-E30 (US EPA, 2009).

$$ILCR_i = CDI_i * CSF_i \qquad \text{(D2-E29)}$$

where the chronic daily intake CDI_i is the daily intake of compound i ($\frac{mg}{Kg-day}$), and CSF_i represents the cancer slope factor of a specific cancer substance ($\frac{Kg-day}{mg}$). The CSF and UR values were extracted from databases of the WHO, IRIS, and OEHHA, with a priority given to the WHO and IRIS (Table A-D2-4).

$$CDI_i = \left(\frac{C_i * IR * ET * EF * ED}{BW * AT * DED}\right) * 90\% \qquad \text{(D2-E30)}$$

where C_i is the concentration of compound i ($\frac{mg}{m^3}$) obtained from Land's Method, IR is the inhalation rate ($\frac{mg}{m^3}$), ET is the exposure time ($\frac{h}{week}$), EF is the exposure frequency (week/ year), ED is the exposure duration (year), BW represents the body weight (kg), AT represents the averaging time (years), and DED is the exposure duration in one year (days). The value of 90% used in equation D2-E30 is the absorption factor of VOCs for humans (Gong et al., 2017). The parameters used in equation D2-E30 are given in Table A-D2-4.

A-D2.2.1.3 Assessment of occupational exposure using the ACGIH method

The cancer risk of the cleanup workers exposed to emitted VOCs during the oil spill response was evaluated using the ACGIH method. The ACGIH provides threshold limit values (TLV) based on short-term exposure limit and time-weighted average standards. The TLVs are based on a time-weighted average (TLV-TWA), which represents the worker's exposure time that cannot be exceeded during an 8-hour workday and 40-hour workweek. The occupational exposure index (E_i) was calculated using equations D2-E31 and D2-E32: In a microenvironment, VOCs with E_i values > 1.0 pose a potential health risk to the cleanup workers.

$$E_i = \sum_i^n \frac{C_i}{TLV - TWA_i} \qquad \text{(D2-E31)}$$

$$TLV - TWA_i{}^i = (TLV - TWA_i) * \frac{5*8}{6*12} \qquad \text{(D2-E32)}$$

Where, C_i is the concentration of VOC compound i ($\frac{mg}{m^3}$), $TLV - TWA_i$ values ($\frac{mg}{m^3}$) were from ACGIH which were obtained under the assumption of working 8 h a day and 5 days per week (see Table A-D2-5). However, for the worst-case analysis, the workers are assumed to work for at least 12 h a day and 6 days a week. Therefore, the $TLV - TWA_i$ was calibrated to $TLV - TWA_i{}^i$ (using 12 h a day and 6 days per week).

References

Gilbert, R.O. (1987). *Statistical Methods for Environmental Pollution Monitoring*. New York, NY:Van Nostrand Reinhold.

Kerr JM, Melton HR, McMillen SJ, Magaw RI, Naughton G, Little GN. (1999). Polyaromatic hydrocarbon content in crude oils around the world. Austin, TX: Conference paper from the 1999 SPE/EPA Exploration and Production Environmental Conference.

Land, C.E. (1975). Tables of confidence limits for linear functions of the normal mean and variance. In *Selected Tables in Mathematical Statistics Vol III* (pp. 385-419). Providence, R.I.: American Mathematical Society.

Pampanin DM, Sydnes MO. (2013). Polycyclic aromatic hydrocarbons a constituent of petroleum: presence and influence in the aquatic environment. In V. Kutcherov & A. Kolesnikov (Eds.), *Hydrocarbon.* London, U.K.: InTechOpen.

US EPA. (1991). Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals). Washington, DC: Office of Emergency and Remedial Response.

US EPA. (1992). Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants (Revised). Research Triangle Park, NC: Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency.

US EPA. (1996). Soil Screening Guidance: User's Guide. Second Edition. Washington, DC: Office of Emergency and Remedial Response.

US EPA. (2004). Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment). Washington, DC: Office of Emergency and Remedial Response.

US EPA. (2009). Risk and Technology Review (RTR). Risk Assessment Methodologies: For Review by the EPA's Science Advisory Board. Washington, DC: US Environmental Protection Agency.

Appendix D-3 Explosion and Fire Hazard Methodology

A-D3.1 Quantitative Risk Analysis (Q^NRA) Methods

The methodology adopted for the analysis in this study considers a worst-case spill scenario, hence a combination of the AQM and SQM, which considered historical data of different events that can potentially contribute to the critical outcome (risk of fatality) from a flammable or explosive product release from the Straits Pipelines.

Information for the AQM was reviewed from numerous sources including but not limited to;

- U.S. Environmental Protection Agency (EPA)
- U.S. Department of Transportation (DOT)
- Pipeline and Hazardous Materials Administration (PHMSA)
- Office of Pipeline Safety (OPS)
- Occupational Health and Safety Administration (OSHA)
- American Institute of Chemical Engineers (AIChE)
- Center for Disease Control (CDC)
- Agency for Toxic Substances and Disease Registry (ATSDR)
- Center for Chemical Process Safety (CCPS)

A-D3.2 Pipeline Failures Potential Consequences

A-D3.2.1 Liquid Pipelines

For crude oil liquid pipelines, there are specific considerations for estimating the Ind_{Risk} because the flow of hazardous liquid products may lead to hazard source location that is not the same as the product release location on the right of way (ROW). Since the potential spill is expected to occur over the lake, the spill can flow to other locations as presented in the fate and transport models previously in this report. Ignition may result to a fire or explosion initiated from the new location several distance away from the release point along the pipeline ROW. The analysis for the worst-case spill scenario in this analysis assumes that the liquid pool will form a circular shape around the failed pipeline's ROW. Other considerations for crude oil releases include the potential for fire and explosion impacts on receptors, which depends mainly on the surface area of the liquid pool formed after the release, the crude oil pool diameter determines the impacts. For the worst-case pipeline rupture, the release is dependent on the bulk flow rate from the pipeline provided that the pumping continues. The overall scenario depends on the pool size formed, which is a function of the release rate, release duration, product solubility in water, oil weathering and the rate of evaporation. These considerations have been incorporated into the consequence model for the worst-case release. In addition to the surface area, the modeling also considered prevailing temperatures, pressure and wind conditions. These were essential for calculating the rate of release of the vapor from the pool and for modeling the dispersion characteristics for the LFL.

A-D3.2.2 Likelihood of Occurrence Under a Worst-case Scenario

The analysis in this section uses actuarial data generated in this report for estimating product release. The probability of fire, explosion, and potential fatalities were determined by considering the conditional probabilities of succeeding in different events that may lead to fatal injury of an exposed individual. The conditional probabilities are dependent on the pipeline characteristics, the distance between the receptor (exposed individual) and the hazard source.

A-D3.2.3 Potential Consequences

The potential consequences of the Line 5 pipeline failure are dependent on the properties of crude oil being transported, the mechanism of pipeline failure, operating pressure, and accident location. The main hazards from the Line 5 pipeline are chemical *toxicity and flammability*. Natural gas and petroleum liquid products are flammable and can potentially lead to fire or explosions under appropriate conditions. The Line 5 pipelines consist of two 20" pipes. The larger the pipeline, the higher the pressure and the closer the damaged pipeline location is to the public, the greater the potential severity of the consequences.

The consequences of product releases were considered based on analyzing selected impacts of these releases. Within the impact zones and distances, toxic inhalation, fires, and explosions can cause direct and secondary adverse effects to the public and their safety. The impact distance is the distance between the hazard source and the evaluation location. There are three release basic scenarios defined for the worst-case analysis with public health consequences. These scenarios represent the release mode (rupture) and the ensuing ignition.

The modeling of the physical impacts/consequences of the catastrophic release was based on the fundamental equations of fluid dynamics and combustion that have been documented in extant studies and technical literature. The dispersion modeling equations estimated the airborne concentrations of vapor from the release, and fire and explosion modeling was used for the estimation of the effects of the potential release that ignites.

Thermal radiation emitted will be the major potential hazard from jet or pool fire. If the exposure to people exceeds a certain threshold for a given exposure period, the people may be at risk of serious injury or fatality. The heat flux intensity varies depending on the fire size (flame dimensions, speed, and other variables), which decreases as the distance from the fire increases. Consequently, fire exposure risk decreases with distance away from the hazard source. The effects from these hazards were estimated by calculating the Ind_{Risk} and potential effects on exposed populations. The magnitude and severity of these effects are dependent on the heat intensity expressed in units of British thermal units (Btu) per square foot transmission area per unit of time, for example per hour ($\frac{Btu}{hr-ft^2}$).

A-D3.3 Pipeline Risk Estimate Calculations

A-D3.3.1 Probabilistic Analysis

Standard calculation procedure was used to provide a numerical estimate for Ind_{Risk} from a possible worst-case scenario of the Line 5 pipeline.

A-D3.3.2 Technical Descriptions of Probability Calculations

The methodology used is based on established methods widely used in loss prevention and reliability engineering. An event tree analysis (ETA) was developed as a standard analytical structure for exploring the potential consequences of an initiating event, in this instance, a potential worst-case pipeline failure and product release from the Line 5 pipeline. The calculation commenced with the estimation of a base probability for Line 5 pipeline failure; then, other conditional probabilities for ensuing events up through the impact were estimated relative to public areas around the Strait of Mackinac. The impact probability is the mathematical product of several event probabilities through the event chains, for different possible hazard scenarios. The developed event tree for a potential pipeline failure based on the worst-case assumptions and the related possible events is illustrated in Figure A-D3-1.

In the event of a catastrophic failure of the Line 5 pipeline, the pipeline products may be released which could result to the dispersion of gas or liquid vapors (unignited), or a flash fire or an explosion that could cause harm to people nearby within the vulnerability zone, defined by injurious intensity levels of the physical effects. These adverse impact levels vary depending on the various locations and distances from the pipeline accident to public resources. The risk estimation involves certain determinations, such as:

- The physical effect of fire incident or explosion at identified receptor locations; for the calculation of the Ind_{Risk};
- The probability of exposure to the impacts (i.e., the probability that an individual would be present along the impact zones at the time of the worst-case release and ensuing fire or explosion); and
- The probability that the exposure would result in one fatality.

The event tree showed the decomposition of the different events and the final event's probability is the mathematical product of the individual event probabilities. The calculations are the basic mathematics of ETA probabilities, as shown in equations D3.1-D3.14.

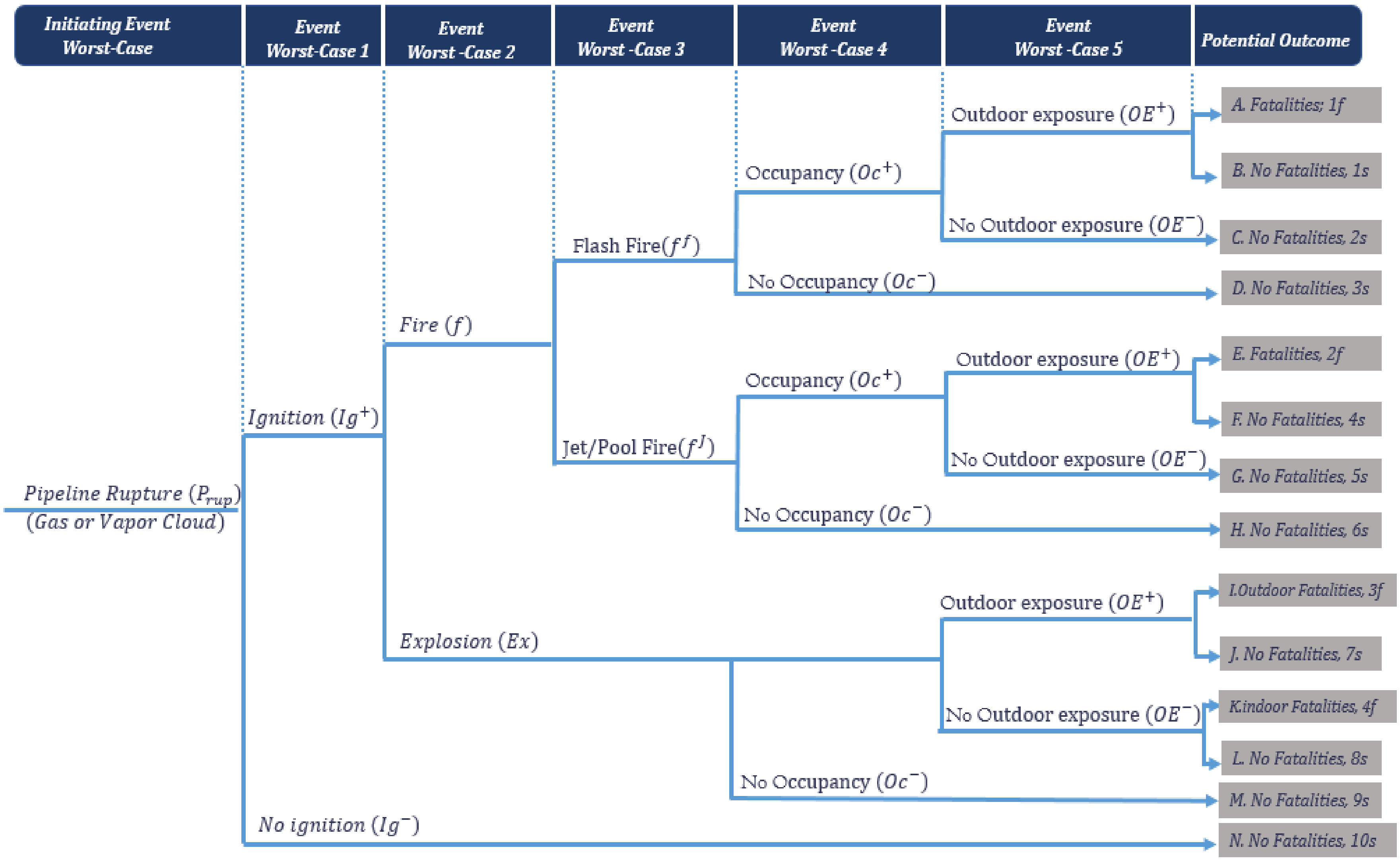


Figure A-D3-1. Event Tree Illustrating the Probability Calculation for Worst-case Pipeline Failure Consequences

A-D3.3.3 Outcome Probabilities[1]:

<u>Failure Outcome A</u>

$$P^{A} \;=\; (P^{P_{rup}})(P^{Ig^{+}})(P^{f})\left(P^{f^{f}}\right)(P^{Oc^{+}})(P^{\,OE^{+}})(P^{1f}) \qquad \text{(D3-E1)}$$

Success Outcome B

$$P^{B} \;=\; (P^{P_{rup}})(P^{Ig^{+}})(P^{f})\left(P^{f^{f}}\right)(P^{Oc^{+}})(P^{\,OE^{+}})(P^{1s}) \qquad \text{(D3-E2)}$$

Success Outcome C

$$P^{C} \;=\; (P^{P_{rup}})(P^{Ig^{+}})(P^{f})\left(P^{f^{f}}\right)(P^{Oc^{+}})(P^{\,OE^{-}})(P^{2s}) \qquad \text{(D3-E3)}$$

Success Outcome D

$$P^{D} \;=\; (P^{P_{rup}})(P^{Ig^{+}})(P^{f})\left(P^{f^{f}}\right)(P^{Oc^{-}})(P^{3s}) \qquad \text{(D3-E4)}$$

<u>Failure Outcome E</u>

$$P^{E} \;=\; (P^{P_{rup}})(P^{Ig^{+}})(P^{f})(P^{f^{J}})(P^{Oc^{+}})\left(P^{\,OE^{\mp}}\right)(P^{2f}) \qquad \text{(D3-E5)}$$

Success Outcome F

$$P^{F} \;=\; (P^{P_{rup}})(P^{Ig^{+}})(P^{f})(P^{f^{J}})(P^{Oc^{+}})\left(P^{\,OE^{\mp}}\right)(P^{4s}) \qquad \text{(D3-E6)}$$

Success Outcome G

$$P^{G} \;=\; (P^{P_{rup}})(P^{Ig^{+}})(P^{f})(P^{f^{J}})(P^{Oc^{+}})(P^{\,OE^{-}})(P^{5s}) \qquad \text{(D3-E7)}$$

Success Outcome H

$$P^{H} \;=\; (P^{P_{rup}})(P^{Ig^{+}})(P^{f})(P^{f^{J}})(P^{Oc^{-}})(P^{6s}) \qquad \text{(D3-E8)}$$

<u>Failure Outcome I</u>

$$P^{I} \;=\; (P^{P_{rup}})(P^{Ig^{+}})(P^{Ex})(P^{\,OE^{+}})(P^{3f}) \qquad \text{(D3-E9)}$$

Success Outcome J

$$P^{J} \;=\; (P^{P_{rup}})(P^{Ig^{+}})(P^{Ex})(P^{\,OE^{+}})(P^{7s}) \qquad \text{(D3-E10)}$$

[1] See Figure A-D3-1 for descriptions of the variables.

Failure Outcome K

$$P^{K} = (P^{P_{rup}})(P^{Ig^{+}})(P^{Ex})(P^{OE^{-}})(P^{4f}) \quad \text{(D3-E11)}$$

Success Outcome L

$$P^{L} = (P^{P_{rup}})(P^{Ig^{+}})(P^{Ex})(P^{OE^{-}})(P^{8s}) \quad \text{(D3-E12)}$$

Success Outcome M

$$P^{M} = (P^{P_{rup}})(P^{Ig^{+}})(P^{Ex})(P^{Oc^{-}})(P^{9s}) \quad \text{(D3-E13)}$$

Success Outcome N

$$P^{N} = (P^{P_{rup}})(P^{Ig^{-}})(P^{9s}) \quad \text{(D3-E14)}$$

A-D3.3.4 Calculating the Individual Risk (Ind_{Risk})

The Individual Risk (Ind_{Risk}) that may result due to potential hazards from a worst-case crude oil release from the Line 5 pipeline is the probability of fatality for an individual exposed to the physical impact of the hazard, at a specific location, within a specified timeframe. The calculation based on the worst-case release follows the standard practice in probabilistic estimation used for Quantitative Risk Analysis ($Q^{N}RA$) of unintended hazardous chemical release, the event impacts are estimated based on annual probabilities.

The Ind_{Risk} for an individual in the Strait of Mackinac, in close proximity to the pipeline would be based on potential exposures to a flash fire, jet fire (for natural gas liquids) or pool fire for crude oil releases), or explosion if there are obstructions along the vapor cloud paths. The effects of these hazards are estimated as Ind_{Risk}, which are determined in this analysis. The individual exposure may be influenced by the ***hazard impact distance***[2] (R_o), which is the distance between the hazard source and the individual receptor (i) location from the shoreline (see Figure D4 in the main report).

An individual at a specific location away from the hazard source, the IR can be estimated using equation D3-E15 (Center for Chemical Process Safety 1989; 1996).

$$IR_{(i,X)} = PC_{(i,x)} * PF_{(i,x)} \quad \text{(D3-E15)}$$

Where,

$IR_{(i,X)}$ = the IR at a specific location, i, for a defined hazard, X $(Rjf, Rff \ or \ Rex)$

[2] Also referred to as “impact radius”, “hazard footprint length” etc.

$PC_{(i,x)}$ = the probability for an individual's exposure to hazard X's impact at location, i; and

$PF_{(i,x)}$ = the probability of fatality, at location,i, from the impact of hazard X. The fatality probabilities are calculated for failure outcomes A, E, I, and E from equations, D3-E1, D3-E5, D3-E9 and D3-E11.

For the given Line 5 pipeline lengths, within the property line around the rupture area, each of the potential hazards has a distinctive pipe length for which the hazard impacts may reach a receptor. Beyond this length, the impacts or consequences could be minimal or negligible to the potential receptor. As illustrated in Figure D9 in the main report, SEG_X is the segment length for which a hazard X can have an impact on the receptors. Following the determination of the IR for each of the hazards identified, the total IR (TIR) for all hazard types was determined from equation D3-E16:

$$TIR = IR_{(Rjf)} + IR_{(Rff)} + IR_{(Rex)} \quad \text{(D3-E16)}$$

A-D3.3.5 Calculating the Hazard Impact Distance ($\boldsymbol{R_o}$)

The applicable hazard consequence modeling of the worst-case product releases from the Line 5 pipeline was used to estimate the hazard impact distances. The hazard categories (flash fires, jet/pool fires, and explosion) were modeled, and the specific data used for the evaluation were;

1. Crude oil constituents in the Line 5 pipeline;
2. Pipeline diameter;
3. Pipeline operating pressure;
4. Minimum distance between the pipeline and the property line (or shoreline)
5. Pipeline orientation to the property line (i.e., parallel, perpendicular, at an angle, etc.);
6. Length of property line exposed to pipe length of concern, the length of the pipeline segment that lies within 46 m of the property line (from US EPA guidelines); and
7. The receptor location distance, which is the center of the property line nearest to the pipeline (or shoreline).

Table A-D3-1 illustrates how some of these data will be compiled.

Table A-D3-1. Data Input Requirements for the Analysis

Description	Variable	Value	Data Source
Pipeline diameter, inches	D	20	Study data request and other information.
Pipeline pressure, psig	P	400	Study data request and other information
Exposed property line length, ft	LPL	500	Site location around the Straits
Receptor location distance nearest hazard source, ft	R_o	250	Selected in accordance with the Analysis.
Nearest property line distance, ft	R	250	This would be the same as R0 when the receptor location is on the nearest property line.

A-D3.3.6 Individual Hazard Segment Length (SEG_X)

The individual hazard "X" segment length (SEG_X) represents the length of the pipe within the segment of concern along the Straits from which a product release can potentially lead to a flash fire, jet/pool fire, or explosion. The consequences or impacts of which could affect the receptors with the possibility for fatalities at a level of at least one percent (1%) mortality (i.e., fatality probability of 0.01). The 1% mortality level is a conservative and reasonable estimate of the boundary of adverse effects and serious damages. Considering the whole number estimates of mortality, the difference between threat level (1% mortality or higher) and level of no-threat (0% mortality), the hazard boundary zone using the 1% tolerance level will give a greater SEG_X length and larger failure probability estimates than other percentages for these scenarios.

The SEG_X length is determined from the longest impact distance (Figure D9 in the main report) from the Line 5 failed pipeline, reaching the receptor with a 1% mortality consequence. The impact distance is determined for each of the hazard types previously discussed, but the distance corresponding to a 1% mortality impact must be determined first. Then the SEG_X can be determined using equation D3.17:

$$〚SEG〛\_X \; = \; 2\,[(R\_x\,(1\%))\verb|^|2 \; - \; R\_o\verb|^|2\,)]\verb|^|0.5 \qquad \text{(D3-E17)}$$

Where,

$R_x(1\%)$ = the distance from the hazard source to the receptor location for a 1% mortality impact (i.e., 0.01 fatality probability impact).

R_o = the distance from the hazard source to the receptor location.

The hazard length was calculated for each of the worst-case basis scenarios discussed previously.

A-D3.4 Maximum and Average Mortality and Fatality Probability

Mortality is fatality probability expressed as a percentage; 100% mortality equals a probability of 1.0, this is dependent on the hazard impact distance. Mortality data were obtained from technical studies for the estimation of the mortality from fire heat radiation and explosion blast overpressure (Gas Research Institute, 2000; Center for Chemical Process Safety, 1996). The overpressure data represents mortality probabilities for indoor exposure, and it will be conservative when applied for outdoor exposure since the risk is greater indoors for explosion scenarios.

Within the zone surrounding the LFL, flash fires are assumed to have 100% mortality. This assumption is based on a worst-case event. However, the survivability in the LFL bounded zone depends mainly on; a) the concentration profile of the vapor cloud mixture, b) the exact pattern of the flame front and mode of ignition, c) the location of persons proximate to the flame front as the flame burns through the cloud and d) other factors unique to each specific situation. There have been fires in which the mortality was less than 100%.

Figures A-D3-2 and A-D3-3 illustrate mortality data for heat radiation from fires based on the mortality from exposure to fire heat radiation, data based on Gas Research Institute Report on natural gas fires (Gas Research Institute, 2000) and for overpressure from explosions from the American Institute of Chemical Engineers, Center for Chemical Process Safety (Center for Chemical Process Safety, 1996) study respectively.

The bottom point on the line in Figure A-D3-3 corresponds to a heat radiation impact of $500\frac{Btu}{hr-ft^2}$ or 1% mortality. The top point on the line corresponds to $12000\frac{Btu}{hr-ft^2}$ or 100% mortality.)

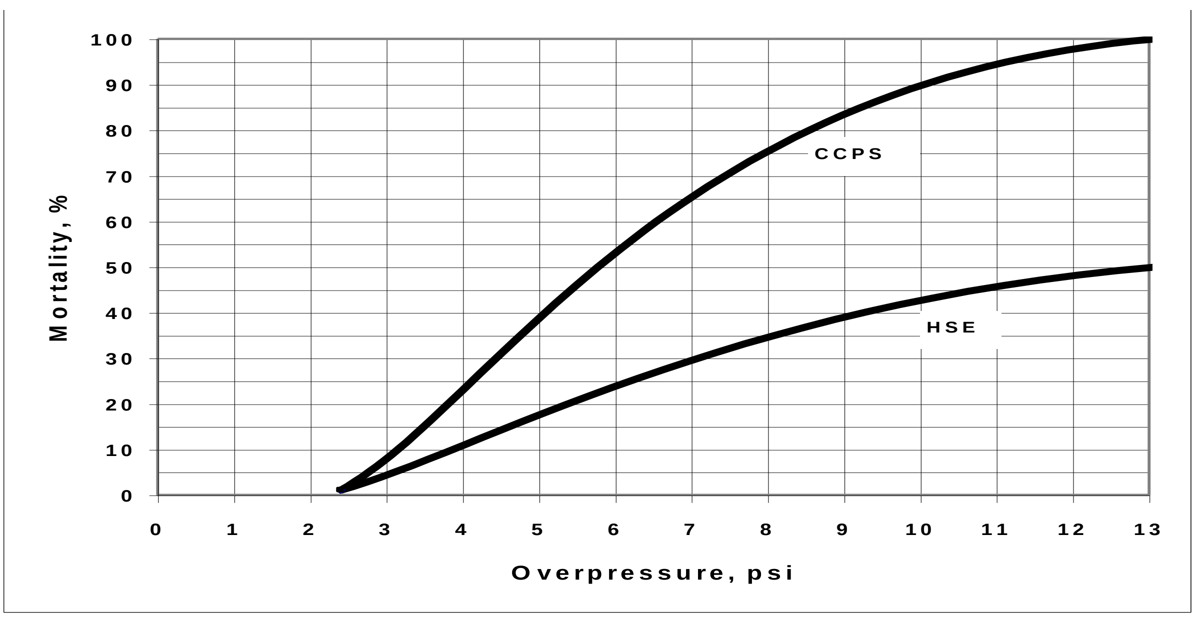


Figure A-D3-2. Estimated mortality vs. Explosion Overpressure (Center for Chemical Process Safety, 1996)

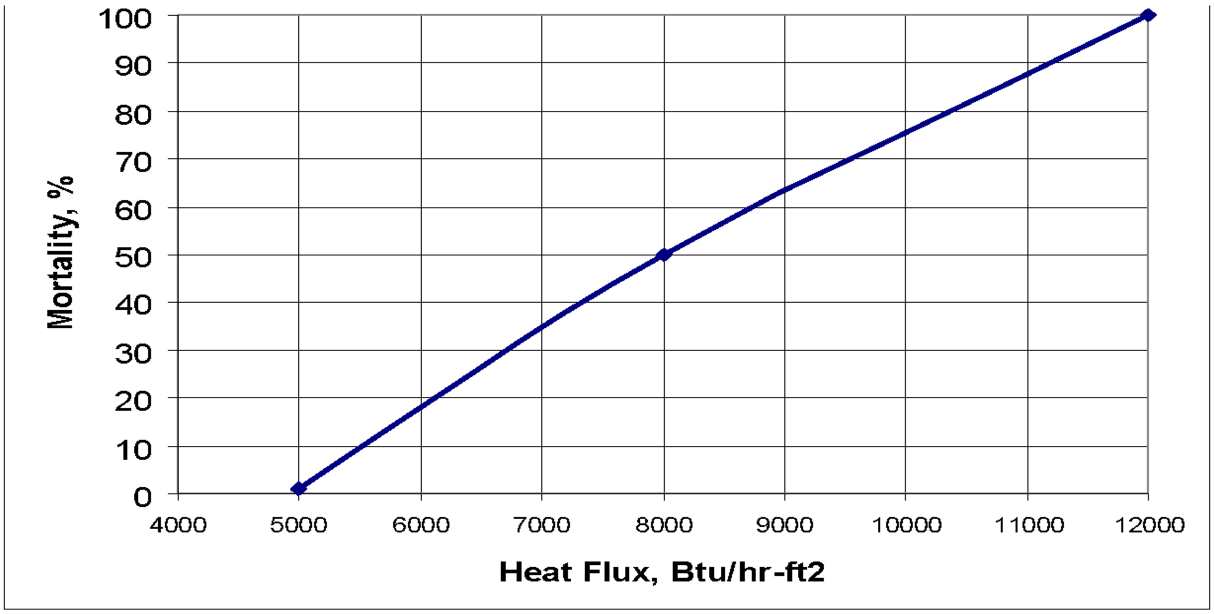


Figure A-D3-3. Estimated Mortality vs. Fire Heat Radiation Intensity (based on 30-second exposure) (Gas Research Institute, 2000)

Based on the CCPS literature, the percentage of mortality can be derived using equation D3-E18, which fits the heat radiation mortality curve with the tabular data in the literature (Center for Chemical Process Safety, 1994).

For a flash fire hazard, the mortality can be described as;

$$M(\%)I_{th} = (-5.55E-07){I_{th}}^{2} + (2.36E-02)I_{th} - 103 \quad \text{(D3-E18)}$$

As for the explosion mortality, the data was fitted from the CCPS technical literature and expressed in equation D3.19 as;

$$M(\%)OP = -0.7817(OP)^{2} + 21.354(OP) - 44.99 \quad \text{(D3-E19)}$$

Where,

$M(\%)I_{th}$ = mortality as a percentage from heat radiation

$M(\%)OP$ = mortality as a percentage from explosion overpressure

I_{th} = heat radiation intensity in $\frac{Btu}{hr-ft^2}$. (Derived from Figure A-D3-3)

OP = the explosion overpressure in psi. (Calculated)

Note: The CCPS curve is only applicable to people in the building, while the Health and Safety Executive (HSE) curve applies to people outdoors.

The average mortality gives the fatality probability $\left(P^F_{(i,X)}\right)$ used in the final IR calculations. This is estimated as the arithmetic average of the maximum mortality, equations D3-E18 and D3-E19, and the 1% mortality, this gives the average over each SEG_X. The SEG_X length was also calculated from the mortality data.

A-D3.5 Probability of Hazard Impacts at Receptor Location on the Straits

The fatality probability $PF(X)$ was determined for specific SEG_X, then the probability of impact from a failure from that pipeline segment was also determined. This involved the determination of the probability of a product release from that segment, and the probability of the given hazard X.

A-D3.6 Base Product Release Frequency and Probability

The base probability value was estimated from the base annual frequency value for pipeline failure and product release, F_O, based on historical data from OPS Gas Pipeline Incident and Hazardous Liquid Pipeline Accident Databases, 2000. Normalized Pipeline Average Failure and Release Frequencies (F_O) for California Pipelines (1984-2001 Period) were reported in the "Brown Book", which suggests these values for estimating pipeline failure rates for frequency calculations in emergency planning (FEMA, DOT, and EPA, 1989). The Crude Oil Transmission Line number of release per mile-year estimate is 2.3E-03 (0.0023).

A-D3.6.1 Base Release Probability

The probability estimation of the Line 5 pipeline failure that would result in the worst-case release of a product with a specified hazard (X) starts with calculating the base probability from the base release frequency (F_O), using a Poisson probability estimate of "one or more" releases in a given year of pipeline operation. A mathematical expression is shown in equation D3-E20:

$$P_O = 1 - e^{(-F_O * t)} \qquad \text{(D3-E20)}$$

Where,

F_O = the average release frequency for the pipeline in releases/mi-year;

t = the time frame of the worst-case probability; all probabilities are based on one year, so t =1.

For the smaller frequency numbers involved for pipeline failure rates in the worst-case analysis, equation D3.20 generates a probability value that is numerically equal to the annual frequency, here t is taken to be a probability time basis of one year; therefore;

$$P_O = 1 - e^{(-2.3E-03 * 1)}$$

$$P_O = 1 - 0.997703$$

$$P_O = 0.002297 \approx 0.0023 \; or \; 2.3E - 03$$

Adjusted P_O = PA, where variations and corrections are present, the probability adjustment factor (PAF) is applied. The PAF = 0.95 in this analysis; therefore;

$$P_A = P_O * PAF = 0.0023 * 1 = 0.0023$$

A-D3.6.2 Base Probability for Each Hazard Segment Length (SEG_X)

The pipe length SEG_X defines the limits of impacts getting to the receptor, hence it is the only length capable of generating an Ind_{Risk} impact at the receptor location for the corresponding hazard, X. Crude oil products releases outside the SEG_X do not pose any fatal threat to receptors. The P_A is converted to $P_A\ (X)$ for each hazard scenario as shown in equation D3-E21:

$$P_A(X) = \left[\frac{SEG_X}{5{,}280}\right] * PA \qquad \text{(D3-E21)}$$

$\frac{SEG_X}{5{,}280}$ is basically the ratio of the given hazard segment length, SEG_X in feet relative to the number of feet in a mile (5,280)

A-D3.6.3 Conditional Probability for Each Hazard Impact

The conditional probabilities for the various hazard impacts, $PCI(X)$, are determined by the following equations courtesy of California Department of Education, 2007:

Rupture Jet or Pool Fire: $PCI(Rjf) = PC(R) * PC(RIg^+) * PC(FIg^+) * PC(jf)$ (D3-E22)

Rupture Flash Fire: $PCI(Rff) = PC(R) * PC(RIg^+) * PC(FIG) * PC(FF)$ (D3-E23)

Rupture Explosion: $PCI(REx) = PC(R) * PC(RIg^+) * PC(ExIg^+)$ (D3-E24)

Analysis default conditional probabilities used in the equations are listed in Table A-D3-3.

A-D3.6.4 Conditional Probability of Individual Exposure

An individual along the Strait of Mackinac can be affected only if present at or around the impact location, at the time of the worst-case incident. The exposure probability $PC(XP)$ is shown in equation D3-E25.

$$PC(XP) = PC(OC^+) * PC(OE^+) \qquad \text{(D3-E25)}$$

Where,

$PC(OC^{+})$ = the probability of occupancy at the receptor location in a given year;

$PC(OE^{+})$ = the probability of being outdoors during occupancy in a given year.

The probability is estimated for an individual area for the average individual.

For regular residents

The default values used in this analysis are based on assumptions of occupancy for residents for 240 days per year, eight hours per day to yield:

$$PC(OC^{+}) = \frac{\left(240\left(\frac{days}{year}\right) * 8\left(\frac{hours}{day}\right)\right)}{\left(8760\left(\frac{hours}{year}\right)\right)} = 0.22$$

$$Note: 365\ days\ *\ 24\ hours\ =\ 8760\ hrs/\ yr$$

$PC(OE^{+})$ is assumed to be three hours per day, so the probability of being outdoors during a 12-hour day is 3/12 = 0.25. Therefore, the default;

$$PC(XP) = 0.22 * 0.25 = 0.055.$$

For seasonal residents

For the tourist or seasonal residents, the default value will be;

$$PC(OC^{+}) = \frac{\left(90\left(\frac{days}{year}\right) * 12\left(\frac{hours}{day}\right)\right)}{\left(8760\left(\frac{hours}{year}\right)\right)} = 0.12$$

The assumption is that tourist or seasonal residents will stay in the area for a maximum of 90 days in a year, 12 hours is assumed for the occupancy exposure because tourists or seasonal residents mostly stay around the residence and do not go to work.

$PC(OE^{+})$ is assumed to be eight hours per day, so the probability of being outdoors during a 12-hour day is 8/12 = 0.67. Therefore, the default;

$$PC(XP) = 0.12 * 0.67 = 0.08.$$

This calculation suggests that seasonal residents have a higher probability of individual exposure.

A-D3.6.5 Calculating Conditional Hazard Probability and Ind_{Risk}

The individual conditional hazard probabilities $PC(X)$, the hazard impacts and the fatality probabilities $PF(X)$, each of the Ind_{Risk} (X), and the $total\ individual\ risks -$ $TInd_{Risk}$ were calculated in the final step.

The following equations give the individual conditional hazard probabilities : see Table D3-3 for $PCI(X)$ values, $P_A(X)$ (from equation D3-E21)

Rupture Jet or Pool Fire: $PC(Rjf) = PA(Rjf) * PCI(Rjf) * PC(XP)$ (D3-E26)

Rupture Flash Fire: $PC(Rff) = PA(Rff) * PCI(Rff) * PC(XP)$ (D3-E27)

Rupture Explosion: $PC(REx) = PA(REx) * PCI(REx) * PC(XP)$ (D3-E28)

The individual risks were determined from the following equations:

Rupture Jet or Pool Fire Ind_{Risk}: $Ind_{Risk}\ (Rjf) = PC(Rjf) * PF(RJF)$ (D3-E29)

Rupture Flash Fire Ind_{Risk}: $Ind_{Risk}\ (RFF) = P_A(Rff) * PCI(Rff)$ (D3-E30)

Rupture Explosion Ind_{Risk} is:

$Ind_{Risk}\ (REx) = P_A\ (REx) * PCI(REx)$ (D3-E31)

The $TInd_{Risk}$ is the summation of each individual hazard (see equation D3.16). The $TInd_{Risk}$ value compared to a reference value (IRC) of 1.0E-06 (P_i), gives an indication of the risk significance (California Department of Education, 2007). $If\ \ TInd_{Risk} > IRC$ = significant; otherwise it is insignificant.

A-D3.7 Numerical Analysis of the Line 5 Worst Case Product Release

Based on the results obtained from the worst-case analysis in this project, the Ind_{Risk} was estimated in this section.

A-D3.7.1 Considering the Worst-case Scenario

The Line 5 20-inch diameter crude oil transmission pipeline with an operating pressure of 400 psig, located within the 46m applicability zone along the Mackinaw City shoreline. Based on the location, the pipeline is estimated to have a segment length of 1050m within the 46m distance zone of interest. The distance between the pipeline and the nearest public property line is about 1600m. The area is considered relatively open with little confinement potential for a vapor cloud explosion. The Ind_{Risk} at the center of the property line for comparison with the IRC was estimated following the risk analysis steps outlined previously.

Using the steps listed in the preceding section, the computation for the rupture pool fire scenario is as follows;

Step 1: Estimate the hazard impact, maximum distance for each Basis Hazard Scenarios.

For a crude oil rupture pool fire, the estimated heat radiation impact distance for a 20-inch 400 psig pipeline was evaluated from Figure A-D3-3 for the 5000 BTU/hr-ft2 or 1% mortality, the corresponding impact distance from the pipeline, are presented in Table A-D3-2.

Step 2: Estimate the hazard segment length, SEG_X for each hazard scenario.

The hazard segment length SEG_X for hazard X is given by Equation D3-E17.

Table A-D3-2. Segment Length Calculations for Each Hazard Type

Pipe Size, Pressure, and Hazard Type			Front Receptor Line - Begin Zone 1			Begin Zone 2			Begin Zone 3			End Zone 3 -Back Receptor Line		
Pipe Size	**Press.**	**Hazard** X	R_x (1%)	R_o	SEG_X	R_x (1%)	R_o	SEG_X	R_x (1%)	R_o	SEG_X	R_x (1%)	R_o	SEG_X
(in)	**(psig)**		**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**
20	400	$RRjf$	3400	500	6726	3400	1000	6499	3400	1500	6102	3400	2000	5499
20	400	$RRff$	8202	500	16373	8202	1000	16282	8202	1500	16127	8202	2000	15909
20	400	$RREx$	16400	500	32785	16400	1000	32739	16400	1500	32663	16400	2000	32555

The SEG_X was used to estimate the base annual probability of the flash fire, rupture pool fire and explosion scenarios were estimated using the results from the SEG_X.

Step 3: The base release frequency **(F_o),** the base annual release probability per mile of the pipeline (P_o), and the adjusted base probability P_A using the probability adjustment factor, PAF was determined previously as 0.95. The base annual probabilities for each hazard scenario for the estimated hazard segment length $P_A(X)$ were determined using equation D3-E21 and the values for the three hazard scenarios are presented in Table A-D3-3. Based on the annual probability of a worst-case accidental release of product from the Line 5 pipeline, P_o. The values for all other variables were calculated based on the assumptions of the worst-case situation and results are presented in Table A-D3-3.

The *PCI* is the conditional probability that the Line 5 pipeline along the Straits of Mackinac worst-case release will be a rupture, pool fire, flash fire or explosion scenario (see Table A-D3-3). It means that for rupture pool fire, 20% of the time the pipeline release will be from a full diameter rupture, and 3% of the time it would ignite, once ignited, 95% of the time it would result in a fire rather than an explosion, and that 95% of the time the fire would be a pool fire. These assumptions are also true for flash fires, except that the flash fire hazard conditional probability would only allow for a flash fire 5% of the time for a crude oil case. Finally, for the explosion scenario, 20% of the time the pipeline release will be from a full diameter rupture, and there is a 3% probability of the vapor cloud igniting and 5% of the time, the fire will ignite and lead to an explosion. The heat radiation intensity levels at close distances from the hazard source exceed $12{,}000\,\frac{Btu}{hr-ft^2}$, (Figure A-D3-3). In this case, the mortality is 100%; if lower, then the estimated mortality for the heat radiation levels was determined from the mortality calculation for heat radiation from fires using equation D3-E31. The probability of fatality at the receptor locations was calculated for the rupture pool fire as 0.9 (the average mortality factor).

Table A-D3-3. Conditional Probability Factors Calculation for Worst-case Line 5 Release Scenario

Table 5.3: Calculations for Conditional Probability Factors for the Worst-Case Line 5 Release Scenario

Base		Worst case rupture			Both		Base Probabilities for segments	
F_O	$2.3E-03$	$PC(R)$	0.2		$PC(OC^{+})$	0.22 **(0.12)**	$PA_{Rjf}=$	$2.78E-03$
P_O	$2.3E-03$	$PC(RIg^{+})$	0.45		$PC(OE^{+})$	0.25 (0.67)	$PA_{Rff}=$	$6.78E-03$
PAF	0.95	$PC(FIg^{+})$	0.99		$PC(XP)$	0.055 (0.08)	$PA_{REx}=$	$1.36E-02$
P_A	$2.2E-03$	$PC(ExIg^{+})$	0.05		$PCI_{Rjf}=$	$8.73E-02$		
P_i	$1.0E-06$	$PC(ff)$	0.01		$PCI_{Rff}=$	$8.91E-04$		
		$PC(jf)$	0.98		$PCI_{REx}=$	$8.91E-04$		
$M(\%)I_{th}=0.8$		$P^{F}_{(X)}$	0.90					
$M(\%)OP=1$								

Hazard Impact Probability $PC(X)$ Calculation

PC_{Rjf}	=	PA_{Rjf} *	PCI_{Rjf} *	$PC(XP)$	= Zone 1 $PC(X)$	= Zone 2 $PC(X)$	= Zone 3 $PC(X)$	= Zone 4 $PC(X)$
		$2.80E-03$	$8.73E-02$	0.055 (0.08)	$1.34E-05$ ($1.95E-05$)	$1.36E-05$ ($1.99E-05$)	$1.28E-05$ ($1.87E-05$)	$1.09E-05$ ($1.60E-05$)
PC_{Rff}	=	PA_{Rff} *	PCI_{Rff} *	$PC(XP)$				
		$6.78E-03$	$8.91E-04$	0.055 (0.08)	$3.32E-07$ ($4.85E-07$)	$3.48E-07$ ($5.08E-07$)	$3.44E-07$ ($5.03E-07$)	$3.23E-07$ ($4.72E-07$)
PC_{REx}	=	PA_{REx} *	PCI_{REx} *	$PC(XP)$				
		$1.36E-02$	$8.91E-04$	0.055 (0.08)	$6.65E-07$ ($9.72E-07$)	$6.99E-07$ ($1.02E-06$)	$6.97E-07$ ($1.02E-06$)	$6.60E-07$ ($9.65E-07$)

Interpretation:

Hazard Type	Population Affected	$PC(X)$	Rank	Severity	
Rupture Jet Fire – Zone 2	Seasonal residents	$1.99E-05$	First	Highest	Seasonal residents are at a higher risks from the three hazard sources. Zone 2 is the worst-case impact area.
Rupture Jet Fire – Zone 2	Permanent residents	$1.36E-05$	Second		
Rupture Explosion - Zones 2 &3	Seasonal residents	$1.02E-06$	Third		
Rupture Explosion - Zones 2	Permanent residents	$6.99E-07$	Fourth		
Rupture flash fire – Zone 2	Seasonal residents	$5.08E-07$	Fifth		
	Residents	$3.48E-07$	Six	Lowest	

Ind_{Risk} Calculation = $P^{F}_{(X)}$ * $PC(X)$

	Zone 1	Zone 2	Zone 3	Zone 4	
$Ind_{Risk}(Rjf)=$	$1.20E-05$ ($1.76E-05$)	$8.29E-06$ ($1.21E-05$)	$1.15E-05$ ($1.68E-05$)	$9.84E-07$ ($1.44E-05$)	Maximum Risk
$Ind_{Risk}(REx)=$	$5.98E-07$ ($8.75E-07$)	$6.29E-07$ ($9.19E-07$)	$6.28E-07$ ($9.17E-07$)	$5.94E-07$ ($8.69E-07$)	
$Ind_{Risk}(RFF)=$	$2.99E-07$ ($4.37E-07$)	$3.13E-07$ ($4.57E-07$)	$3.10E-07$ ($4.53E-07$)	$2.90E-07$ ($4.24E-07$)	Minimum Risk

$TInd_{Risk}$ Calculation

$TInd_{Risk}$		$\frac{TInd_{Risk}}{P_i}$ Ratio[1]	Comment
$TInd_{Risk}$ 1	$1.29E-05$ ($1.89E-05$)	13 (19)	$TInd_{Risk}$ calculation begin ZONE 1 – Front Property Line
$TInd_{Risk}$ 2	$9.24E-06$ ($1.35E-05$)	9 (14)	$TInd_{Risk}$ calculation end ZONE 1 – begin ZONE 2
$TInd_{Risk}$ 3	$1.24E-05$ ($1.82E-05$)	12 (18)	$TInd_{Risk}$ calculation end ZONE 2 – begin ZONE 3
$TInd_{Risk}$ 4	$1.07E-05$ ($1.57E-05$)	11 (16)	$TInd_{Risk}$ calculation end ZONE 3 – Back of receptor Line
$TInd_{Risk}$ **indicator ratio**		**= 0.88**	This indicates that the risk from the hazard sources is 88% credible.

[1]The ratio value > 1.0E-06, therefore risk is significant. The ratio value is the number of times the risk is larger

The hazard conditional probability is highest for rupture pool fire, followed by the hazard conditional probability from explosion hazards for seasonal residents. Total individual risks for seasonal residents in zone 1 is 19 times greater than the benchmark value. The total individual risks in all zones are greater by double-digit except for the total individual risks to permanent residents in zone 2, which is nine times greater risk than baseline.

A-D3.8 Total Individual Risk Indicator Ratio

The total individual indicator $TInd_{Risk}$ is the total Ind_{Risk} averages across the depth of the area of concern to the Ind_{Risk} at the receptor center line. The $TInd_{Risk}$ was evaluated at the boundaries of the defined zones and the $TInd_{Risk}$ values for the zone boundary locations gave an overall average $TInd_{Risk}$. The $TInd_{Risk}$ Indicator Ratio is defined as the ratio of the Average $TInd_{Risk}$ to the front receptor line $TInd_{Risk}$ as described in equation D3-E32.

$$TInd_{Risk}\ Indicator\ Ratio\ = \frac{TIR(AVG)}{TInd_{Risk}\ (FRONT\ RECEPTOR\ LOCATION\ LINE)} \qquad \text{(D3-E32)}$$

This measure indicates how quickly the TIR decreases across the area, hence it represents an indirect measure of the risk level to the people in those areas. The smaller the value, the less risk to the population for a given property line $TInd_{Risk}$. The risk to the population around a specific receptor location line is minimized or lesser if $TInd_{Risk}$ indicator ratio value is small.

The results for this analysis are presented in Table A-D3-3 where the front location line is 3400 ft from the pipeline (towards Mackinaw City). A-D3.9 Population Risk Indicator Calculation

The population risk indicator (PRI) is estimated by dividing the area of concern into some population zones. The PRI begins from the receptor line closest to the ruptured pipeline and moving away from the receptor line toward the opposite side of the area, zone boundaries are then defined at appropriate intervals, with the zone boundaries parallel to the property line. The calculated IR was evaluated at each zone boundary, and the IR for the area was taken as the average of these zone boundary values. Therefore, the average impact was determined by estimating the potentially affected population for each zone, and the total affected population of the area was calculated.

The impact of the scenario is computed for the zones defined in Table A-D3-3. The hazard impact was evaluated at the front and rear boundary for each zone, same as for the TIR calculation. The difference is that the highest impact from the hazard source was estimated at the center of each zone boundary. The corresponding potential mortality values for each of the hazard scenarios were then determined.

The simple arithmetic mean of the front and rear boundary mortality values for each zone was taken as the average mortality for the zone. The average fatality probability $\left(Avg\ P^{F}_{(X)}\right)$ corresponding to the mortality (expressed as a percentage $(M(\%)$)) for the zone is the mortality divided by 100. The total number of people at risk per zone (Ψ_n) was estimated using equation D3-E33

$$\Psi_n\ =\ Avg\ P^{F}_{(X)} * \Omega \qquad \text{(D3-E33)}$$

where, $Avg\ P^F_{(X)}$ is the average probability of fatality; Ω is the zone population (estimated number of people in each zone, evenly distributed).

For the worst case scenario PRI calculation, a uniform average outdoor population of 99% of the total receptor location population was assumed to be distributed evenly across the zones.

Assuming for this analysis, at receptor location depth of 450 ft and there are 1000 people in the area. The assumed outdoor population event is 99% of the site population or 990 persons. Each of the zone population for the three zones would be $\Omega = \frac{990}{3} = 330$ persons per zone. For the 450-ft receptor location depth, the depth of each of the three zones would be 150 ft.

The $Avg\ P^F_{(X)}$ in each zone was calculated as the average of the probability at the front and rear boundaries of each zone as presented in Table A-D3-4 and the PRI was calculated using equation D3-E34. Table A-D3-4 was prepared only for potential pool fires population impacts since it is the most dominant hazard for the pipeline risk.

$$PRI = \sum\{\ \Psi_{Z1} +\ \Psi_{Z2} +\ \Psi_{Z3}\} \qquad \text{(D3-E34)}$$

The result obtained from the PRI calculation is a conservative indicator that measures the location aggregate population at risk for a potential worst-case pipeline incident in the area. It is an indicator and not an estimate of risk.

Table A-D3-4. Population Risk Indicator for Vapor Cloud Release with Pool Fire

Zone	Distance from Pipeline (ft)		Zone Boundary Mortalities (Rjf) (%)		$Avg\ P^F_{(Rjf)}$ Mortality (Rjf) (%)		Zone Population (Ω)	People at risk per zone Ψ_n
	Begin	End	Begin	End				
1	1500	3500	100	55	77.5	0.775	330	256
2	3500	6860	55	1	28	0.28	330	92
3	6860	12000	1	0	0.5	0.005	330	2
							PRI =	350

The result shows that there is an indication that about 35% of the population within those zones may be affected from the potential pool fires that may arise due to a worst-case vapor release from the Line 5 pipeline. However, the population centers in the region fall outside these zones.

Appendix GI-1 Economic Calculations

A-GI1.1 Structure and Foundation of Economic Transactions Impacts

Standard input-output (IO) modeling will be applied to estimate the economic transactions impacts of worst-case scenarios of a Line 5 rupture or prolonged leak into the Mackinac Straits. Regional IO models are commonly used in regional assessments of changes in the economy. The underlying structure of these models has been recognized since the 1700s, but the mathematical framework that formalized the IO model structure was developed in the 1940s with the work of Wassily Leontief. The importance of this framework for understanding the structure of national economies was recognized with the widespread adoption of national economic statistical reporting agencies and the widespread adoption of IO modeling for estimating national and regional economic impacts of policy and industry changes. IO models are often applied as predictive models in before-the-fact assessments of proposed changes, but can also be used after-the-fact to assess the post-implementation outcomes (Richardson 1972). In this regard, the IO framework is applied predictively to assess how a worst-case scenario will play out through changes in economic activities.

IO models have become staple economic impact models for regional analysis (Green Leigh and Blakely 2013). They provide a systematic and intuitive approach to estimating economy-wide impacts of a change in the local economy by tracing the flow of transactions associated with each sector of the economy. This approach uses linear relationships to reflect production processes that equate industry inputs and outputs. The linear transactions that define a SAM are generalized in a set of multipliers that capture the full extent of transactions associated with any changes in the level of production in an industry (Cabrera et al. 2008). To exemplify, within the IO analysis, the total impact is specified in the value of transactions as,

$$\textit{Total Effect} = \textit{Direct Effect} + \textit{Indirect Effect} + \textit{Induced Effect} \qquad \text{(GI1-E1)}$$

The IO model takes changes in demand called direct effect and relates them to the overall economic impact called total effect through a set of mathematical equations described above. The indirect effect is the value of secondary inter-industry transactions in response to direct effects. The induced effect is the value of transactions resulting from changes in income in response to direct effects. Because the relationships are linear, the direct, indirect and induced effects can be specified as multiples of the direct effect and equation GI1-E1 can be restated as,

$$\textit{Total Effect} = (1 + k_1 + k_2) \bullet \textit{Direct Effect}, \qquad \text{(GI1-E1.1)}$$

where k_1 and k_2 greater than or equal to zero. More simply, Equation GI1-E1.1 can be restated as,

$$\textit{Total Effect} = k \bullet \cdot \textit{Direct Effect} \qquad \text{(GI1-E2)}$$

where $k = (1 + k_1 + k_2)$. Equation GI1-E2 says that the economy-wide impact, Total Effect, is some multiple of the direct effect, where the multiplier takes a positive value equal to or greater than one. The minimum value the multiplier can take, one, reflects the intuitive result that if the economy's output of agricultural products, for example, expands by $1 million, the associated economic activity will expand at least by $1 million. However, if the indirect and induced effects are not equal to zero, this $1 million increase in output will spur other industries to expand output of goods and services and will generate household income that are applied to the purchase of goods and services in the economy; generating a total economic impact greater than the initial $1 million expansion.

Generally, the economic multiplier is specified as a ratio of the total to direct effects. Rearranging equation (2) provides,

$$k = \frac{Total\ Effect}{Direct\ Effect} \qquad \text{(GI1-E3)}$$

where the multiplier, *k* encompasses all the direct, indirect and induced effects for a given industry and denotes the impact of a change in direct effects on the total economic system. Each industry in a region is characterized by its own multiplier *k*. Industries with expansive localized production chains will tend to have higher multipliers than industries that rely on suppliers outside of the modeling region. When there is adequate supply within the state, the state has more potential to retain the total effects of the industry. However, when producers have to depend on supplies outside the state, leakage occurs, and part of the total effect is lost.

The above overview provides broad perspectives on the elements of IO impact analyses but does not provide details as to how the different effects are measured. To understand these measures, consider the standard NIFA definitions of national income. National income can be calculated using the expenditure approach, as the sum of output (sales) as:

$$X = \sum_{j-1}^{N} Z_j + (C + I + G + E), \qquad \text{(GI1-E4)}$$

Where Z_j is the business to business sales of intermediate goods and services, C is sales for final consumption, I is sales to investment (including inventory), G is sales to government and E is exports. Similarly, the output can be measured with the income approach, as the sum of incomes as:

$$X = \sum_{i-1}^{N} Z_i + (L + V + M), \qquad \text{(GI1-E5)}$$

Where Z_i is payments for intermediate inputs, L is payments to labor including employment taxes, V is payments to property type income plus business taxes and includes payments to proprietors, and M is imports. Because every sale (income) is the counterpart to an expenditure equations GI1-E4 and GI1-E5 can be combined as:

These two approaches can be represented graphically in what economists term a dog-leg representation of the national accounts. In Figure GIA1, summing down the columns provides the income approach to measuring final output X, while summing across the rows, provides the expenditure approach to the same output measure. The upper left-hand corner represents the business to business transactions of intermediate goods and services required to generate final goods for domestic or exports.

Interindustry matrix $\left(\sum_{j=1}^{N} Z_j = \sum_{i=1}^{N} Z_i\right)$	Final Demands $(C+I+G)$	Exports (E)	Total Sales (X)
Regional Income $(L+V)$			
Imports (M)			
Total Purchases (X)			

Figure A-GI1-1. Dog-Leg Representation of National Income

The stylized representation in Figure A-GI1-1 is a conceptual representation of the intersectoral flows that make up an economy. It suggests that if total sales increase, some combination of income also increases (Regional Income), and contributes to the more formal specification of IO models once adding industry details to the mix. In the IO framework, Figure A-GI1-1 is reproduced with industry detail in a table called the transactions table. Figure A-GI1-2 shows a standard transaction format for a three-industry economy [1, 2, 3]. Reading down the industry *i* column shows what is purchased by industry *i*, while reading across the industry *j* row shows who purchased from industry *j*.

	1	2	3	Final demand	Exports	Gross output
1	Z_{11}	Z_{12}	Z_{13}	F_1	EX_1	X_1
2	Z_{21}	Z_{22}	Z_{23}	F_2	EX_2	X_2
3	Z_{31}	Z_{32}	Z_{33}	F_3	EX_3	X_3
Gross income	V_1	V_2	V_3			V
Imports	M_1	M_2	M_3			M
Gross payments	X_1	X_2	X_3	F	EX	X

Figure A-GI1-2. Standard Transactions Table

Figure A-GI1-2 is the basis of the matrix representation of the economic structure, where all entries are measured in dollars of sales (output). If we assume that final demands and exports are independently determined and represented as $Y_{i|j}$, the industry rows can be stated as a system of equations as:

$$x_1 = z_{11} + z_{12} + z_{13} + Y_1$$
$$x_2 = z_{21} + z_{22} + z_{23} + Y_2 \qquad \text{(GI1-E6)}$$
$$x_3 = z_{31} + z_{32} + z_{33} + Y_3.$$

A system of technical coefficients that relates the share of output made up of component incomes (columns sum to one) can be specified as:

$$\left(a_{ij} = \frac{z_{ij}}{x_j}\right). \qquad \text{(GI1-E7)}$$

That is, a_{ij} is the share of the output of industry *j* income commanded by industry *i* as an input.[3] Solving for z_{ij} and substituting for each of the z_{ij} in equation GI1-E6 provides:

$$x_1 = a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + Y_1$$
$$x_2 = a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + Y_2 \qquad \text{(GI1-E8)}$$
$$x_3 = a_{31}x_1 + a_{32}x_2 + a_{33}x_3 + Y_3.$$

Equation A8 shows the inter-relatedness of the individual sectors of the economy, in that industry *i* depends on industry *j* for inputs and vice versa. As a system of interdependent linear equations, equation GI1-E8 can be represented in matrix form as:

$$\mathbf{X} = \mathbf{A} \cdot \mathbf{X} + \mathbf{Y} \qquad \text{(GI1-E9)}$$

where **A** is the matrix of technical coefficients, and **X** and **Y** are conforming vectors of output and final demands, respectively. Equation GI1-E9 can be solved for **X** subtracting $\mathbf{A} \cdot \mathbf{X}$ from both sides and premultiplying by $(\mathbf{1} - \mathbf{A})^{-\mathbf{1}}$ to derive:

$$\mathbf{X} = (1 - \mathbf{A})^{-1}\mathbf{Y}. \qquad \text{(GI1-E10)}$$

That is, the vector of outputs (**X**) can be determined by the vector for final demands (**Y**). Matrix differentials $\mathbf{dX/dY}$ provides measures of impacts to policy or final demand changes.

$$\Delta\mathbf{X} = (1 - \mathbf{A})^{-1}\Delta\mathbf{Y}. \qquad \text{(GI1-E11)}$$

$\Delta\mathbf{Y}$ is the vector of direct effects that drive larger effects throughout the economy. While not obvious in equation GI1-E11, a change in one industry final sales will lead to not only an increase it that industry's output (direct effect), but also the output of other industries that supply it inputs (indirect effects). This accounts for the multipliers being larger than one.

As we have outlined the calculations here, the impacts estimated are limited to direct and indirect effects. This is because the example above is inclusive up to the industry to industry transactions. The same calculations would be undertaken to derive induced effects, but inclusive of final demand components (column or columns) and income components like labor income and proprietors income (row or rows). Including these otherwise independent demand and income sectors in the equations, GI1-E6 to GI1-E11 would mathematically

[3] For example, if it takes \$1 of coal to make \$10 worth of electricity, the technical coefficient $a_{coal,electricity} = \$1/\$10$, or .10.

recognize that households and other institutions' incomes also change, as well as their expenditures in the economy from those changes. The resulting vector of **ΔX,** entailing this larger set of closures, would create larger effects than the indirect effects alone. Subtracting direct effects from these larger effects would provide the induced effects. Together, the direct, indirect and induced effects will provide an estimate of the total effects from a change in direct sales.

X, in equation GI1-E11, is measured in terms of sales (output), but can be measured in other units as well. Extended IO models use fixed ratios to industry output to measure impacts in terms of employment,[4] labor income, proprietor's income and contributions to the gross domestic product (value added). In this, an element-by-element multiplication of the fixed ratios transformed output impacts into these other common measures of impact.

Some considerations are relevant to having established the framework for estimation. First, the transactions tables are generally collected at the national level and not at the regional level. Hence, the national transactions table must be regionalized. Several approaches to regionalizing a national transactions table are documented in the literature (Jensen 1990; Miernyk 1976; Stevens et al. 1983). All of these approaches use some approach to layer local industry-level data over the national transactions table, deferring those transactions to industries in short supply in the local economy to imports. The software we have chosen does this in a standardized way that has been largely accepted by the academic community (Alwward, Olson and Lindall 1998).

In addition, the IO impact evaluation model requires several restrictive assumptions. First, the model imposes constant returns to scale, such that a doubling of output requires a doubling of all inputs. Second, technology is fixed with no substitution. These two assumptions impose that an increase in industry output requires an equal and proportionate increase in all inputs. Additionally, supply is assumed perfectly elastic such that there are no supply constraints. This final assumption also asserts that all prices are fixed, such that an increase in demand for any commodity will not result in price changes for that industry. IO models have been criticized on the grounds that some of these assumptions are overly restrictive and the magnitude of the bias generated by these assumptions are greater the larger the industry direct effects are relative to the overall size of the industry (Coughlin and Mandelbaum 1991). Despite this criticism, IO models have become a standard by which economic impact assessment generated.

[4] Employment conversions require a price adjustment if the fixed ratio is measured in prices different from prices in the modeling year.

Appendix GI2: Short-term Impacts on Petroleum Supply from a Line 5 Disruption

Alice Lippert[1] and Joanne Shore[2]

1. Independent Contractor, Retired U.S. Department of Energy
2. Independent Contractor, Retired American Fuel & Petrochemical Manufacturers (AFPM)

A-GI2.1 Introduction

Line 5 provides a large volume of crude oil to refineries that operate in the Michigan area. One of the consequences of a catastrophic failure of Line 5 is the loss of petroleum product supply in Michigan and the surrounding region because of the loss of Line 5 crude oil feedstock into area refineries. The northern Midwest does not have crude oil or product supply flexibility like areas on the Gulf Coast or New York Harbor. Following any large, extended supply disruption in that part of the upper Midwest, petroleum product marketers act quickly to bid away existing supplies, and with supply falling short of demand, prices would typically increase substantially. In turn, a disruption in supply causing a spike in cost would help to attract product from more distant areas, which would ease the initial price surge, but infrastructure limitations challenge the ability to deliver distant supplies into this part of the country.

The following discussion provides an overview of the current petroleum demand, supply and infrastructure associated with petroleum products in Michigan and nearby areas and describes the general supply response hurdles and dynamics that occur in the short term, immediately following a supply disruption.

A-GI2.2 Approach

Much of this chapter is a qualitative description of the supply sources and movements of feedstocks and products in Michigan. The descriptive analysis was based on publicly available information from state and Federal agencies, company websites, and review of articles and trade press. Detailed data are not readily available due to the fungibility of products that move in regional networks and to business confidentiality. Where data are used, sources are provided, and in some cases, ranges of estimates from different sources are noted to illustrate variations.

A-GI2.3 Michigan's Reliance on Petroleum

Michigan relies on petroleum products to meet a large share of its energy needs. In 2016, Michigan consumed an estimated 171.6 million barrels (7.2 billion gallons) of petroleum products, the majority of which were motor fuels, such as gasoline and diesel fuel, refined from crude oil (MAE, 2018). Propane is an important fuel for heating homes in the Midwest, including Michigan. The fuel is also used for industrial purposes and agricultural use, specifically crop drying during the harvest season.

While Michigan has one refinery located near Detroit that produces petroleum products for use in the state, most of its petroleum product supply comes from outside the state. When an unanticipated, large supply disruption occurs, such as the Line 5 event being analyzed in this report, Michigan petroleum markets may experience short-term disruptions as markets respond to redistribute supplies to areas experiencing losses. Michigan's Energy Assurance Plan and Petroleum Shortage Response Plan lay out potential energy vulnerabilities and action plans to respond (MPSC, 2013).

In a testimony given to the Subcommittee on Energy, US House Committee on Energy and Commerce, a Michigan official discussed the state's dependencies and vulnerabilities of its petroleum assets in the event of major energy disruption:

> *…the petroleum market is highly interconnected. We rely on products produced or refined out of state or across the border in Canada, and other states and Canadian provinces rely on products produced in, or transported through, Michigan. For example, natural gas liquids such as propane are procured in part from western Canada; products are refined in neighboring states and shipped to Michigan via rail, truck, and pipeline; and Ontario's crude oil supplies are largely supplied via pipelines in Michigan. The interconnectivity of the petroleum market means that small events can create regional price shocks, and larger events can quickly cascade into a national crisis requiring federal action and assistance* (Brader, 2017).

In 2017, roughly two-thirds of the petroleum consumed in the state was gasoline followed by distillate fuel oil, primarily diesel. Both gasoline and diesel fuels are used predominantly in the transportation sector, with only small amounts used for other purposes. The single largest use of gasoline is for commuting. Gasoline demand in Michigan is projected to be 4.76 billion gallons (310 thousand barrels per day) for 2018, an increase of 2.7 percent from a year ago. This projected demand will be the sixth straight year of gasoline consumption growth (MAE, 2018) Table A-GI2-1 highlights the amount of petroleum products consumed in 2017. Propane demand numbers are for 2016.

Table A-GI2-1: 2017 Michigan Petroleum Product Demand

Product Demand	Year	Millions of Gallons	Thousand Barrels/Day
Gasoline	2017	4,643	303
Distillates	2017	1,178	77
Propane	2016	487	32
Jet Fuel	2017	192	13

Sources: Petroleum product demand volumes (gasoline, distillates, and jet fuel) are provided by the Energy Information Administration's Prime Suppliers Sales Volumes. Retrieved from https://www.eia.gov/dnav/pet/pet_cons_prim_dcu_SMI_a.htm . Given that the estimates for propane demand varied widely by source, volumes from the Michigan Propane Gas Association (MPGA) were used for this report. MPGA used volumes from the American Petroleum Institute. (2017). *2016 Sales of Natural Gas Liquids and Liquified Refinery Gases.*

While most households in the state use natural gas to heat their homes (77 percent), the remaining households use either propane, fuel oil or kerosene (EIA, 2018a). Michigan has one of the largest residential propane consumption rates in the nation, with 8.3 percent of households using propane. According to the Michigan Agency for Energy (MAE), Michigan has close to 320,000 households that use propane, with approximately seven percent residing in the Upper Peninsula (UP). In 2016, propane sales to residential customers in Michigan totaled 361 million gallons per the American Petroleum Institute. In rural counties where households may not have access to natural gas or other heating alternatives, propane is more prevalent and often-used heating fuel. A smaller percentage of homes (1.3 percent) in the state use fuel oil for space heating (EIA, 2018a).

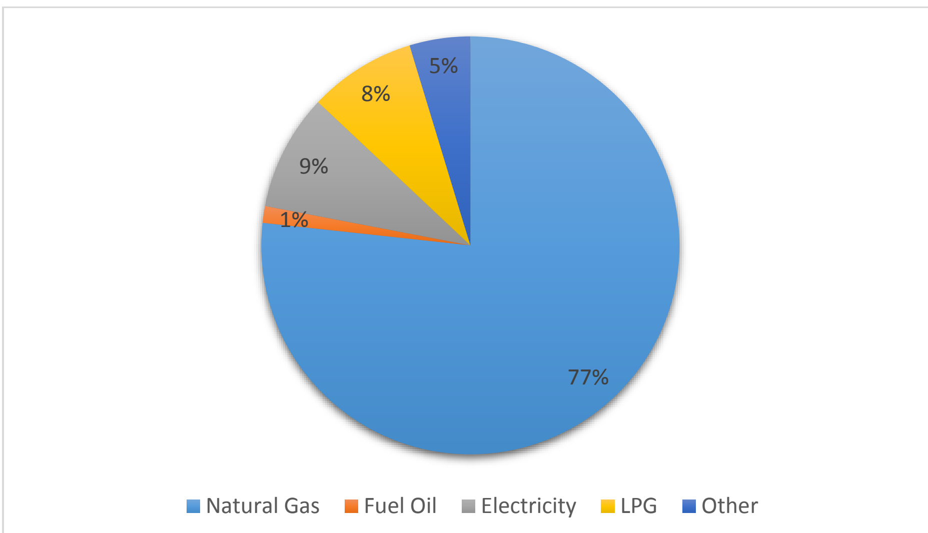


Figure A-GI2-1: Michigan energy sources of home heating, 2016. Source: Energy Information Administration. (2018, April 19). Michigan State Energy Profile and Analysis. Retrieved from https://www.eia.gov/state/analysis.php?sid=MI

A-GI2.4 Michigan Petroleum Supply and Infrastructure

Gasoline, diesel fuel, jet fuel and other products produced from crude oil generally follow a different supply path to consumers than does propane, although there is some overlap. The next section focuses on the delivery infrastructure and refineries involved in production and delivery of petroleum products other than propane, followed by a section describing propane supply and infrastructure.

A-GI2.4.1 Petroleum Supply and Infrastructure Excluding Propane

Michigan is part of a larger regional network of petroleum product supply that includes refineries as far away as the Gulf Coast. Such networks help to increase supply flexibility and ensure reliable supply, but during large disruptions, the network may not have enough unused space to fill in a large loss. As described below, it is necessary to understand the network during normal operations in order to understand how and why product flows change during supply disruptions.

A-GI2.4.1.1 Refinery and Product Pipeline Network

Figure A-GI-2 provides a view of the petroleum product supply network serving Michigan. Most refined product leaves a refinery and moves by pipeline to terminals, where trucks pick up product both from refinery truck racks and from terminal truck racks to deliver fuels to customers throughout the rest of the state.

Three U.S. refineries that have access to Line 5 crude oil provide Michigan with gasoline, distillate fuel (diesel and heating oil), and jet fuel for airports in Michigan, including the Detroit Metropolitan Wayne County Airport. The three refineries (Marathon Detroit, Michigan facility and PBF and BP-Husky refineries in Toledo, Ohio) are located on a bidirectional product pipeline corridor operated by Buckeye Partners and Sunoco Logistics running from Lima, Ohio to Detroit. (The pipeline system also moves product one direction to terminals north of Detroit.) Husky Energy's Lima refinery is also on this corridor. As shown in Figure A-GI2-2, products are delivered into this Lima-Detroit corridor from product hubs in Indiana and Illinois, and from Marathon's Robinson refinery, which is connected directly through a pipeline to the Lima product hub.

BP River Rouge Pipeline Supply to Michigan

River Rouge is a FERC-regulated refined products pipeline with a capacity of approximately 80 k barrels per day. It moves refined products for BP from BP's Whiting Refinery near Chicago to third party terminals along the line. River Rouge is the most direct pipeline route for refined products from the Chicago area to the Detroit market and serves four other third-party terminals between the refinery and the River Rouge terminal.

From the west, the large refining center and pipeline terminal hubs in Chicago, Illinois also provide products into Michigan, mainly through the Wolverine Pipeline that flows from Chicago into Michigan, with lines terminating at Detroit, Bay City, and Ferrysburg. The Wolverine Pipe Line Company claims to deliver 30% of Michigan's petroleum product demand. (Wolverine, n.d.) The BP River Rouge pipeline also delivers product from BP's large Whiting Refinery near Chicago to Detroit. (See BP River Rouge Pipeline Supply to Michigan text box.)

There are no product pipelines into the UP area. Trucks deliver product into that region from a variety of locations, including nearby terminals in the Lower Peninsula (LP) and Wisconsin. The UP also receives some product imports from Canada, but typically the state receives little gasoline, diesel, or jet fuel from Canada.

Figure A-GI2-2 also highlights why it is not possible to know exactly what refineries supply Michigan. The Chicago hub has refineries in the Chicago area feeding that hub, but the Explorer Pipeline brings product from the Gulf Coast to that hub as well. Product is fungible. Marketers may buy product from a company that has product in the Chicago terminals, but the refining source of that product would not generally be known. However, as indicated above, Marathon's Detroit refinery, BP Husky's Toledo refinery, PBF's Toledo refinery, and BP's Whiting refinery located in Indiana (near Chicago) serve Michigan directly. These refineries serve other areas as well.

Table A-GI2-2 highlights the crude processing capacity of the refineries on the Lima-Detroit corridor and refineries that are located in the Chicago hub area.

Table A-GI2-2. Crude Oil Capacity of Refineries in Michigan Area

Owner	**Site**	**Operable capacity as of January 1, 2018 (barrels/calendar day)**
Ohio and Michigan		
Marathon Petroleum	Detroit, MI	139,000
BP-Husky	Toledo, OH	155,000
PBF	Toledo, OH	172,800
Husky Energy	Lima, OH	177,000
Chicago Area		
BP	Whiting, IN	413,500
PDV Midwest Refining	Lemont, IL	179,265
ExxonMobil	Jolliet IL	238,600

Source: Energy Information Administration. (2018, July). *Refinery Capacity Report*. Retrieved from https://www.eia.gov/petroleum/refinerycapacity/table3.pdf

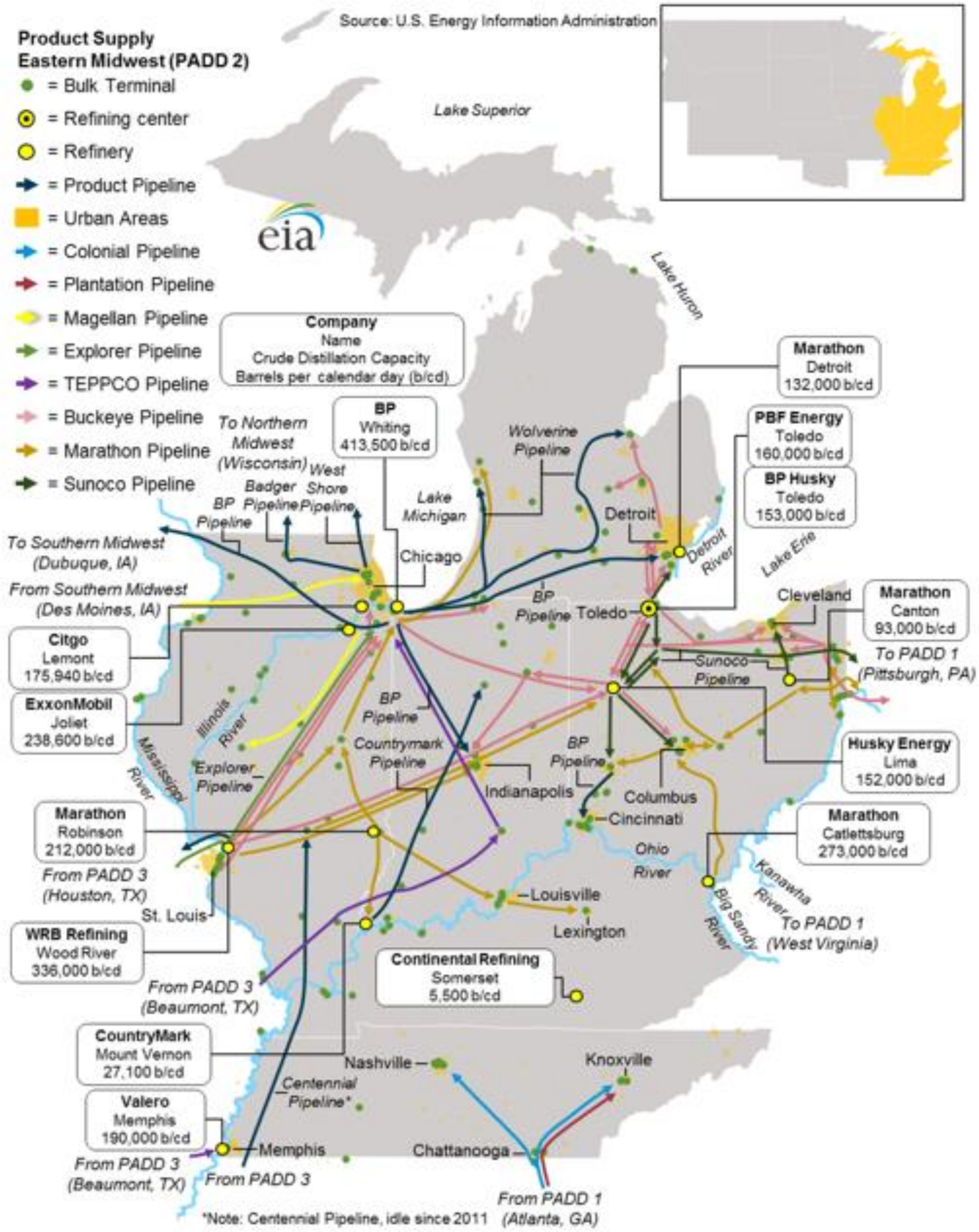


Figure A-GI2-2: Petroleum product supply network supporting Michigan. Source: Energy Information Administration. *(2017,* March 8). *Midwest and Rocky Mountain Transportation Fuels Markets.* Retrieved from https://www.eia.gov/analysis/transportationfuels/padd2n4/

A-GI2.4.1.2 Petroleum Product Imports and Exports

While total diesel and gasoline imports of gasoline and diesel fuels from Canada into Michigan are relatively small (991 thousand barrels or 2.7 thousand barrels per day in 2017), almost 60% of those gasoline and diesel import volumes, including 100% of the conventional gasoline and low sulfur diesel, are delivered into the UP (Table A-GI2-3).

Table A-GI2-3. 2017 Petroleum Product Imports from Canada into Michigan (Thousand barrels/day)

Port of Entry	Biomass-Based Diesel Fuel	Distillate, 15 ppm Sulfur and under	Conventional Blendstock for Oxygenate Blending (CBOB)*	Reformulated Blendstock for Oxygenate Blending (RBOB)*	Total Diesel & Gasoline Imports
Detroit, MI (LP)	0.14			0.71	0.85
Port Huron, MI (LP)	0.33				0.33
Sault Saint-Marie, MI (UP)		0.36	1.01	0.17	1.54
Grand Total	0.46	0.36	1.01	0.88	2.71

*Most U.S. gasoline is blended with ethanol at terminals to produce finished gasoline. Thus, refineries produce and deliver through pipelines to terminals sub-octane blends called "Blendstock for Oxygenate Blending" or BOBs rather than finished gasoline.

Energy Information Administration. (2018b, July 2). Company Level Imports, Historical Imports by Month. Retrieved from https://www.eia.gov/petroleum/imports/companylevel/archive/

EIA reported that small volumes of gasoline and distillate fuel (which includes diesel and heating oil) moved by truck across the border into Ontario. Larger volumes of jet fuel were delivered from Detroit to Toronto Pearson International Airport in 2015. Exports from Detroit averaged 23,000 barrels per day (EIA, 2017).

A-GI2.4.1.3 Sources of Crude Oil for Detroit and Toledo Refineries

The Detroit and Toledo refineries that serve Michigan and access Line 5 have crude oil capacities totaling almost 467,000 barrels per day (Table A-GI2-2); although, actual utilization typically runs less than listed calendar capacity. Midwest refiners averaged 93.7% utilization in 2017. If the Detroit and Toledo, Ohio refineries averaged 93.7% utilization, they would have used 437,000 thousand barrels of crude oil.

Two important Enbridge crude pipeline paths serving the Michigan area refineries begin and end in the same places (Figure A-GI2-3). Line 5 begins at a terminal in Superior, Wisconsin, enters Michigan from the northwest, crossing the UP, and then heads south through the LP before turning east to end at the terminal in Sarnia, Ontario. The Line 6/Line 78 path also begins at the terminal in Superior, but heads southeast towards the Chicago area, then crosses Michigan from the south, and ends at the terminal in Sarnia, Ontario. These two pipeline paths bring supplies from both the U.S. Bakken producing region as well as Western Canada. From the Sarnia terminal, crude oil continues to move east in Canada (Line 7 and Line 9) (Enbridge, 2018). Enbridge indicates that "nearly 30 percent of the light crude carried by Line 5 – more than 100,000 barrels per day – stays in the region to feed [Michigan] area refineries". (Enbridge, n.d.)

Light and Heavy Crude Oils

Crude oil varies in density or weight over a large range. Refineries need different equipment to process different quality crude oils. For convenience, crude oils are frequently discussed as light, medium or heavy quality oils. Light crude oil contains a higher percentage of light weight material (much of which is similar in density and boiling range to gasoline and diesel fuel) than heavy crude oil contains. Heavy crude oil has a lower share of light material and a higher share of heavy, dense material. Heavy crudes typically require more processing steps in order to be turned into useful finished products. Medium density crudes fall in between light and heavy.

Source: American Fuel and Petrochemical Manufacturers, Refining U.S. Petroleum, A Survey of U.S. Refinery Use of Growing U.S. Crude Oil Production, March 2015. https://www.afpm.org/uploadedFiles/Content/documents/Refining-US-%20Petroleum-a-Survey-of-Capacity.pdf

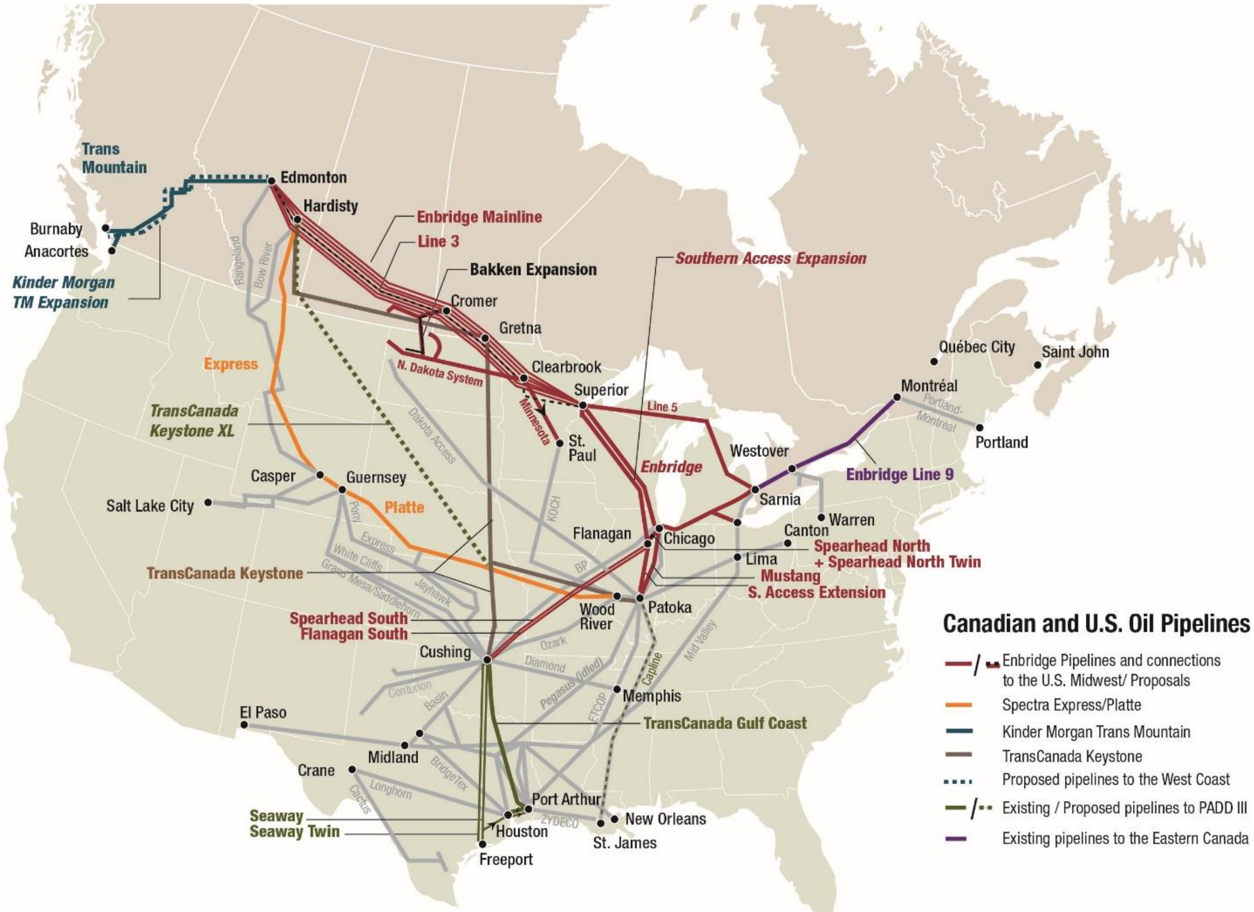


Figure A-GI2-3: Major Existing and Proposed Canadian and U.S. Crude Oil Pipelines. Reprinted with permission from Canadian Association of Petroleum Producers (CAPP). (2018). *2018 Crude Oil Forecast, Markets and Transportation*. Reprint permission does not imply CAPP's endorsement of this report or of any of the services or products provided by the contributors to this report. Retrieved from https://www.capp.ca/publications-and-statistics/crude-oil-forecast

Additional crude supply comes crude delivered into Lima, Ohio via pipeline both from a large crude distribution center at Patoka, Illinois and from Texas. The crude delivered to Lima can then move north to Toledo and Detroit. The alternative routes outside of Line 5 run at or near capacity, which means these alternative routes cannot make up for any an extended supply disruption of Line 5.[5]

Michigan produces crude oil and is one of the crude supply sources feeding into Line 5. The state's production is from small wells scattered across the LP. At its peak, the state produced 35 million barrels per year in 1979, however, production has declined to 5.4 million barrels (14,700 barrels per day) in 2017 (EIA, 2018). For context, that volume is only about 11% of the crude volume input into a single refinery the size of the Detroit refinery.

[5] See Alternative 2 and Alternative 6 (Dynamic Risk, 2017).

The three refineries that serve Michigan and have access to Line 5 crude oil use different qualities of crude oil in their facilities. The PBF refinery uses light and medium quality crude oils and relies heavily on Line 5.[6] The Marathon Detroit and BP-Husky Toledo refineries use a mix of crude oils that includes light crude oils (the quality of crude carried by Line 5), medium quality crude oils, and heavy crude oils mainly from Canada. (See Light and Heavy Crude Oils text box)

Note that refineries that use heavy crude oil typically use a mix of crude qualities, including light crude oils. Their equipment configurations would generally not be able to process all light crude or all heavy crude oil. Marathon reports that its 139,000-barrel-per-day Detroit refinery may use up to 80,000 barrels per day of heavy crude oil, with the rest being lighter quality crude oils (Marathon, n.d.). Marathon Detroit and BP-Husky also tie into other pipelines like Line 78 and pipelines from Lima, Ohio. It is not clear how much Line 5 crude these two refiners use on a regular basis.

Typically, refineries do not store much crude oil at their facilities. Energy Information Administration (EIA) data indicate Midwestern refineries average about four days of supply of crude oil at the refinery. Refineries receive crude oil in "batches". For example, they receive a batch of the crude oil quality they need periodically via pipeline. Crude supply delivered by water arrives by discrete tanker or barge deliveries. Refiners have adequate tankage to receive a given batch of crude oil. They then draw that batch down to prepare for the next receipt. Generally, refiners would be able to operate normally for several days before having to reduce their crude runs (and thus product production). If an outage should occur right after they receive a large batch of crude oil, they may have a little more time following a sudden crude supply disruption than if the disruption were to occur when their crude oil tanks were drawn down in readiness to receive the next batch. In either case, they carry very little crude oil inventory to cushion an unexpected crude oil supply loss.

A-GI2.4.1.4 Sources of Crude for Ontario Refineries

Most refineries in Ontario lie right across the Michigan U.S. border in Sarnia. Most of these refineries rely heavily on lighter crude oils (CNEB, 2018). Three refineries in Sarnia receive direct deliveries from Line 5 (Imperial Oil, Suncor, and Shell). The Imperial refinery in Nanticoke receives crude oil indirectly from Line 5. While Canadian refineries do not typically provide much gasoline, diesel or jet fuel into Michigan, should the Ontario refineries lose Line 5 crude unexpectedly, they would be faced with potentially reducing crude runs and having to reach for other sources of product supply in the short term. This would typically include reaching out to Chicago markets and other areas to which Michigan suppliers would also be reaching. The Ontario refineries may also be supplying some of their propane production back into Michigan. Thus, Michigan consumers would feel the Canadian refinery supply loss effects of a Line 5 outage even though Michigan normally receives little gasoline, diesel, or jet fuel imports from the Ontario refineries.

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[6] Letter to Michigan Governor Rick Snyder, from Matthew Lucey, President PBF Holding Company LLC, January 18, 2018.

A-GI2.4.2 Propane Supply and Infrastructure

In the Midwest (PADD 2),[7] propane comes from three primary sources: propane production from petroleum refineries and natural gas processing plants (See Gas & NGL Processing text box); domestic movements by pipeline, rail, and truck from the Gulf Coast region and Conway, KS; and imports from Canada. PADD 2 is also home to the Conway storage facility in Conway, Kansas, the largest propane storage reserve in the Midwest. (Figure A-GI2-4).

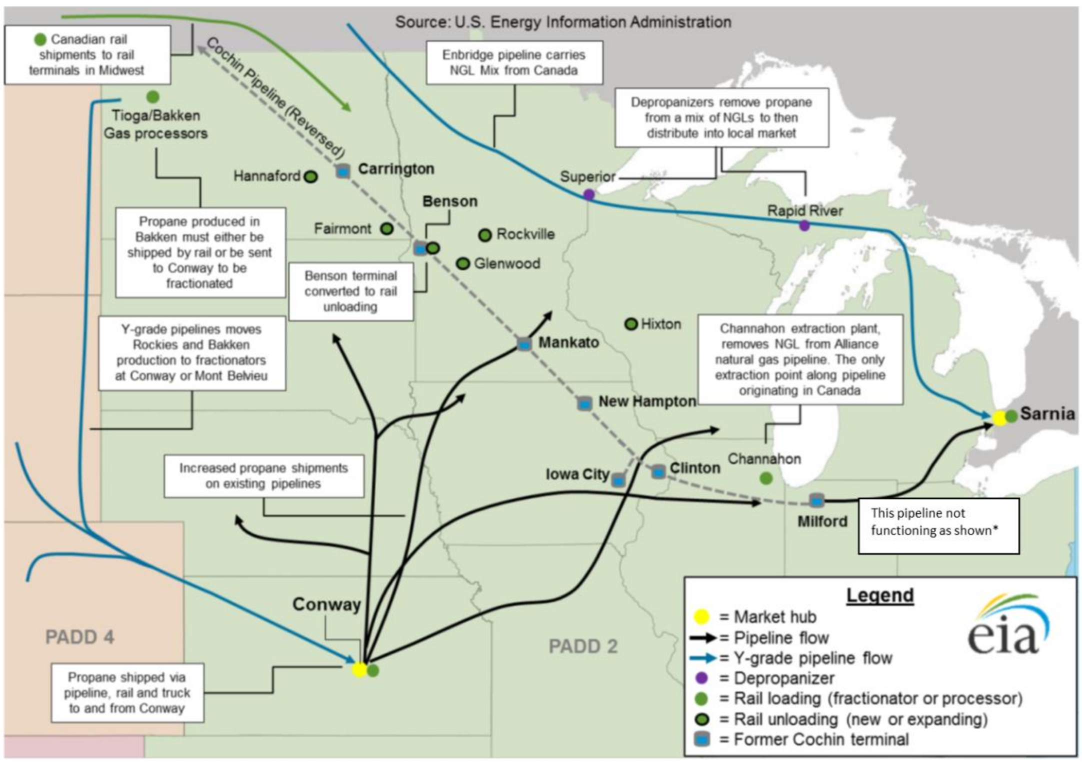

Figure A-GI2-4. Midwest propane infrastructure. Note that pipeline shown from Milford to Sarnia is not functioning currently. Notation added to map. Sieminski, A. (2014, October 7). "Winter Fuels Outlook", presentation for National Association of State Energy Officials in Washington, DC. Retrieved from https://www.eia.gov/pressroom/presentations/sieminski_10072014.pdf

Similarly, Michigan receives its propane supplies from domestic refineries and NGL fractionating facilities, by truck or rail, and imports from Canada. A major source of propane supply comes from fractionating plants (depropanizers) in Superior, Wisconsin and Rapid River, Michigan. Line 5, which carries natural gas liquids (NGL), is a feedstock to these facilities.

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[7] States in the Petroleum Administration for Defense Districts (PADD) 2 include Il, IN, IA, KS, KY, MI, MN, MO, NE, ND, OH, OK, SD, TN, and WI.

Gas & NGL Processing: How Does it Work?

“Major transportation pipelines usually impose restrictions on the make-up of the natural gas that is allowed into the pipeline. Natural gas processing consists of separating all of the various hydrocarbons and fluids from the pure natural gas, to produce what is known as 'pipeline quality' dry natural gas. Associated hydrocarbons, known as 'natural gas liquids' (NGLs) can be very valuable by-products of natural gas processing. NGLs include ethane, propane, butane, isobutane, and natural gasoline. These NGLs are sold separately and have a variety of different uses; including enhancing oil recovery in oil wells, providing raw materials for oil refineries or petrochemical plants, and as sources of energy. The actual practice of processing natural gas to pipeline dry gas quality levels can be quite complex, but usually involves four main processes to remove the various impurities:

- Oil and Condensate Removal
- Water Removal
- Separation of Natural Gas Liquids
- Sulfur and Carbon Dioxide Removal

“After processing, the pipeline quality natural gas is injected into gas transmission pipelines and transported to the end users.” The NGLs may be sent long distances by pipeline before being separated into purity products like propane, butane, etc. in fractionation plants

Source: Department of Transportation, Pipeline and Hazardous Materials Safety Administration, “Fact Sheet: Natural Gas Processing Plants,” https://primis.phmsa.dot.gov/comm/factsheets/fsnaturalgasprocessingplants.htm ; See also: https://www.wlpga.org/about-lpg/production-distribution/ and https://www.energy.gov/sites/prod/files/2018/06/f53/NGL_Primer.pdf

The Rapid River NGL fractioning facility is in the UP and supplies a major share[8] of propane to UP customers. As such, it is an important supply source, particularly, during the heating season. Currently, Line 5 is Rapid River's sole source of NGL supply. The facility only separates propane from its Line 5 NGL feedstock, sending the remainder of the NGL stream back into Line 5. Rapid River is estimated to produce about 730,000 barrels per year (average 2,000 barrels per day) of propane, but volumes vary seasonally. During the peak winter season, as much as 3,000-3,500 barrels per day are produced at this facility (Figure A-GI2-5).[9]

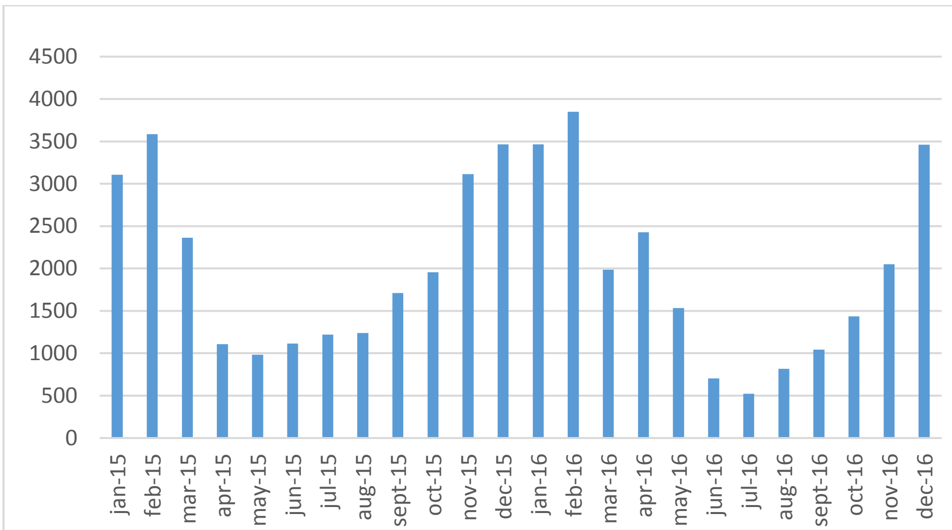


Figure A-GI2-5: Rapid River estimated propane supplied (thousand barrels per day, 2015-2016) Dynamic Risk. (2017, October 26). *Alternatives Analysis for the Straits Pipelines*, Appendix C, Tables C1-C2, Doc. No: SOM-2017-01-RPT-001; Rev. No: 2

Rapid River has a truck loading rack where propane supplies are picked up and distributed to local markets. A propane storage terminal located in the UP at Kincheloe also serves parts of northern Michigan.

Supplies of NGL not processed into propane at Rapid River are returned to Line 5 and transported to the Plains/Pembina Fractionator in Sarnia, ON. A portion of these NGLs is processed into propane and often imported back into Michigan.

The LP receives its propane from refineries in Detroit, Michigan and the Toledo, Ohio refineries as well as rail and truck across the region, but the bulk of its propane (as stated above) is imported from Sarnia, ON. Average annual imports of propane, according to EIA, stood at about

[8] Various sources quote different shares, which are often conditional on market factors, seasonality, etc. Therefore, no specific percentage was used for this report.
[9]Line 5 capacity of about 90 thousand barrels per day of natural gas liquids (NGLs) was estimated by Dynamic Risk Assessment Systems, Inc., *Alternatives Analysis for the Straits Pipelines*, October 26, 2017, p. 2-2. Propane product assumed to be the difference between NGL inputs and outputs since this is the only purity product Rapid River removes from the NGL feedstock.

19,000 barrels per day in 2016 and 17,000 barrels per day in 2017, respectively, all of which entered the U.S. at Detroit and Port Huron. (EIA, 2018b)

Marketers import propane via pipeline into propane terminals located in St. Clair and Marysville. These terminals not only serve Michigan but are also a source of propane to the region. A propane storage facility is also located in the Western part of the state at Alto that receives propane supplies via rail.

Due to Michigan's large cavern storage and propane supply sources, propane dealers and wholesalers from other states buy propane in Michigan and transport it out of the state. Inventories in the Midwest generally are built up during the summer low-demand period for use in late fall and winter. Propane inventories serve an important role for drying crops during the harvest season and for heating homes during winter. Figure A-GI2-6 illustrates the strong seasonal variation of inventories for select years including a five-year average.

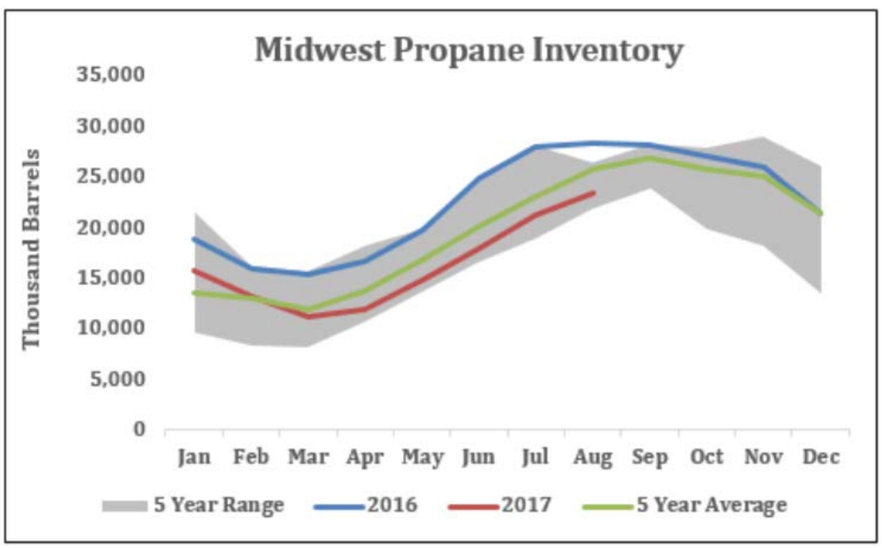


Figure A-GI2-6. Midwest Propane Inventories, 2017-2018. Michigan Agency for Energy. (2017, November). "Michigan Energy Appraisal, Winter Outlook 2017-18", Retrieved from https://www.michigan.gov/documents/energy/ea-winter17_606208_7.pdf

A-GI2.5 Market Dynamics Following a Line 5 Supply Disruption

Michigan is part of a large petroleum product network that extends outside of the state, but much of that network runs at capacity normally. The product supply loss from refinery reductions during an extended Line 5 shutdown would likely be large. Marketers would be scrambling to line up what additional supplies they could find in places like Chicago, but much supply would have to be delivered from distant sources by truck – a costly supply solution. Similarly, the loss of propane supply in the area would result in propane dealers diverting their trucks to more distant sources of supply. And out-of-state propane dealers that typically buy propane in Michigan would have to find other sources as well. Expensive sources of marginal supply and concerns over the availability of volumes to replace losses combine to increase pressure on product prices.

A-GI2.5.1 Petroleum Market Response Excluding Propane

To provide some perspective on the way a loss of Line 5 would likely create regional petroleum product disruptions, note that Line 5 typically carries about 450 thousand barrels per day of light quality crude oil. (Dynamic Risk, 2017). That is more than the quantity of all crude oil volume generally used at the Marathon Detroit, BP-Husky and PBF refineries combined, assuming they could process purely light crude oil. The loss of that volume of light crude oil also indicates affected refineries would not only have to run at reduced rates but also would likely run less optimally as they likely would have to shift away from their optimal light/heavy crude oil input mix. As described below, the situation might result in the loss of more refinery production capacity than the Line 5 crude volumes alone imply. The loss would likely affect the upper Midwest region and neighboring areas in Canada.

A-GI2.5.1.1 Line 5 Petroleum Refinery Operations Following Supply Disruption

With an unexpected and extended disruption in some portion of crude flow to a refinery, operators will quickly assess the situation. If alternative crude supplies can be located and delivered to a refinery, refinery operators will attempt to keep the refinery running, albeit potentially at reduced levels, using existing inventories and remaining sources of crude supply until new replacement volumes from the disrupted supply can be established. Refineries are designed to run 24-7 without transients. Unplanned emergency shutdowns, such as when a sudden loss of power to a refinery occurs, can present large safety issues and potential for mechanical damage (EIA, 2007). As a result, if crude supply replacement cannot be found, and the refinery has inadequate remaining supplies arriving to continue running at reduced levels, operators will do a controlled shutdown.

The Marathon Detroit and BP Husky refineries use some lighter crude oils along with their heavy crude. For example, Marathon indicates they use up to 80,000 barrels per day of heavy crude in their 139,000 barrel-per-day refinery (Marathon, n.d.). Thus, about 50,000 barrels per day of light and/or medium quality crudes are also used, assuming the refinery runs at about 93% utilization (average utilization in the Midwest in 2017). Both Marathon and BP-Husky refineries need light crude oil, at least some of which comes from Line 5 during the year.

With other crude pipelines generally running near capacity most of the time, they would not be able to replace the 450,000 barrels of crude oil lost from Line 5. The remaining pipelines would typically shift their batches to deliver more light crude oil at the expense of their heavy oil deliveries. That would serve to replace some of the light crude oil lost by the Line 5 shutdown, but it also results in a reduction of regional refinery heavy oil receipts. All refineries in the region would experience reduced crude supply, regardless of the qualities of crude they use, and would likely not be able to get their optimal mix of crude qualities, which can further affect their ability to meet product demand.

PBF's Toledo refinery does not process heavy crude, and it receives a significant share of its crude oil from Line 5. Any large loss of crude volume to a refinery means it faces a physical issue of possibly not having adequate volumes to keep units in the refinery running. Even if a small increased volume of needed crude oil could replace a fraction of the Line 5 volumes, a refinery still may not be able to run for an extended period at very low utilization levels. If it could run at a very reduced level of utilization, it might not be economic. The same will be the case for the Ontario refineries, which mainly use light or medium quality crude oils and rely on Line 5 crude oil. Refineries in this situation may be running at lower utilization than their remaining crude volumes (net of Line 5 volumes) would indicate. Thus, the product production impact could be larger than the Line 5 volumes alone imply.

In the short term, refineries in the Michigan area have little ability to switch from pipeline deliveries to other delivery methods such as rail, water or even truck (in small volumes). Furthermore, these delivery methods are more expensive, and the cost of the replacement crude oil may be more expensive as it would have been bid away from other refiners.

Michigan-produced crude oil, which is light quality, is normally gathered and delivered into Line 5. With a Line 5 disruption these producers lose their normal outlet. However, the crude producers have access to truck loading facilities. Additional trucks could theoretically deliver the crude to terminals that have truck offloading capability.[10] However needed trucks and drivers may not be available, and this crude volume is very small relative to Line 5 crude oil volumes that are being used in the Michigan region.

In summary, while a portion of Line 5 light crude might be shipped on Line 6/Line 78 or other pipelines feeding the Lima, Ohio terminal, it will be done at the expense of heavy crude oil shipments. Thus, the Line 5 shutdown in the short term would not only limit light crude oil, but heavy crude as well to refineries in Illinois, Ohio, Michigan, and Canada. The unexpected loss of 450,000 barrels per day of crude oil will require large reductions of refining crude inputs at facilities that affect Michigan and surrounding regions – and a loss of product production that could even exceed that implied by the Line 5 crude volume loss alone.

A-GI2.5.1.2 Petroleum Product Markets Response to Supply Shortfall

Supply disruptions are most challenging during high demand seasons. Gasoline demand is highest during the summer months, while diesel fuel demand typically peaks during the fall harvest season in the Midwest. Heating fuel demand is highest during the winter.

As refining supply of gasoline, diesel, jet fuel and other petroleum products fall during a crude disruption like the Line 5 outage scenario, product inventories are drawn down to help meet demand. But product inventories are limited. For example, gasoline inventories average about nine days of supply at refineries, with another five days at bulk terminals. In addition, inventories typically vary seasonally to help meet demand variations.

[10] Dynamic Risk estimated 30-50 trucks to transport 7,000-12,000 barrels per day from Lewiston. (Dynamic Risk, 2017)

Marketers know the supply system and recognize the potential impacts of an evolving supply decline. They begin to search for new product sources well beyond their usual sources and are willing to bid higher prices to obtain the supply in the tight market. Nearby refineries, may be facing reduced crude runs, but refiners further way and less affected will have incentives to attempt to provide more product. Although refineries generally run near full capacity when they are not undergoing maintenance, their utilization varies, and even small increases in utilization add product to the system.

Nearby product pipelines, like the Explorer that brings product from the Gulf Coast to Chicago, typically run at capacity and may not have much room for increased product volumes. But Chicago supply to Michigan may be more limited by logistics in Detroit. The Wolverine product pipeline from Chicago typically has some extra space, but it is uneven. While the Wolverine may have space to deliver more product into its Woodhaven terminal, it typically would not have space into other Detroit terminals.

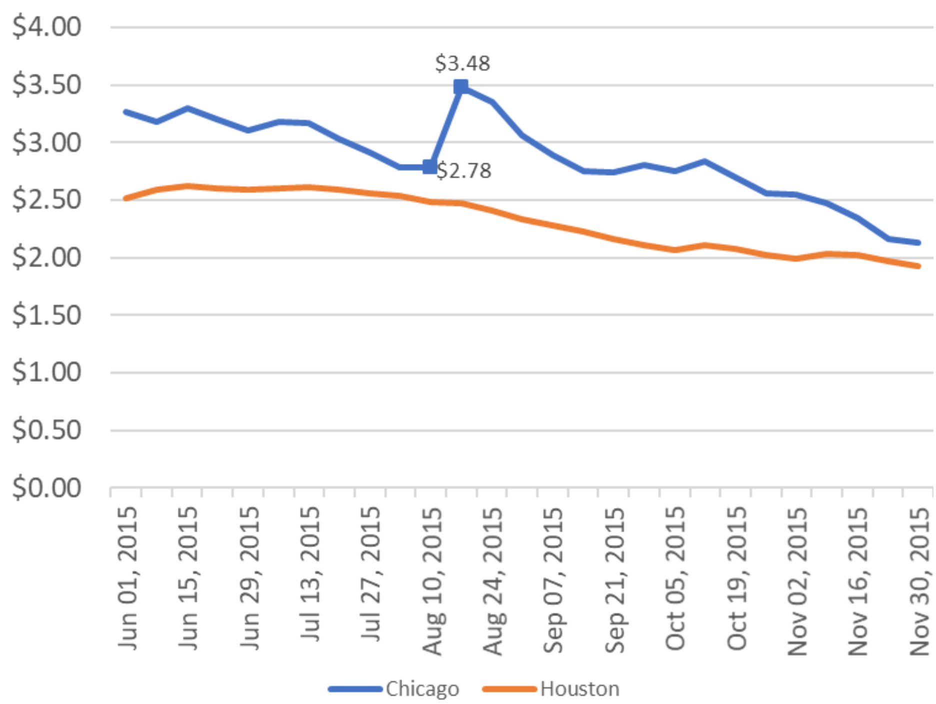
It is not unusual for marketers to have to find alternative terminals for supply, and then to truck those supplies from long distances. In this manner, the loss of supply from the Line 5 refineries does not just affect the Michigan market but begins to cascade to other areas as well. This process helps to prevent or minimize actual product outages at the retail level, but the incremental volumes that are being found and moved to the Michigan area would generally be more expensive volumes than the typical supply.

Increased trucking delivery plays a role in most petroleum supply disruptions, but trucking has its limitations. Truck drivers must be trained for hazardous material transport, and surplus truck drivers and tanker trucks are not generally available. Trucks already in use may be traveling longer distances to find a supply, which increases the hours traveling between supply and delivery points. During emergencies, drivers may be given waivers to drive for longer hours (see below), which helps to increase supply.

Jet fuel also presents challenges in Michigan. Large airports typically have pipelines carrying the fuel to their facilities as they are large consumers, and truck deliveries would be impractical. Fuel inventories held in tanks at airports provide a cushion between demand changes and pipeline flows and would not be very large. Chicago Midway International Airport (MDW) and Detroit Metropolitan Wayne County Airport (DTW) likely get fuel supplies from some or all of the refineries in the Lima-Detroit corridor that use Line 5 crude oil. If faced with a large reduction of jet fuel supply in the event of a supply disruption, airlines may be faced with redirecting flights.

In the event of an unexpected and extended Line 5 outage, various emergency responses would be activated. For example, with product needing to be brought to Michigan by truck over long distances, driver hour waivers would most likely be put in place. Normally truck drivers are limited, for safety reasons, to a set number of hours during a day. But during emergencies, these hours may be extended with waivers. An exemption to the hour -of-service requirement can be made through an emergency declaration by a state or the by US Department of Transportation (NASEO, 2018). The state also has procedures to deal with potential product shortages, including ensuring priority transportations sources (e.g., emergency, police, etc.) have fuel. Other waivers are available as needed to assist supply restoration. For example, the Detroit area uses a low RVP gasoline[11] for air emission control that is not produced or available everywhere. During large supply disruptions, waivers for boutique fuels of this nature may also be implemented.

Price increases during significant supply losses serve to cover increased costs of supplies from longer distances as well as reduce demand. Such price increases can be large. An illustration of price changes during an unexpected disruption occurred in August 2015 (Figure A-GI2-7). BP had to shut down a large part of its Whiting refinery unexpectedly. While the refined product supply loss was less than likely would occur with an unplanned Line 5 outage, prices immediately increased as marketers knew the difficulty of replacing the lost supply. EIA publishes retail price data for Chicago every week. (EIA does not have weekly Michigan data.) EIA Chicago retail prices rose 70 cents per gallon from August 10 to August 17 and did not return to August 10 levels until mid-September. (Houston prices are shown for comparison.) In part, the increase in price was exacerbated by the fact that the Chicago area is required to use reformulated gasoline that is not available from all supply sources, but the example illustrates how large price increases can occur quickly with unplanned supply losses in that region.



[11] RVP stands for Reid Vapor Pressure, which is a measure gasoline evaporation. Some areas, like Detroit, use lower RVP gasoline than is generally required during the summer to reduce evaporative emissions that contribute to ground-level ozone.

Figure A-GI2-7. Chicago & Houston Retail Gasoline Prices During Refinery Outage ($/gallon). Energy Information Administration. (2018, June 25). Weekly retail gasoline prices, all grades. Retrieved from https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_nus_w.htm

In another example, Enbridge had to close three lines during the summer of 2010 to investigate and fix potential leaks. Even though the last line shut down was back in operation quickly when no problems were found, prices in the area had risen substantially with the loss of crude supply and associated product production. A spokesperson for the Oil Price Information Service reported that gasoline prices rose up to 30 cents per gallon in some areas (Smith, 2010).

A-GI2.5.2 Propane Market Dynamics Following a Line 5 Disruption

In the event of a Line 5 disruption, potential short-term propane shortages could occur. While parts of the state have storage facilities to accommodate supplies to some parts of Michigan, primarily the LP, areas like the UP would be impacted fairly quickly. The UP has less flexibility to receive alternative supplies given that a large share of its supply needs are met by the Rapid River, Michigan facility, which would lose its only supply of NGL feedstock. Propane supplies from the LP would most likely be available for some time. However, this would depend on storage levels and the time of year. During the winter season, supplies could be limited since resupply from sources such as refineries in the region and Ontario would also be impacted by lack of crude supply. In addition, propane dealers and wholesalers from outside the region may begin to haul propane to surrounding states displacing supplies.

Such was the case during the winter of 2013-2014, known as the Polar Vortex, when demand surged due to a late crop drying season and near record cold temperatures. The winter season began with lower than normal propane inventories. Supplies of propane were further limited by production and transportation constraints, including reduced pipeline capacities into the Midwest. The Rapid River plant, a key supply source for the UP, was idled due to pipeline equipment work in Wisconsin (MPSC 2014a, MPSC 2014b). For a period, Rapid River did not produce one million gallons (28,800 barrels) of propane (EIA, 2014a). The cumulation of events resulted in localized shortages of propane in Michigan and surrounding states. Suppliers in need of propane sent trucks and large transporters to other States as far away as Kansas and Texas to pick up supplies and deliver them back to Midwest states experiencing shortages.

Propane prices hit record levels at the wholesale and retail levels. Figure A-GI2-8 highlights prices spikes that occurred during the 2013-14 winter. Prices hit record levels in January 2014. The low inventories in the Midwest caused propane spot prices at Conway, Kansas to spike way above the Gulf Coast spot price at Mont Belvieu, Texas. At the beginning of December, spot wholesale prices were about the same at the trading hubs in Conway and Mont Belvieu, both near $1.20 per gallon. At the beginning of January 2014, Conway prices started to increase from the $1.20 per gallon as winter weather got colder and supplies became tight; by January 23, 2014, the Conway price was well over $4.00 per gallon, a spread of almost $3.00 per gallon over the Mont Belvieu price (DOE, 2015).

Residential propane prices in the Midwest that began the heating season at $1.85 reached an average weekly price peak at $4.20 on January 27, 2014. Prices for Michigan reached a high of $3.77 on February 3, 2014, after starting the heating season at $2.06 per gallon (EIA, 2014b).

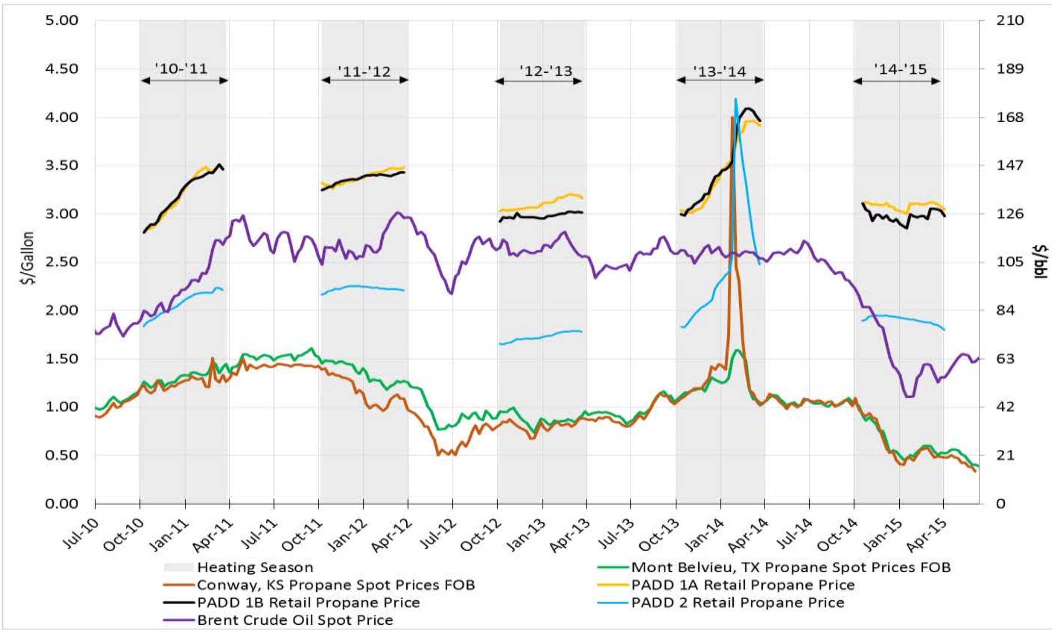


Figure A-GI2-8. Midwest wholesale and retail propane prices, 2010-2015. US Department of Energy. (2015, October). *An Assessment of Heating Fuels and Electricity Markets During the Winters of 2013-2014 and 2014-2015*. Retrieved from https://www.energy.gov/sites/prod/files/2015/10/f27/DOE_OE_Two%20Winters%20Report_Final_10.19.15.pdf

The spike in retail propane prices stressed budgets for many residential and commercial consumers. To meet demand, some propane marketers facing tight supplies "short-filled" customers' to spread limited supplies among more consumers. Many small "Mom and Pop" propane retailers experienced problems with credit limits. Some states with larger rural populations opened warming centers for consumers who could not obtain or afford propane fuel. The State of Michigan held weekly conference calls with Midwest states, Federal agencies, and the propane industry to monitor and assess the severity of the propane situation.

During the 2013-14 propane event, the Federal Government also took many actions including conference calls with impacted states and industry. The US Department of Transportation's Federal Motor Carrier Safety Administration issued Hours of Service waivers for Midwest and Northeast states.

Congress held numerous hearings in Spring 2014 to obtain information from the states, Federal officials and industry to better understand the shortages and impacts (Sieminski, 2014; Kenderdine, 2014)

Congress passed the Reliable Home Heating Act and signed into law on June 2014 mandating the Federal Motor Carrier Safety Administration to accept the hours-of-service extensions declared by governors during emergencies for up to two additional 30-day periods. The law also requires that the Energy Information Administration notify governors when inventories of residential heating fuel (natural gas, propane or heating oil) in their PADD regions have been the below the most recent five-year average for three consecutive weeks.

A-GI2.6 Conclusion

The crude oil, NGL and product delivery systems in the Michigan area have multiple sources and paths, which help to ensure reliability during normal supply or demand shifts, including planned maintenance. But the system does not have the flexibility to replace a large unexpected supply loss quickly. The supply network generally runs near capacity, which creates challenges in making up for lost volumes. With the loss of Line 5 light crude oil, other pipelines would typically increase their volumes of light crude deliveries, but it would be at the expense of their heavy crude oil deliveries. Thus, a Line 5 shutdown in the short term would not only limit light crude oil, but heavy crude as well to refineries in Illinois, Ohio, Michigan, and Canada. The unexpected loss of 450,000 barrels per day of crude oil will require large reductions of refining crude inputs at facilities that affect Michigan and surrounding regions – and a loss of product production that could even exceed that implied by the Line 5 crude volume loss alone.

The NGL loss from Line 5 and its associated propane production is also not easy to make up quickly in the short term. Depending on the length of time of the pipeline outage, tight market conditions could occur similar to those seen in the 2013-14 propane shortage, and if so, would likely result in similar response actions.

A-GI2.7 References

Brader, V. (2017, June 14). Testimony before the Subcommittee on Energy U.S. House Committee on Energy and Commerce June 14, 2017. Retrieved from https://docs.house.gov/meetings/IF/IF03/20170614/106112/HHRG-115-IF03-Wstate-BraderV-20170614.pdf

Canadian National Energy Board (CNEB). (2018, April). *Canadian Refinery Overview, Energy Market Assessment*. Retrieved from https://www.neb-one.gc.ca/nrg/sttstc/crdlndptrlmprdct/rprt/2018rfnryrprt/2018cndnrfnrvrvw-eng.pdf

Dynamic Risk Assessment Systems, Inc. (2017, October 26). *Alternatives Analysis for the Straits Pipelines*, Final Report, prepared for the state of Michigan, October 26, 2017, Document No. SOM-2017-01-RPT-001 Revision 2. Retrieved from https://mipetroleumpipelines.com/document/alternatives-analysis-straits-pipeline-final-report

Enbridge Energy Partners. (n.d.). Website, Line 5 Fact Sheets and Brochures. Retrieved from http://www.enbridge.com/~/media/Enb/Documents/Projects/line5/Line_5_and_Pipelines_in_Michigan.pdf

Enbridge Energy Partners. (2018, May 31). *Enbridge Energy Infrastructure Assets*. Retrieved from https://www.enbridge.com/~/media/Enb/Documents/Factsheets/FS_EnergyInfrastructureAssets.pdf?la=en

Energy Information Administration (EIA). (2018a, April). Michigan State Energy Profile Analysis, April 19, 2018. Retrieved from https://www.eia.gov/state/analysis.php?sid=MI,

Energy Information Administration (EIA). (2018b, July 2). Company Level Imports, Historical Imports by Month. Retrieved from https://www.eia.gov/petroleum/imports/companylevel/archive/

Energy Information Administration (EIA). (2017, March). *Midwest and Rocky Mountain Transportation Fuels Markets,* March 8, 2017. Retrieved from https://www.eia.gov/analysis/transportationfuels/padd2n4/

Energy Information Administration (EIA). (2014a). Michigan Presentation at 2014 State Heating Oil and Propane Program Workshop. Retrieved from https://www.eia.gov/petroleum/heatingoilpropane/workshop/2014/pdf/michigan.pdf,

Energy Information Administration (EIA). (2014b). Weekly Residential Heating Oil and Propane Prices, State Heating Oil and Propane Program, 2014. Retrieved from https://www.eia.gov/dnav/pet/pet_pri_wfr_a_EPLLPA_PRS_dpgal_w.htm

Energy Information Administration (EIA). (2007, March). *Refinery Outages: Description and Potential Impact on Petroleum Product Prices,* March 2007, SR/OOG/2007-01. Retrieved from https://www.eia.gov/analysis/requests/2007/SROOG200701.pdf

Kenderdine, M. (2014, May 1) Testimony by DOE Kenderdine to U.S. Senate, Committee on Energy and Natural Resources. Retrieved from https://www.gpo.gov/fdsys/pkg/CHRG-113shrg91556/html/CHRG-113shrg91556.htm

Michigan Agency for Energy (MAE). (2017, November). Michigan Energy Appraisal, Winter Outlook 2017/18. Retrieved from https://www.michigan.gov/documents/energy/ea-winter17_606208_7.pdf

Michigan Agency for Energy (MAE). (2018, May 18). Michigan Energy Appraisal, Summer Outlook 2018. Retrieved from https://www.michigan.gov/documents/energy/ea-summer18_623676_7.pdf

Marathon Petroleum Corporation. (n.d.). Website, Detroit Refinery: Detroit, Michigan. Retrieved from https://www.marathonpetroleum.com/Operations/Refining_and_Marketing/Refining/Detroit_Refinery/

Michigan Public Service Commission (MPSC) (2013, August). Michigan Petroleum Shortage Response Plan, 2013. Retrieved from https://www.naseo.org/Data/Sites/1/michigan-petroleum-shortage-response-plan-2013.pdf

MPSC Press Release. (2014a, January 17). Propane Supply to Upper Peninsula Faces Additional Challenges. Retrieved from https://www.michigan.gov/mpsc/0,4639,7-159-16400_17280-319883--,00.html on July 6, 2018

MPSC Press Release. (2014b, January 30). Michigan Propane shortage: Supplies improving but still tight as Snyder directs agencies to assist residents. Retrieved from https://www.michigan.gov/snyder/0,4668,7-277-57577-320841--,00.html on July 6, 2018

National Association of State Energy Officials (NASEO). (2018, February). *Guidance for States on Petroleum Shortage Response Planning, February 2018*. Retrieved from https://www.naseo.org/Data/Sites/1/petroleum-guidance/final-naseo-petroleum-guidance-feb-2018.pdf, pg. 84-85

Sieminski, A. (2014, March). Testimony by EIA Administrator to U. S. House of Representatives, Committee on Energy, Retrieved from https://www.energy.gov/sites/prod/files/2014/03/f13/3-6-14_Adam_Sieminski%20FT%20HEC%20-%20w%20Attachments.pdf

Smith, A. (2010, September 14). "Oil spills cause gas price spike in Midwest" *CNNMoney.com*. Retrieved from http://money.cnn.com/2010/09/14/news/companies/enbridge_spill_gas_price/#

US Department of Energy (DOE). (2015, October). *An Assessment of Heating Fuels and Electricity Markets During the Winters of 2013-2014 and 2014-2015*. Retrieved from https://www.energy.gov/sites/prod/files/2015/10/f27/DOE_OE_Two%20Winters%20Report_Final_10.19.15.pdf

Wolverine Pipe Line Company. (n.d.). Website, About Us. Retrieved from http://wolverinepipeline.com/about-us/

Appendix J: Response to Comments on the Independent Risk Analysis of Straits Pipelines Draft Report

On July 19, 2018, the State of Michigan released the draft report on the Independent Risk Analysis of the Straits Pipelines to obtain stakeholder input through public comment. The comment period for the draft framework concluded on August 19, 2018. During that time, the State of Michigan received 62 comments through the page set up at the Michigan Petroleum Pipelines Information website (https://mipetroleumpipelines.com/) and one comment through an email that was passed on to the analysis team. An additional 27 comments were provided in person at a public presentation of the draft report and feedback session held at 6 p.m. on Monday, Aug. 13, at the Boyne Highlands Convention Center in Harbor Springs. The slides from that presentation are available at https://mipetroleumpipelines.com/document/risk-analysis-presentation-august-13-2018.

This appendix serves as a record of the comments received and provides responses from the analysis team. Some comments were addressed to the State of Michigan or focused on issues outside of the scope of work defined for this analysis; the team could not provide substantive responses to these comments, but they have been reviewed by the State. The analysis team thanks all those who participated in the public comment process to help inform a decision by the State on Line 5.

Some comment submissions were extensive and comprised a number of individual statements that related to different sections of the report. This appendix consists of two tables; Table J1, which numbers the comments and includes the full text and the name provided by the commenter, and Table J2, which sorts the comments by report section and includes responses from the analysis team using the same numbering system. Comments from the State of Michigan (comment 63 in Table J1) are included together with the other comments. Comments that address cross-cutting and related issues that do not correspond to a specific report section are grouped as ‘General’ in Table J2. Several submissions also included attachments; these are labeled and included in this Appendix following the tables.

Table J1. Comments on the Draft Report on the 2018 Independent Risk Assessment for the Straits Pipelines. Attachments to comments are included as PDFs at the end of this appendix.

#	Name	Comment
1	Alex Sagady	When the Draft independent risk analysis for the Straits Pipelines was published and comments invited, the announcement DID NOT INCLUDE A DEADLINE FOR PUBLIC COMMENTS.
2	Randy Wojtowicz	Hello, My comment is WHY TAKE THE RISK . It sounds to me like we do not benefit from this pipe line, The oil goes straight to Canada am I right? So why is it coming thru Michigan, Money? Is the money worth more than our water, Our shoreline, Our economy, I think not, And if you put it to a vote I would bet most residents of Michigan would say SHUT IT DOWN.....NOW. If it is Canadian oil let them run a pipeline on their soil not ours. Thank you
3	James Weiner	I do not want the State to take the risk but ff they are going to keep Line 5 Enbridge needs to put up a bond in the amount of $10 Billion dollars to ensure against a catastrophic failure as described.
4	Robbie Layton	With hardly any benefit to Michigan I think the pipeline should go on the land in other states, so a leak can be detected and stopped before 4000 + gallons of oil destroy our environment.
5	Lois Korpalski	This about The People of Michigan and the safety of our environment. The People have spoken! Shut down Line 5.
6	Carrie Dollar	I agree with the previous statement that Michigan appears to get very little benefit from Line 5. The line appears to carry materials from Canada to Canada with some but little sell off in Michigan. Don't risk it. Shut it down.

7	B. C. Knol	The report purports to calculate the maximum “plausible” or believable spill. Tier 4 & Tier 5 failures are NOT plausible. Page 8 of the Executive Summary even states concerns over plausibility yet the results of Tier 5 were presented in the States Summary without any comment on probability or plausibility. Here’s what independent events must happen for Tier 4 and Tier 5 to occur. 1) One 20” line fully ruptures 2) Second 20” line fully ruptures 3) Primary valves fail to close 4) Secondary valves fail to close 5) It takes 2 hours to manually shut the primary valves 6) The pump continues to operate at full capacity for 2 hours. (Apparently the low pressure pump shut-off malfunctions and no one in Enbridge seems to remember to turn it off.) 7) A batch of NGL enters the straits area and sweeps all crude from the line after the valves are closed adding another 7,500 barrels to the spill. Does this seem plausible to you? Has there ever been a historical event with a full guillotine rupture and failure of primary and redundant systems? The preceding list represents “double jeopardy” which is explicitly excluded in Process Hazard Analysis or in Hazard and Operability Studies (HAZOP). Tier 4 and 5 results should be deleted from the report; they are implausible. At a minimum, the calculations should be rerun assuming the pump is turned off in a reasonable amount of time or the time for the low pressure transient to reach the pump for automatic shut-off should be calculated. In addition, an expert in Process Hazard Analysis should comment on the plausibility of Tier 4 and 5.
8	B. C. Knol	The report is incorrectly named. The definition of “risk” in the Business Dictionary is “a probability or threat of damage, injury, liability, loss, or any other negative occurrence that is caused by external or internal vulnerabilities, and that may be avoided through preemptive action”. Merriam Webster states “the chance of loss or the perils to the subject matter of an insurance contract; also the degree of probability of such loss.” Calculation of “the largest foreseeable discharge” in the report “explicitly excludes consideration of the probability” (p. 3 Executive summary) which is another way of saying risk has not been calculated. The report itself further states “...this assessment extends to risks with low probabilities of occurrence.” Failure to attempt to quantify the probability of occurrence is a major shortcoming of this report. The report should be modified to include risk calculations. Without risk calculations, it is difficult to assess what is truly "foreseeable". Without risk calculations, "foreseeable" is subjective, politicized and highly dependent on an individual's position on the operation of line 5. If risk calculations are not calculated, then this alternate report title is suggested: “Calculation of Worse Case Discharge for the Straits Pipeline Excluding Risk Consideration.”

9	M Kincaid	As I read the comments above and the analyses that have been quoted, I wonder if the age of the pipeline has been included as a factor. It's one thing to predict risk. It's another to do that with a product that is over 4 decades old. But more important is the issue that this pipeline is there more for the benefit of Enbridge and their Canadian customers more so than it is for American business. And then we assume all risk in the Great Lakes region where the pipeline lies. I agree with Alex Sagady that most Michiganders would vote to shut down line 5 if it ever makes it to a vote.
10	Leo	Any Oil at all, can ruin the fresh water for years. Consider the Gulf of Mexico- It took years to finally bring back the fishing industry. We have a very fine balance in the Great Lakes for our water related industries, any glitch (one gallon or 1000) can have devastating effects. The pipe can be run on top of the land so any leak can be spotted. Unfortunately money is the factor. Our world is slowly deteriorating and we do not need to speed it up with a oil leak in our great lakes.
11	Nancy Shiffler	The report's estimates of volume leakage and subsequent damage are highly dependent on its estimates of the amount of time that passes between initial detection and full response. While acknowledging the plausibility of errors that could result in longer time periods, the report ultimately draws on operating procedures provided by Enbridge. The estimated time for leak detection ranges from 5 minutes (for ruptures) to 30 minutes (for pin-hole leaks) using the leak detection systems deployed by Enbridge. However, the report acknowledges that a PHMSA-funded study from 2012 found that these automated systems are not the most likely source of leak detection; reports from workers or the general public were more likely (as was the case with Enbridge's Kalamzoo spill). Once a leak is detected, the protocol requires that the operator have 10 minutes to determine the nature of the problem and decide on a response. For the Kalamzoo spill it took 17 hours. After the decision is made, the expectation is that the automated system could shut down the valves within 3.5 minutes. If the automated valves don't close for some reason (equipment failure, security breaches, etc.) then they would have to be shut down manually by local personnel. Enbridge estimates this could be done within 15 minutes to 2 hours, subject to personnel location, time of day, and weather/travel conditions. The report's worst-case scenario envisions a situation in which multiple steps reach their estimated maximum times, resulting in a loss of up to 58,000 barrels. The report admits that even larger failures are plausible but does not claim a firm basis for extending its calculations of estimates. In a sense, then this is the lower end of a worst-case scenario. Even so, the report describes, along with the economic costs, a potential for environmental harm where "an event like an oil spill may represent a point of no return for species loss and extirpation."

12	Ashley O'Reilly	The risk analysis Enbridge seems to require as well as the Govener and AG is - what is the risk to it's business w/o Line 5, while Michigan/Canada/Wisconsin can analyise that same risk through the lense of job creation, how many jobs are created through building a different line, or different energy source AND how much risk is reduced to the Great Lakes if Line 5 is closed (no Line 5 = no risk to Pure Michigan from Line 5). Do the right thing, create jobs - by closing the Line, create jobs by investing in alternative industry, preserve Pure Michigan related job.
13	Scott W Kelley	I believe the scope of the report was limited and only concerned two areas of risk. How much time and money will be needed for the company to return to normal business and how much money the State tax payer will pay and the Federal will pay. Any guess to how much has been spent so far to combat the citizen and our opposition to this pipeline is measurable and will be held accountable one way or another as the report details. It appears to that the report is only giving one outlook at the question of risk. One question to be asked is what is the risk to the state, company and federal if the pipeline where to be decommissioned or re-purposed. The report details a drastic change that the people were not included into the argument as there were obviously too many unknowns with evident with blanks not filled in with a number. I also want to mention that we have no idea what our neighbors think about this, states and a country? There are so many questions, but they all lead to one thing Why? Is this Insane? What are We Doing? I really don't want us saying What Did We Do? What Are We Going to Do? It's time for a change and Michigan needs to start the Trend of Change. Michigan has been in the for front of past trends and I believe we can start a new on. I know in Emmet County we strive everyday with our Recycling with a bright look on how we want our future to look like, the pictures we were shown and graphs did not show a very nice future or anywhere I would want to live. I do not believe the Report considers us homo-sapiens in the risk at all, in matter of fact out of the whole state that was shown it appeared just 10% Lake Michigan and Huron where in concern with no respect to any life after the 200 foot barrier of shoreline along those lakes. No where did it address us humans who live on land, how it would really impact my county or it's residence which are citizens of this state and country. Please listen to us and do the right thing, shut it down scardee cat, what are you afraid of, us? I think the report shows what one should be scared of.

14	Scott W Kelley	I have to add that with a little math a 20" pipe over 5.5 miles is 4800 barrels at 44 gallons per barrel...they are saying the only oil that can or will escape, probably no matter what is the oil in the line and their automatic shut off will detect a leak by pressure and flow rates. The panel said they inspected these or viewed these newly added safety features but no where were they in the report, not even a picture to identify that it really happened. This was no where in the report but someone has the details, maybe the Coast Guard..who knows. Anyways They have full confidence that there will never be a problem, I guess that is why we are questioning the pipeline, what risk? There's no risk, just probability. I guess they have pumps to pump the oil out of the line and shut it down if they need to, and then it will be too late unless we obviously just stop the oil from flowing through our water, you ca't drink oil, lead mercury so why is this stuff in our water? Why can't we eat the fish today and everyday? Why is Flint not able to have fresh water? Why will we not have fresh water anywhere soon. Please stop the madness and listen to the people for once..please!
15	Richard Barron	The report fails to state the obvious: the risk of massive environmental damage exceeds the benefits to Michigan residents. Shut 'er down.
16	Dorothy Krueger	After reading this, I cannot recommend that we keep the Line 5. While they are planning to keep it safe, it was planned for 50 years, it is now 60+ years and we are having spills. The thoughts that they will keep it safe and collect all spills is laughable. We cannot risk the loss of fish, birds, plants and even humans. There is no risk worth this!! The loss of one line, with a lock that does not close and maybe two locks that do not close is too much, not worth the risk. We must remove the risk and make is more safe. st stop this now.
17	Joanne M Cantoni	Given how old Line 5 is, given Enbridge's track record (re truthfulness about condition of the pipeline and the timeline to make repairs), and given the dire consequences for the water quality of the Great Lakes, tourism, fish life and more, I DO NOT see any benefit for the US to continue to allow Enbridge to ship oil/gas to Canada, via the Straits. All I see is VERY expensive risk.
18	Jay Jasinski	Why on earth would we put the greatest source of freshwater in the world at risk so a foreign oil company can make millions? It's not a matter of if it will break, it's a matter of when it will break! We can't put Michigan's second biggest economic industry (tourism) at risk. We can't put our Great Lakes at risk. We can't put our wildlife at risk. We can't put our children's health at risk. For once, let's prevent a catastrophe form happening instead of all crying about it after it happens.
19	Kara Gregory	The fact that Michigan is willing to put our Great Lakes at risk is absolutely ridiculous. It is embarrassing enough after the water issues we have in Flint especially with the largest fresh water source in the world. We’ve already allowed too many businesses to take water from the GLs and we cannot allow this pipe to burst and ruin what makes Michigan and this earth beautiful. Prevent this before it happens !!

20	Cheryl Dinger	This is a submission of some of the notes after I spoke at the Public Meeting in Harbor Springs on August 13 per request of moderator: I am speaking from the heart...and asking each of you to think with the heart in the the next few moments please. Maya Angelo once said, "When you know better you do better." I think we can all agree that we all know better and have much more information than we did 65 years ago in 1953 when Line 5 Pipeline was constructed to transport oil across the straits of Mackinaw and our peninsulas. We now have almost 400 pages of information from the Risk Analysis Research Report to prove it as it states we should have known better.. should there be an oil spill in our beautiful Great Lakes. We need to remember that corporate contracts, foreign or domestic, are just pieces of paper. No heart. No soul...probably not even a human handshake in the making. That's why it works so well when it comes to making a profit. But, I have to ask ..Where is your heart going to be should there be a large oil spill in the Great Lakes? ...What you are going to tell the children when they wonder how this happened in the first place? What will this teach our children and grandchildren? ...I predict your heart will be sick from the seeing the sight of black oily water floating for 441 miles (according to the research) of oil soaked fish and wildlife that lay slain on our shores, and worries about your property values, a family job loss of someone who depends on fresh water (or tourism) for a living, and concerned about customers who are concerned about the same things, and they stop spending their hard-earned money and Michigan's economy, literally, comes to a screaming hault. Also, as a people, how can we afford to cause more trauma and cultural harm to the heritage and identity of native americans who make it a part of their way of life to honor and care for water, land, and wildlife habitats (that benefit all) by risking an oil spill in our Great Lakes? Let us take heed from the ancient wisdom of these people. Harm to native Americans can stop here. If an oil spill occurs, we can no longer blame our non-native ancestors to the harm done against native americans; it will be us, it will be us...and the people we place in office! Take heed... We need to get to the heart of the matter and close Line 5 for good! It is the right thing to do because we now know better and because the damages and costs that the Risk Analysis provided is the expert evidence needed and confirms our serious concerns, and because, hopefully, your heart says it is the right thing to do also. Thank you.
21	Dania Gutierrez	Too much risk. Shut it down
22	Judy Lammers	RisK and no real benefit....I hope this report gives the decision makers the courage to do the right thing. DO THE RIGHT THING!!! MUSTER YOUR DAMN COURAGE!
23	Terri Wilkerson	Regarding your final report summary chart, it would be helpful if you would: 1) Include number of gallons of oil as most people don't know it's barrels x 42 2) Qualify the 40% clean up statement "could be recovered from the water surface if..."' 3) Add standard for clean up like, "Shoreline clean-up to EPA standards would take 12-24 months" 4) Add a number to "sensitive and threatened habitats and species would be harmed" Like, over 500, 2,000... "Over .... sensitive..." I don't think most people realize just how many species rely on the area 5) List a few of what the "intangible costs" are - "Intangible costs such as related health care costs..., would also be very high" 6) List the number of drinking water supplies at risk and how many people could be impacted. Personally, I would put this up higher in the list. Thanks again for the work you did - and for allowing us to ask questions at the draft presentation. I hope that our government realizes the daily risk Line 5 poses and shuts it down very soon while they discuss if alternatives are worth considering.

24	Susan Wheadon	So what is this really about? The fossil fuel industry is lining the pockets of our politicians and setting the energy policies for this country. Their profits are obscene. And how about environmental ethics? Anyone look into the past environmental catastrophes? Of course you have but greed is always the key. I was conscious of the high rate of cancer and birth defects where I grew up.I grew up near the Love Canal and near a town where the Army and a defense contractor dumped more than 37 million gallons of radioactive waste from the World War 11 atomic bomb project. My Dad was a chemist for the company that worked for it and when he was 90 got a call saying that if he should develop cancer, his company (now Dow Chemical) would pay for it. We don't want to sit back and be controlled by industries that pollute. We are tired of the greed, and corruption. We have children and grandchildren and care about them. So tired of all of your task forces and studies that only lead to more task forces and studies. Stop this. You have one life. Why not make a positive difference?
25	Beth Knol	As a professional engineer with 30+ years of experience in the oil and gas industry, allow me to take exception to some items in the Independent Risk Analysis Report. Utilizing a full bore rupture or guillotine failure to calculate the largest foreseeable discharge is required by Federal regulation and comparing these results to the more likely 3" hole is useful. However, I take exception to associating a 3 inch hole with external corrosion, utilizing external corrosion as a primary threat (failure mode) and defining a 3" hole as a "pinhole leak." I also take exception to associating incorrect operations with a guillotine failure and listing over pressure as the specific incorrect operation. These concerns are addressed in more detail below. Recommended changes to the report most importantly Tables A4 and A5 are included as a separate file along with a Dynamic Report reference. A) Corrosion – The report first uses the word "pinhole leak" associated with corrosion as a primary threat in Table A4 on page 45 and in Table A5 on page 48. "Pinhole" is not associated with a 3" diameter hole until page 52 in Table A6 and Table A7. The rationale for using a 3 inch "pinhole" is never presented and the word "pinhole" itself is grossly misleading. Evaluating a 3" hole is reasonable for calculating discharge quantities; attributing the 3" hole to external corrosion is not. In the report by Dynamic Risk, external and internal corrosion were listed as secondary threats (page 2-44). The corrosion risks were considered so remote that a probability of failure was not calculated (pages 2-46 & 2-47). In addition, Dynamic Risk noted that "cases of significant external corrosion on offshore pipelines are extremely rare" (page TS-12). The Independent Risk report implies that the coating gaps found at three locations in 2017 (including a photograph in Figure A4) justify including corrosion as a primary source of a "future pinhole" leak. The current report ignores the overall excellent external coating and lack of holidays confirmed by the CPCM inspection in September 2016 (Dynamic Report page TS-11). More significantly, the current report ignores the impressed current cathodic protection system located on both sides of the straits which protects the underwater pipe from external corrosion where coating is damaged or missing by applying electrical current to the pipeline. It is standard operating practice and a regulatory requirement to assume that external coating has flaws or damage and to provide cathodic protection for additional external corrosion protection. It is a "bonus" that the coating of Line 5 can be visually inspected compared to the inaccessibility of buried pipelines. My recommendations are to delete corrosion as a primary cause ("threat") of a 3" leak, delete the misleading word "pinhole" throughout the report and eliminate the coating gap discussion. B) Incorrect Operations – The Dynamic Report lists incorrect operations as a principal threat. The report determined that a 3" hole should be assumed after using probability weighting of actual offshore pipeline hole sizes for this mode of failure without identifying a specific operating error (page 2-44). In contrast, the Independent Risk report lists a guillotine rupture for incorrect operations and lists over pressure and hammer shock as the underlying cause without any supporting historical or analytic evidence. How would overpressure occur? Pumps have a local high pressure

		alarm, a local high pressure shut down and a safety relief valve that discharges to the suction of the pump which limits maximum pressure and results in no net flow to the pipeline. Furthermore, a pump would most likely break before developing enough pressure to burst a 20” seamless pipe with .812” wall thickness. Pipeline pressure would have to exceed 2850 psi before plastic yield (permanent deformation not bursting) of the 20” pipe even initiated. Transient pressure shock i.e. hammer shock occurs when a valve is closed too quickly in a liquid line. Automation of valve closure on Line 5 prevents this from happening. How fast would an operator have to manually shut a valve for a significant pressure transient to occur? Is this even physically possible? The validity of this failure mode should be investigated further. Finally, assume it is possible for a valve or valve sequence to be shut so quickly that hammer shock occurs with a resulting leak. The valve(s) is/are already closed so a Tier 4 or Tier 5 scenario is not possible. It is my recommendation that over pressure and hammer shock as specific incorrect operation examples be deleted and that a 3” hole instead of a guillotine rupture be used. C) Supporting data from the Dynamic Report is included as a file with this transmittal combined with proposed changes to the Independent Risk Report are included as a separate file.
26	Julius Moss	Attached are copies of oral comments from 8/13/18 presentation on the Independent Risk Analysis by FLOW's Executive Director, Elizabeth Kirkwood; and FLOW's Legal Intern, Julius Moss.
27	Dr. Sue Anderson	I grew up in Michigan's beautiful Upper Peninsula and have spent most of my adult life in Ann Arbor. My husband and I spend a great deal of time in upper Michigan -- the Traverse City area on up to the bridge -- and in the U.P. We treasure the natural beauty of this area and would never want to see any of our wilderness areas or the Great Lakes threatened in any way. We feel Line 5 poses such a threat and are opposed to continuing with its operation. We are opposed to any upgrading, expansion, or replacement of this line that would allow it to continue to operate. It is abundantly clear that this pipeline is unnecessary and that there are other viable alternatives to transporting anything this company needs to transport -- alternatives that are much safer and do not threaten the health of the Great Lakes in the way that Line 5 does. When other alternatives are available, why would we play Russian Roulette with our future? ANY spill in this area would be so devastating that the long term consequences are inestimable -- not just for the environment, wildlife, health of the fisheries, and health consequences for people living in that area (ground water and drinking water contamination, exposure to toxic chemicals, etc.), but for the economy of the immediate region and for the entire State of Michigan. There is no scenario where tolerating the risks associated with an aging pipeline makes sense. Please, SHUT IT DOWN NOW! And do not allow any other lines to ever be placed under the Straits of Mackinaw again! We are stewards of this land and great waterway. We must act intelligently, in our own best interest now, and in the best interest of all future generations to come, to protect this vital resource. In 100 years, we will no longer be here. But the land and water will still be here. And our children's children will be here. They are counting on YOU to do the right thing and protect the incredible natural resources that we have been entrusted with. Please protect this area and close down Line 5 once and for all. You have the power to protect the Great Lakes for us and for future generations. Please don't let the selfish interests of one company outweigh the good that can come from shutting this project down. Thank you.
28	Dr. Kenneth Ogilvie	I am a life-long resident of Michigan. I have a PhD in mechanical engineering and work in the auto industry. As an engineer, I can tell you with 100% confidence that materials fail. Every man-made item has a shelf life. Decay happens. No materials

		last forever. No matter how well something is designed, no matter how much care goes in to crafting it, nothing is foolproof. Things that are engineered fail all the time. It may be due to human error, contaminants in the manufacturing process, neglect, accident, unforeseen complications, or a host of other reasons, but whether we want to admit it or not, nothing is foolproof. Because of this, I have grave concerns about subjecting something as important as our Great Lakes to any potential man-made hazard. Line 5 is an excellent example of such a hazard -- a disaster waiting to happen. Because there are alternatives available, it would be foolish to continue using Line 5 in its current location under the straits. If it fails, the consequences will be so monumental that the area will never fully recover to its pristine condition. It would be even more foolish to place another line there -- no matter what assurances you are getting from the company that wants to put it there. The company that built the Titanic touted it as the best, safest, most sea-worthy ship ever! And look what happened there. Let's avoid another disaster and get rid of Line 5.
29	Ann Hause	The scientific research is in and indicates that the huge risks far outweigh ANY benefit derived from the continued use of Line 5. The company has repeatedly shown that profits are the priority, not the environment. Considering the risk to Michigan and the Great Lakes, Line 5 needs to be shut down. If the fuel is critical to Ontario and other provinces, Enbridge needs to re-route their line through Canada, not the United States.
30	Lee Burton	The risks of allowing Line 5 to continue operating far outweigh any benefits. A leak would prove disastrous to the environment, to water supplies, to the fishing industry and to tourism. Who benefits from Line 5? Mostly Enbridge, a Canadian company. The oil is a pass-through shortcut back to Canada and is exported. Propane use for the UP can be obtained elsewhere. Why do we even consider allowing this line to operate when so much is at stake?
31	Captain J. Porter	Line 5 pipeline poses a great threat to our water supply. The leak that recently occurred on the Kalamazoo River here in Michigan is an example of some of the dangers involved with leaking Pipelines and our water supply. Other factors are important but our water supply is number one
32	Douglas Taylor	Money concerns seem to be topmost in today's business and political environs. Long term environmental and health concerns that take decades to "fix" or recover from unfortunately are distant priorities. Money can be recovered quickly; environmental damage (and the resultant loss in an economy) cannot be quickly reversed. A decades old pipeline in one of our nation's most-prized waterways being put at risk by a foreign-owned private company for profit (and benefit of another country) is something lawmakers should have the courage to stand up against. There are land alternative for this oil to get to "market."
33	Stuart H. Gage	The Great Lakes are "Jewels of the Biosphere". Destroying these jewels is absurd. Line 5 is too old and therefore is at risk of leaking. If this happens during winter, recovery will be difficult or impossible. Shut down Line 5.
34	Alan Darbe	There is no good reason to let this old pipeline to put the Great Lakes at risk.
35	Lori Dostal	It is not worth the risk to our Great Lakes to keep this pipeline open. There are plenty of other ways to get clean energy to the people who need it. Shut this line down now, not later.
36	C. D. Tchalo	The Great Lakes are THE largest deposit of fresh water IN THE WORLD. How is any amount of oil worth more than THAT?! Why are we Michiganders taking SO MUCH RISK and LIABILITY for so little benefit? This is absurd and even heinous. The devasting risks far outweigh the tiny benefit. For less than a lousy 10% of the "dollar benefit" of this pipeline, look what we stand to lose: our entire Michigan economy, our wildlife, our fisheries, unparalleled scenic beauty, DRINKING WATER, and literally 1000s of miles of shoreline of private and public recreational beachfront property enjoyed by 100s of 1000s of people each year. Enbridge only carries a paltry $1million of liability insurance in contrast to the BILLIONS it would cost us. If logic

		and reason do not dictate that Line 5 be shut down immediately, then all the key decision makers are either stupid fools or evil doers. Attorney General Schuette has the power to shut Line 5 down immediately. Why does he not care about Michigan's economy and the environment enough to shut Line 5 down? It's time to put ALL LIFE first and oil profits last. Stop Line 5 immediately! Thank you!
37	Jennifer McKay	Please see the attached comments on behalf of Tip of the Mitt Watershed Council. Thank you.
38	Jim Smyth	Shut down Line 5 now, before it's too late.
39	Dr. Donnie Beas...	Pipeline 5 is a hazard to the people, flora, & fauna that surrond the Great Lakes. Any damage could be irreversible for years to come! We need to put the wants/needs of many before that of a few.
40	Oliver Warner	Line 5 is at the end of it's life, is risky (as the recent anchor incident proves), and provides little economic value to our state. We need to reduce carbon fuel infrastructure and drive up the price of oil to force people to make better transportation choices.
41	Jon R Lewis	our great lakes define our beautiful state. let's protect them.
42	Liz Kirkwood	Dear Governor Snyder, Attorney General Schuette, Director Grether, Director Talberg, Director Creagh: The notice published by the State on the Pipeline Advisory Board's website calls for substantive analysis and comments by the public before August 19, 2018. In the spirit of this public notice and request for thoughtful comments, FLOW submits the attached analysis, comments, and conclusions regarding the Independent Risk Analysis for the Straits Pipelines. The attached analysis and comments address: (1) the methodology and assumptions utilized in the Risk Analysis' assessments; (2) the conclusions reached in the Risk Analysis; (3) the discrepancies between the Risk Analysis' findings and Dr. Richardson's report produced for FLOW titled Oil Spill Economics: Estimates of the Economic Damages of an Oil Spill in the Straits of Mackinac in Michigan; and (4) the lack of information regarding Enbridge's current insurance policy for liabilities stemming from a Line 5 spill. FLOW would also like to thank Dr. Meadows and his team for both recognizing and incorporating FLOW's previous work into the Risk Analysis. Specifically, Dr. Richardson's study that was produced for FLOW as well as Richard Kane's memo titled Defining a Worst-Case Release Scenario for the Enbridge Crude Oil Pipelines Crossing the Straits of Mackinac – Line 5. Although there are discrepancies both in the methodology and conclusions of FLOW's previous work and the Risk Analysis performed by Dr. Meadows, all studies clearly demonstrate that Line 5's Mackinac Straits crossing poses an unacceptable risk to the Great Lakes and the State of Michigan, which is further detailed in our comments. Thank you for the opportunity to comment. Should you have any questions or desire further information, we are willing to meet with you and technical experts to discuss the above. Sincerely Yours, Liz Kirkwood Jim Olson Executive Director President and Legal Advisor
43	Pam Medelis	For years, Enbridge has assured us that Line 5 is safe and not to worry about an oil spill. However, we now know that to be untrue. Enbridge lied about Line 5 safety when it knew that since 2003 numerous bottom support anchors were missing and failed to disclose it until 2017, nine months after a report documented that pipeline spans of up to 286 feet had no anchor support. In addition, in 2017 Enbridge claimed that missing protective coatings along the Straits pipeline were a mere "hypothetical" possibility, while at the same time a video IN THEIR POSSESSION showed areas of missing coatings. It is

		proven. They lie to protect their interest, meanwhie the Great Lakes, the people that live on them and the animmalotgat live in them are a constantly a risk for a huge catastrophe.
44	Ryan Graydon	Dear Governor Snyder, Attorney General Schuette, Director Grether, Director Talberg, Director Creagh, Dr. Meadows and study team: First, I want to express my gratitude for the creation of the Pipeline Safety Advisory Board and for ordering the assessments of Line 5 and all the pipelines that traverse Michigan. Seeking objective facts to understand the risks of Line 5 is crucial to determine the best option for the State of Michigan's (and more broadly the entire Great Lakes basin's) economy, society, and environment. I have followed the actions and reports to the Michigan Pipeline Safety Task Force and the Pipeline Safety Advisory Board since their inception. After reading the Independent Risk Analysis for the Straits Pipelines executive summary and draft report, and attending the public presentation of the study at Boyne Highlands Resort, the limitations of this study particularly the amount of costs not included in the total financial estimate are glaring. Under Task D, the public health and safety impacts were assessed predicting an increased risk in cancer to permanent residents. However, the costs of healthcare to permanent residents, clean-up workers, seasonal residents, and tourists exposed to the oil and its fate chemicals (VOCs and PAHs) were not assessed nor included in this study. Under Task F, only the primary costs (return injured resource and services to baseline) were assessed. The compensatory costs (reimburse the public for losses) were not included. Although nearly certain and predicted to be quite high, the costs of litigation and liability were not included in this study. Under Task G/I, the estimate of public and private economic damages ($1.37 billion) only considered coastal counties (as far south in Michigan as Oceana County) and excluded economic damages to any inland counties. My experience as a former Tampa resident and my intuition tells me that tourists' negative perceptions of an oil spill would drive potential tourists to avoid the area (including neighboring inland counties) resulting in additional economic damages not included in this estimate. Why visit oil slicked Michigan, Wisconsin, and Ontario when there are so many other uncontaminated places to visit? My conclusion is that this risk assessment was methodologically rigorous, but like any assessment, has its limits. The limitations of this study include numerous expenses that lead me to conclude that the staggering $1.8 billion financial estimate is an underestimate. In addition to the potential adverse economic outcome, the potent effects to the environment and society would be irreparable. In light of less hazardous alternatives to the Line 5 pipeline for energy production and transportation, including decentralized renewable energy technologies such as residential solar and wind, and the global need to reduce our carbon footprint to mitigate global warming and climate change, I am in favor of decommissioning and removing Line 5. Let's transition to cleaner, renewable energy and protect our image of Pure Michigan. Thank you for your consideration. Ryan C. Graydon, MPH
45	Lisa Dawn Perschke	Dear Governor Snyder, Attorney General Schuette, Director Grether, Director Talberg, Director Creagh, Dr. Meadows and study team: I have lived most of my whole live in the Great Lakes Region, both in Indiana and Michigan. One year I lived in California...I missed the Midwest. Our states are so lucky, and at the same time very spoiled to have so much fresh water at our disposal. The Great Lakes are THE largest deposit of fresh water IN THE WORLD. Many states and other foreign countries are not as lucky as we are. California is suffering from the current drought that they are experiencing there; wild fires that are burning

		down their homes, communities and devastating their agricultural footprint in our country. Michigan is the 2nd top agricultural producing state in the US. We need our fresh water to maintain such a status to feed this country as well as our state! We need to safe guard and protect this great trust that we have been endowed with by taking action to protecting this very resource. If we allow big corporations and businesses especially foreign businesses, to tell us what is safe, then we are compromising our very state's well being! It has been shown that this pipeline, its technologies and steel structural bodies are vulnerable and getting old. We are the ones who will pay a heavy price if this pipeline fails. We need to ensure that our Great Lakes waters and natural bodies stay pristine and untainted from oil products. Please help to protect the rights of all of the US citizens in this region from such a natural disaster that this pipeline failure could produce. We have seen such a failure in the Kalamazoo, Michigan region. The residents there are still suffering from that devastating spill; many are learning they have resulting health issues. We don't want to repeat such terrible past historical decisions as Enbridge has been making. It is our citizens that are paying for such poor planning and unwise decision making. We don't want to have oil mixed in with our pure water. It has been shown that if such a pipe system failure occurs in the Straits of Mackinac, then the flow of the currents from Lake Michigan and Lake Huron will make it very difficult to contain and control such a spill. It will be much worst than the spill that happened in the Gulf in Mexico. Please learn from the past by proactively planning for the future. Please utilize the bipartisan specialists, our engineers and environmental ecologists, who have the experience and knowledge to make wise recommendations. Please keep the Great Lakes safe while keeping the oil flowing at a later time. Please don't build a tunnel around this demised pipeline. It is only a band aid solution. The time is now, to shut down this pipeline! It is time to build a new stronger pipe with many safeguard devices. Please shut down this pipeline and have Enbridge put in a new line, with many safety valve shut offs and alarm systems, 24/7 monitoring devises before it is too late. We need to make sure we protect these waters for us and our future generations. The future; our children, their children and future generations depend on this very resource, this fresh WATER, the land and air that this pipeline runs through... it all needs to be protect as much as the all mighty $$$$! Yes we need jobs but we also need a healthy environment to live in. You are our elected officials; you have been given a "public trust" obligation to represent us, your constituents. You must represent our interest and needs for clean water, land and air; to represent our wants for this pipe to be shut down; as well as the wisdom of your subconscious to know what is needed. Karma is present all around; it is only those who do what they know they must do who will be blessed. Those who take money from corrupt corporations for their own individual benefit are going to have to answer to a "higher court". It is time to take your public trust to that level and be the men that you are; representative and honest. Thank you! Sincerely, Lisa
46	John Vick	Get Line 5 out of the water and the Straits. The water at the tip of the mit is to valuable to risk. Why wait to remove it when it has out lived it's life expectancy.
47	Roger Moon	The risk is senseless and the cost of recovery astronomical.. I cannot understand why the need for this pipeline continues. Please turn it off and get the pipe out of our lake.
48	Lee Jasinski	We cannot continue to risk the future of our State and our Planet any longer. The human race continues to destroy our only home. When the pipeline does fail...and it will we'll all be wondering why we allowed this to happen once again. The pipeline owner Enbridge will put on a show doing a surface clean up. However another pristine part of nature and our habitat will be gone forever.

49	David Schonberger	The dirty and dangerous Enbridge Line 5 petroleum pipeline assembly is a most imprudent gamble for the state of Michigan and threatens to become a truly horrific and unprecedented, manmade disaster for the entire Great Lakes region. Finally, we are having a real public discussion about what is at stake in the unlikely event of a worst-case severe accident. Unfortunately, the same cannot be said for how we look at our state's nuclear energy infrastructure. Please forgive me....I feel obligated in the absence of federal leadership to issue this public call for an equivalent, independent state-funded worst-case risk analysis of Michigan's age-degraded nuclear power facilities. Needless to say, the global history of actual nuclear power plant disasters suggests a severe accident in southeast or southwest Michigan on our Great Lakes shoreline near large population centers would be catastrophic. Yet, inexplicably, the U.S. Nuclear Regulatory Commission (U.S. NRC) does not evaluate worst-case scenarios for U.S. nuclear power plants during the federal license review process. It is important to understand nuclear safety/security is regulated by the federal government, but the Michigan State Constitution explicitly allows for regulation of atomic energy matters within the territorial boundaries of the state. Let's not continue to ignore such existential threats hiding in plain sight. Shutdown before meltdown!
50	Enbridge Energy	Dear Directors Creagh and Grether Enbridge has read and reviewed the Draft Independent Risk Analysis of Straits Pipelines prepared by the team of researchers led by Michigan Technological University and directed by professor Guy Meadows of Michigan Tech's Great Lakes Research Team. It is our understanding that data from this report will be considered when determining the future of Line 5 and how best to enable the region to continue to safely receive the energy on which everyone depends. Based upon the worst-case conditions that the team of researchers was directed to follow, the scenarios that are presented in the report are purely hypothetical and the probability of the events actually occurring is extraordinarily unlikely. That being said, Enbridge has the plans, the people, the expertise, the training and the equipment to respond quickly and effectively in the unlikely event of any incident on Line 5 in the Straits. Enbridge pipelines operate with multiple layers of safety in mind. These layers include a 24-hour control center that constantly monitors all of our lines and can initiate a shutdown in minutes; automatic shut-off valves located on either side of the Straits that would minimize the amount of product that could be released; and well-trained local personnel with emergency response equipment who could be onsite quickly. For more than 60 years, Line 5 has safely and reliably transported the energy families and businesses require each day in a manner that also protects Michigan's natural resources and supports the region's economy. We all agree that the State's natural resources are a treasure that must be protected. Enbridge is working with the State of Michigan to evaluate and implement measures that will improve pipeline safety. As part of our robust maintenance program, we are exploring new technologies to ensure Line 5 – and our entire pipeline system – remains a reliable part of the nation's energy system, and a critical link in the Straits of Mackinac that connects Michigan's two peninsulas to the energy that people need each day. Looking to the future, two feasible alternatives to the existing dual pipeline crossings have been identified to help ensure the continued safety and protection of the Great Lakes for future generations, and we look forward to our continued collaboration with the State to further explore the viability of these options.
51	Jolene Shrake	This pipeline is too risky to our beautiful, necessary Lake Michigan. We know there can be tragic accidents.
52	Pamela Dodt	My comments are as follows:

		Even if valves are closed remotely in 13.5 minutes (p. 5, column 4), including the 10 minute response time, in the real world, it is likely that the shutdown time could be 30 minutes or more. Additionally, residual release of oil within the line would still occur following shut down. The lower range leak volume is likely low. The term "pinhole" leak is misleading. In the document, a pinhole is defined at a 3" hole. This is not a pinhole. I would hope that Dave Schwab from the U of M (performed the leak scenarios presented at a Line 5 League presentation last year) reviewed this document. Looks like a different model was used for the MTEC report (page 10). This is not necessarily a bad thing but the more technical experts who agree with the model which forms the basis of the document, the better. Costs were based on the Line 6B spill (page 26), a very different environment than the Straits and shoreline and islands of the area. Much of the shoreline in the area of the Straits is rocky with heavy currents and potentially high wave action. The report suggests around 450 (plus or minus) miles of shoreline could be impacted. The report contemplates removing oily beach materials and replacing with like materials. The cost estimate of $500 million (presented in the report for a spill of this nature, page 31) is low considering the complexity of the environment and potential weather conditions. The amount of equipment that would need to be mobilized, materials, labor costs, disposal costs, restoration of the shoreline with like materials, and rehab/disposal of dead wildlife for a major spill is likely understated. Considering that the cost of constructing a two-lane highway is approximately $3,000,000 per mile, it would appear that remediation costs for an oil spill consisting of 58,000 bbl (2,436,000 gallons) spoiling 450 plus miles of shoreline in the Straits area, would exceed those presented in the document. Assuming that equipment would be ready for deployment and manned with operators within 2 hours (page 20) of the spill is a very big assumption and is likely not realistic. Finally, costs incurred by the State for the cleanup are to be reimbursed by Enbridge. Where would these government funds be taken and what other program would be shorted? Additionally, the costs associated with remediation are often disputed which delays reimbursement. The reimbursement process places an undue burden on the State and surrounding States for a pipeline that provides very little benefit to the community. There is only a very small segment of the population that derives some benefit (receives propane) from Line 5. According to the London Economics International Report, there would be a $0.05 per gallon increase in propane costs if Line 5 ceased operation. I can't believe the state "leadership" is still considering alternatives other than a complete shutdown.
53	Roger Gauthier	As a former staffer of the U.S. Army Corps of Engineers, Detroit District and of the Great Lakes Commission, I would like to provide the following comments on the draft Independent Risk Analysis for the Straits Pipelines. My comments are specifically focused on the following elements of the draft Risk Analysis: 1) the assumptions made affecting the worst-case scenario (WCS) and its dispersion and ultimate fate; 2) assumptions on containment and clean-up efforts; 3) assumptions on the duration of economic and ecological impacts; and 4) the assumptions of and paucity of information on WCS impacts on private and public property values. I recognize the substantial efforts expended by Dr. Meadows and his academic team to assess the magnitude of losses that our communities would incur if a WCS occurred from Enbridge's Line 5 under the Straits of Mackinac. Unfortunately, this effort was compromised from the outset by poor vision and management by responsible State of Michigan agencies. In 2015, the Michigan Petroleum Pipeline Task Force called for completion of a comprehensive and independent risk assessment on Line 5 to ascertain a defensible estimate of liability coverage that Enbridge should provide under the 1953 Easement with the State. Unfortunately, this task was left to the end of the Governor Synder / Attorney General Schuette administrations, with too little time provided for public comment and buy-in. This situation is frankly objectionable and

		unacceptable. The public has a right to better understand the risk that continued operations of Line 5 poses to the citizenry of the State and to those beyond who treasure the binational resources of the Great Lakes. My critique of the draft Risk Analysis report is as follows: I. WCS and its Dispersion and Ultimate Fate The definition of a WCS used in the draft Risk Analysis report is generally consistent with the federal definition of "the largest foreseeable discharge of oil" in accordance with prevailing federal legislation. The draft Risk Analysis, however, limits the magnitude of the WCS to a complete rupture of both 20" lines under the Straits of Mackinac and a potential corresponding delay in shutting down flow within the pipeline. The upper bounds of the WCS as described in the draft Risk Analysis report is 58,000 barrels, while other independent estimates indicate that the two 20" lines can contain as high as 63,000 barrels over the 4.1 miles between shut-off valves (without any additional losses from failure of automated shut-offs on either end of this line segment.) The draft Risk Analysis report does not differentiate between the toxicity of the variety of products that can be shipped through Line 5. Hence, the Risk Analysis fails to consider the worst possible ecological and human health impacts with this massive oversight. The dispersion of the WCS and ultimate fate is highly reliant upon the calibration of the FVCOM to real-world observations which are spatially limited to a few sampling locations west of the Mackinac Bridge and temporally limited to current observations from only 2 to 3 open water seasons. The current hydrodynamic models do not adequately describe bottom currents that occur during major atmospheric disturbances across the region. These limitations showcase significant inconsistencies between the FVCOM model output used in the draft Risk Analysis report and those produced in 2016 by the University of Michigan Water Center study. The draft Risk Analysis study shows large stretches north and south of Green Bay in Lake Michigan that would be affected by a WCS release, while the U of M study shows significant oil beaching in Lake Huron including into Georgian Bay and Saginaw Bay. The draft Risk Analysis report relies upon a major assumption that oil would be distributed for only a maximum of 60 days. This assumption is critical as it affects both the economic impact assessments and natural resource damage calculations. There is little referenced evidence that a WCS from the Straits of Mackinac segment of Line 5 would be contained and cleaned-up within the 60-day modeling timestep. The longer the oil is not contained and removed from the system, the larger the damaged area will become. The hydrodynamic model also does not consider reoccurrence of oiled beaches. Oil that resides in the offshore can be brought onshore repeatedly through littoral transport mechanism, poorly assessed in the draft Risk Analysis report. Furthermore, the FVCOM model output that drives most of the draft Risk Analysis report are based on the climatology and meteorology from just one year (2016), which may be a close surrogate for conditions in 2018 or the foreseeable future. However, the model output likely under-assesses currents in the Straits of Mackinac and northern lakes Michigan and Huron during other years when extreme hydrologic, meteorologic and climatologic conditions occurred. No sensitivity analysis was conducted to evaluate the uncertainties in the hydrodynamic modeling output. This would never be accepted for academic research of this importance. 2. Containment and Clean-up The draft Risk Analysis report failed to achieve a critical assessment of the inadequacies of the approved Enbridge contingency plan to field trained personnel and equipment within the first 36-hours of a WCS. Due to highly fluctuating current conditions in the Straits and multiple months of unstable ice conditions across the region, containment of a WCS is highly improbable for the majority of any given year. Conventional oil spill containment methods are likely incapable of being

		utilized due to the high currents, high wind and wave conditions or due to ice coverage. Enbridge's Superior Region Contingency Plan (Version 3) clearly outlined the limitations of use of conventional oil spill containment techniques. The assumption should have been clearly made in the draft Risk Analysis report that containment within the immediate area of the Straits of Mackinac would not be achieved and that these efforts would be required for several hundreds of miles of shoreline affected by the WCS. 3. Duration of Economic and Ecological Impacts The draft Risk Analysis under-evaluates the duration of clean-up and remediation activities. The draft Risk Analysis is built upon an assumption that an oil spill in the Straits will only have a short-term effect on the region's economy, including tourism, recreational uses, commercial fishery and coastal property values lasting only one to two-years or even a few weeks for commercial navigation through northern lakes Michigan and Huron. The draft Risk Analysis report fails to provide clear definitions of what constitutes "restoration", "remediation", or "clean-up" and how independent evaluations would be made to assess progress on these efforts. Suggesting that clean-up and remediation can occur within one or two years of a WCS is unrealistic ad unacceptable. Baseline biological conditions have not been adequately addressed in the draft Risk Analysis report. Little to no effort is expended to identify how clean-up goals will be determined and how metrics will be collected to assess progress towards remediation. What is an acceptable recovery rate (30%, 40%, 50%, etc.)? What programs will be necessary to restore debilitated populations of fish and wildlife, along with landscapes and flora? 4. Private and Public Property Values The biggest individual shortfall of the draft Risk Analysis report is a gross under-assessment of the impact of a WCS from Line 5 under the Straits of Mackinac on riparian property values across the region and, in particular, in the most likely impacted shorelines in Cheboygan, Emmet and Mackinac counties. The academic researchers engaged in this ventured failed to canvas the nearly 8,000 parcels that would be directly affected by a WCS oil spill on their beaches. The 8,000 parcels include all shoreline and immediately adjacent parcels on the mainland and all parcels on Mackinac, Bois Blanc and the Les Cheneaux islands. The draft Risk Analysis report fails miserably in assessing the likelihood of major losses to shore property owners by assuming that market values would only decline for a year or two and only by less than 15%. This assumption leads to a few tens of million dollars in impacts. The simple perception of damaged property would drive home prices and other coastal parcels down more likely in the 60-80% range in the affected counties and persist for 3-6 years. My professional assessment is that market value declines in the most likely affected counties would total between $1.7 and 2.9B, with the most likely estimate being $2.3B. Obviously, there is a significant disagreement between these estimates. In addition, the draft Risk Analysis report did nothing to estimate condemnation of coastal properties who have shallow ground water wells that could be contaminated for decades to come. Over 78% of all parcels in Cheboygan, Emmet and Mackinac counties have ground-water wells for potable use. The draft Risk Analysis report only accounts for a miniscule amount of these impacts and limits the prospective loss to testing of groundwater wells for two years. Conclusion In conclusion, the draft Risk Analysis report is a noble effort, albeit highly flawed due to a clear lack of time and opportunity for peer and public review followed by necessary revision before the work is completed. The $1.9B estimate of losses from a WCS is clearly too low when considering all the limitations of this analysis. Other studies are showing that the "true" risk of a WCS from Line 5 will exceed $6B and could go as high as $20B. It is imperative for our elected officials, and the staff of the State agencies that they oversee, to demand that Enbridge provide a bond or similar liability coverage in exceedance of $6B.

		Enbridge must assume the risk of its operations, not the taxpayers of the State of Michigan and other taxpayers across Canada and the United States.
54	C. Moellering f...	Little Traverse Bay Bands of Odawa Indians' traditional way of life, and rights to hunt, fish and gather in the Ceded Territory were reserved in the 1836 Treaty of Washington and reaffirmed by the Federal Court in the case of United States v. Michigan. The Straits of Mackinac are in the heart of this Ceded Territory and is an important fishing, and fish spawning ground. Any oil spill in this area will be detrimental to these activities. This initial Risk Analysis completed by Dr. Guy Meadows and his team is appreciated, but the State of Michigan should have included all of Line 5 in the scope of this analysis. The many other segments of Line 5 including those near Lake Michigan, and its tributaries also pose a risk to LTBB's treaty rights, and should also be analyzed. Regardless, because of the irreparable harm caused by a rupture of any segment of Line 5, it needs to be decommissioned and safely removed. Thank you for this opportunity to provide feedback.
55	Sue	IF the line is to continue it must be physically protected from damage and a monitoring system must be applied to the full length of the line at no cost to Michigan. Having said that, if there is no benefit to Michigan and the benefit is 100 % to the Canadians, then there is plenty of room in Ontario for this line and no need to.endanger Michigan water, wildlife or people.
56	jordan sons	I am impressed by the information that you have on this blog. It shows how well you understand this subject.
57	Colin M. Frazier	Dear Director Creagh and Director Grether, The American Petroleum Institute has reviewed the draft report and has provided comments in the attached. Sincerely, Colin M. Frazier Policy Advisor American Petroleum Institute
58	Alexander Pushman	In this scenario, we have an opportunity to minimize risk and make sure we avoid catastrophic issues for our Great Lakes and the generations to come. It's important we don't let greed or lobbying control the future of our beloved lakes and outdoor community here in Michigan and the surrounding states. Take action, and let's do the right thing, we can't have Line 5 keep running after every known report says it shouldn't be anymore.
59	Gayle Turner	For all of the reasons stated, Line 5 needs to be decommissioned, unequivocally.
60	C Diane Macaulay	Any pipeline spill is dangerous, but in water the danger spreads over a far greater area, killing a far greater number of native plants and animals. This is unacceptable, and probably would not even be suggested under a saner Administration. No. No. No.
61	Melanie Caughey	This line should be shut down. Water is too important, as well as our entire Great Lakes Region, to take such a terrible chance when failure can be imminent. Don't take any more chances with Michigan water! Shut this pipeline down right away!
62	Gary Street	PUBLIC COMMENTS ON MTU RISK ANALYSIS FOR STRAITS PIPELINES AS REQUIRED PURSUANT TO EXECUTIVE ORDER NO. 2015 – 14 AND PROCEEDINGS OF THE PSAB AND THE GOVERNOR SNYDER-ENBRIDGE AGREEMENT, NOVEMBER 27, 2017 August 18, 2018 Dear Governor Snyder, Attorney General Schuette, Director Grether, Director Talberg, Director Creigh: The notice published on the Pipeline Safety Advisory Board website calls for substantive analysis and comments by the public by August 19, 2018. My inputs are attached. Gary L. Street, M.S., P.E.

63	State of Michigan	These comments are submitted on behalf of the Department of Natural Resources (MDNR), the Department of Environmental Quality (MDEQ), and the Michigan Agency for Energy (MAE) and were developed by technical staff with expertise in a variety of areas.

Table J2. Responses to Comments from Analysis Team, Sorted by Report Section. Comment numbers (#) correspond to Table J1.

	Section	*#*	*Comment (page numbers refer to Draft Report)*	*Analysis Team Response*
2	Intro	37	Acknowledge that the risk to the public trust waters of the Great Lakes does not solely come from the twin pipelines located on the State-owned bottomlands in the Straits of Mackinac. The text mentions that line 5 crosses navigable waters and is located near Great Lakes shorelines, but fails to state that a leak or rupture along this portion could still result in an oil spill in Lakes Michigan-Huron and the Straits of Mackinac. This is emphasized in Task X. U.S. Coast Guard (USCG) personnel and emergency managers both pointed to the stretch of the pipeline along U.S. Highway 2 near Lake Michigan's northern shore as their worst-case scenario, citing a combination of less robust technology such as pipeline wall thickness and monitoring equipment, as well as higher vulnerability to an errant strike and potential access problems for containment and cleanup equipment, as well as difficult terrain and environment for cleanup activities. (p. 33)	Statement clarified to read: "This assessment was limited to the potential impacts of spills specifically from the Straits Pipelines segment of Line 5, though other portions of the line could also impact the Great Lakes because it runs close to the shorelines and crosses navigable waters."
3	Intro	37	When making the comparison between the 2010 spill from Enbridge's Line 6B into the Kalamazoo River and a spill in the Straits, it is important to highlight the difference between spills in a riverine ecosystem versus an open water system. Riverine environments by their nature often allow for easier and greater containment and recovery of oil than open water spills. Unlike in open water or the Straits of Mackinac, currents in a river are generally directed downstream. This greater predictability of	Difference between river and lake behavior is now included with: "Oil spilled in a river is carried downstream, whereas variable currents in large lakes can carry material across a wide area."

			river currents makes it easier to forecast which way the oil will move. (p. 33)	
4	Intro	37	The tasks and scenarios are listed in Table 1. but are not provided or noted prior in the text. Tasks need to be explained or laid out in the beginning of the introduction so the table is understandable. (p. 35)	Good point; task descriptions have been added to the introduction.
5	Intro	63	Page 32, last paragraph – The discussion of multiple worst case scenarios is potentially confusing when compared to the single, representative worst case scenario selected in the report and its associated financial impacts. We suggest reiterating this distinction throughout the report and ensure there is clarity when referring to the single worst case liability versus the various circumstantial worst case scenarios. In addition, any dollar figures relating to scenarios other than the single worst case should be denoted accordingly to avoid confusion.	Discussion of scenarios has been clarified in the introduction and throughout.

6	A	7	The report purports to calculate the maximum "plausible" or believable spill. Tier 4 & Tier 5 failures are NOT plausible. Page 8 of the Executive Summary even states concerns over plausibility yet the results of Tier 5 were presented in the States Summary without any comment on probability or plausibility. Here's what independent events must happen for Tier 4 and Tier 5 to occur. 1) One 20" line fully ruptures 2) Second 20" line fully ruptures 3) Primary valves fail to close 4) Secondary valves fail to close 5) It takes 2 hours to manually shut the primary valves 6) The pump continues to operate at full capacity for 2 hours. (Apparently the low pressure pump shut-off malfunctions and no one in Enbridge seems to remember to turn it off.) 7) A batch of NGL enters the straits area and sweeps all crude from the line after the valves are closed adding another 7,500 barrels to the spill. Does this seem plausible to you? Has there ever been a historical event with a full guillotine rupture and failure of primary and redundant systems? The preceding list represents "double jeopardy" which is explicitly excluded in Process Hazard Analysis or in Hazard and Operability Studies (HAZOP). Tier 4 and 5 results should be deleted from the report; they are implausible. At a minimum, the calculations should be rerun assuming the pump is turned off in a reasonable amount of time or the time for the low pressure transient to reach the pump for automatic shut-off should be calculated. In addition, an expert in Process Hazard Analysis should comment on the plausibility of Tier 4 and 5.	Several comments related to the definition of the worst-case discharge volume in Task A. Some commenters suggested that the Tier 4 and 5 scenarios were not plausible, where others pointed out that other documents have included estimates higher than 58,000 bbl/243,600 gal and that therefore the Tier 5 estimate did not seem large enough. The assumptions for the Tier 4 and 5 estimates were driven in large part by prevailing federal regulations (49 CFR 194.105) that detail how a worst-case discharge should be estimated. This regulation specifically calls for the use of the maximum shutdown response time and maximum flow rate based on the maximum daily capacity of the pipeline, plus the largest line drainage volume after shutdown of the line section. If the pumps were to shut down before the valves were closed in a Tier 4 or 5 scenario, this would indeed reduce the discharge volume, but that is outside of our federally driven assumptions. Some commenters criticized the assumed detection/shutdown times in view of the 2010 Enbridge Line 6B spill, in which shutdown took approx. 17 hours. Due to both the safety systems in place at the Straits that were not in operation for the Line 6B spill and the greater visibility and the higher visibility of a floating oil sheen in the Straits area, which would likely result in faster observer reporting in the event of a spill, a timeline similar to the one that occurred during the 2010 Line 6B spill was not considered plausible for these different circumstances. The times and flow rates assumed for this analysis based in part on pipeline specifications provided by Enbridge that are considered critical energy infrastructure information and therefore are not public data. This may account for some of the differences between our worst-case discharge volume and estimates provided by others who did not have access to this information. One commenter stated that Tiers 4 and 5 are not

	plausible because they combine a failed automated valves/manual shutdown scenario with a batch of NGL entering the Straits area and "adding another 7,500 barrels to the spill", constituting "double jeopardy". Tiers 4 and 5 do not include an assumption of NGL entering the Straits pipelines, and there is no reference to the 7,500 bbl value in our Draft Report.

7	A	8	The report is incorrectly named. The definition of "risk" in the Business Dictionary is "a probability or threat of damage, injury, liability, loss, or any other negative occurrence that is caused by external or internal vulnerabilities, and that may be avoided through preemptive action". Merriam Webster states "the chance of loss or the perils to the subject matter of an insurance contract; also the degree of probability of such loss." Calculation of "the largest foreseeable discharge" in the report "explicitly excludes consideration of the probability" (p. 3 Executive summary) which is another way of saying risk has not been calculated. The report itself further states "...this assessment extends to risks with low probabilities of occurrence." Failure to attempt to quantify the probability of occurrence is a major shortcoming of this report. The report should be modified to include risk calculations. Without risk calculations, it is difficult to assess what is truly "foreseeable". Without risk calculations, "foreseeable" is subjective, politicized and highly dependent on an individual's position on the operation of line 5. If risk calculations are not calculated, then this alternate report title is suggested: "Calculation of Worse Case Discharge for the Straits Pipeline Excluding Risk Consideration."	Some of the comments received applied more to the scope of work and content of the State of Michigan's Request for Information, which framed this analysis. The wording of the State's Request is outside of what the analysis team can address as part of this public comment process, but those comments have been received and reviewed by the State.

8	A	9	The report’s estimates of volume leakage and subsequent damage are highly dependent on its estimates of the amount of time that passes between initial detection and full response. While acknowledging the plausibility of errors that could result in longer time periods, the report ultimately draws on operating procedures provided by Enbridge. The estimated time for leak detection ranges from 5 minutes (for ruptures) to 30 minutes (for pin-hole leaks) using the leak detection systems deployed by Enbridge. However, the report acknowledges that a PHMSA-funded study from 2012 found that these automated systems are not the most likely source of leak detection; reports from workers or the general public were more likely (as was the case with Enbridge’s Kalamzoo spill). Once a leak is detected, the protocol requires that the operator have 10 minutes to determine the nature of the problem and decide on a response. For the Kalamzoo spill it took 17 hours. After the decision is made, the expectation is that the automated system could shut down the valves within 3.5 minutes. If the automated valves don’t close for some reason (equipment failure, security breaches, etc.) then they would have to be shut down manually by local personnel. Enbridge estimates this could be done within 15 minutes to 2 hours, subject to personnel location, time of day, and weather/travel conditions. The report’s worst-case scenario envisions a situation in which multiple steps reach their estimated maximum times, resulting in a loss of up to 58,000 barrels. The report admits that even larger failures are plausible but does not claim a firm basis for extending its calculations of estimates. In a sense, then this is the lower end of a worst-case scenario. Even so, the report describes, along with the economic costs, a potential for environmental harm where “an event like an oil spill may represent a point of no return for species loss and extirpation.”	Please see response to comment 7

9	A	25	As a professional engineer with 30+ years of experience in the oil and gas industry, allow me to take exception to some items in the Independent Risk Analysis Report. Utilizing a full bore rupture or guillotine failure to calculate the largest foreseeable discharge is required by Federal regulation and comparing these results to the more likely 3” hole is useful. However, I take exception to associating a 3 inch hole with external corrosion, utilizing external corrosion as a primary threat (failure mode) and defining a 3” hole as a “pinhole leak.” I also take exception to associating incorrect operations with a guillotine failure and listing over pressure as the specific incorrect operation. These concerns are addressed in more detail below. Recommended changes to the report most importantly Tables A4 and A5 are included as a separate file along with a Dynamic Report reference. A) Corrosion – The report first uses the word “pinhole leak” associated with corrosion as a primary threat in Table A4 on page 45 and in Table A5 on page 48. “Pinhole” is not associated with a 3” diameter hole until page 52 in Table A6 and Table A7. The rationale for using a 3 inch “pinhole” is never presented and the word “pinhole” itself is grossly misleading. Evaluating a 3” hole is reasonable for calculating discharge quantities; attributing the 3” hole to external corrosion is not. In the report by Dynamic Risk, external and internal corrosion were listed as secondary threats (page 2-44). The corrosion risks were considered so remote that a probability of failure was not calculated (pages 2-46 & 2-47). In addition, Dynamic Risk noted that “cases of significant external corrosion on offshore pipelines are extremely rare” (page TS-12). The Independent Risk report implies that the coating gaps found at three locations in 2017 (including a photograph in Figure A4) justify including corrosion as a primary source of a “future pinhole” leak. The current report ignores the overall excellent external coating and lack of holidays confirmed by the CPCM inspection	A pinhole diameter fo 3 inches was chosen based on historical data from European offshore pipelines (the CONCAWE and EGIG databases, see references in final report; similar records were not available for US lines) showing that 95% of small leaks involved a hole with a diamater of 3 inches or less. The 3 inch hole scenario therefore represents the largest likely "pinhole". A scenario based on a 0.6" hole was also analyzed in order to capture both ends of the likely range of pinhole sizes; because the 0.6" pinhole scenario resulted in a lower release volume than the 3" scenario, only the worst pinhole case (a 3 inch hole) was included in the reporting. We agree that it could be helpful to the reader to include this context in the report. A 3 inch hole could result from several causes (i.e., puncture, third-party damage, external or internal corrosion, etc.), and the focus of this report was the consequences of such damages rather than the causes.

in September 2016 (Dynamic Report page TS-11). More significantly, the current report ignores the impressed current cathodic protection system located on both sides of the straits which protects the underwater pipe from external corrosion where coating is damaged or missing by applying electrical current to the pipeline. It is standard operating practice and a regulatory requirement to assume that external coating has flaws or damage and to provide cathodic protection for additional external corrosion protection. It is a “bonus” that the coating of Line 5 can be visually inspected compared to the inaccessibility of buried pipelines. My recommendations are to delete corrosion as a primary cause (“threat”) of a 3” leak, delete the misleading word “pinhole” throughout the report and eliminate the coating gap discussion.

10	A	25	B) Incorrect Operations – The Dynamic Report lists incorrect operations as a principal threat. The report determined that a 3" hole should be assumed after using probability weighting of actual offshore pipeline hole sizes for this mode of failure without identifying a specific operating error (page 2-44). In contrast, the Independent Risk report lists a guillotine rupture for incorrect operations and lists over pressure and hammer shock as the underlying cause without any supporting historical or analytic evidence. How would overpressure occur? Pumps have a local high pressure alarm, a local high pressure shut down and a safety relief valve that discharges to the suction of the pump which limits maximum pressure and results in no net flow to the pipeline. Furthermore, a pump would most likely break before developing enough pressure to burst a 20" seamless pipe with .812" wall thickness. Pipeline pressure would have to exceed 2850 psi before plastic yield (permanent deformation not bursting) of the 20" pipe even initiated. Transient pressure shock i.e. hammer shock occurs when a valve is closed too quickly in a liquid line. Automation of valve closure on Line 5 prevents this from happening. How fast would an operator have to manually shut a valve for a significant pressure transient to occur? Is this even physically possible? The validity of this failure mode should be investigated further. Finally, assume it is possible for a valve or valve sequence to be shut so quickly that hammer shock occurs with a resulting leak. The valve(s) is/are already closed so a Tier 4 or Tier 5 scenario is not possible. It is my recommendation that over pressure and hammer shock as specific incorrect operation examples be deleted and that a 3" hole instead of a guillotine rupture be used.	Thank you for your comment. The perceived risk posed by pressure could be better characterized as differential pressures, i.e., large fluctuations in internal pressure that could stress the pipeline material over time. This change in wording has been applied in the final report.

11	A	26	The Risk Analysis' WCS assumes Enbridge will be able to detect a rupture in the dual pipelines immediately due to Line 5's automated leak detection systems. However, a PHMSA-funded report found that between 2010 and 2012 pipeline company employees and/or contractors detected the largest number of pipeline leaks. The public ranked second. Automated leak detection systems ranked third.	Multiple public comments noted a PHMSA-funded report (Leak Detection Study DTPH56-11-D-000001) that found, from an analysis of historical spill events, that pipeline company employers/contractors or members of the public have been the first to identify a spill more frequently than leak detection systems. The analysis team is aware of this report, and it is referenced in the Task A chapter. It is notable that the statistics on the initial identifier of release incidents presented in that report are based on analyzed spills of a wide range of volumes, and that pipeline monitoring systems are most effective for detecting large ruptures. Additionally, the incidents analyzed for that study include a range of leak detection systems, not all of which are equivalent in capability to the detection systems in place at the Straits. The analysis team did not identify a plausible scenario in which the overlapping monitoring systems at the Straits could fail and result in a release volume greater than that already identified for the Tier 5 scenario currently described in our report.
12	A	37	Oil spills are rarely detected immediately. In addition, the tiers of failure are based upon Enbridge Energy properly following operating procedures. History of oil spills, including Enbridge incidents in Michigan, has shown that human error comes into play more often than not and operating procedures are not always properly implemented in emergencies.	Please see response to comment 7
13	A	37	Coating gaps were confirmed at more than three locations. Three locations were identified as a result of the diver inspections conducted at anchor locations. However, the biota investigation, conducted as part of the Consent Decree, identified eight additional bare spots. These coating gaps need to be acknowledged in the report. (p. 46)	Some comments raised specific concerns, such as the potential risk to pipeline integrity posed by coating gaps or by acidic mussel secretions. This report proceeds from the assumption that a worst-case spill has occurred and estimates the foreseeable consequences. As such, it may be better termed a spill consequence analysis than a risk analysis, but assessing the probabilities of various modes of failure, or the risks posed by specific concerns such as coating gaps or overspanning, is outside of the scope of work requested by the State.

14	A	37	The draft report acknowledges scenarios where loss of containment is not detected by Computational Pipeline Monitoring (CPM) or a detected leak is ignored due to human error, leading to a longer than expected detection time. However, the report fails to account for these plausible scenarios in identifying the worst-case release. The total expected decision and isolation times of 3.5 minutes, if the decision to shut down is made immediately, and 13.5 minutes, allowing for the full allotted decision-making time, should be modified to account for such feasible and likely situations. (p. 49)	Please see response to comment 7
15	A	37	The automatic valves on either sides of the Straits will only close in the event of a rupture, where there is a drop in pressure significant enough to trigger the closure. The valve on the west line automatically closes if pressure levels fall below 65 psi and the valve on the east line automatically closes if pressure drops below 45 psi. A leak would not drop pressure below this threshold to trigger the automatic closure. (p. 49)	Section A.2.5.3 of the Draft Report stated, in part, "The valves on either side of the Straits are designed to close automatically in response to pressure drops that may indicate a leak or rupture." One comment noted that the automated shutoff valves are triggered by significant pressure drops (to below 65 psi for the West Line or 45 psi for the East Line), and that a pinhole leak would not drop pressure below this threshold. This may be accurate, although Enbridge has stated that the breach size required to drop the pressure below the shutdown threshold values is "complex in nature and highly dependent on the operating condition of the line". Given that Enbridge refers to this part of their leak detection strategy as "rupture detection", the analysis team agrees that it is appropriate to revise that statement in the Final Report to focus on ruptures.
16	A	37	Tiers 4 and 5 only account for the two hour response time for a manual valve closure. The initial detection time is not included, which would be 10 minutes IF Enbridge procedures were properly followed and not subject to human error. In addition, based upon history of Enbridge incidents as well as other oil pipeline spills, it is not necessarily reasonable to expect that a large spill would be isolated within a two-hour window. (p. 52)	Tiers 4 and 5 assume a total of two hours of oil flow before the pipeline damage is isolated. This includes detection/decision time. It is true that there have been historical incidents with longer times to isolation, but for this specific site, given the locations of the primary and secondary valves and the proximity of on-call Enbridge staff, the analysis team believes that two hours is a realistic maximum value.

17	A	50	Table A1: Comparison of assumptions for this and previous estimates of spill volumes at the Straits. (Pages 37/38) The identified information extracted from the Dynamic Risk report for the 3” leak case is not consistent with the information provided in the 2017 Dynamic Risk report. Both the “Equipment Design Standards” and the “Values Assumed for Calculations” in Table 2-9 (p. 2-75) of the DRAA report provide different values than those in Table A1 of the MTU Risk Analysis report. There are inconsistencies in terminology and uncertainties in the alignment of the MTU extracted information.	Table A1 of the Draft Report cites DRAA assumptions of an immediate detection time for rupture cases and a 20 min detection time for 3" leak cases, followed by a 10 minute decision time after leak detection in all cases, and finally a 3.5 minute shutdown time (DR 2017 Appendix N, Table N-1). The detection and decision time values provided in Table A1 are based on the 10 minute and 30 minute "Detection & Response" times for a rupture and a 3-inch hole, respectively, under "Values Assumed for Calculations" in Table 2-9 of the DRAA report. The basis for the 10- and 30-minute values are not well explained in the DRAA report, but it was reasonable to assume that the 10 minute "Detection & Response" time for a rupture is based on Enbridge's "10 minute rule" operating standard, requiring all pipeline operations to be stopped after a maximum of 10 minutes of uncertain operating status. That would logically extend to the same 10-minute decision time being included in the DRAA 30 minute detection & response time for a 3-inch leak, leaving 20 minutes for the initial leak detection. The 3.5 minute shutdown time in our Table A1 corresponds directly to the 0.5 minute pump shutdown time plus 3 minute valve closure time cited in DRAA Table 2-9. Total response time assumed by the DRAA (detection, response decision and shutdown/valve closure) is 13.5 minutes for a rupture and 33.5 minutes for a 3-inch hole according to both the DRAA report and our report's Table A1.
18	A	50	Enbridge takes exception that the response time to manually close valves is being reported as two hours, as suggested in Tier 4 and Tier 5 scenarios. A more realistic time would be one hour and, in practicality, may be less as noted below. Regarding response timing for manual closure of isolation valve(s) in the event of communication loss during an incident, Enbridge has a number of employees based in the area of the Straits, and has an on-call rotation to cover nights and weekends. One of the	In a 2015 letter to Attorney General Bill Schuette and MDEQ Director Dan Wyant, publicly available at https://www.michigan.gov/documents/deq/Appendix_B.6_493994_7.pdf, Enbridge Energy VP of US Operations Bradley Shamla provided an estimate of the time required for valve closure of "between 15 minutes to 2 hours depending on the time of day and location of existing personnel". In the absence of convincing evidence that the maximum manual valve

			stipulations for being on-call is that on-call employees must remain in the local area while on-call, so as to maintain the capacity to respond within one hour. Loss of communication and control of multiple remote control valves would most likely involve a loss of control / communication with all remote equipment on Line 5. This loss of communication would enforce local station logic that is independent of the Enbridge Control Centre SCADA system. Local logic at initial pumping station of the pipeline at Superior Terminal would initiate a shutdown of booster pumps after 10 minutes of continuous loss of communications / control. The loss of boosters would cause the shutdown of Line 5 mainline units at Superior. Superior Terminal is manned 24/7 so if the local logic did not shutdown boosters and mainline units, local operations personnel would be directed to stop both booster and mainline pumps at Superior. Control Centre process would be to initiate contact with Regional Operations Management to identify the need for a coordinated field response versus an on-call technician response due to the magnitude of the outage. Management would determine who could be contacted to minimize travel response times for each station and valve location.	closure time would be shorter, such as unannounced readiness testing conducted by a third party, it appeared reasonable to the analysis team to apply that 2 hour maximum as the worst-case assumption. This 2-hour assumption also accounts for potential delays beyond the control of on-call responders, such as a weather-related Mackinac Bridge shutdown or a facility evacuation in response to a credible threat. The release volume associated with a one-hour senario was also analyzed as part of Task A. Additional information on the impacts of a one-hour release scenario are provided in the response to comment 63. Since the one hour scenario does not represent the worst case with a two-hour estimate also provided officially, the two-hour scenario and its impacts are the focus of this study.
19	A	50	Task A.2.5.1 Spill/Leak Detection Time (Pages 45) The report states, “Operators install a combination (hybrid) of these systems because the pipeline is used to transport various products such as crude, refined and Natural Liquid Gas (NLG) using the same conduit according to seasonal needs.” This is not an accurate statement. A combination of internal and external systems does not make up a “hybrid” system. Operators like Enbridge employ a Leak Detection strategy which employs several complementary layers. The strategy encompasses several primary leak monitoring methods, each with a different focus and featuring differing technology, resources and timing. Used together, these methods provide an overlapping and	The monitoring systems in place at the Straits Pipelines may be better characterized as a "combination of overlapping components" rather than a "hybrid" system. This change in wording has been made in the final report. The draft report does provide some information on the methods described in this comment, but the text of the final report has been updated to include more information.

comprehensive leak detection capability. These methods include:
-- Visual surveillance and reports - Enbridge has people, processes and infrastructure established that facilitate the reporting of oil or oil odors from third parties and from Enbridge's aerial and ground line patrols. Enbridge manages third-party reports through its emergency telephone line, and communicates with affected public and local emergency officials through its public awareness program. Aerial pipeline patrols are conducted in accordance with regulatory requirements and risk based approaches.
-- Controller monitoring - Enbridge's Pipeline Controller monitors pipeline conditions (such as pipeline pressure) through the Supervisory Control And Data Acquisition ("SCADA") system, which is designed to identify unexpected operational changes, such as pressure drops along the pipeline, that may indicate a leak. Additional sensors at facilities are monitored through SCADA such as concentrations of explosive vapor, pump seal failures, equipment vibration levels and sump levels are used by the controller to identify potential leaks.
-- Computational Pipeline Monitoring Systems (CPM)
o Enbridge employs computer-based pipeline monitoring systems that utilize measurements and pipeline data to detect and alarm on anomalies that could indicate possible leaks. The Enbridge primary computational pipeline monitoring system (or Material Balance System, aka "MBS") is a sophisticated real-time transient model (RTTM) representative each
individual Enbridge pipeline. The system continuously monitors changes in calculated volume of liquids to alert the operator and analyst on shift of potential leak conditions.
o Rupture Detection – Enbridge employs complementary computer-based pipeline monitoring systems that utilize pump station pressure and flow measurements to identify
and alarm on pipeline rupture events. The control center

			procedures require immediate shutdown of the pipeline upon receipt of a rupture alarm. o Automated Pressure Deviation – Enbridge employs complementary computer-based pipeline monitoring system that utilize pressure measurements during pipeline shut-in conditions and generate alarms if a significant pressure drop occurs. o Automated Volume Balance - Enbridge employs complementary computer-based pipeline monitoring system that determines a time-averaged volume imbalance using injection and delivery flow meters during running conditions. If the imbalance exceeds a pre-set threshold, it will generate an alarm. o Acoustic Inline Inspection - Acoustic inline inspection tools are specially designed to confirm the integrity of the pipeline and for the detection and localization of very small leaks through unique acoustic signatures. Deployment of these tools is focused on pipeline risk profile such as high consequence areas.	
20	A	50	o Enbridge has installed an additional, internal hybrid CPM system on L5 Straits. This hybrid system combines two leak detection methodologies: volume balance calculations and pressure wave functionality. The internal hybrid CPM system is described in the Consent Decree Alternative Leak Detection report, and in Enbridge's State of Michigan Additional Available Leak Detection technologies report. Also, Line 5 does not carry refined products as (incorrectly) stated. The report also states, "These detections systems are only accurate for steady-state operations. A pipeline under transient conditions (start-up and shut-down) produce additional background noise which results in inaccurate detection." This statement is incomplete and inaccurate. It is not true that these systems are only accurate for steady-state operations. CPM sensitivity can be degraded by certain transient conditions, but the basic functionality for leak	The erroneous reference to refined products has been corrected in the final version of the report. With respect to comments on detection systems with pipeline under transient flow, the following modifications have been made. These detections systems are most accurate for steady-state operations. A pipeline under transient conditions (start-up and shut-down) produces additional background noise which results in less accurate detection. It is critical for operators to have exact procedures to minimize the potential for error during start-up and shut-down.

			detection continues. In general, external leak detection systems are not affected by transient pipeline operations.	
21	A	50	Appendix A-1 Leakage Calculations (Page A-2) Comments to this section are with regards to the detailed calculation of Leakage after Valves closed for Base Case of Rupture/Pin-hole. Exchange flow of oil and underwater must be taken into account when calculating potential oil spill volumes from leaking underwater pipelines, which highly depends on hydrostatics pressure and pipeline geometry. The study did not take account pipe geometry or the elevation into consideration while estimating the potential drain down volume for each release location. The study took the distance from release location to lowest elevation point and measured the available product inside the pipe based on this particular length of distance of pipe. The study also assumed all products inside the pipe will drain out in same amount of time for all five types of tier failures considered in estimating the WCD volume, which over estimates the volume for the pinhole leaks which will take significantly longer to drain.	The release volume calculations have considered the exchange flow of oil and water and the geometry of the pipe. To be conservative, although five locations were selected to analyze, the largest elevation variation of the pipe was considered to calculate the largest leakage of drain-down volume. Although drainage from a pinhole leak would take a longer time, eventually, with a 3'' pinhole, all of the oil will drain. Thus, the calculation estimates that the pinhole leakage has a larger release volume than the rupture due to the larger volume released pre-isolation in the case of a pinhole leak.
22	A	52	Even if valves are closed remotely in 13.5 minutes (p. 5, column 4), including the 10 minute response time, in the real world, it is likely that the shutdown time could be 30 minutes or more. Additionally, residual release of oil within the line would still occur following shut down. The lower range leak volume is likely low. The term "pinhole" leak is misleading. In the document, a pinhole is defined at a 3" hole. This is not a pinhole.	Please see response to comment 7
23	A	53	The definition of a WCS used in the draft Risk Analysis report is generally consistent with the federal definition of “the largest foreseeable discharge of oil” in accordance with prevailing federal legislation. The draft Risk Analysis, however, limits the magnitude of the WCS to a complete rupture of both 20” lines under the Straits of Mackinac and a potential corresponding	Please see response to comment 7

			delay in shutting down flow within the pipeline. The upper bounds of the WCS as described in the draft Risk Analysis report is 58,000 barrels, while other independent estimates indicate that the two 20" lines can contain as high as 63,000 barrels over the 4.1 miles between shut-off valves (without any additional losses from failure of automated shut-offs on either end of this line segment.)	
24	A	62	Corrosion by Zebra and Quagga Mussels The impact of zebra and quagga mussels on an underwater pipeline was not an issue in 1953 when Line 5 was constructed. They are an invasive species, and did not appear in the Great Lakes until 1991. They are now pervasive in the Straits. Why is this important? The excrement from the mussels is slightly acidic. The U.S. Army Corps of Engineers and several universities have confirmed it corrodes bare steel because it is acidic. Turning to the pipeline, it has been recently confirmed there is bare steel at 42 of the 48 locations that divers visited, with the largest being 16 inches long and 10 inches wide. 87.5 % of the supports have created bare spots on the steel. And this is just for those inspected. Some of the supports were installed in 2003. Pitting Corrosion, which is caused by the zebra and quagga mussels, may have caused the thickness of the pipe wall to be reduced by as much as 40-50% since that time. Even for the supports installed in 2014, the pipe wall thickness could be reduced by 15%. Such possible reductions in pipe wall thickness are cause for alarm. This issue must be addressed in the MI Tech Risk Analysis. (See Appendix 2)	Please see response to comment 37 in row 13.
25	A	63	Section A.2.2 presents information regarding primary and secondary valves. For clarity, the distances between the primary and secondary valves should be shown.	Thank you, this has been clarified in the final report.
26	A	63	Section A.2.3, Page 42: For clarity, the elevation profile should identify the areas of the Straits pipelines which are generally	Thank you, this has been clarified in the final report.

			buried and those which are not. If possible, it may be beneficial if the elevation can be provided relative to the nearest valves as well.	
27	A	63	Section A.2.4: We suggest deleting the phrase, “with fatigue being the most likely.” This statement is not fully justified and may be irrelevant if there are several plausible causes for a pinhole leak.	Thank you, we agree that likelihood/probability was not a focus for this report and have deleted that phrase in the final text.
28	B	37 a	Enbridge transports synthetic crude derived from the oil sands in Western Canada through Line 5. We have little, if any at all, science on how this particular product behaves in a freshwater environment in the event of a spill. The National Academies released a report, “Spills of Diluted Bitumen from Pipelines: A Comparative Study of Environmental Fate, Effects, and Response,” that concludes that bitumen, if spilled, has unique properties that affect its behavior in the environment. What we do not know is if weathering of the synthetic crude would be similar to weathering of diluted bitumen and if it would also generate a residue similar to the initial bitumen that may be more likely to submerge. This unknown could dramatically impact both the fate and transport and ability to contain and cleanup an oil spill in the Straits.	To address this reviewer comment, the authors of the Task B section of the analysis have revised the paragraph of text included in Section B.4.2 of the report. The revised text is provided here for reference: "The oil dispersal simulations conducted in this study did not make considerations for any processes that could contribute to crude oil or any of its indivudal components sinking in the water column following release or additional degradation processes beyond evaporation that could change its chemical and phyical characteristics. For example, as the more volatile components of the oil evaporate, the physical properties of the remaining oil will change and the remaining oil could potentially be more prone to other weathering processes such as dissolution, degradation, emulsification, and biodegradation. Additionally, when floating, semi submerged, or dispersed oil comes into contact with suspended sediment, the sediment can bind to it causing the oil to sink. These processes were not included in the current study and could potentially exacerbate impacts in cases where a significant amount of oil remains offshore for an extended period of time. The oil spill model also does not consider resuspension of beached oil. Oil that is resuspended from the beach can be brought onshore repeatedly through the littoral transport mechanism, and potentially increase the extent of impacted shoreline. However, the general chemical and physical characterisitcs of the crudie oil products transported through the Line 5 pipeline dictate that the majority of these products

				or their consituents would remian afloat until becoming beached along the shoreline or evaporate over time during dispersal."
29	B	37	In the oil dispersal simulations, particles were released on the water surface owing to specific gravities that are less than that of water. However, we have little, if any at all, science on how this particular product behaves in a freshwater environment in the event of a spill. The National Academies released a report, "Spills of Diluted Bitumen from Pipelines: A Comparative Study of Environmental Fate, Effects, and Response," that concludes that bitumen, if spilled, has unique properties that affect its behavior in the environment. What we do not know is if weathering of the synthetic crude would be similar to weathering of diluted bitumen and if it would also generate a residue similar to the initial bitumen that may be more likely to submerge. (p. 67)	Please refer to response to comment 37a in row 28.
30	B	37	The light synthetic commodities transported through Line 5 generally have a lower mass percentage of BTEX compounds than the other sweet or sour commodities. It would be more prudent to estimate the emissions of BTEX compounds based upon the other commodities to represent a true worst-case scenario. (p. 72)	Composition information was available for 18 products transported by Line 5 including light synthetic, sweet and sour crude oils. Composition information regarding BTEX constitutents did not differ significantly among these broader classes and the Shell Synthetic Light product used for dispersal simulations represents the general composition of bulk crude oil contained within the pipeline. As such the proportions of BTEX including in the modeling and risk assessment efforts were conducted sequentially and are representative of worst case release of the transported Line 5.
31	B	37	It is important to mention that once all the lighter compounds have evaporated, some oils can be close to the density of water. Additionally, when floating, semi submerged or dispersed oil comes into contact with suspended sediment, the sediment can bind to it causing the oil to sink. (p.82)	Please refer to response to comment 37a in row 28.
32	B	50	Task B.2.3 Oil Dispersal Simulation (Page 64) It should be noted that there is a difference between particle tracking (used in this section) and fate/trajectory modeling of	Please refer to response to comment 37a in row 28.

			hydrocarbons. Because particle tracking treats oil as an inert and neutrally buoyant there are many chemical and physical fates that this model does not include or may incorporate inaccurately therefore likely exacerbating the impacts of the oil. Task B.2.3 Oil Dispersal Simulation (Page 65) Report states, “Evaporation or weathering of oil is one of the most important processes…” This statement makes it sound like evaporation is the only weathering process that can occur to oil and that is incorrect. We recommend other weathering processes including dissolution, degradation, emulsification, biodegradation, etc. be noted and included in the analysis.	
33	B	50	Task B.3.1 Hydrodynamic Modeling Results – Oil Beaching (Page 71) The report states that the single greatest distance of oiled shoreline was predicted from the release event in February. This is contradictory to what is stated in the ice season (from January to late April). Ice reduces the impacts of currents and wind on a spill therefore this suggest that the model does not accurately predict how a spill will act during ice conditions.	By reducing the impacts of currents, ice cover can extend the time time that the oil remains on the water allowing it to spread and potentially affect more shoreline than a spill in ice-free conditions. Additionally, the presence of ice reduces evaporation which increses the persistence of oil in the enironmental and can also result in a larger amount of oil available for beaching.
34	B	52	I would hope that Dave Schwab from the U of M (performed the leak scenarios presented at a Line 5 League presentation last year) reviewed this document. Looks like a different model was used for the MTEC report (page 10). This is not necessarily a bad thing but the more technical experts who agree with the model which forms the basis of the document, the better.	Dr. David Schwab was a co-author of Task B of this report. The models and assumptions used in his 2016 Univeristy of Michigan report were explicitly compared to models and assumptions used in this report and are presented in Table B2.
35	B	53	The dispersion of the WCS and ultimate fate is highly reliant upon the calibration of the FVCOM to real-world observations which are spatially limited to a few sampling locations west of the Mackinac Bridge and temporally limited to current observations from only 2 to 3 open water seasons. The current hydrodynamic models do not adequately describe bottom currents that occur during major atmospheric disturbances across the region. These limitations showcase significant inconsistencies between the FVCOM model output used in the	1) The maps in the UM study showed probability statistics of the affects from all cases considered in the study. The current report only shows results from selected “worst” individual cases from each month. When results from the current study were analyzed statistically, they produced statistical probability maps almost identical to the UM study for the case of no wind. When wind effects were included, the maps differed somewhat showing that wind could spread oil further than currents alone, but in some cases could also cause oil to

			draft Risk Analysis report and those produced in 2016 by the University of Michigan Water Center study. The draft Risk Analysis study shows large stretches north and south of Green Bay in Lake Michigan that would be affected by a WCS release, while the U of M study shows significant oil beaching in Lake Huron including into Georgian Bay and Saginaw Bay. The draft Risk Analysis report relies upon a major assumption that oil would be distributed for only a maximum of 60 days. This assumption is critical as it affects both the economic impact assessments and natural resource damage calculations. There is little referenced evidence that a WCS from the Straits of Mackinac segment of Line 5 would be contained and cleaned-up within the 60-day modeling timestep. The longer the oil is not contained and removed from the system, the larger the damaged area will become. The hydrodynamic model also does not consider reoccurrence of oiled beaches. Oil that resides in the offshore can be brought onshore repeatedly through littoral transport mechanism, poorly assessed in the draft Risk Analysis report. Furthermore, the FVCOM model output that drives most of the draft Risk Analysis report are based on the climatology and meteorology from just one year (2016), which may be a close surrogate for conditions in 2018 or the foreseeable future. However, the model output likely under-assesses currents in the Straits of Mackinac and northern lakes Michigan and Huron during other years when extreme hydrologic, meteorologic and climatologic conditions occurred. No sensitivity analysis was conducted to evaluate the uncertainties in the hydrodynamic modeling output. This would never be accepted for academic research of this importance.	beach more quickly. 2) The results from both this report and the UM report show that there are very few cases with a substantial amount of oil remaining on the water after 20 days, and almost none with more than 10% of the initial volume still afloat after 40 days. 3) See reply in row 2. 4) We agree that running cases for more years can only result in uncovering even more extreme cases than the monthly extremes found during 2016, but we had to stop somewhere. As much as we would have liked to run more years and done a more thorough sensitivity analysis, it was not possible logistically within the time and effort constraints of this report. FVCOM model predictions were previously validated against Straits of Mackinac current measurements reported from both NOAA and MTU monitoring buoys across both spatial and temporal scales including year-round monitoring results from 2014-2018 and throughout the water column. The dispersal statisitics and scenarios determined in the current report for the year 2016 were very similar to those determined for hydrodynamic and meterological conditions for 2014 as demonstrated by the University of Michigan report. These indicate that the FVCOM hydrodynamic framework suitably captures any annual variability in hydrodynamic and meteorological conditions in the Straits of Mackinac and Northern Lake Michigan and Huron regions. While additional simulations for other years would have been preferable, they could not be feasibly completed within the timeframe of the current analysis.
36	B	63	In section B.3.1 it would be helpful to identify the sensitivity/threshold which, when met, would designate a given area of shoreline as being oiled (e.g. grams/meter squared or other like units).	In almost all worst cases considered in the analysis, the NOAA thresholds for socioeconomic and ecological impacts discussed in Task E of the report (1 and 100 g m^2, respectively) were exceeded. In the smallest volume spill

				considered, 4,400 bbl, only 26 km of 1024 km did not require cleanup by NOAA's standards.
37	C	23	Qualify the 40% clean up statement "could be recovered from the water surface if..."' Add standard for clean up like, "Shoreline clean-up to EPA standards would take 12-24 months"'	Unable to find this statement in Task C text.
38	C	37	Enbridge transports synthetic crude derived from the oil sands in Western Canada through Line 5. We have little, if any at all, science on how this particular product behaves in a freshwater environment in the event of a spill. The National Academies released a report, “Spills of Diluted Bitumen from Pipelines: A Comparative Study of Environmental Fate, Effects, and Response,” that concludes that bitumen, if spilled, has unique properties that affect its behavior in the environment. What we do not know is if weathering of the synthetic crude would be similar to weathering of diluted bitumen and if it would also generate a residue similar to the initial bitumen that may be more likely to submerge. This unknown could dramatically impact both the fate and transport and ability to contain and cleanup an oil spill in the Straits.	The simulations performed here tried to estimate how clean up could be performed simulating the oil that is being transported through the line. This included using many of the physical properties of the synthetic crude oil in the response options calculator.
39	C	37	The Northern Michigan Area Contingency Plan was updated in 2017. The most recent version can be accessed at https://homeport.uscg.mil/Lists/Content/Attachments/20682/NMACP.pdf. (p. 89, 96)	Reference has been updated to 2017.
40	C	37	The report mentions that the throughput efficiency of the Current Buster equipment was high in calm seas, and is approximately 80% in chop up to 1 ft., when towed at lower speeds. It would also be helpful to include when the Current Buster is no longer efficient or cannot be operated. (p.91)	A variety of factors (speed of towing, temporary storage, and sea states (e.g., current, wave height, wind speed, salinity)) affect the efficiency of current busters, therefore it is difficult to provide a single parameter related to lack of efficiency.
41	C	37	In Table C2, in the category “Description and limitation,” “limitation” needs to be plural. (p. 94) Table C2 was meant to provide the description and limitations for equipment used for oil containment and recovery on shorelines. However, the table only includes a descriptions of	The word "limitation" was removed in the revised text. Limitations are site specific and dependent on unique physical conditions for each situation, therefore we cannot provide general limitations for each strategy. To avoid confusion, only descriptions are provided.

			the strategies. Limitations of the strategies were not included and should be. (p.94)	
42	C	37	Additional documents regarding emergency response in the Straits of Mackinac should be reviewed by the team. Enbridge's Straits of Mackinac Tactical Response Plan and the Straits of Mackinac Emergency Response Self-Assessment would have more information specific to the Straits and could provide essential information pertinent to the analysis.	The TRP was reviewed by the team and some information from these documents were included in the discussion.
43	C	37	Significant effort has gone into exploring the use of in-situ burn (ISB) technology to enhance preparedness for pollution incidents on the waters of Northern Michigan. ISB is the intentional burning of floating oil as a method to remove large amounts of oil from the water's surface. The workgroup consisted of Area Committee members, including the U.S. Coast Guard, Environmental Protection Agency, National Oceanic and Atmospheric Administration, Michigan Department of Health and Human Services, U.S. Fish and Wildlife Service, Tribal sovereign nations, Michigan Department of Environmental Quality, and others. To establish a framework for the application of ISB on the Great Lakes, the workgroup reviewed hundreds of pieces of research publications and collaborated with research entities and academia including the Coast Guard Research and Development Center. The workgroup also studied information about ISB use in Alaska to gain best practices for utilization in severe cold weather environments. The group's efforts culminated in a set of guidelines to request approval for use of ISB on the waters of the Great Lakes in Northern Michigan. In August 2017, U.S. Coast Guard, Sector Sault Sainte Marie, in partnership with member agencies from federal, state, local and tribal stakeholders, held a widely attended environmental workshop in Mackinaw City, Michigan, to determine the feasibility of using ISB as a response tactic in addition to mechanical recovery of an oil spill in the Straits of Mackinac. The Area Committee and Regional Response Team 5 (RRT 5)	Thank you for providing insight into the in-situ burn option in the Great Lakes region. We have incorporated these description into the revised report.

			members discussed the risk versus reward of ISB, operational parameters necessary to conduct ISB, and public outreach. This workshop was the first of its kind in RRT 5 to evaluate the use of an alternative technology on the Great Lakes. (p. 97)	
44	C	37	Can the recovery rates provided by Enbridge Energy be verified by an independent third party? The rates provided seem extremely optimistic and unrealistic. (p.105/106)	It is not possible to independently verify these rates at this stage. For simulations presented here, the recoveries were determined using the estimates from the response options calculator and not the recovery rates reported by Enbridge.
45	C	37	Unfortunately, not all incidents are discovered immediately and not all incidents are reported immediately. In fact, only certain incidents are reportable under current law. Therefore, not all entities, including Mackinac county emergency office, USCG Sector Sault Ste Marie and other state offices will be notified within minutes of an incident. (p.107)	Agreed, text was modified.
46	C	37	Were the Straits weather conditions taken into consideration for time estimates for deployment and staging of booms? Adverse weather conditions in the Straits region can hinder, if not prevent, deployment of boom. (p. 107)	Yes, weather conditions were taken into consideration.
47	C	37	Two different recovery rates are provided for the response equipment available at the Straits, including the Current Buster II, Current Buster IV and Lamor bucket recovery system. One is estimated using the Genwest Estimated Recovery Systems Potential calculator and the other with no explanation (Ex. Current Buster II based on the Estimated Recovery Systems Potentials calculator is 1,551 US gallons/hr. or 36.9 bbl./hr. versus other is 3,780 gallons/hr. or 90 bbl./hr.) One recovery rate should be provided or provide an explanation to clarify the difference. (p.108)	The type of current busters (II versus IV) is the difference in recovery rate.
48	C	37	Note the time unit in Figures C6 and C7. (p.112/113)	Added.
49	C	37	Include the original volume discharged in Table C6. (p. 113)	Total amount of oil released is mentioned in the procedure section.
50	C	42	The Risk Analysis glosses over the complex landscape of determining when clean-up and remediation processes are complete. Baseline biological data must be incorporated into	Biological data are reported in chapters E and F.

			the report to fully comprehend the goals of any clean-up and remediation process and whether those goals were satisfied.	
51	C	42	The Risk Analysis grossly underestimates the amount of time it will likely take to remove the dispersed oil and start restoring the water and shorelines of Lake Michigan and Lake Huron. If a WCS Line 5 spill were to occur, and approximately 441 miles of shoreline were affected, then clean-up crews would have to restore over a mile of beach every day to ensure the shoreline would be in adequate condition for the next summer season, when the majority of Michigan tourism and recreational activities take place. Moreover, the Risk Analysis does not provide a clear definition of what constitutes “restoration”, “recovery”, or “clean-up”, and makes no mention of baseline data or measurements that independently verify the effects and impacts are no longer present in the water, shoreline, or affected environment. Without an understanding of when clean-up and remediation may be deemed adequate, the estimate to recreational impacts is difficult to accurately quantify.	Regarding what constitutes clean-up, the endpoints for shoreline cleanup are decided upon during the SCAT process and these are used to clarify what constitutes cleanup. The text has been updated to clarify when endpoints for clean up are decided upon.
52	C	42	The Risk Analysis estimates that time to clean up oils on the shorelines of Lake Michigan and Lake Huron will take anywhere from one (1) to two (2) years.22 The Risk Analysis briefly explains that “the decision for when cleanup is complete is made by the [Federal On-Site Coordinator] FOSC.”23 This brief explanation does not adequately describe the complex process of determining when clean-up and remediation efforts are complete, and what standards and/or processes must be completed or met before such a critical decision is made. While there is no singular federal or state guideline for oil spill clean-up standards, the Federal On-Site Coordinator (“FOSC”) is guided by several key factors, including the results from net environmental benefit analysis (“NEBA”) and mass balance calculations that determine the percentage of oil recovered. Understanding how the FOSC and appropriate state officials determine when water resources or shoreline are “clean” or	As mentioned in Tasks E and F some baseline data are available but not over the entire ecosystem for all species that would be affected by an oil spill. The text has also been amended to address the point that baseline conditions could be used in monitoring of cleanup and in defining the cleanup metrics.

			"remediated" is fundamental to evaluating the potential duration of the clean-up process after a WCS Line 5 spill. The final Risk Analysis should articulate the complex nature of clean-up standards and guidelines in the event of a catastrophic oil spill. Without an explanation of how the FOSC and coordinated state officials determine when a segment of shoreline is deemed "clean" or "remediated," the Risk Analysis fails to fully describe how shoreline clean-up would be completed within 12 to 24 months.24 Furthermore, the Risk Analysis also should explain how baseline biological data can help evaluate the remediation process. If no such baseline biological data currently exists for the Straits area that could be impacted by a WCS Line 5 spill, the Risk Analysis should recommend that baseline data be acquired as soon as possible so that if a Line 5 spill were to occur, the FOSC and appropriate state officials can utilize this baseline information to efficiently determine when the necessary clean-up and remediation processes are complete.	
53	C	50	Task C Time to contain and cleanup the worst-case release (Page 84) Although this section, in general, attempts to address response actions, there is analysis to show how these response actions will impact the modeling. Response actions will reduce the potential impacts and fate of the oil.	Is addressed in report.
54	C	50	Task C.2.1 Overview of Spill Response – SCAT methodology (Page 84 and again on 104) The phases listed for SCAT are not consistent with the practices employed NOAA or Enbridge. Below are the simplified steps in SCAT: 1. Conduct reconnaissance survey(s). 2. Segment the shoreline. 3. Assign teams and conduct SCAT surveys. 4. Develop cleanup guidelines and endpoints. 5. Submit survey reports and shoreline oiling sketches to the ICS	The text has been updated to more fully address the various stages of the SCAT proces and bring up the point that endpoints are agreed upon early in the process.

			Planning Section. 6. Monitor effectiveness of cleanup. 7. Conduct post-cleanup inspections. 8. Conduct final evaluation of cleanup activities Most important of these is that endpoints are agreed upon early in the process not at the end.	
55	C	50	C.2.2 Incident Command System and the Unified Command Structure (Pages 86) Enbridge, USCG, MI DEQ, local EM, and Tribal would form a Unified Command using ICS. A JFO would not be used.	We have removed the JFO statement in the revised document.
56	C	50	C.2.3 Tactics to Respond to and Clean Up Oil Releases (Pages 87) Report states that oil responses can be broken down into two different categories, Enbridge believes there are three; Open Water Recovery, Near Shore Recovery, and Shoreline clean up. Near shore would be similar to inland water course as deflection, protective, containment boom, could be used to allow skimmer recovery without oil beaching. Near shore is addressed in the report in Section C.2.3.2.1 page 89.	All areas were addressed in the report even if not in the same break-down as Enbridge.
57	C	50	C.2.3.2.2 Near-shore recovery and removal Table C1 (Page 91) Related to the exclusionary booming wave height information, the EPA manual referenced does not recognize the larger boom “Sea Sentry” or “Ocean Boom”. The Sea Sentry boom has 21 inch freeboard and 21 inch draft. Tinsel strength in excess of 40,000 lbs. The design is to military standards and is the choice of the US Navy. The boom can be deployed and anchored or held in place in 8 foot waves or greater. Enbridge has 10,000 ft. of this boom, 5000 ft. at the Straits, 5000 ft. in Escanaba. This has a positive impact on Enbridge’s ability to respond.	This is included in the equipment list.
58	C	50	C.2.4 Reviews of Documents for the Straits of Mackinac (Page 92) Report mentions the Great Lakes Region ICP but neglects to include other ER plans (Straits of Mackinac Tactical Response Plan, Great Lakes Field Emergency Response Plan and the Control Point Mapping Site Sheets).	We did not have access to specific information.

			C.2.4 Reviews of Documents for the Straits of Mackinac (Page 94) This section only partial summarizes the Integrated Contingency Plan (ICP). Missing is information for the specific region and a high level summary of the Tactical Response Plan (TRP): The purpose of the TRP is to provide Enbridge with a response plan to provide the necessary information to respond quickly and effectively to an incident, which may occur at or near the pipeline crossing. The TRP is developed to maximize the protection of the public's health and safety, and environmentally sensitive areas that could potentially be affected.	
59	C	50	C.2.4.4 Programmatic Agreements Among Agencies (Page 94) There is no mention of Enbridge's participation in regional/area activities, including exercises. This facilitates an understanding among all parties on capability to respond together.	Communication/collaboration between private industry, local and federal emergency managers is mentioned in section 3.2.
60	C	50	C.3.1 Fate of Oil in the Worst Case Scenario – Figure C4 (Page 97) As shown in Figure C4, the concept that 20,000 bbls of oil would remain steady on water from 144 to past 216 hours without change is not logical as effects of emergency response would remove oil from the water.	This figure does not take into account clean up activities we have adjusted the figure legend to clarify this. The subsequent figures address the extent of oil remaining on water when cleanup activities are taken into account.
61	C	50	C.3.4 Interviews with Enbridge representatives (Pages 101) There is no recognition that Enbridge would engage other Enbridge resources from neighboring regions. These resources would be able to be at site within the 5 day window of response. This excludes Enbridge resources in Canada, USCG boom caches, or boom in Sault Ste. Marie Ontario.	Additional equipment is mentioned in the extensive list provided in Appendices.
62	C	50	C.3.5 List of Equipment Identified (Pages 104) MTC should be MPC. It also should be noted that they are the two closest OSRO's but additional resources would be mobilized as necessary. C.4.1 Containment and Recovery on Water (Pages 105) Although there is extensive research done to create this section,	The text was modified to change MTC to MPC. We have tried to describe that the equipment used in the simulations is a conservative estimate of equipment. Simulations with the full equipment available was limited due

	this addresses only response equipment available in the first 6 hours and then extrapolate that into 106 hours of response. Enbridge's response would be considerably greater. C.4.1 Containment and Recovery on Water Table C5 (Page 107) The analysis focuses on a small sample of equipment, a sample that is considerably less than what Enbridge would deploy in such a situation. Over a 5-day period, Enbridge would deploy equipment from across its system across the United States, including various OSROs under contract to Enbridge, and not just ER equipment in the vicinity of the Straits. For example, Enbridge facilities in the states of Illinois, Minnesota and Wisconsin are approximately a 6-12 hours from the Straits (including crew activation). These facilities can bring an additional 21,000 ft. of boom, 16 boats, and 33 skimmers. Taking into account similar Enbridge capability across the US, including our contracted OSROs, brings our estimated total recovery capability to over 500,000 bbls over 5 days. This was calculated using the following assumptions: • A response of Enbridge and contracted OSRO resources in most of the United States; • 2 hours was assumed to notify and activate crews prior to departing their home locations • 12 hours driving time/day and 8 hours sleep/day • Deployment at the Straits assumed 2 hours to deploy • Recovery was based on USCG d-rating of skimmers; • A work day of 8 hours (for safety, Enbridge does not deploy on water at night, though some shoreline activities may occur). The 8 hour work day was also based on the sunrise/sunset data for the Straits in December. Not included are regions in Canada, which have similar resources as regions in the United States but crews do not have HAZWOPER qualifications. Canadian crews could be trained to the 40 hour HAZWOPER standard; however, qualification would only take affect by the end of day 5. This assumes the	to not have specific description of all of the equipment available for the response.

			requirement for HAZWOPER 40 hrs. includes the need to do post ER recovery and remediation. Should the crews from Canada take HAZWOPER 24, it would allow additional response capabilities in days 4 and 5, especially for those crews deploying from Sarnia and Southwestern Ontario where there are considerable resources, as well as an additional Oil Spill Response Contractor (ERMC).	
63	C	50	C.5.1 Time to Contain and Recover Oils on Water Figure C9 (Page 113) The figure heading states that there is limited oil recovery with increasing wind speed. The Current Buster design creates a quiescent area within the apex such that any skimmer can be used with relatively high efficiency. This also limits the impact of environmental conditions on skimmer recovery efficiency.	There are still limitations in high winds and high wave heights.
64	C	50	C.5.2 In situ Burning (Pages 114) A much greater amount of oil would be burned than stated as regular boom and even a current buster could be used to supply oil to the containment area surrounded by the 500 feet of fire boom (Enbridge have a total of 1000’ of fire boom). By continually feeding product to the burning area greater amounts will be burned.	We have updated the simulation to account for the fact that Enbridge would have 1000’ of fire boom available.
65	C	50	C.7 References ROC Users Guide (Pages 119) Reviewing the Recovery System Performance (User’s Guide, p26), a 10-knot wind leads one to predict recovery efficiency of 20 to 25% for Group C (weir skimmers family), 25 to 55% for Group B (paddle belt, fixed and moving submersion plane), and 55 to 85% for Group A (oleophilic devices). This is very conservative for weir devices in particular, and somewhat conservative for oleophilic devices. It would be helpful to know the precise algorithms to confirm the accuracy of these calculations. There are similar problems with the broad conclusions one could infer from Recovery System Performance (User’s Guide, p27), which purports to relate skimmer efficiency with ranges of	ROC is an industry standard simulator for such calculations.

			oil type. For example, Group B skimmers are estimated to have only 65 to 85% efficiency, and Group C devices (i.e., weir skimmers) could be as low as 25%. Again, it would be helpful to know the precise algorithms.	
66	C	52	Assuming that equipment would be ready for deployment and manned with operators within 2 hours (page 20) of the spill is a very big assumption and is likely not realistic.	Information provided by local emergency managers and Enbridge staff.
67	C	53	The draft Risk Analysis report failed to achieve a critical assessment of the inadequacies of the approved Enbridge contingency plan to field trained personnel and equipment within the first 36-hours of a WCS. Due to highly fluctuating current conditions in the Straits and multiple months of unstable ice conditions across the region, containment of a WCS is highly improbable for the majority of any given year. Conventional oil spill containment methods are likely incapable of being utilized due to the high currents, high wind and wave conditions or due to ice coverage. Enbridge's Superior Region Contingency Plan (Version 3) clearly outlined the limitations of use of conventional oil spill containment techniques. The assumption should have been clearly made in the draft Risk Analysis report that containment within the immediate area of the Straits of Mackinac would not be achieved and that these efforts would be required for several hundreds of miles of shoreline affected by the WCS.	Equipment limitations due to weather are described in the report.
68	C	63	Suggest replacing term "Beach" with Shoreline. The majority of shorelines in the straits would not be considered a beach.	Beach has been replaced with shoreline where appropriate in the text.
69	C	63	Section C.2.3.1 On water oil response strategies • The text should expand on examples of physical response efforts in addition to the already provided examples of chemical or biological response.	The text is already focused on physical responses efforts. No changes made to the text.
70	C	63	• In Section C.2.3.1.2, in situ burning is described as requiring approval from the Federal On-Scene Coordinator (FOSC) to be used on the Great Lakes. The FOSC will also need to get approval from the Regional Response Team (RRT) (EPA Region 5), which	The text has been modified to clarify the need for approval for in-situ burning.

			held a workshop in Mackinaw City, MI, in August of 2017 on the potential use of this technique in response to a spill in the Straits area. It is not clear how approval for burning oil would be provided (e.g. permit, exemption, EPA waiver, RRT, Governor's proclamation of state of disaster or emergency)	
71	C	63	• Michigan air pollution control regulations do not allow open burning of oil without proper evaluation of emissions and issuance of an air permit. Part 55 of NREPA does not give anyone in the DEQ authority to waive the requirements of an air permit. Air Quality Division of MDEQ maintains the position there may need to be a declaration by the Governor to grant approval, unless there is some type of Memorandum of Understanding (MOU) or other agreement between the state and federal agencies pre-approving the activity under specified circumstances.	The text has been modified to clarify the need for approval for in-situ burning.
72	C	63	• The statement in Section C.2.3.2.1. that a "limitation of the large-scale use of sorbent booms is the creation of large amounts of contaminated wastes" is not appropriate. In the high consequence area of the Straits utilizing sorbent booms is a reasonable trade off in that it removes oil/contaminants from the environment and proper contaminated waste handling is an anticipated part of any spill response.	The text has been modified to reflect this comment.
73	C	63	• In Section C.2.4.1 there is a need to define "UCG."	Done. UCG (Unified Coordination Group)
74	C	63	• The last 4 paragraphs in Section C.2.4.4. are not needed and should be deleted.	Most of the text has been deleted.
75	C	63	Section C.3.2 Interview with Mackinac County Emergency Managers • There needs to be a short description of what occurred during the "ATC Incident" to provide necessary context for further discussion. It is not accurate to state that notification occurred within minutes (the Anchor drag took place on April 1 it was reported by ATC at 4:30 April 2). We suggest taking a critical look to determine if all of the information in this section is necessary and/or relevant.	The text has been modified to remove the statement about a 2mn notification time even though this is the information that was provided by the emergency managers. A link is now provided to the ATC website for details on the incident.

76			• The sentence "In the event of a spill in the Straits area, a similar procedure would be used" does not make sense as the ATC incident did involve a spill.	The ATC incident involved a release of a chemical into the straits and is therefore relevant to the emergency procedure to be used in the case of an oil spill.
77			• Reference to space shuttle landing strip is unnecessary. There is no reason to assume that only the National Guard could bring equipment to the local airstrip near the Mackinac Bridge.	Agreed, the statement has been removed.
78			• The reference to the "MICEMS" database should be corrected to read Michigan Critical Incident Management System (MI CIMS). Please include MI CIMS in the list of acronyms.	Done.
79			• It is not clear whether the last four paragraphs Section C.3.2 refer to information gleaned from interviews with Mackinac County Emergency Managers or to information acquired elsewhere.	Words have been added to clarify the source of the information in the last 4 paragraphs of section 3.2.
80	C	63	Section C.3.3 Interview with the US Coast Guard Sector Sault Sainte Marie • The reference to "2mm oil thick" in the third paragraph appears to be a typo. The word "oil" should be removed, as the reference is to the thickness of ice.	The sentence has been rewritten as it refers to the minimum thickness of oil.
81	C	63	Section C.3.4 Interviews with Enbridge Representatives • The second paragraph at bottom states that Enbridge has: "an incident management plan including various documents and guidelines." We suggest adding details about the documents and guidelines or deleting this statement.	The statement has been removed.
82	C	63	Section C.3.4.1 Equipment and recovery rate provided by Enbridge • The first paragraph references "locally available equipment listed above", however the report does not provide a concise list of locally available response equipment.	Section 4.1 and Table C.5 provide a concise list of equipment locally available and used in the calculations. Appendices provide an extensive equipment list.
83	C	63	Section C.4.1 Containment and Recovery on Water • The second paragraph on page 106 discusses how the Response Options Calculator simulates treatment of oil by dispersant application, among other things. It is worth noting that dispersant application may not be authorized for use in the	The ROC simulations included mechanical recovery only. No dispersant application was included in the simulations. The text has been modified to clearly state that dispersant applications were not part of the response measures considered in these simulations.

			Great Lakes, so using this method as part of the calculator's estimate for response time may not be appropriate.	
84	C	63	Section C.5.2 In situ Burning • See above comments on Section C.2.3.1.2 – It is not clear how ISB will be allowed.	As mentioned above the text has been modified.
85	D	37	There are federally recognized Indian Tribes that are not included in the populations at risk. Emmet County is home to the Little Traverse Bay Bands of Odawa Indians and Hannahville Indian Community is located in Menominee County. Based on the fate and transport simulations, both of these Tribes could be impacted by an oil spill in the Straits of Mackinac. (p. 126)	The text has been modified to recognize these tribes
86	D	37	McLaren Northern Michigan has a campus in Cheboygan, which is located directly in the affected region on the southern side of the Mackinac Bridge. (p. 128)	The Cheboygan campus does not have emergency room facilities; the facilities listed in the report are those with 24/7 emergency facilities that could handle acute health problems.
87	D	37	Michigan Water Quality Criteria should be used rather than Oregon Water Quality Criteria or provide an explanation of why Michigan's criteria is not being used. (p. 131)	Corrected in chapter
88	D	37	Table D2. is missing the carcinogenic classification for both Carbon monoxide and Carbon dioxide. (p.132)	The International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP), and EPA have not classified carbon monoxide and carbon dioxide for human carcinogenicity (ATSDR, 2009). The EPA has designated carbon monoxide as a hazardous air pollutant (HAP) under the Clean Air Act (CAA) (Agency for Toxic Substances and Disease Registry (ATSDR). 2009. Toxicological Profile for Carbon Monoxide (Draft for Public Comment). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.
89	D	37	It would be helpful to make Table D4 easier for public consumption. I would suggest color coding or some way to signify which ones are acceptable/negligible risks versus serious harm.	Color coded to indicate total ILCR and total HQ that represent increased risk to human health
90	D	37	Emmet County has only one "t." (p. 157)	Corrected
91	D	37	Make clear that the use of dispersants or other oil emulsifiers is not pre-approved anywhere in the Great Lakes. (p. 161)	Clean up activities and methods are discussed in Task C

92	D	42	The Risk Analysis acknowledges that "mental health issues are a significant concern after disasters such as a potential oil spill at the Straits of Mackinac."33 This finding is consistent with mental health studies conducted after the DWH spill which found individuals experienced symptoms such as mistrust, anger, anxiety, as well as acute stress with symptoms of posttraumatic stress disorder.34 These symptoms demonstrate that adverse mental health impacts a WCS Line 5 spill could cause. Additionally, tribal members have significant and sacred connections with the water, natural resources, and wildlife that would be directly impacted by a WCS Line 5 spill. The Risk Analysis indicates that "restrictions of access to cultural heritage sites, recourse allocation, and equitable compensation issues may include legal proceedings, and these could potentially lead to post-traumatic chronic stress disorder."35 As significant as the effects to mental health on residents and tribal members, the Risk Analysis fails to discuss the potential costs of long-term mental health counseling, therapy, and other services that needed to prevent or treat the mental health symptoms caused by a WCS Line 5 spill.	A quantitative analysis of the health impact was conducted for physical health only. Mental health impacts were addressed qualitatively, therefore costs cannot be calculated.
93	D	42	However, the Risk Analysis fails to evaluate the risks to the public drinking water supply on Mackinac Island as well as the emergency response plan that would have to be implemented to ensure Mackinac Island residents and visitors have adequate drinking water supplies following a WCS Line 5 spill.	The impact to possible residential areas that may be affected was assessed, adequacy of drinking water should be referred to broader impact group or restoration
94	D	42	Despite the significant risks laid out in the Risk Analysis, the report concludes that the short- and long-term risks to public health and safety due to a WCS Line 5 spill are relatively low.39 This conclusion contradicts the Risk Analysis findings concerning the potential effects to resident's mental health and public and private drinking water supplies within the Straits area. The Risk Analysis conclusion to Task D – evaluating risk to public health and safety, must be revised to accurately reflect the Risk	The risk projection from hazards that are quantifiable shows minimal risks, mental health was not quantified, the effect to water supply was also determined to be minimal

			Analysis' findings concerning mental health impacts and drinking water contamination.	
95	D	44	Under Task D, the public health and safety impacts were assessed predicting an increased risk in cancer to permanent residents. However, the costs of healthcare to permanent residents, clean-up workers, seasonal residents, and tourists exposed to the oil and its fate chemicals (VOCs and PAHs) were not assessed nor included in this study.	The impact of a worst-case spill was analyzed using a deterministic human health risk assessment (HHRA), not an epidemiologic study. An HHRA indicates whether there is an increased risk of non cancerous and cancerous adverse events, but does not assess the specific type of health effect within these broad groups (e.g. type of cancer, type of non-cancerous effect), which would be needed to estimate health care costs.
96	D	50	Appendix D3.7.1 Considering the worst-case scenario (Page 46) The release base frequency considered in the Individual Risk calculation does not match with the scenario, which is the worst case discharge (WCD). The report uses the pipeline average release frequency, which includes all sizes of releases from very small leaks to large rupture and interprets this frequency as WCD. This assumption skews the average to a higher magnitude and derives higher individual risks for the concerned locations. For HVL products, explosion occurs due to the delayed ignition of the cloud. The event tree did not take consideration of this event in calculating outcome event probabilities. The calculation assumes that the probability of traveling or dispersion of the release product to the populated area is 100%, which is not realistic since it is highly dependent on metrological conditions, such as wind speed/direction and water flow direction. An underwater release should not be modelled the same as a release from exposed pipe on land. This overstates the entire individual risk calculation. As the temperature underwater is less than atmospheric temperature, an underwater release takes longer to transform the released product into gas.	The individual risk calculation considered the highest possible release frequency, not a summation of all possible cases The event tree considered the ignition potential and the delayed ignition was incorporated into the event probability assumption, if the igntion is instantaneous then the vapor will burn immediately without considerable dispersal, our analysis considered the delayed ignition effects The analysis considered a worst case metrological wind stability class F, which is the worst-case wind regime used commonly for predictive analysis as such, and following the guidance of the US EPA worst-case analysis Our analysis modeled the release from the surface in open air dispersal
97	D	53	The draft Risk Analysis report does not differentiate between the toxicity of the variety of products that can be shipped through Line 5. Hence, the Risk Analysis fails to consider the	The toxicological profile of the substances with potential human health effects were considered and based on the quantities present in the mixture, the most consequencial

			worst possible ecological and human health impacts with this massive oversight.	toxicants that could result to a case of adverse health outcome were analyzed extensively
98	D	63	Section D.2.5 discusses contaminants of potential concern and a reference to a water quality criterion for the State of Oregon is used. Michigan Water Quality standards are more relevant. If a discussion of the Oregon criteria remains in the report, there should be an explanation of their relevance to the State of Michigan and the Great Lakes. o Michigan Water Quality Standards (Part 4 Rules) are available at: https://www.michigan.gov/deq/0,4561,7-135-3313_3681_3686_3728-350340--,00.html	Michigan criteria have been incorporated.
99	E	37	Michigan's Water Quality Standards should be used, if possible. If not, a justification should be provided explaining why not. (p. 183)	Michigan Water Quality Standards (WQS) list many specific compounds but do not quantify levels of non-specific hydrocarbon contamination. The Alaska Water Quality Standard (WQS) gives a limit for hydrocarons that aligns with the Michigan Rule 57 that states "Toxic substances shall not be present in the surface waters of the state at levels that are or may become injurious to the public health, safety, or welfare, plant and animal life, or the designated uses of the waters." Additionally, among the states, Alaska has the most direct and longest-term experience with spills of crude oil; hence the experience and data necessary to define a critical WQS. Further, they provide the WQS in terms of both Total Aqueous Hydrocarbons (TAqH) and Total Aromatic Hydrocarbons (TAH) that are allowed. Finally, this is the standard used in many of the references consulted. A statement was added to clarify the Michigan rules.
100	E	37	According to the Great Lakes Coastal Wetland Consortium, Michigan has approximately 275,748 acres of coastal wetlands. This does not represent 73% of all coastal wetlands in the Great Lakes. (p. 194)	There are 202,343 hectares or 500,000 acres of Coastal Wetlands in the Great Lakes Basin (EPA, MIDEQ). Of that amount 70% or 365,000 acres are located in US (Bourgeau-Chavez et al. 2008). In Michigan, the Great Lakes Coastal Wetland Consortium cites ~275,748 acres of the 350,000 are located in Michigan. Therefore ~75-80% of US Great Lakes coastal wetlands are located in Michigan. The text has been

				modified to clarify and reflect coastal wetland distribution in Michigan.
101	E	37	In the listing of rare or endangered species located within the coastal dunes, the “t” in Lake Huron tansy and the “g” in Houghton’s goldenrod do not need to be capitalized. (p. 194)	Capitalization was corrected in text.
102	E	37	Third full sentence, there is a typo with the word “observed.” (p. 197)	Spelling of observed was corrected in text.
103	E	37	Dreissenids would include zebra and quagga mussels, not brown mussels. (p. 198)	Dreissenids do not include brown mussels and was removed from text.
104	E	53	The draft Risk Analysis report does not differentiate between the toxicity of the variety of products that can be shipped through Line 5. Hence, the Risk Analysis fails to consider the worst possible ecological and human health impacts with this massive oversight.	In our analysis we focused on the most toxic compounds, i.e., PAHs, that we knew about and was shared with us. Our ecological analysis examined both the short-term and long-term impacts to plants and animals considering the toxicity of the oil. We examined the more immediate effects of exposure to the bulk oil following a Line 5 leak, which will kills organisms that are directly exposed by physical smothering and exposure to the many toxic volatile compounds in the oil. We also examined the longer term impacts to organisms residing in the sediments and along the shoreline in different habitats expected to be exposed to the oil, including specifically due to exposure of toxic PAHs, given different models of the amount of oil spilled using state-of the-art models developed for a Line 5 oil spill and Great Lakes weather conditions. Our analysis showed that NOAA metrics for shoreline clean-up and remediation were exceeded and that biological metrics, TEC and PEC, that used a low and high estimate of PAH exposure, were exceeded in many instances, signifying significant toxicity to organisms and need for cleanup to protect and preserve the ecosystem. No changes to the report were made in the text.
105	E	63	• General comment: the overall feel of the section is that it was authored by multiple authors with varying degrees of attention to detail and sentence structure/grammar.	We have attempted to provide a common voice in the revision.

106	E	63	In E3.1 reference is made to an Alaska water quality standard. Again, Michigan water quality standards are more relevant. If a discussion of the Alaska standard is retained in the report, there should be an explanation of its relevance to Michigan and the Great Lakes.	The Alaska Water Quality Standard (WQS) was chosen because it is the most stringent standard of all the states and such a stringent standard seemed relevant due to the extreme importance of the Great Lakes among all fresh water bodies. Additionally, among the states, Alaska has the most direct and longest-term experience with spills of crude oil; hence the experience and data necessary to define a critical WQS. Further, they provide the WQS in terms of both Total Aqueous Hydrocarbons (TAqH) and Total Aromatic Hydrocarbons (TAH) that are allowed. Finally, this is the standard that was being used in many of the references we located and used for our portion of the report. No changes to the report text were made.
107	E	63	Table E.4. Michigan's natural communities at risk following a rupture in the Line 5 pipeline in the Mackinac Straits • The word "birds" should be inserted after "migratory" in the section describing the importance of Limestone Bedrock Lakeshore. See https://mnfi.anr.msu.edu/communities/community.cfm?id=10717 "Limestone bedrock lakeshore provides stopover and feeding corridors for migratory songbirds, including many warbler species." In addition to "songbirds", shorebirds, raptors and other types of birds use this area.	Text has been amended as suggested by the reviewer.
108	E	63	• Page 190, paragraph 1- MNFI natural community classification recognizes 76 rare and natural communities native to Michigan (remove the word "rare". Not all of the 76 communities are considered rare). In addition, there are other plant communities that are NOT recognized by MNFI because they are not considered "Natural"; for example, Aspen stands.	Text has been amended as suggested by the reviewer.

109	E	63	"These habitats have been designated critical by MNFI…." Only S1 habitats are considered "Critically imperiled"; the other ranks don't use the word critical in their definition and the examples given are all S2 and S3 communities. Wording could be changed to say, "critically imperiled, imperiled, and rare".	Text has been amended as suggested by the reviewer.
110	E	63	• Page 191- examples of conservation areas of greatest risk should include DEQ Environmental Areas, DNR Ecological Reference Areas, and non-profit coastal reserves.	Text has been amended as suggested by the reviewer.
111	E	63	• Coastal Wetlands and Dunes page 194, paragraph 2- regarding wetland monocultures this data set is from 2008 and significant time and money has been spent over the past decade reducing the amount of European Phragmites on the landscape which is not reflected in the Bourgeau-Chavez et al., dataset. Although in principle diverse wetland complexes are better than monocultures, some rare species seek out Typha and Schoenoplectus dominated systems such as Black Tern, Least Bittern, Marsh Wren, etc.	Text has been amended as suggested by the reviewer.
112	E	63	First bullet under freshwater dunes discusses the piping plover, which should state that it is referring to the Great Lakes population (the Great Plains and Atlantic Coast population are not endangered).	Text has been amended as suggested by the reviewer.
113	E	63	o For the listed plants; both Houghton's Goldenrod and Pitcher's Thistle have the same distribution (Houghton's Goldenrod is a bit narrower) and are considered Great Lakes Endemic species. Pitcher's Thistle is found throughout the Great Lakes region.	Text has been amended as suggested by the reviewer.
114	E	63	Section E.3.3.2 "s" is missing from impacts.	Text has been amended as suggested by the reviewer.

115	E	63	• Submerged Aquatic Vegetation- “ecosystem important services” should read “important ecosystem services”	Text has been amended as suggested by the reviewer.
116	E	63	• Page 197- first full sentence- “The” should be “They”.	Text has been amended as suggested by the reviewer.
117	E	63	• Page 198- Mollusks. There is no mention of rare and listed mussel species in this section, otherwise the invertebrate’s section is thorough.	Text has been amended as suggested by the reviewer. - With 125 species of bivalves occurring in the Laurentian Great Lakes (GLERL, 2018), mollusks play a vital role in the ecosystem, including the state-listed endangered Black Sandshell and Eastern Pondmussel, threatened Slippershell, and species of special concern, Elktoe and Rainbow (MNFI, 2018).
118	E	63	• On page 196-197, Crustaceans, Annelids, and Ciliophora, etc. should be given their own headings instead of being imbedded in the description of Mollusks.	Text has been amended as suggested by the reviewer.
119	E	63	• Please clarify that the references to response of annelids and polychaetes to oil spills on page 197 are from spills in salt water; thus, leaving even greater uncertainty as to whether annelids and polychaetes are capable of biodegrading oil spilled in freshwater.	Text has been amended as suggested by the reviewer.
120	E	63	• The second paragraph reads “Those species with status under Endangered Species Act (ESA) include Burbot, Coho, Chinook, Rainbow Trout and the Long-Nose Sucker (Table E6).” While these species may have status under the ESA in other states, they do not have status in Michigan. See https://mnfi.anr.msu.edu/data/specialanimals.cfm#grp15.	Text has been amended as suggested by the reviewer.
121	E	63	• The second paragraph refers to “Important fish spawning habitat in the Straits have been identified for other species, including Alewife, Rainbow Smelt, and Walleye (Table E6).” Note that the Straits area also holds important spawning habitat for Lake Trout, See https://www.glahf.org/explorer/.	Text has been amended as suggested by the reviewer.

122	E	63	• Table E6. Fish species in Lakes Michigan and Huron that are most vulnerable to oil exposure following rupture of the Line 5 pipeline in the Mackinac Straits o What does Commercial Value for Fisheries mean as related to the Straits? Not all species marked with an X under the "Fisheries" column are considered commercial species by the State of Michigan.	Text has been amended as suggested by the reviewer based on economically valuable commercial fishery in the Great Lakes (NOAA 2016). Listed commercially important spp: lake whitefish, lake trout, channel catfish, carp, white bass, chinook salmon, walleye, yellow perch, brown bullhead, rainbow smelt, round whitefish, coho salmon, rockbass, burbot, rainbow trout (steelhead), cisco (lake herring), carp. Not listed commercially important spp: quillback, goldfish, bigmouth buffalo, freshwater drum, suckers, white perch, siscowet (fat trout), chubs, bowfin, crappies (and sunfish, for tribe licensed fishing in Michigan (2015)
123	E	63	o What does Commercial Value for Aquaculture mean as related to the Straits?	Column removed from text.
124	E	63	• Page 209, explain how the properties of bunker C oil relate to oil transported by Line 5.	Text has been amended to describe relevance.
125	E	63	• In the paragraph describing Yellow Perch on page 209, the mention of Walleye, Largemouth Bass, and Northern Pike does not make sense.	Text has been modified to clarify meaning.
126	E	63	• In the paragraph describing Lake Sturgeon on page 209, it should be clarified that they are listed as Threatened under the Endangered Species Act of the State of Michigan (Part 365 of PA 451, 1994 Michigan Natural Resources and Environmental Protection Act).	Text has been amended as suggested by the reviewer.
127	E	63	• The section "Oil Toxicity to Birds" does not clearly relate marine or other regional bird research to birds likely to be found in Michigan.	This text is included to show that the range of oil toxicity effects to birds exposed to oil. Whether the birds use marine or freshwater habitats, they are at risk of toxicity from oil.
128	E	63	• In general, much attention is given to federally listed threatened and endangered species, while State listed T&E species aren't mentioned in the text (though they are acknowledged in the table).	Both federal and state listed birds are at risk of oil impacts following a rupture in Line 5. For brevity and we included available literature information for oil toxicity and vulnerable

				species in the area. Reviewing each species that are listed in addition to the listings in the Table was deemed redundant.
129	E	63	• Page 221- the piping plover section probably should have been the last paragraph in this section as it interrupts the flow of the discussion and other species could have been mentioned as well. Piping plover is an important coastal species, mentioning others as examples (colonial nesting water birds such as Common Tern) would strengthen the discussion.	Text has been amended as suggested by the reviewer.
130	E	63	• Page 222- Timing of Waterbird Migration- “For example, the breeding piping plover arrives on its breeding territories”. Remove the first “breeding” as it is redundant, and some of the piping plover that return aren’t breeding.	Text has been amended as suggested by the reviewer.
131	E	63	• Page 222- these species are also of cultural importance to Native Americans.	Text has been amended as suggested by the reviewer.
132	E	63	• MNFI “Biotic” data should read “Biotics.”	Text has been amended as suggested by the reviewer.
133	E	63	The phrase “impacts from chronic exposure to oil were also seen” is the first mention of impacts to chronic exposure to oil so the word “also” doesn’t fit.	Text has been amended as suggested by the reviewer.
134	E	63	Section E.3.4 Overall Ecosystem Impacts • There isn’t any mention about the impacts to rare plant species and rare natural communities.	Text has been added to address reviewer's suggestion - Distribution along shoreline areas would also place > 50,000 acres of natural communities including Great Lakes Marsh, Open Dunes and Wooded Dune and Swale Complex areas at greatest risk
135	E	63	Section E.3.5 Summary • This section does not address secondary resource impacts caused by response efforts such as vegetation removal, wetland disturbance, increased boat and pedestrian traffic, disturbance or destruction of habitat, or potential introduction of invasive species. The sentence just before the summary reads “It is, therefore, possible that the extent of risk on natural resources	Impacts arising from restoration activities were not included in this analysis, as speculation toward approaches to restoration and their effects on natural resources were outside the scope of this analysis. We do agree that restoration activities will impart some negative impact on natural resources given the proposed methods by Task F. However the extent of restoration, should a rupture occur in

			could be reduced given clean-up activities and time of year of an event."	Line 5 is dependent on the spill dispersion and consultation with State and Federal agencies toward restoration response. Text has been added in reference to secondary impacts. - Secondary resource impacts caused by response efforts such as vegetation removal, wetland disturbance, increased boat and pedestrian traffic, disturbance or destruction of habitat, or potential introduction of invasive species following a rupture in Line 5 may initially increase risk to natural resources. These secondary resource impacts and measure for restoration proposed by Task F were not evaluted as part of our assessment, as our considerations of worst-case scenario include the greatest extent of risk and response activities require consultation with state and federal authorities prior to implementation. However, given the ecological, cultural and economic value of natural resources in the Mackinac Straits and associated areas, these secondary impacts will need to be considered in response efforts.
136	F	37	It would be helpful to explain the Natural Resource Damage Assessment (NDRA) process as part of the Introduction as well as defining "trustee" under NRDA. (p. 236)	A section was added in the first paragraph of the introduction which outlines the NRDA process and tries to define what trustee is.
137	F	37	It should be noted that restoring wetlands does not produce the same functions and values as the original, natural wetland. Despite our best attempts, we cannot create nature better than nature itself. (p. 245)	A few sentences were added in the limitations section of wetlands to discuss the potential limitations of restoration of natural wetlands and potential for limited recovery of all functions depending on the extent of injury.
138	F	37	The approach for restoring wetlands is missing information regarding how to properly address threatened and endangered species. (p. 245)	All restoration activities including those conducted specifically in wetland habitats will include safegurards for all natural resources, specifically endangered and threatened species. Prior to implementation of any restoration alternatives, additional layers of consultation with appropriate state and/or federal authorities with be undertaken. Species-specific

				safeguards were not included in Task F as determining appropriate restoration alternatives will be dependent on oil spill event.
139	F	37	Under Macrobenthos, “straits” should be capitalized. (p. 253)	Change has been made
140	F	44	Under Task F, only the primary costs (return injured resource and services to baseline) were assessed. The compensatory costs (reimburse the public for losses) were not included. Although nearly certain and predicted to be quite high, the costs of litigation and liability were not included in this study.	Text has been added to clarify the costs of litigation and liability would be in excess of the estimated costs
141	F	52	Costs were based on the Line 6B spill (page 26), a very different environment than the Straits and shoreline and islands of the area. Much of the shoreline in the area of the Straits is rocky with heavy currents and potentially high wave action. The report suggests around 450 (plus or minus) miles of shoreline could be impacted. The report contemplates removing oily beach materials and replacing with like materials. The cost estimate of $500 million (presented in the report for a spill of this nature, page 31) is low considering the complexity of the environment and potential weather conditions. The amount of equipment that would need to be mobilized, materials, labor costs, disposal costs, restoration of the shoreline with like materials, and rehab/disposal of dead wildlife for a major spill is likely understated. Considering that the cost of constructing a two-lane highway is approximately $3,000,000 per mile, it would appear that remediation costs for an oil spill consisting of 58,000 bbl (2,436,000 gallons) spoiling 450 plus miles of shoreline in the Straits area, would exceed those presented in the document.	In the Task F section, we chose to present a potential range of costs associated with restoration. This range was based on the Deepwater Horizon and Line 6B spills. We agree that there is potential for the restoration costs to be above the $500 million number and the range of costs presented account for potential increase in the costs depending on the severity of the spill and locations impacted.
142	F	53	Baseline biological conditions have not been adequately addressed in the draft Risk Analysis report. Little to no effort is expended to identify how clean-up goals will be determined and how metrics will be collected to assess progress towards remediation. What is an acceptable recovery rate (30%, 40%, 50%, etc.)? What programs will be necessary to restore	The definition of clean-up goals and the collection of metrics is undertaken as part of the NRDA/DARP process. Thus, fleshing out these details is part of the legal process following an oil spill and is the responsibility of the stakeholders. Task F provides an overview of primary restoration strategies that have been utilized in previous oil spills and would undoubtedly be part of the DARP developed in the event of a spill in the

			debilitated populations of fish and wildlife, along with landscapes and flora?	Straits of Mackinaw. The goal of primary restoration is the return to conditions prior to the spill, or the baseline. It would behoove the State of Michigan to determine which parameters are appropriate to monitor and to establish the baseline condition now, as a step towards preparation for a spill. Additional language to that effect is now included in F.4 Discussion.
143	F	63	• This section does not address measures to mitigate affected natural resources, including the availability, effectiveness, and costs of potential mitigation measures. The authors appear to erroneously assume that compensatory restoration costs under Natural Resource Damage Assessment authorities or mitigation costs cannot be estimated.	The text of this section has been modified to address this comment and we have tried to more accurately discuss compensatory restoration and have added text in both the introduction and in the discussion of cost to try to take into account compensatory restoration throughout the report.
144	F	63	F.1 Introduction • In the first sentence, "Damage Assessment and Restoration Plan" and "DARP" should be deleted.	This has been removed
145	F	63	• The first paragraph states that "scientists" believe … please provide a reference to this as it suggests that "all scientists" believe…	A reference was added and the statement was changed to some scientists …
146	F	63	• Figure F1- Articulating Cultural and Natural Resources Laws in the US. The figure caption should have the word "Federal" placed within. In Paragraph 1, all the laws mentioned are Federal laws, any relevant state laws and policies should be included.	Federal was added to this figure legend and text added throughout
147	F	63	• The second paragraph includes a statement that compensatory restoration "cannot be determined until the losses have been inventoried and full recovery has occurred." This needs additional explanation or clarification as it is not true that full recovery must have occurred for trustee agencies to estimate losses over time and make a claim for compensatory restoration.	This is a very good point. We have removed this statement and have tried to more clearly discuss compensatory restoration in the report and ways in which compensatory restoration can occur simulatenously with primary restroation.

148	F	63	• The second paragraph includes a sentence that says, "We will discuss injuries to examples of resources that may require both primary and compensatory restoration, but the latter costs cannot be included." This needs additional explanation or clarification as we understand relevant examples of compensatory restoration and associated costs do indeed exist.	We have removed this statement and made changes to the discussion to more accurately reflect and include compensatory restoration into the discussion of cost estimates.
149	F	63	• The paragraph on page 236 about primary restoration mischaracterizes the cleanup work that was conducted after the first year as primary restoration. Most of the work described was still cleanup work being conducted pursuant to orders from the U.S. EPA using their response authorities. The boundary between cleanup and primary restoration is more a legal one than a practical one. "Cleanup" is conducted under response authorities and "primary restoration" is conducted under NRDA authorities. Practically speaking, a cleanup operation may accomplish all the goals that the trustee agencies would seek under their authorities to make claims for primary restoration. In the case of the Enbridge Line 6B oil discharges, significant work to restore habitats impacted by the oil and the response activities was required by the U.S. EPA and MDEQ under their response authorities. The definition of "primary restoration" used throughout Task F seems to be confusing long-term cleanup actions with primary restoration under NRDA. This should be clarified.	Added a statement that corrected the previous statement and clarified the difference between clean up and restoration. We have sought to clarify this differences throught the report. Also, many of the appraoches that were discussed have been used as part of NRDA acctions in previous spills. We have thus tried to clarify this in the introduction.
150	F	63	F.2.1. Definition of Worst-case Scenario • The last sentence of the first paragraph ends with "the restoration of baseline and that timeline cannot be simulated", but NRDA trustee agencies routinely estimate trajectories for return to baseline and calculate the lost levels of ecological services over acres and years (see	We appreciate this comment. A more detailed discussion of equivalency analysis has been included in the introduction.

			https://darrp.noaa.gov/economics/habitat-equivalency-analysis).	
151	F	63	F.3 Analysis • In the first paragraph, the statement "yet, it could be claimed that the natural resources damaged in the case of Deepwater Horizon were of greater significance than those in the case of Line 6B spill in Marshall MI." should be deleted.	This sentence was deleted.
152	F	63	Table F1. Oil Spill Comparison • While use of the term "Primarily wetland" for types of shoreline impacted because of the Enbridge Line 6B spill is correct, given that the impacted area was primarily floodplain, it does not account for the wooded floodplain, emergent marshes, rare fen, areas of submerged and floating vegetation, and riverine riffles and pools that were also impacted.	We have added more of these habitat types to the table to more accurately reflect the types of environments impacted by the Line 6B spill
153	F	63	Section F.3.1.1 Wetlands • Under limitations or plantings; care must also be taken not to introduce non-native invasive species.	A statement was added to the limations section to this effect.
154	F	63	Section F.3.1.1.2 Approach for restoration- Sediment Removal • In addition to limited manual cleanup, another alternative to addressing oil in sensitive wetland habitats is to monitor for natural recovery and not employ direct intervention.	We have added text to include this point
155	F	63	Section F.3.1.4.1 • Page 251"Habits" should be "habitats" "13 unique terrestrial communities- the examples include coastal fens and Great Lakes marshes and gravel cobble shoreline which are not considered terrestrial but are palustrine communities.	Habits was changed to habitats and terrestrial was removed from this sentence.
156	F	63	Section F.3.2.4.1 • Page 255- last sentence refers to endangered reptiles	This change has been made

			and amphibians in the straits. There aren't any species listed as endangered; species of conservation concern or rare would cover it though.	
157	F	63	Section F.3.2.6 Birds Page 258 • "Waterbirds such as loons, grebes and cormorants many of which have both high ecological value and Economic value as important game species"- None of the examples are game species so including waterfowl in the list would be important especially as the Straits is a high migratory waterfowl staging area. Many would disagree with the statement that cormorants have high ecological value.	Text has been amended to address reviewer comment.
158	F	63	• Does Migratory bird hunting include woodcock? The report should state that "Migratory waterfowl hunting" or water fowl hunting instead of "migratory bird hunting".	This change has been made
159	F	63	• Page 259 "Sediment removal and replacement will take place in sand environments typically used by these nesting shorebirds". What nesting shorebirds is this referring to?	Examples of shorebird species have been included as suggested by reviewer.
160	F	63	• Page 259 "Restore lost birds by facilitating additional reproduction and/or reduce mortality of injured bird species"." It is unclear how seasonal waterfowl closures will help mitigate loss during oiling; the assumption is that seasonal waterfowl closures refer to closures for waterfowl hunting? Waterfowl hunting is typically considered compensatory mortality instead of additive mortality so further clarification would be helpful.	The reviewer raises a good point. The rationale behind reducing human-bird interactions is most relevant for nesting shorebirds. From this perspective reducing interactions would be expected to reduce stress related to reproduction. Text has been modified to reflect importance of this measure for shorebirds as opposed to waterfowl.
161	F	63	Section F.3.2.6.3 Monitoring • "Observation and collection of bird species will take place…" What does "collection" refer to?	The reviewer raises a good point. We have modified the text from collection to estimation.
162	F	63	• "there are a number of monitoring systems in place to collect the number and distribution of birds in Michigan". Should "Collect" read Estimate?	See previous response

163	F	63	• National Audubon IBAs is not a monitoring system but a designation of important habitat.	The reviewer raises a good point. The text has been modified to reflect the use of MNFI as an absence/presence information source and the removal of IBA.
164	F	63	• MNFI information can be used to report on presence or absence of species but it wouldn't be useful for population monitoring.	The text has been changed to reflect this.
165	F	63	Section F.3.2.7 Terrestrial Mammals • Page 260 "these species are considered of economic importance…" they are also culturally significant species to tribal members.	Text has been amended to address reviewer comment.
166	F	63	• Monitoring- "MI DNR monitors mammal populations through the issuance of trapping permits". The issuance of a fur bearer license cannot be used to monitor mammal populations. The only species listed in this section that requires mandatory registration is river otter, so some information could be gleaned for that species about distribution. There is a trapper harvest survey that asks questions about harvest that could also provide information about distribution, but it would be hard to assess populations from this.	The reviewer raises a really important point and highlights the limited data regarding mammal populations in Michigan. The text has been modified to reflect the limitations to monitoring mammal populations following restoration.
167	F	63	Section F.3.4.2.2. Marshall MI • The reference to $62,000,000 for primary shoreline restoration is incorrect as it included restoration costs beyond what occurred along the shoreline (e.g., wetlands), payments for compensatory restoration projects, mitigation projects, and provisions for agency cost reimbursement among other things. Much of what the report is referring to as primary restoration was instead conducted under cleanup actions that were not part of the monetized value of the compensatory restoration included as the bulk of the $62 million reported in the press releases for the NRDA settlements. Instead of using shoreline restoration as a	The text has been modified to try to address this comment. We have altered our discussion of costs to mention that the $62 million from Line 6B was mainly for compensatory restoration and primary restoration costs were included with cleanup operations. We have now also estimated costs based on Deepwater Horizon to include the compensatory restoration operations as well.

			surrogate for all potential restoration and mitigation measures, it would be more accurate to use the $62 million over 112.6 km as a surrogate for estimating compensatory restoration and mitigation than for primary restoration.	
168	G	26	the Risk Analysis assumes that impacts to Michigan's tourism and recreational economy will last only a year after a WCS Line 5 spill. This assumption is based on a Deepwater Horizon ("DWH") oil spill recreational study. However, the DWH spill and a potential Line 5 spill are significantly different. The DWH spill occurred approximately 41 miles offshore, while a Line 5 spill would occur two miles offshore at most. Moreover, given Line 5's proximity to the shoreline of Lake Michigan and Lake Huron, a release of oil from Line 5 would likely have greater impacts, in terms of both the scope of impacts and their duration. Furthermore, the Risk Analysis assumes that lost amenity values to residential properties will total $2.6 million. This ignores the effects a Line 5 spill would likely have on the coastal properties of both the lower and upper peninsulas, as well as Mackinac and Bois Blanc Island. This underestimate is similar to the Risk Analysis' assumption that the commercial fishing industry will only be impacted for one season, even though the Risk Analysis states that fish stocks may face irrevocable harm and might not fully return to an altered habitat in the Straits area.'	1. Regarding the length of time a spill affects tourism: The risk analysis assumes impacts to Michigan's tourism and recreational economy will last between one and two years depending on the region and the activity. Economic damage assessments of other spills indicate that impacts typically last less than one year, however the duration can be shorter or longer depending upon the activity affected by the spill. With respect to recreation and tourism economic activity, the Deepwater Horizon (DWH) oil spill is an extensively assessed, recent large-scale spill and we use scenarios derived from DWH which found that shoreline visitation had recovered in most areas after one year and recovered in all areas after two years (Tourangeau et al. 2017). Our tourism impact estimates follow this two-year span, where tourism visits declined over two consecutive years in core-impacted counties, but only over one year along periphery regions. Durations observed for other oil spills provide additional evidence that economic damages typically last between a few months and two years. In particular, • The Exxon Valdez oil spill on March 24, 1989, which occurred approximately 2 miles from shore, affected tourism in the region for one year, with normal visitation patterns resuming in 1990 (ARI, 1993). Although biologically the fishery may have experienced damages that lasted several years or longer (Peterson et al., 2003), harvest levels recovered one year after the spill (Cohen, 1995). Cohen, M.J., 1995. Technological disasters and natural resource damage assessment: an evaluation of the Exxon Valdez oil spill. Land Economics, pp.65-82.

• The S.S. Glacier Bay oil spill on July 2, 1987, which occurred approximately a dozen miles off the shore of Alaska, was observed to have no effect on recreational fishing activity in the spill region. Prices for commercial fishing declined due to a record catch in the spill year (ARI, 1993). Advanced Resources International (ARI). 1993. Economic Impacts of Oil Spills: Spill Unit Costs for Tankers, Pipelines, Refineries, and Offshore Facilities. Report prepared for U.S. Department of Energy. Available at < https://www.osti.gov/servlets/purl/10186611>.

• The Ixtoc I oil spill on June 3, 1979, and the Burmah Agate oil spill on November 1, 1979, were found to have decreased tourism activity in Texas in "the seasons during which the spills occurred" (Restreppo et al., 1980), implying that economic damages lasted one tourism season. The Ixtoc I spill occurred in the Bay of Campeche and oil drifted into U.S. waters, and the Burmah Agate spill occurred in Galveston Bay.

• The Amoco Cadiz oil spill on March 16, 1978, which occurred approximately three miles off the coast of Brittany, France, affected economic activity for one year or less. One report found "[w]ithin 2 months, most fishermen had returned to their boats and, in fact, fishing effort in 1978 was not significantly lower than normal" (Grigalunas et al., 1986).

• Other spills reported at NOAA's DARRP website (https://darrp.noaa.gov/explore-projects?oilSpill) show patterns and timelines of recreational impacts that rarely last more than a year, including the following spills: Cosco Busan (up to 8 months for beach uses; 3 months for fishing; one month for boating); Enbridge Pipeline (losses lasting up to two years with large losses in year one); Athos (losses for less than a year with higher losses in core area and lower losses in periphery).

2. Regarding the scope of spill scenarios: The extent of beach

	oiling was modeled based on water flows across the Great Lakes system, and account for various weather patterns that may impact those flows. Drawing from multiple scenarios, the GI team selected three worse-outcome simulations as the basis for estimates. 3. Regarding lost amenity values to residential properties: To asses property losses we use data on housing stocks and values for all relevant coastal areas of Michigan and Wisconsin, including islands. We use U.S. Census data covering the entire state of Michigan (including its various islands) and parcel-level housing data from the State of Wisconsin to calculate the value of affected homes. This data is exhaustive. We only count homes/properties within 1 mile of affected shoreline, consistent with the extent of losses in the literature. Our data show 9,500–12,300 affected properties, depending on the scenario, with a total estimated fair market value of \$2.6–2.8 billion (note this is a total value and not the loss in value). These properties form the basis of the analysis presented in the risk assessment. We have added detail to the text making this clear. Peer-reviewed economic studies (cited in the analysis) find that property values recover quickly after a spill. There is some evidence of “stigma” effects for some non-oil spill environmental harms in which property values do not fully recover. However, there is no estimate of these stigma effects for oil spills, so we do not explicitly include them here. However, we did update our assumptions regarding both the magnitude of losses to property values after a spill and the duration of these losses based on additional peer-reviewed studies we found. The final draft of the report also provides additional detail about the procedure we used to calculate the loss to residential properties for clarification.

	4. Regarding fish stocks: The weight of evidence indicates that damages to commercial fishing will accrue in the first year of the spill. We recognize that the Exxon Valdez oil spill affected the biology of Alaskan fisheries for several years or decades (Peterson et al., 2003), however harvest levels recovered one year after the spill (Cohen, 1995). The one-year duration of damages is supported by additional research on the Exxon Valdez oil spill (ARI, 1993) and other spills (Grigalunas et al., 1986). The Braer oil spill on January 5, 1993, damaged Shetland fisheries, but particularly the caged salmon and shellfish fisheries, neither of which resemble the Great Lakes fishery; nevertheless, it has since been concluded that "all other environmental impacts of the Braer oil spill can be shown as having had no impact after 1994" (Ritchie, 2001); and most economic effects are due to Shetland's fisheries prominent position in the U.K. food market (Goodlad, 1996), which again does not resemble the Great Lakes fishery. However, there is evidence that Gulf pelagic fishery harvests may have been damaged due to the DWH oil spill for up to two years, and have updated our assumptions regarding both the magnitude and duration of losses based on this particular instance. Although these pelagic fisheries are not directly comparable to Great Lakes fisheries, they did suffer larger losses than other fisheries types affected by DWH. We now use these larger loss scenarios as a worst case, which should also cover any long term losses due to the ecological losses mentioned, but unquantified, by Task F. We have updated the report to assume theser large losses and to allow commercial fishery damages that last for two seasons in the core area. (Goodlad, J., 1996. Effects of the Braer oil spill on the Shetland seafood industry. Science of the Total Environment, 186(1-2), pp.127-133. Peterson, C.H., Rice, S.D., Short, J.W., Esler, D., Bodkin, J.L., Ballachey, B.E. and Irons, D.B., 2003. Long-term

				ecosystem response to the Exxon Valdez oil spill. Science, 302(5653), pp.2082-2086. Ritchie, W. Residual Impacts of the Major “Braer” Oil Spill (In 1993) on the Coastal and Marine Environments of Shetland, UK. Proceedings of the 12th Biennial Coastal Zone Conference.)
169	G	37	It is unwise to rely on the Dynamic Risk Report. That report was highly criticized by all stakeholders because it was riddled with flawed methodologies and assumptions, had extensive data gaps, and ultimately failed to meet the scope and statement of work. (p. 310)	For our section on energy impacts, we reviewed the Dynamic Risk report and we utilize some of that report's data and results. A qualitative assessment of energy markets and potential responses is provided in the appendix. The Dynamic Risk report and some of the numbers used in the report are also used for anlaysis by the Michigan Agency for Energy (MAE) for economic effects, and is therefore deemed reliable by the team.
170	G	37	According to the report “Economic Impacts of Maritime Shipping in the Great Lakes – St. Lawrence Region,” released July 2018, cargo moved on the Great Lakes-St. Lawrence Seaway System totaled 143.5 million metric tons (158.3 million short tons) valued at $15.2 billion. This commerce supported 237,868 jobs and $35 billion in economic activity. (p. 307)	The authors are familiar with this report and agree that the Saint Lawrence Seaway is a vital link in the regional economies. However, the total value of the economic activity related to shipping does not tell how economic value changes if there is a spill. Because the U.S. Coast Guard, through testimony, would anticipate a temporary disruption in Great Lakes navigation, we expect transportation costs will be borne by shippers through lost productivity, rather than along the production value chains. That is, production interruptions will be mitigated through operating with existing inventories, alternative transportation routes or other means to absorb these short shipment delays. Though some producer costs may be experienced due to delays, the estimates provided in the report represent the largest component of costs to shipping and are based on the lost shipping costs of idled freighters and tugs. Moreover, evidence from other spills shows that vessels are sometimes permitted to pass through spill areas to mitigate economic losses so we do not anticipate long term closure for commercial shipping.
171	G	37	Line 5 is 645 miles and transports synthetic crude, in addition to light crude. (p 308)	Section GI 4.8 now mentions that Line 5 transports synthetic crude.

172	G	37	The team should review and amend the section Effects on Michigan's Energy Supply, as appropriate, based upon a recent report "Assessment of alternative methods of supplying propane to Michigan in the absence of Line 5," prepared by London Economics International LLC. (p. 308)	The Team reviewed that report. However, the Dynamic Risk report and some of the numbers used in the report are also used for anlaysis by the Michigan Agency for Energy (MAE) for economic effects, and is therefore deemed reliable by the team. For our section on energy impacts, we reviewed the Dynamic Risk report and we utilize some of that report's data and results. A qualitative assessment of energy markets and potential responses is provided in the appendix.
173	G	42	Even though the Risk Analysis arrives at an adequate "worst-case-scenario" ("WCS"), underlying assumptions should be carefully reviewed for the final report as they relate to the conclusions about the ecological impacts (Task E), economic impacts (Task G), and broader impacts (Task X) from a worst-case scenario Line 5 spill in the Straits of Mackinac and extending across Lake Huron and Lake Michigan. For example, the Risk Analysis assumes only one year of impacts for decreased tourism expenditures. Similarly, the Risk Analysis takes a very conservative approach to commercial fishing and estimates one year of impacts of $0.5 to $1.6 million. In contrast, Dr. Richardson's Economic Impact Report estimates that commercial fishing will face a $61 million-dollar impact.	1. Regarding the timeline of impacts, see response 1 above (row 168). 2. Regarding the fishery impacts, see response 4 above (row 168), and note that we have updated our impact scenario for commercial fisheries. In addition, note that the Risk Analysis damage estimates do not include economic multipliers, as conventionally used in economic impact analysis, because economic impact analysis measures changes in spending in an economy and the ripple effects on economic activity due to these changes in spending. As noted in the updated text of the report, these measures of total economic activity and impact do not measure reductions in economic value and therefore do not constitute economic damages. Further, we cannot fully explain the differences between the damage estimates in the Risk Analysis report and the estimates in Dr. Richardson's Economic Impact Report because the latter does not provide the information needed for replication. Michigan's Great Lakes fishery had landings valued at $8 million in 2016, with Lake Michigan and Lake Huron contributing $1 million and $4.8 million, respectively (NMFS). all of Lake Michigan and Lake Huron commercial fisheries would have to be closed, including in at least some Wisconsin and Canadian ports, for an entire year, for direct damages to harvesters to exceed $5.8 million per year in

				losses. We are not aware of an oil spill that has affected a water system to such an extent.
174	G	42	The Risk Analysis assumes that the impact to the Michigan's recreational and tourism economy will only last one (1) year from a WCS Line 5 spill in the Straits.13 This includes impacts to: the number of day-trips to state and national parks, the number of overnight camping trips, and the economic benefits from recreational boating and fishing. The Risk Analysis bases this assumption of a short-term economic impact on a recreation assessment for the Deepwater Horizon ("DWH") oil spill.14 The recreational assessment for the DWH spill found the number of shoreline visitations had recovered in most areas after one year and recovered in all areas after two years.15 However, the Risk Analysis does not recognize that the DWH spill and a Line 5 spill are drastically different scenarios. Mainly, that the DWH spill occurred roughly 41 miles off the coast of Louisiana, while a potential Line 5 spill would occur approximately two miles offshore at most.16 This proximity to the shoreline and coastal communities drastically amplifies the immediate and long-term impacts that a WCS Line 5 spill would likely cause to the recreational and tourism economies of northern Michigan. Moreover, the Risk Analysis does not provide definitions of what constitutes a determination that the recreational economy is no longer affected, and a lack information regarding how long the loss in economic multiplier effect would last.	1. Regarding the length of time a spill affects tourism: The risk analysis assumes impacts to Michigan's tourism and recreational economy will last between one and two years depending on the region and the activity. Economic damage assessments of other spills indicate that impacts typically last less than one year, however the duration can be shorter or longer depending upon the activity affected by the spill. With respect to recreation and tourism economic activity, the Deepwater Horizon (DWH) oil spill is an extensively assessed, recent large-scale spill and we use scenarios derived from DWH which found that shoreline visitation had recovered in most areas after one year and recovered in all areas after two years (Tourangeau et al. 2017). Our tourism impact estimates follow this two-year span, where tourism visits declined over two consecutive years in core-impacted counties, but only over one year along periphery regions. Durations observed for other oil spills provide additional evidence that economic damages typically last between a few months and two years. In particular, • The Exxon Valdez oil spill on March 24, 1989, which occurred approximately 2 miles from shore, affected tourism in the region for one year, with normal visitation patterns resuming in 1990 (ARI, 1993). Although biologically the fishery may have experienced damages that lasted several years or longer (Peterson et al., 2003), harvest levels recovered one year after the spill (Cohen, 1995). Cohen, M.J., 1995. Technological disasters and natural resource damage assessment: an evaluation of the Exxon Valdez oil spill. Land Economics, pp.65-82. • The S.S. Glacier Bay oil spill on July 2, 1987, which occurred approximately a dozen miles off the shore of Alaska,

	was observed to have no effect on recreational fishing activity in the spill region. Prices for commercial fishing declined due to a record catch in the spill year (ARI, 1993). Advanced Resources International (ARI). 1993. Economic Impacts of Oil Spills: Spill Unit Costs for Tankers, Pipelines, Refineries, and Offshore Facilities. Report prepared for U.S. Department of Energy. Available at < https://www.osti.gov/servlets/purl/10186611>. • The Ixtoc I oil spill on June 3, 1979, and the Burmah Agate oil spill on November 1, 1979, were found to have decreased tourism activity in Texas in "the seasons during which the spills occurred" (Restreppo et al., 1980), implying that economic damages lasted one tourism season. The Ixtoc I spill occurred in the Bay of Campeche and oil drifted into U.S. waters, and the Burmah Agate spill occurred in Galveston Bay. • The Amoco Cadiz oil spill on March 16, 1978, which occurred approximately three miles off the coast of Brittany, France, affected economic activity for one year or less. One report found "[w]ithin 2 months, most fishermen had returned to their boats and, in fact, fishing effort in 1978 was not significantly lower than normal" (Grigalunas et al., 1986). • Other spills reported at NOAA's DARRP website (https://darrp.noaa.gov/explore-projects?oilSpill) show patterns and timelines of recreational impacts that rarely last more than a year, including the following spills: Cosco Busan (up to 8 months for beach uses; 3 months for fishing; one month for boating); Enbridge Pipeline (losses lasting up to two years with large losses in year one); Athos (losses for less than a year with higher losses in core area and lower losses in periphery). 2. Regarding the scope of spill scenarios: The extent of beach oiling was modeled based on water flows across the Great Lakes system, and account for various weather patterns that

	may impact those flows. Drawing from multiple scenarios, the GI team selected three worse-outcome simulations as the basis for estimates. 3. Regarding lost amenity values to residential properties: To asses property losses we use data on housing stocks and values for all relevant coastal areas of Michigan and Wisconsin, including islands. We use U.S. Census data covering the entire state of Michigan (including its various islands) and parcel-level housing data from the State of Wisconsin to calculate the value of affected homes. This data is exhaustive. We only count homes/properties within 1 mile of affected shoreline, consistent with the extent of losses in the literature. Our data show 9,500–12,300 affected properties, depending on the scenario, with a total estimated fair market value of \$2.6–2.8 billion (note this is a total value and not the loss in value). These properties form the basis of the analysis presented in the risk assessment. We have added detail to the text making this clear. Peer-reviewed economic studies (cited in the analysis) find that property values recover quickly after a spill. There is some evidence of "stigma" effects for some non-oil spill environmental harms in which property values do not fully recover. However, there is no estimate of these stigma effects for oil spills, so we do not explicitly include them here. However, we did update our assumptions regarding both the magnitude of losses to property values after a spill and the duration of these losses based on additional peer-reviewed studies we found. The final draft of the report also provides additional detail about the procedure we used to calculate the loss to residential properties for clarification. 4. Regarding fish stocks: The weight of evidence indicates that

	damages to commercial fishing will accrue in the first year of the spill. We recognize that the Exxon Valdez oil spill affected the biology of Alaskan fisheries for several years or decades (Peterson et al., 2003), however harvest levels recovered one year after the spill (Cohen, 1995). The one-year duration of damages is supported by additional research on the Exxon Valdez oil spill (ARI, 1993) and other spills (Grigalunas et al., 1986). The Braer oil spill on January 5, 1993, damaged Shetland fisheries, but particularly the caged salmon and shellfish fisheries, neither of which resemble the Great Lakes fishery; nevertheless, it has since been concluded that "all other environmental impacts of the Braer oil spill can be shown as having had no impact after 1994" (Ritchie, 2001); and most economic effects are due to Shetland's fisheries prominent position in the U.K. food market (Goodlad, 1996), which again does not resemble the Great Lakes fishery. However, there is evidence that Gulf pelagic fishery harvests may have been damaged due to the DWH oil spill for up to two years, and have updated our assumptions regarding both the magnitude and duration of losses based on this particular instance. Although these pelagic fisheries are not directly comparable to Great Lakes fisheries, they did suffer larger losses than other fisheries types affected by DWH. We now use these larger loss scenarios as a worst case, which should also cover any long term losses due to the ecological losses mentioned, but unquantified, by Task F. We have updated the report to assume theser large losses and to allow commercial fishery damages that last for two seasons in the core area. (Goodlad, J., 1996. Effects of the Braer oil spill on the Shetland seafood industry. Science of the Total Environment, 186(1-2), pp.127-133. Peterson, C.H., Rice, S.D., Short, J.W., Esler, D., Bodkin, J.L., Ballachey, B.E. and Irons, D.B., 2003. Long-term ecosystem response to the Exxon Valdez oil spill. Science, 302(5653), pp.2082-2086. Ritchie, W. Residual Impacts of the

				Major “Braer” Oil Spill (In 1993) on the Coastal and Marine Environments of Shetland, UK. Proceedings of the 12th Biennial Coastal Zone Conference.)
175	G	42	The Risk Analysis’ assumption of a short-term economic impact does not account for any lingering stigma effects that a catastrophic environmental disaster would likely have. The long-term taint and diminution of property values from a release of hazardous substances and water pollution are well documented.17 The Risk Analysis’ assumption that the reduction in the value of lakefront properties would only amount to $2.6 million is an underestimate of the effects an environmental catastrophe would have on the residential housing market. Furthermore, a WCS Line 5 spill would significantly influence the general public’s perception about the quality of recreational activities available in Michigan, such as boating, swimming, and fishing. The Risk Analysis fails to address how a Line 5 spill would affect the “Pure Michigan” brand that helped spur $2.1 billion in visitor spending last year.18	1. Regarding stigma effects: It is conceivable that stigma effects could lead to long-lasting impacts on recreation and tourism, and property values. However, research does not consistently provide evidence of stigma effects lasting longer than one or two years after an oil spill. There is evidence of stigma effects that permanently capitalize into property values and hence property values do not fully recover after certain non-soil spill events. However, to our knowledge there is no evidence of a permanent stigma effects attributable to oil spills, so we do not explicitly include them here (although we do acknowledge these effects in the risk assessment). 2. Regarding property values: Our estimate of the reduction in value of coastal properties due to an oil spill comes directly from peer-reviewed economic studies of past oil spills (cited in the analysis). Likewise, peer-reviewed economic studies (cited in the analysis) find that property values recover quickly after a spill. We have added additional details about our property value calculation to the assessment text. We updated our assumptions regarding both the magnitude of losses to property values after a spill and the duration of these losses based on additional peer-reviewed studies we found. The final draft of the report also provides additional detail about the procedure we used to calculate the loss to residential properties for clarification. (See also response to comment in row 168 item 3). 3. Regarding any effects on “Pure Michigan”: The effect of a spill on an advertising campaign is not directly related to economic measures od lost economic value (outlined at the start of Section GI) unless it affects behavior. Although there is

				no way to know what effect a spill would have on this advertising campaign, evidence from other spills does not show a long term decline in recreation and tourism.
176	G	42	The Risk Analysis also assumes that the effects to commercial fishing from a WCS Line 5 spill would only persist for one (1) year. The Risk Analysis concludes that reduction in whitefish, trout, walleye, yellow perch, and chinook salmon harvests would not be impacted in the second season after a WCS Line 5 spill.19 This assumption contradicts the Risk Analysis previous conclusion that there would likely be irreversible harm to fish populations and fish habitat in the Straits area.20 Additionally, studies of prior oil spills, such as the Exxon Valdez spill, have determined that these spills significantly affected marine wildlife and habitat for over a decade.21 Therefore, the Risk Analysis assumption that commercial fishing will only be impacted for a year after a WCS Line 5 spill is highly unlikely.	See comments above in item 4 of row 168.
177	G	42	There are many manufactures that rely on Great Lakes shipping to provide raw materials for their production processes. Therefore, the Risk Analysis' $42 million impact is likely an underestimate of the overall impact a delay in commercial shipping would cause.	See comments above for row 170.
178	G	44	Under Task G/I, the estimate of public and private economic damages ($1.37 billion) only considered coastal counties (as far south in Michigan as Oceana County) and excluded economic damages to any inland counties. My experience as a former Tampa resident and my intuition tells me that tourists' negative perceptions of an oil spill would drive potential tourists to avoid the area (including neighboring inland counties) resulting in additional economic damages not included in this estimate. Why visit oil slicked Michigan, Wisconsin, and Ontario when there are so many other uncontaminated places to visit?	In our spill scenaris, we define core and periphery counties and base losses on the measurements from the DWH spill. In the DWH spill, Tampa shorelines were measured to have lost visitation in year 1 due to stigma or perception effects even though no oil appeared on those shores. We are unaware of any measred effects from any oil spills on inland visitation, and none were measured in the DWH assessment.
179	G	53	The draft Risk Analysis under-evaluates the duration of clean-up and remediation activities. The draft Risk Analysis is built upon an assumption that an oil spill in the Straits will only have a	The duration assumed in the report is based on evidence from previous spills. See responses to previous comments.

			short-term effect on the region's economy, including tourism, recreational uses, commercial fishery and coastal property values lasting only one to two-years or even a few weeks for commercial navigation through northern lakes Michigan and Huron.	
180	G	53	The draft Risk Analysis report fails to provide clear definitions of what constitutes "restoration", "remediation", or "clean-up" and how independent evaluations would be made to assess progress on these efforts. Suggesting that clean-up and remediation can occur within one or two years of a WCS is unrealistic ad unacceptable.	Task GI defined the period based on the time activities such as recreation were seen to recover in other spills such as DWH, not on actual cleanup times at all locations within a spill area. Thus, Task GI uses an economic definition based on when activities are expected to, on average, recover to their baseline. Since these are then average recovery times, some sites might recover faster and others slower but the average is applied to al sites in a region.
181	G	53	The biggest individual shortfall of the draft Risk Analysis report is a gross under-assessment of the impact of a WCS from Line 5 under the Straits of Mackinac on riparian property values across the region and, in particular, in the most likely impacted shorelines in Cheboygan, Emmet and Mackinac counties. The academic researchers engaged in this ventured failed to canvas the nearly 8,000 parcels that would be directly affected by a WCS oil spill on their beaches. The 8,000 parcels include all shoreline and immediately adjacent parcels on the mainland and all parcels on Mackinac, Bois Blanc and the Les Cheneaux islands. The draft Risk Analysis report fails miserably in assessing the likelihood of major losses to shore property owners by assuming that market values would only decline for a year or two and only by less than 15%. This assumption leads to a few tens of million dollars in impacts. The simple perception of damaged property would drive home prices and other coastal parcels down more likely in the 60-80% range in the affected counties and persist for 3-6 years. My professional assessment is that market value declines in the most likely affected counties would total between \$1.7 and 2.9B, with the most likely estimate being \$2.3B. Obviously, there is a significant	1. Regarding property values, see above responses to comments on property values (especially item 3 in response to comment on row 168). Note too that we find no evidence in the literature of persistent losses in property values due to oil spills that are of such magnitude or duration. 2. Regarding condemnation of properties due to contaminated wells: Based on hydrologic information on groundwater flows (discussed by task D), contamination of wells is not anticipated. Thus, we did not estimate the lost value from condemnation of coastal properties due to groundwater contamination. Although, groundwater contamination is not expected to occur (see Section GI.4.9 of the risk assessment), we did incorporate costs of testing wells for well near shoreline areas where oil lands.

			disagreement between these estimates. In addition, the draft Risk Analysis report did nothing to estimate condemnation of coastal properties who have shallow ground water wells that could be contaminated for decades to come. Over 78% of all parcels in Cheboygan, Emmet and Mackinac counties have ground-water wells for potable use. The draft Risk Analysis report only accounts for a miniscule amount of these impacts and limits the prospective loss to testing of groundwater wells for two years.	
182	G	62	Impact on Gasoline in Michigan Brad Shamla, Enbridge Vice President of U.S. Operations, has stated that Line 5 provides enough crude to Michigan to fuel 120,000 cars and light trucks per day. While this sounds impressive, per MDOT (2018) there are 7,817,182 such vehicles in MI. Thus, while 120,000 of the vehicles in Michigan depend on gasoline derived from Line 5, it is only 1.5% of the total vehicles in the State. Shutting down Line 5 would have virtually no impact on the supply of gasoline to Michigan. Impact on Propane in the U.P. A recent report sponsored by the NWF, and authored by the London Economics Institute states if Line 5 were shut down, the impact on the price of propane in the U.P. only would be $0.05 per gallon. This is within the daily price fluctuations and "would be lost in the noise of typical price variability." As with gasoline, the impact of shutting down Line 5 on the price of propane in the U.P. would go unnoticed.	Our scope of work did not ask us to assess the costs of shutting down Line 5. For a spill, we estimated effects on gasoline prices that there would be a $0.02 per gallon. We determined there would be a larger short term effect on U.P. propane prices, but agree it would not be outside the normal range of flutuation of prices. Never-the-less, a shift in prices affects economic values. The Team is aware of the NWF report. However, the Dynamic Risk report and some of the numbers used in the report are also used for anlaysis by the Michigan Agency for Energy (MAE) for economic effects, and is therefore deemed reliable by the team. For our section on energy impacts, we reviewed the Dynamic Risk report and we utilize some of that report's data and results. A qualitative assessment of energy markets and potential responses is provided in the appendix.
183	G	62	Clean Up Costs and Economic Impact In 1989 the Exxon Valdez incident resulted in at least $7 billion of cleanup costs. It contaminated 1300 miles of shoreline. The MI Tech Risk Analysis shows a wide variation in the miles of oiled shoreline, the minimum number is 442 miles (see Shoreline Affected above). If we roughly compare Line 5 to Exxon Valdez, the shoreline involved is 442/1300 = 34%, Thus, 0.34 x $7 billion = $2.38 billion (in 1989). Escalating to 2018, the	Clean-up costs are covered in Task H. Regarding the report by Dr. Richardson, we have modified the Task G report to discuss some of the key differences between our methods and his that render the results incomparable.

			cost would be $9.3 billion. However even this number does not include loss of property value and subsequent loss of property tax income by local government, as well as the many local businesses that would be forced to permanently shut their doors. A report on the same subject by Dr. Robert Richardson of MSU put these costs at $6.3 billion. Based on the above, I believe the cost would be at least $10 billion, and perhaps significantly more. It is difficult to accept the approximate estimate of $1.8 billion that appears in the MI Tech Risk Analysis. It almost certainly is 3 to 5 times that amount.	
184	G	63	Section G.I.2.2 Assessing Losses • The third paragraph starts with “Our assessment of natural resource damages estimates economic losses for injuries to recreational uses of natural resources.” The report should clarify why the analysis focused on injuries to recreational uses and what other types of damages to natural resources have not been estimated. The report should also clarify the distinctions between the scope of the analysis presented and a full natural resource damage assessment under the Oil Pollution Act.	We have modified the report to address this and have emphasized this again in the conclusions.
185	G	63	Section G.I.5 Conclusions • The first sentence on page 322 says “Our estimates do not include dollar values – such as use and non-use values – lost due to injuries to habitat and wildlife that are not manifested through recreational uses.” This limitation should be explained and clarified in relation to Task II-G (2) in the Statement of Work which includes analyzing "the economic value of the natural resources destroyed or impaired". • Also, on page 322, the last sentence in the first bullet reads “If the restoration of habitat and wildlife services from section F does not compensate for the lost services during the injury period, the standard approach in NRDA would be to assess these losses via habitat-scaling approaches such as habitat	We have modified the report to address this and have emphasized this again in the conclusions. Our modification also address the second point.

			equivalency analysis, which is beyond the scope of our assessment and outside the expertise of economists." This should be explained and clarified in relation to Task II-G (3) in the Statement of Work which includes analyzing "The economic value of the public uses and ecological services . . . that would be lost until a final cleanup and restoration is complete", as well as Subtasks II-G 2 and II G 3-4	
186	G		Comment about water supply on Mackinaw Island There are some concerns of how to transport alternative water supply to the Mackinaw Island if ferries are shut down during the spill event.	We have added text to the report to address this. Based on other oil spills, it is highly likely that the Coast Guard will allow some vessels to travel through the spill area for water (food or other supply) and other emergency concerns. For example, during the Texas oil spill Coast Guard officials did allow cruise ships to travel through the incident area to minimize inconvenience to the thousands of passengers aboard and limit economic impacts from the spill (https://www.usatoday.com/story/news/nation/2014/03/23/texas-oil-spill/6793951/).
187	H	37	The Northern Michigan Area Contingency Plan was updated in 2017. The most recent version can be accessed at https://homeport.uscg.mil/Lists/Content/Attachments/20682/NMACP.pdf. (p. 335)	The 2015 ACP was cited in this chapter as the source of Figure H1. The 2017 update to the Plan does not include the same figure, but the contents of the figure are still accurate.
188	H	37	This section needs a concluding summary, similar to the other Tasks. (p. 348)	Thank you, the revised version includes a summary section.
189	H	63	Section H.1.2 The Line 5 Oil Spill "Policy Network" • On page 330, please note that the Office of the Great Lakes is now located within the Michigan Department of Natural Resources. Regardless, this parenthetical statement should be deleted as the Office of the Great Lakes does not have a specific role in oil response efforts.	The parenthetical has been deleted in the revised text.
190	H	63	Section H.2.2 Government Benefits: Gain in State and Federal Tax Revenues • The assumption that total oil-spill cleanup costs will be $500,000,000 paid by responsible parties as referenced in Section F.3.4.3 may be inaccurate based on concerns with using	The final text retains $500M as a reasonable estimate of total cleanup costs for "Scenario 1". It may be notable that a $500M total cleanup cost is similar to the $454M cost estimated by LP Environment for cleanup of a worst-case spring/summer spill.

			shoreline restoration as a surrogate for all potential restoration and mitigation measures and an incorrect dollar amount used in the case of the Marshall spill.	
191	X	63	Task X and the rest of the main report fail to discuss in detail any of the broad impacts relating to energy supply disruptions to Michigan and the region following a worst case spill. A report detailing such impacts was included as Appendix GI-2, but neither Task X nor any other section of the main report references or makes consequential use of the information contained in this appendix.	The Tasks G/I and Task X chapters both reference Appendix GI-2 in the revised text.
192	Summary	37	A more detailed and comprehensive summary should be compiled. The summation should include the conclusions or results from each of Tasks providing the overall consequences of a worst-case scenario spill so the State of Michigan can establish the amount of the required financial assurance and to help guide decisions about the future of the Pipeline. (p.395)	While the full report's Summary of Costs is brief by design, the analysis team has also produced a 35-page Executive Summary that accomplishes this. A draft version was provided to the state along with the Draft Report and it has been updated along with the Final Report.
193	General	1	When the Draft independent risk analysis for the Straits Pipelines was published and comments invited, the announcement DID NOT INCLUDE A DEADLINE FOR PUBLIC COMMENTS.	Thank you for your comment.
194	General	2	Hello, My comment is WHY TAKE THE RISK . It sounds to me like we do not benefit from this pipe line, The oil goes straight to Canada am I right? So why is it coming thru Michigan, Money? Is the money worth more than our water, Our shoreline, Our economy, I think not, And if you put it to a vote I would bet most residents of Michigan would say SHUT IT DOWN.....NOW. If it is Canadian oil let them run a pipeline on their soil not ours. Thank you	This report is intended to be an unbiased, fact-based analysis designed to assist the State of Michigan in decisions regarding the Straits Pipelines. Therefore the authors are unable to include recommendations or opinions on any specific course of action. All public comments have been received by the State for their review and consideration.
195	General	3	I do not want the State to take the risk but ff they are going to keep Line 5 Enbridge needs to put up a bond in the amount of $10 Billion dollars to ensure against a catastrophic failure as described.	Please see response to comment 2 in row 194.
196	General	4	With hardly any benefit to Michigan I think the pipeline should go on the land in other states, so a leak can be detected and stopped before 4000 + gallons of oil destroy our environment.	Please see response to comment 2 in row 194.
197	General	5	This about The People of Michigan and the safety of our environment. The People have spoken! Shut down Line 5.	Please see response to comment 2 in row 194.

198	General	6	I agree with the previous statement that Michigan appears to get very little benefit from Line 5. The line appears to carry materials from Canada to Canada with some but little sell off in Michigan. Don't risk it. Shut it down.	Please see response to comment 2 in row 194.
199	General	9	As I read the comments above and the analyses that have been quoted, I wonder if the age of the pipeline has been included as a factor. It's one thing to predict risk. It's another to do that with a product that is over 4 decades old. But more important is the issue that this pipeline is there more for the benefit of Enbridge and their Canadian customers more so than it is for American business. And then we assume all risk in the Great Lakes region where the pipeline lies. I agree with Alex Sagady that most Michiganders would vote to shut down line 5 if it ever makes it to a vote.	Please see response to comment 2 in row 194.
200	General	10	Any Oil at all, can ruin the fresh water for years. Consider the Gulf of Mexico- It took years to finally bring back the fishing industry. We have a very fine balance in the Great Lakes for our water related industries, any glitch (one gallon or 1000) can have devastating effects. The pipe can be run on top of the land so any leak can be spotted. Unfortunately money is the factor. Our world is slowly deteriorating and we do not need to speed it up with a oil leak in our great lakes.	Please see response to comment 2 in row 194.
201	General	12	The risk analysis Enbridge seems to require as well as the Govener and AG is - what is the risk to it's business w/o Line 5, while Michigan/Canada/Wisconsin can analyise that same risk through the lense of job creation, how many jobs are created through building a different line, or different energy source AND how much risk is reduced to the Great Lakes if Line 5 is closed (no Line 5 = no risk to Pure Michigan from Line 5). Do the right thing, create jobs - by closing the Line, create jobs by investing in alternative industry, preserve Pure Michigan related job.	Please see response to comment 2 in row 194.
202	General	13	I believe the scope of the report was limited and only concerned two areas of risk. How much time and money will be needed for the company to return to normal business and how much money the State tax payer will pay and the Federal will pay. Any guess to how much has been spent so far to combat the citizen and our opposition to this pipeline is measurable and will be held accountable one way or another as the report details. It appears to that the report is only giving one outlook at the question of risk.	Please see response to comment 2 in row 194.

			One question to be asked is what is the risk to the state, company and federal if the pipeline where to be decommissioned or re-purposed. The report details a drastic change that the people were not included into the argument as there were obviously too many unknowns with evident with blanks not filled in with a number. I also want to mention that we have no idea what our neighbors think about this, states and a country? There are so many questions, but they all lead to one thing Why? Is this Insane? What are We Doing? I really don't want us saying What Did We Do? What Are We Going to Do? It's time for a change and Michigan needs to start the Trend of Change. Michigan has been in the for front of past trends and I believe we can start a new on. I know in Emmet County we strive everyday with our Recycling with a bright look on how we want our future to look like, the pictures we were shown and graphs did not show a very nice future or anywhere I would want to live. I do not believe the Report considers us homo-sapiens in the risk at all, in matter of fact out of the whole state that was shown it appeared just 10% Lake Michigan and Huron where in concern with no respect to any life after the 200 foot barrier of shoreline along those lakes. No where did it address us humans who live on land, how it would really impact my county or it's residence which are citizens of this state and country. Please listen to us and do the right thing, shut it down scardee cat, what are you afraid of, us? I think the report shows what one should be scared of.	
203	General	14	I have to add that with a little math a 20" pipe over 5.5 miles is 4800 barrels at 44 gallons per barrel...they are saying the only oil that can or will escape, probably no matter what is the oil in the line and their automatic shut off will detect a leak by pressure and flow rates. The panel said they inspected these or viewed these newly added safety features but no where were they in the report, not even a picture to identify that it really happened. This was no where in the report but someone has the details, maybe the Coast Guard..who knows. Anyways They have full confidence that there will never be a problem, I guess that is why we are questioning the pipeline, what risk? There's no risk, just probability. I guess they have pumps to pump the oil out of the line and shut it down if they need to, and then it will be too late unless we obviously just stop the oil from flowing through our water, you ca't drink oil, lead mercury so why is this stuff in our	Please see response to comment 2 in row 194.

			water? Why can't we eat the fish today and everyday? Why is Flint not able to have fresh water? Why will we not have fresh water anywhere soon. Please stop the madness and listen to the people for once..please!	
204	General	15	The report fails to state the obvious: the risk of massive environmental damage exceeds the benefits to Michigan residents. Shut 'er down.	Please see response to comment 2 in row 194.
205	General	16	After reading this, I cannot recommend that we keep the Line 5. While they are planning to keep it safe, it was planned for 50 years, it is now 60+ years and we are having spills. The thoughts that they will keep it safe and collect all spills is laughable. We cannot risk the loss of fish, birds, plants and even humans. There is no risk worth this!! The loss of one line, with a lock that does not close and maybe two locks that do not close is too much, not worth the risk. We must remove the risk and make is more safe. st stop this now.	Please see response to comment 2 in row 194.
206	General	17	Given how old Line 5 is, given Enbridge's track record (re truthfulness about condition of the pipeline and the timeline to make repairs), and given the dire consequences for the water quality of the Great Lakes, tourism, fish life and more, I DO NOT see any benefit for the US to continue to allow Enbridge to ship oil/gas to Canada, via the Straits. All I see is VERY expensive risk.	Please see response to comment 2 in row 194.
207	General	18	Why on earth would we put the greatest source of freshwater in the world at risk so a foreign oil company can make millions? It's not a matter of if it will break, it's a matter of when it will break! We can't put Michigan's second biggest economic industry (tourism) at risk. We can't put our Great Lakes at risk. We can't put our wildlife at risk. We can't put our children's health at risk. For once, let's prevent a catastrophe form happening instead of all crying about it after it happens.	Please see response to comment 2 in row 194.
208	General	19	The fact that Michigan is willing to put our Great Lakes at risk is absolutely ridiculous. It is embarrassing enough after the water issues we have in Flint especially with the largest fresh water source in the world. We've already allowed too many businesses to take water from the GLs and we cannot allow this pipe to burst and ruin what makes Michigan and this earth beautiful. Prevent this before it happens !!	Please see response to comment 2 in row 194.
209	General	20	This is a submission of some of the notes after I spoke at the Public Meeting in Harbor Springs on August 13 per request of	Please see response to comment 2 in row 194.

moderator:
I am speaking from the heart...and asking each of you to think with the heart in the the next few moments please.
Maya Angelo once said, "When you know better you do better." I think we can all agree that we all know better and have much more information than we did 65 years ago in 1953 when Line 5 Pipeline was constructed to transport oil across the straits of Mackinaw and our peninsulas. We now have almost 400 pages of information from the Risk Analysis Research Report to prove it as it states we should have known better.. should there be an oil spill in our beautiful Great Lakes. We need to remember that corporate contracts, foreign or domestic, are just pieces of paper. No heart. No soul...probably not even a human handshake in the making. That's why it works so well when it comes to making a profit.
But, I have to ask ..Where is your heart going to be should there be a large oil spill in the Great Lakes? ...What you are going to tell the children when they wonder how this happened in the first place? What will this teach our children and grandchildren? ...I predict your heart will be sick from the seeing the sight of black oily water floating for 441 miles (according to the research) of oil soaked fish and wildlife that lay slain on our shores, and worries about your property values, a family job loss of someone who depends on fresh water (or tourism) for a living, and concerned about customers who are concerned about the same things, and they stop spending their hard-earned money and Michigan's economy, literally, comes to a screaming hault.
Also, as a people, how can we afford to cause more trauma and cultural harm to the heritage and identity of native americans who make it a part of their way of life to honor and care for water, land, and wildlife habitats (that benefit all) by risking an oil spill in our Great Lakes? Let us take heed from the ancient wisdom of these people. Harm to native Americans can stop here. If an oil spill occurs, we can no longer blame our non-native ancestors to the harm done against native americans; it will be us, it will be us...and the people we place in office! Take heed...
We need to get to the heart of the matter and close Line 5 for good! It is the right thing to do because we now know better and because the damages and costs that the Risk Analysis provided is the expert evidence needed and confirms our serious

			concerns, and because, hopefully, your heart says it is the right thing to do also. Thank you.	
210	General	21	Too much risk. Shut it down	Please see response to comment 2 in row 194.
211	General	22	RisK and no real benefit....I hope this report gives the decision makers the courage to do the right thing. DO THE RIGHT THING!!! MUSTER YOUR DAMN COURAGE!	Please see response to comment 2 in row 194.
212	General	23	Include number of gallons of oil as most people don't know it's barrels x 42	Thank you for your comment, the final draft has been updated to include both barrels and gallons for all volumes.
213	General	24	So what is this really about? The fossil fuel industry is lining the pockets of our politicians and setting the energy policies for this country. Their profits are obscene. And how about environmental ethics? Anyone look into the past environmental catastrophes? Of course you have but greed is always the key. I was conscious of the high rate of cancer and birth defects where I grew up.I grew up near the Love Canal and near a town where the Army and a defense contractor dumped more than 37 million gallons of radioactive waste from the World War 11 atomic bomb project. My Dad was a chemist for the company that worked for it and when he was 90 got a call saying that if he should develop cancer, his company (now Dow Chemical) would pay for it. We don't want to sit back and be controlled by industries that pollute. We are tired of the greed, and corruption. We have children and grandchildren and care about them. So tired of all of your task forces and studies that only lead to more task forces and studies. Stop this. You have one life. Why not make a positive difference?	Please see response to comment 2 in row 194.
214	General	27	I grew up in Michigan's beautiful Upper Peninsula and have spent most of my adult life in Ann Arbor. My husband and I spend a great deal of time in upper Michigan -- the Traverse City area on up to the bridge -- and in the U.P. We treasure the natural beauty of this area and would never want to see any of our wilderness areas or the Great Lakes threatened in any way. We feel Line 5 poses such a threat and are opposed to continuing with its operation. We are opposed to any upgrading, expansion, or replacement of this line that would allow it to continue to operate. It is abundantly clear that this pipeline is unnecessary and that there are other viable alternatives to transporting anything this company needs to transport -- alternatives that are much safer and do not threaten the health of the Great Lakes in the way that Line 5 does. When other	Please see response to comment 2 in row 194.

			alternatives are available, why would we play Russian Roulette with our future? ANY spill in this area would be so devastating that the long term consequences are inestimable -- not just for the environment, wildlife, health of the fisheries, and health consequences for people living in that area (ground water and drinking water contamination, exposure to toxic chemicals, etc.), but for the economy of the immediate region and for the entire State of Michigan. There is no scenario where tolerating the risks associated with an aging pipeline makes sense. Please, SHUT IT DOWN NOW! And do not allow any other lines to ever be placed under the Straits of Mackinaw again! We are stewards of this land and great waterway. We must act intelligently, in our own best interest now, and in the best interest of all future generations to come, to protect this vital resource. In 100 years, we will no longer be here. But the land and water will still be here. And our children's children will be here. They are counting on YOU to do the right thing and protect the incredible natural resources that we have been entrusted with. Please protect this area and close down Line 5 once and for all. You have the power to protect the Great Lakes for us and for future generations. Please don't let the selfish interests of one company outweigh the good that can come from shutting this project down. Thank you.	
215	General	28	I am a life-long resident of Michigan. I have a PhD in mechanical engineering and work in the auto industry. As an engineer, I can tell you with 100% confidence that materials fail. Every man-made item has a shelf life. Decay happens. No materials last forever. No matter how well something is designed, no matter how much care goes in to crafting it, nothing is foolproof. Things that are engineered fail all the time. It may be due to human error, contaminants in the manufacturing process, neglect, accident, unforeseen complications, or a host of other reasons, but whether we want to admit it or not, nothing is foolproof. Because of this, I have grave concerns about subjecting something as important as our Great Lakes to any potential man-made hazard. Line 5 is an excellent example of such a hazard -- a disaster waiting to happen. Because there are alternatives available, it would be foolish to continue using Line 5 in its current location under the straits. If it fails, the consequences will	Please see response to comment 2 in row 194.

			be so monumental that the area will never fully recover to its pristine condition. It would be even more foolish to place another line there -- no matter what assurances you are getting from the company that wants to put it there. The company that built the Titanic touted it as the best, safest, most sea-worthy ship ever! And look what happened there. Let's avoid another disaster and get rid of Line 5.	
216	General	29	The scientific research is in and indicates that the huge risks far outweigh ANY benefit derived from the continued use of Line 5. The company has repeatedly shown that profits are the priority, not the environment. Considering the risk to Michigan and the Great Lakes, Line 5 needs to be shut down. If the fuel is critical to Ontario and other provinces, Enbridge needs to re-route their line through Canada, not the United States.	Please see response to comment 2 in row 194.
217	General	30	The risks of allowing Line 5 to continue operating far outweigh any benefits. A leak would prove disastrous to the environment, to water supplies, to the fishing industry and to tourism. Who benefits from Line 5? Mostly Enbridge, a Canadian company. The oil is a pass-through shortcut back to Canada and is exported. Propane use for the UP can be obtained elsewhere. Why do we even consider allowing this line to operate when so much is at stake?	Please see response to comment 2 in row 194.
218	General	31	Line 5 pipeline poses a great threat to our water supply. The leak that recently occurred on the Kalamazoo River here in Michigan is an example of some of the dangers involved with leaking Pipelines and our water supply. Other factors are important but our water supply is number one	Please see response to comment 2 in row 194.
219	General	32	Money concerns seem to be topmost in today's business and political environs. Long term environmental and health concerns that take decades to "fix" or recover from unfortunately are distant priorities. Money can be recovered quickly; environmental damage (and the resultant loss in an economy) cannot be quickly reversed. A decades old pipeline in one of our nation's most-prized waterways being put at risk by a foreign-owned private company for profit (and benefit of another country) is something lawmakers should have the courage to stand up against. There are land alternative for this oil to get to "market."	Please see response to comment 2 in row 194.
220	General	33	The Great Lakes are "Jewels of the Biosphere". Destroying these jewels is absurd. Line 5 is too old and therefore is at risk of	Please see response to comment 2 in row 194.

			leaking. If this happens during winter, recovery will be difficult or impossible. Shut down Line 5.	
221	General	34	There is no good reason to let this old pipeline to put the Great Lakes at risk.	Please see response to comment 2 in row 194.
222	General	35	It is not worth the risk to our Great Lakes to keep this pipeline open. There are plenty of other ways to get clean energy to the people who need it. Shut this line down now, not later.	Please see response to comment 2 in row 194.
223	General	36	The Great Lakes are THE largest deposit of fresh water IN THE WORLD. How is any amount of oil worth more than THAT?! Why are we Michiganders taking SO MUCH RISK and LIABILITY for so little benefit? This is absurd and even heinous. The devasting risks far outweigh the tiny benefit. For less than a lousy 10% of the "dollar benefit" of this pipeline, look what we stand to lose: our entire Michigan economy, our wildlife, our fisheries, unparalleled scenic beauty, DRINKING WATER, and literally 1000s of miles of shoreline of private and public recreational beachfront property enjoyed by 100s of 1000s of people each year. Enbridge only carries a paltry $1million of liability insurance in contrast to the BILLIONS it would cost us. If logic and reason do not dictate that Line 5 be shut down immediately, then all the key decision makers are either stupid fools or evil doers. Attorney General Schuette has the power to shut Line 5 down immediately. Why does he not care about Michigan's economy and the environment enough to shut Line 5 down? It's time to put ALL LIFE first and oil profits last. Stop Line 5 immediately! Thank you!	Please see response to comment 2 in row 194.
224	General	37	The report would be improved if many of the tables were formatted in a manner that was easier for readability and public consumption	Thank you for your comment, formatting updates have been made throughout the final version of the report.
225	General	37	Correct the formal title of the owner and operator of Line 5. In legal documents with state and federal governments, including the 2016 Consent Decree and the November 2017 Agreement, the owner of Line 5 is referred to “Enbridge Energy, Limited Partnership, ” as opposed to “Enbridge Energy Limited Partners.’ (p. 32)	Thank you for your comment, this correction has been made throughout the report.
226	General	38	Shut down Line 5 now, before it’s too late.	Please see response to comment 2 in row 194.
227	General	39	Pipeline 5 is a hazard to the people, flora, & fauna that surrond the Great Lakes. Any damage could be irreversible for years to	Please see response to comment 2 in row 194.

			come! We need to put the wants/needs of many before that of a few.	
228	General	40	Line 5 is at the end of it's life, is risky (as the recent anchor incident proves), and provides little economic value to our state. We need to reduce carbon fuel infrastructure and drive up the price of oil to force people to make better transportation choices.	Please see response to comment 2 in row 194.
229	General	41	our great lakes define our beautiful state. let's protect them.	Please see response to comment 2 in row 194.
230	General	43	For years, Enbridge has assured us that Line 5 is safe and not to worry about an oil spill. However, we now know that to be untrue. Enbridge lied about Line 5 safety when it knew that since 2003 numerous bottom support anchors were missing and failed to disclose it until 2017, nine months after a report documented that pipeline spans of up to 286 feet had no anchor support. In addition, in 2017 Enbridge claimed that missing protective coatings along the Straits pipeline were a mere “hypothetical” possibility, while at the same time a video IN THEIR POSSESSION showed areas of missing coatings. It is proven. They lie to protect their interest, meanwhie the Great Lakes, the people that live on them and the animmalotgat live in them are a constantly a risk for a huge catastrophe.	Please see response to comment 2 in row 194.
231	General	45	Dear Governor Snyder, Attorney General Schuette, Director Grether, Director Talberg, Director Creagh, Dr. Meadows and study team: I have lived most of my whole live in the Great Lakes Region, both in Indiana and Michigan. One year I lived in California...I missed the Midwest. Our states are so lucky, and at the same time very spoiled to have so much fresh water at our disposal. The Great Lakes are THE largest deposit of fresh water IN THE WORLD. Many states and other foreign countries are not as lucky as we are. California is suffering from the current drought that they are experiencing there; wild fires that are burning down their homes, communities and devastating their agricultural footprint in our country. Michigan is the 2nd top agricultural producing state in the US. We need our fresh water to maintain such a status to feed this country as well as our state! We need to safe guard and protect this great trust that we have been endowed with by taking action to protecting this very resource. If we allow big corporations and businesses especially foreign businesses, to tell us what is safe, then we are	Please see response to comment 2 in row 194.

compromising our very state's well being! It has been shown that this pipeline, its technologies and steel structural bodies are vulnerable and getting old. We are the ones who will pay a heavy price if this pipeline fails. We need to ensure that our Great Lakes waters and natural bodies stay pristine and untainted from oil products. Please help to protect the rights of all of the US citizens in this region from such a natural disaster that this pipeline failure could produce. We have seen such a failure in the Kalamazoo, Michigan region. The residents there are still suffering from that devastating spill; many are learning they have resulting health issues. We don't want to repeat such terrible past historical decisions as Enbridge has been making. It is our citizens that are paying for such poor planning and unwise decision making.

"We don't want to have oil mixed in with our pure water. It has been shown that if such a pipe system failure occurs in the Straits of Mackinac, then the flow of the currents from Lake Michigan and Lake Huron will make it very difficult to contain and control such a spill. It will be much worst than the spill that happened in the Gulf in Mexico. Please learn from the past by proactively planning for the future. Please utilize the bipartisan specialists, our engineers and environmental ecologists, who have the experience and knowledge to make wise recommendations. Please keep the Great Lakes safe while keeping the oil flowing at a later time. Please don't build a tunnel around this demised pipeline. It is only a band aid solution. The time is now, to shut down this pipeline! It is time to build a new stronger pipe with many safeguard devices. Please shut down this pipeline and have Enbridge put in a new line, with many safety valve shut offs and alarm systems, 24/7 monitoring devises before it is too late.
We need to make sure we protect these waters for us and our future generations. The future; our children, their children and future generations depend on this very resource, this fresh WATER, the land and air that this pipeline runs through... it all needs to be protect as much as the all mighty $$$$! Yes we need jobs but we also need a healthy environment to live in.
You are our elected officials; you have been given a ""public trust"" obligation to represent us, your constituents. You must

			represent our interest and needs for clean water, land and air; to represent our wants for this pipe to be shut down; as well as the wisdom of your subconscious to know what is needed. Karma is present all around; it is only those who do what they know they must do who will be blessed. Those who take money from corrupt corporations for their own individual benefit are going to have to answer to a ""higher court"". It is time to take your public trust to that level and be the men that you are; representative and honest. Thank you! Sincerely, Lisa"	
232	General	46	Get Line 5 out of the water and the Straits. The water at the tip of the mit is to valuable to risk. Why wait to remove it when it has out lived it's life expectancy.	Please see response to comment 2 in row 194.
233	General	47	The risk is senseless and the cost of recovery astronomical.. I cannot understand why the need for this pipeline continues. Please turn it off and get the pipe out of our lake.	Please see response to comment 2 in row 194.
234	General	48	We cannot continue to risk the future of our State and our Planet any longer. The human race continues to destroy our only home. When the pipeline does fail...and it will we'll all be wondering why we allowed this to happen once again. The pipeline owner Enbridge will put on a show doing a surface clean up. However another pristine part of nature and our habitat will be gone forever.	Please see response to comment 2 in row 194.
235	General	49	The dirty and dangerous Enbridge Line 5 petroleum pipeline assembly is a most imprudent gamble for the state of Michigan and threatens to become a truly horrific and unprecedented, manmade disaster for the entire Great Lakes region. Finally, we are having a real public discussion about what is at stake in the unlikely event of a worst-case severe accident. Unfortunately, the same cannot be said for how we look at our state's nuclear energy infrastructure. Please forgive me....I feel obligated in the absence of federal leadership to issue this public call for an equivalent, independent state-funded worst-case risk analysis of Michigan's age-degraded nuclear power facilities. Needless to say, the global history of actual nuclear power plant disasters suggests a severe accident in southeast or southwest Michigan on our Great Lakes shoreline near large population centers would be catastrophic. Yet, inexplicably, the U.S. Nuclear Regulatory Commission (U.S. NRC) does not evaluate worst-	Please see response to comment 2 in row 194.

			case scenarios for U.S. nuclear power plants during the federal license review process. It is important to understand nuclear safety/security is regulated by the federal government, but the Michigan State Constitution explicitly allows for regulation of atomic energy matters within the territorial boundaries of the state. Let's not continue to ignore such existential threats hiding in plain sight. Shutdown before meltdown!	
236	General	51	This pipeline is too risky to our beautiful, necessary Lake Michigan. We know there can be tragic accidents.	Please see response to comment 2 in row 194.
237	General	54	Little Traverse Bay Bands of Odawa Indians' traditional way of life, and rights to hunt, fish and gather in the Ceded Territory were reserved in the 1836 Treaty of Washington and reaffirmed by the Federal Court in the case of United States v. Michigan. The Straits of Mackinac are in the heart of this Ceded Territory and is an important fishing, and fish spawning ground. Any oil spill in this area will be detrimental to these activities. This initial Risk Analysis completed by Dr. Guy Meadows and his team is appreciated, but the State of Michigan should have included all of Line 5 in the scope of this analysis. The many other segments of Line 5 including those near Lake Michigan, and its tributaries also pose a risk to LTBB's treaty rights, and should also be analyzed. Regardless, because of the irreparable harm caused by a rupture of any segment of Line 5, it needs to be decommissioned and safely removed. Thank you for this opportunity to provide feedback.	Please see response to comment 2 in row 194.
238	General	55	IF the line is to continue it must be physically protected from damage and a monitoring system must be applied to the full length of the line at no cost to Michigan. Having said that, if there is no benefit to Michigan and the benefit is 100 % to the Canadians, then there is plenty of room in Ontario for this line and no need to.endanger Michigan water, wildlife or people.	Please see response to comment 2 in row 194.
239	General	56	I am impressed by the information that you have on this blog. It shows how well you understand this subject.	Thank you for your comment.

240	General	57	While we appreciate the authors' statements regarding the low-probability of occurrence when referring to the events representing the 'worst-case scenarios' described in the draft report, these statements do not adequately analyze the risk, as implied by the title of the draft report. To properly analyze the risk associated with these events, we urge the authors to evaluate the probabilities of these events so that the impacts described may be put in the proper context. Without that frame of reference readers are not able to conceptualize the likelihood a spill will have the described effects on the region. If this analysis cannot be performed, it is suggested that the title of the report be modified to better capture the scope of the report, as 'risk-analysis' is not appropriate due to the lack of consideration of probability.	As dictated by the Scope of Work defined by the State, the starting point of this analysis was the assumption that the "worst case spill scenario" has occurred. Given this assumption, defining the likelihood specific events occurring, is outside the scope of work.
241	General	57	Further to the worst-case scenarios, we also ask that authors be more explicit in their descriptions that are associated with each Task and its associated scenario. Please see the following excerpt from Page 32: "For example, a winter spill would be the most difficult to respond to safely and effectively; a spring spill would generate the highest economic costs, as outlined in the report for Tasks G and I; and a summer spill would pose the highest risks to public health and safety due to the seasonal changes in population in the Straits area, as described in the report for Task D. To effectively capture the worst foreseeable scenario for each of these areas that the State described as a subtask in the assessment scope of work, the same spill volume and location was carried across all tasks, but the spill timing assumed for evaluation varied depending on the worst outcome for that particular task's focus area." Because of this approach, a distinct and separate scenario was used for each analysis. However, a general reader could reasonably conclude that the analyses performed on the worst-case impacts from the different Tasks and subject areas are the	The use of different scenarios has been clarified in the introduction and throughout the document. A common scenario (referred to in the text as G/H/I "Scenario 1")was considered for the final cost analysis.

			result of a singular scenario. We ask that the authors include a detailed description of this wherever possible to ensure readers are aware that the different outcomes evaluated in each Task cannot be considered cumulative in nature due to them being wholly separate events and scenarios.	
242	General	58	In this scenario, we have an opportunity to minimize risk and make sure we avoid catastrophic issues for our Great Lakes and the generations to come. It's important we don't let greed or lobbying control the future of our beloved lakes and outdoor community here in Michigan and the surrounding states. Take action, and let's do the right thing, we can't have Line 5 keep running after every known report says it shouldn't be anymore.	Please see response to comment 2 in row 194.
243	General	59	For all of the reasons stated, Line 5 needs to be decommissioned, unequivocally.	Please see response to comment 2 in row 194.
244	General	60	Any pipeline spill is dangerous, but in water the danger spreads over a far greater area, killing a far greater number of native plants and animals. This is unacceptable, and probably would not even be suggested under a saner Administration. No. No. No.	Please see response to comment 2 in row 194.
245	General	61	This line should be shut down. Water is too important, as well as our entire Great Lakes Region, to take such a terrible chance when failure can be imminent. Don't take any more chances with Michigan water! Shut this pipeline down right away!	Please see response to comment 2 in row 194.

246	General	62	Shoreline Affected The report is inconsistent regarding the km of shoreline affected by a spill. On page 85, the maximum oiled shoreline is said to be 711 km (442 miles). On page 343, it is said to be 996 km (619 miles). But on page 345, the maximum oiled shoreline is stated as 2,007 km (1247 miles). Obviously, the range of cleanup costs would be drastically different, depending on which of the oiled shoreline distances is used. The various oiled shoreline distances must be better explained or corrected to a single, agreed upon value, involving the individuals who were responsible for the various sections of the report.	Thank you for your comment. The inconsistency of shoreline length has been better described in the Introduction (Table 1). Multiple worst case scenarios were used by different Tasks to capture worst case conditions for each specific component. This results in a range of shoreline lengths effected.
247	General	63	Section A.4.5 recognizes that a shutdown of manual valves could occur in either 120 or 60 minutes and provides the volume differences. The cost assumption presented later in the report uses a 120-minute shut down time. A cost assumption using 60 minutes should have also been presented.	In an effort to clarify the effects of valve closure times on the total cost and extent of clean up, we have undertaken the following actions: · We have discussed the request and methods we could use to provide an answer with our task teams (A – X). · Based on these discussions, we have conducted an analysis comparing the worst case spill (58,000 bbl, two-hour spill closure time) to a spill resulting from a Tier 4 failure (29,000 bbl), and to our Tier 1 minimum spill (4,400 bbl). · The analysis compares the amount of shoreline oiled in each case and what % of the oiled shoreline falls below the NOAA thresholds for both socioeconomic (1 g/m^2) and ecological (100 g/m^2) impacts. · The summary of this analysis is provided in the diagram on the following page for the worst case spill for both Lakes Michigan and Huron (separately). In summary: The length of shoreline requiring cleanup based on NOAA's established thresholds that prompt a socioeconomic and/or ecological impact response was

compared for the Tier 1, Tier 4 and Tier 5 worst-case scenario discharge volumes defined in the draft report, using the worst spill response weather conditions observed/modeled in 2016 for each lake as examples. For the Lake Michigan WCS, a Tier 1 spill would require cleanup of 97% of the length of shoreline requiring cleanup from a Tier 5 spill. For the Lake Huron WCS, a Tier 1 spill would require 85% of the cleanup of a Tier 5 spill. For both lakes' worst cases, the length of the oiled shoreline is not sensitive to release volume using the more stringent 1 g/m^2 threshold (Tier 1 oiled shoreline is >85% of the Tier 5 shoreline). Using the 100 g/m^2 cleanup threshold, a Tier 4 spill results in 86-90% of the oiled shoreline of a Tier 5 event, and a Tier 1 spill is ~1/3 the shoreline of Tier 5.

Since the clean-up will occur over the same sections and lengths of shoreline, the costs will be less, the smaller the spill, but not appreciably. An alternate approach may be: To significantly reduce the amount of oiled shoreline (and consequent cleanup costs) below the worst case estimates for a Tier 1 spill of 4,400 bbl would require the containment of oil already within the underwater section of the pipeline after valve closures. With respect to what would be needed to significantly reduce the length of the oiled shoreline, in the current Task A analysis, we don't assume that all oil in the underwater section of the pipeline drains into the lake after valve closures, just the volume that's between the leak location and the lowest elevation point along the Straits crossing or 15% of the total volume of the Straits segment (approx. 1000 barrels), whichever is larger. This is to account for how the specific gravity difference between oil and water would limit draindown. Based on our current results, to cut the length of oiled shoreline > 1 g/m^2 in half would require reducing the spill volume to approx. 1200 barrels. Even assuming an instant leak/rupture detection and shutdown decision, because it takes 3.5 minutes for the valves to close, reducing the spill volume to that extent doesn't seem possible for the existing pipeline configuration.

Supplement to Comment 63 Response (Table A-J2, Row 247)

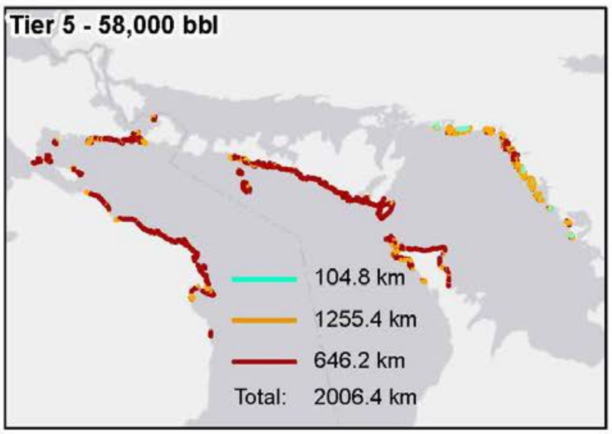
Comparison of Oiled Shoreline Cleanup Needs for Task A
Tier 1, 4 & 5 Release Volumes

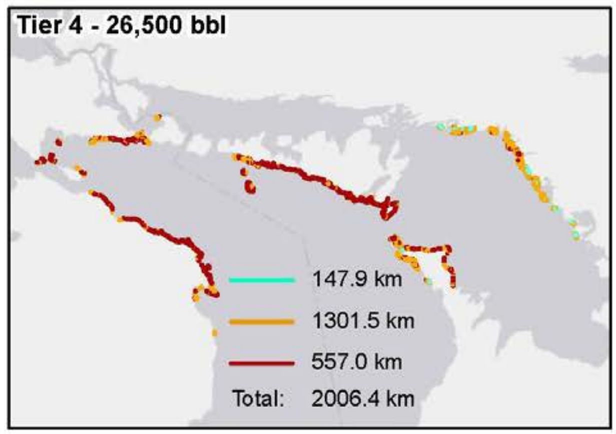
Legend

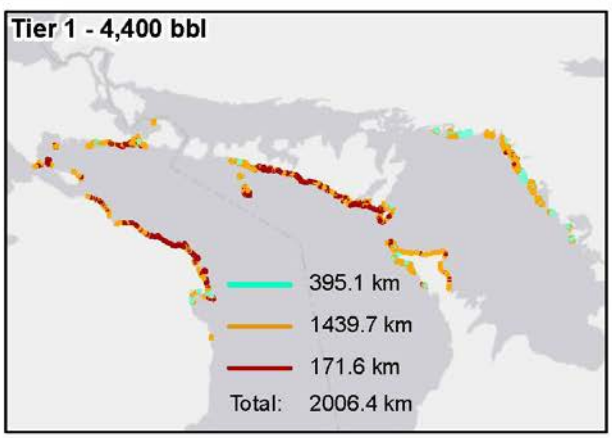
Shoreline oiling (g/m²)

- Below NOAA thresholds for both socioeconomic & ecological impacts (no cleanup)
- Over NOAA threshold for socioeconomic impacts (1 g/m², (~1um thick, equivalent to a heavy sheen)
- Over NOAA thresholds for both socioeconomic (1 g/m²) and ecological (100 g/m², ~0.1mm thick) impacts

Lake Huron Worst Case (No On-Water Recovery, Accounts for Weathering)







Summary: The length of shoreline requiring cleanup based on NOAA's established thresholds that prompt a socioeconomic and/or ecological impact response was compared for the Tier 1, Tier 4 and Tier 5 worst-case scenario discharge volumes defined in the draft report, using the worst spill response weather conditions observed/modeled in 2016 for each lake as examples. Two potential shoreline oil thickness thresholds, 1 and 100 g/m², were evaluated. Both these values have previously been used as thresholds for triggering shoreline cleanup activity. The draft Independent Risk Analysis was based on cleanup at the the 1 g/m² threshold.

For the Lake Huron WCS, a Tier 5 spill would require cleanup of 1902 km based on a more stringent threshold of 1 g/m² or 646 km of shoreline based on a threshold of 100 g/m². A Tier 4 spill of half the volume would require cleanup of 1858.5 km (98% of the length of shoreline requiring cleanup from a Tier 5 spill) using a 1 g/m² threshold or of 557 km (86% of Tier 5) using the 100 g/m² threshold. A Tier 1 spill would require cleanup of 1611 km (85% of the Tier 5 shoreline length) at the 1 g/m² threshold or 172 km (27%) at the 100 g/m² threshold.

Supplement to Comment 63 Response (Table A-J2, Row 247)

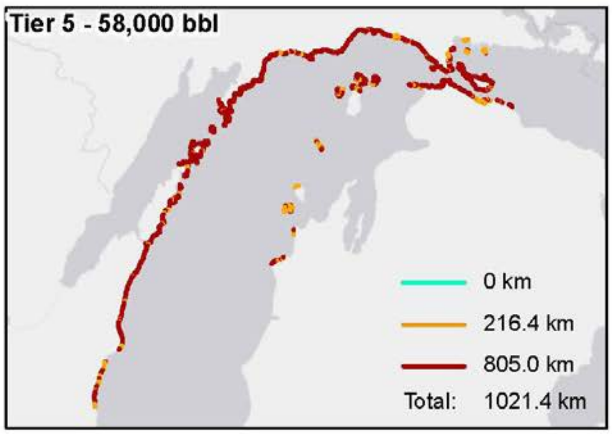
Comparison of Oiled Shoreline Cleanup Needs for Task A
Tier 1, 4 & 5 Release Volumes

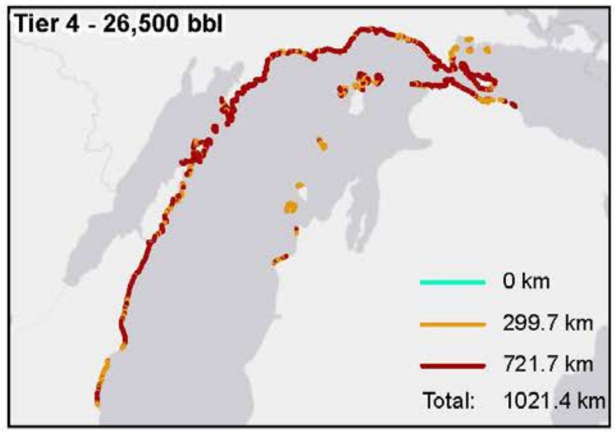
Legend

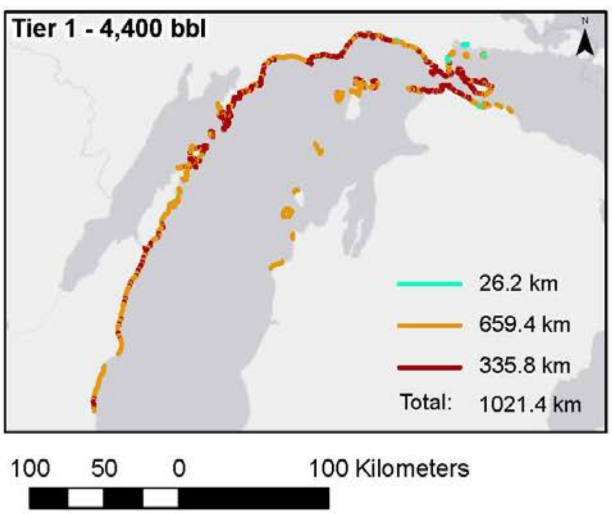
Shoreline oiling (g/m^2)

- Below NOAA thresholds for both socioeconomic & ecological impacts (no cleanup)
- Over NOAA threshold for socioeconomic impacts (1 g/m^2, (~1um thick, equivalent to a heavy sheen)
- Over NOAA thresholds for both socioeconomic (1 g/m^2) and ecological (100 g/m^2, ~0.1 mm thick) impacts

Lake Michigan Worst Case (No On-Water Recovery, Accounts for Weathering)







Summary: The length of shoreline requiring cleanup based on NOAA's established thresholds that prompt a socioeconomic and/or ecological impact response was compared for the Tier 1, Tier 4 and Tier 5 worst-case scenario discharge volumes defined in the draft report, using the worst spill response weather conditions observed/modeled in 2016 for each lake as examples. Two potential shoreline oil thickness thresholds, 1 and 100 g/m^2, were evaluated. Both these values have previously been used as thresholds for triggering shoreline cleanup activity. The draft Independent Risk Analysis was based on cleanup at the the 1 g/m^2 threshold.

For the Lake Michigan WCS, a Tier 5 spill would require cleanup of 1021 km based on a more stringent threshold of 1 g/m^2 or 805 km of shoreline based on a threshold of 100 g/m^2 . A Tier 4 spill of half the volume would require cleanup of 100% of the length of shoreline requiring cleanup from a Tier 5 spill using a 1 g/m^2 threshold or of 722 km (90% of Tier 5) using the 100 g/m^2 threshold. A Tier 1 spill would require cleanup of 97% of the Tier 5 shoreline length at the 1 g/m^2 threshold or 336 km (33%) at the 100 g/m^2 threshold.

Attachments to Comments

2.4.1.1.1.4.1.3 Incorrect Operations

As outlined in Section 2.4.1.1.1.3.10, since the Marshall incident in 2010, Enbridge has undertaken a review and upgrade of the management systems by which it controls its pipeline operations. Despite this, numerous pipeline investigation analyses have shown that regardless of the direct cause, some element of incorrect operations, such as procedural, process, implementation or training factors invariably plays a role in the root causes of pipeline failure. Furthermore, it is often impossible to foresee in advance what sequence of events and breakdown in management systems and operating practices might lead to failure. For this reason, failures that are related to incorrect operations cannot be discounted, and are considered a Principal Threat.

Failure Probability Estimation

The US DOT's Pipeline and Hazardous Materials Safety Administration's Hazardous Liquids Failure Incident Database was used to provide historical estimates of failure likelihood associated with incorrect operations in offshore transmission pipeline infrastructure in liquids service (e.g., crude oil and NGLs).

Failure Mechanism

Due to the range of conditions leading to a failure that are considered under this threat, the distribution of potential hole sizes is broad. For the purposes of associating failures attributed to incorrect operations with consequences in the determination of risk, a 3-in. (75 mm) diameter hole was determined through probability-weighting the distribution of hole sizes for offshore pipelines. [71, p. 40]

3" HOLE

2.4.1.1.1.4.2 Secondary Threats

Secondary Threats, defined as those threats for which an evaluation of susceptibility attributes indicates a relatively insignificant vulnerability and that therefore have the potential to contribute only at a second-order level in terms of overall failure probability, include the following:

- external corrosion
- internal corrosion
- selective seam corrosion
- stress corrosion cracking (SCC)
- construction and fabrication defects
- manufacturing defects
- equipment failure (non-pipe pressure containing equipment)
- time-dependent failure due to resident mechanical damage
- activation of resident damage from pressure-cycle-induced fatigue.

Attachment to Comment 25

East Seg. Loc. 3 (339.40 ft)	1.56	0.00	West Seg. Loc. 3 (330.68 ft)	1.63	0.00
East Seg. Loc. 4 (443.11 ft)	1.73	0.17	West Seg. Loc. 4 (454.72 ft)	2.10	0.47
East Seg. Loc. 5 (504.49 ft)	3.01	1.45	West Seg. Loc. 5 (506.17 ft)	3.17	1.54
East Seg. Loc. 6 (651.71 ft)	3.88	2.32	West Seg. Loc. 6 (651.15 ft)	3.88	2.25

A.2.4 Potential Causes of Failure

The possible causes of a maximum worst-case spill from Line 5 in the Straits include corrosion, construction and material defects (cracking and fatigue), natural hazards, third party damage (accidental or sabotage), and operational errors. The Alternatives Analysis identified third party damage and incorrect operations as the principal threats to the pipeline. In line with the understood definition of a worst-case scenario, potential causes were considered if they were plausible, even if very unlikely.

The following assessment includes both pinhole leak and full-bore rupture failure modes. A ~~pinhole~~ leak could plausibly be caused by ~~corrosion, defects~~ operator error, fatigue or third party damage, with fatigue being most likely. ~~In 2017, Enbridge provided an interim report of coating damage found during inspections (Figure A4). Coating gaps were confirmed at three locations with an inconclusive result reported for one additional location. Coating gaps were confirmed to cause bare pipe metal to be exposed to the environment. Even though no evidence of metal loss was found to date, the absence of coating increases the probability of corrosion and thus could plausibly contribute to future pinhole leakage.~~ 3rd

BASIS?

Attachment to Comment 25

Delete.
Irrelevant for
current report.

~~Figure A4: Coating damage found during a pipeline inspection~~

A rupture scenario could be caused by incorrect operation~~, such as accidental over-pressurization or improper closing or opening of valves~~; spanning-related stress such as fatigue caused by vortex-induced vibration or excessive unsupported span length; or mechanical damage (including accidental damage, such as anchor drag or damage during maintenance, and malicious third-party damage). The possibility of malicious damage was not addressed in the Alternatives Analysis, but pipeline systems are recognized as a physical target for terrorist groups and have been the focus of numerous plots intended to cause significant damage, as Dancy & Dancy recently summarized:

> *In 2005, a U.S. citizen sought to conspire with Al Qaeda to attack a major natural gas pipeline in the eastern region of the United States. In 2006, federal authorities discovered a posting on a website purportedly linked to Al Qaeda that encouraged attacks on U.S. pipelines using weapons or hidden explosives. In 2007, the U.S. Department of Justice arrested members of a terrorist group planning to attack jet fuel pipelines and storage tanks at the John F. Kennedy International Airport. In 2011, an individual planted a bomb, which did not detonate, along a natural gas pipeline in Oklahoma. In 2012, a man who reportedly had been corresponding with "Unabomber" Ted Kaczynski unsuccessfully attempted to bomb a natural gas pipeline in Plano, Texas. Canadian pipelines have also been targeted by physical attacks. Natural gas pipelines in British Columbia, Canada, were bombed six times between October 2008 and July 2009 by unknown perpetrators in acts classified by authorities as environmentally motivated "domestic terrorism.* (2016, p. 589)

Table A4 summarizes the possible threats considered in this assessment and the related potential failure modes of the pipeline.

Table A4: Primary Line 5 Threats and Associated Failure Modes.

Threats	Mode	Pipes Likely Affected
~~*Corrosion*~~	~~Pinhole leak~~	~~One 20"~~
Cracking (defects and fatigue)	Larger area hole	One 20"
Spanning-related stress	Guillotine rupture	One 20"
3rd Party damage	3" ~~Any~~ hole size	One or both 20"
Incorrect Operation ~~*(over pressure/hammer shock)*~~	ANY SIZE HOLE TO Guillotine rupture	One or both 20"

Secondary Cause.

A.2.5 System Detection and Response Time

The total response time to an incident equals the spill detection time plus the time required to decide how to respond and to isolate the affected pipeline section, as shown below:

$$\text{Total Response Time} = \text{Spill/Leak Detection Time} + \text{Decision/Isolation Time} \qquad (1)$$

A.2.5.1 Spill/Leak Detection Time

Based on real-time transient model sensitivity performance testing on Line 5 following API 1130 conducted in fall of 2017, the Computational Pipeline Monitoring (CPM) system can detect a rupture immediately, and a small leak in 30 minutes or less. Exact detection times are confidential but have been provided for this analysis.

A scenario where either the loss of containment is not detected by the CPM or a detected leak is ignored due to human error, leading to a longer than expected detection time, is also plausible. Leak detection systems complemented by a Supervisory Control and Data Acquisition (SCADA) and CPM, such as those in place at the Straits crossing, are used by the pipeline industry to reduce both the frequency and volume of liquid (oil and natural gas liquids) and gas spilled. In addition to aiding in leak detection, SCADA and CPM systems are capable of quickly closing valves and shutting down the pumps. Leak Detection (LD) and monitoring systems are essential tools for any pipeline operator. The primary purpose of an LD system is to detect and provide the approximate location of the leak. A system that is automated could provide for a timely warning and could prevent a major spill by closing valves and stopping the flow in a pipe.

There are two major categories of LD, internal and external; both of them use technologies such as sensors detecting hydrocarbons, acoustic, temperature variation, pressure drop and material balance. Operators install a combination (hybrid) of these systems because the pipeline is used to transport various products such as crude, refined and Natural Liquid Gas (NLG) using the same conduit according to seasonal needs. These detections systems are only accurate for steady-state operations. A pipeline under transient conditions (start-up and shut-down) produce additional background noise which results in inaccurate detection. It is critical for operators to have exact procedures to minimize the potential for error during start-up and shut-down.

5, upstream and downstream of the Straits. In addition, our practice is to dispatch staff to site to control any manual valves in the area, which would include closing the valves at the Straits. Such actions would take between 15 minutes to 2 hours depending on the time of day and location of existing personnel. (Shamla 2015, emphasis added):

This length of time seems appropriate given that, although there are Enbridge personnel based locally in the Straits area, in a worst case scenario with severe weather conditions, travel could be difficult and the Mackinac Bridge could be closed, significantly increasing the typical response time. Furthermore, we requested that Enbridge estimate the time that would be required to manually close the valves at the north side of the Straits only, thus interrupting the flow toward the underwater portions of Line 5. This time has been estimated by Enbridge to be approximately 1 hour. Therefore, we have also estimated the volume that would be released in a scenario where the northern end of the Straits pipelines is closed after one hour.

A.2.6 Tiers of Failure

As previously defined in Table A4, several failure types were considered based upon plausible threats. In Table A5 below, these threats are now grouped into five Tiers of failure in order of severity in creating plausible worst case scenarios.

Table A5. Primary Threats Induced Pipeline Manifestation

Threats	Manifestation	Pipes Likely Affected	Tier
Spanning stress	Guillotine rupture	One 20"	Tier 1 Rupture or Pin-hole in one 20" line with immediate response
Cracking (fatigue)	Larger area hole	One 20"	
~~*Corrosion*~~	~~Pinhole leak~~	~~One 20"~~	
Third-party damage	Any hole size	One 20"	Tier 2 Rupture or Pin-hole in one 20" line with maximum allowable response time
Incorrect Operation (~~over-pressure/hammer shock~~)	~~Guillotine rupture~~ 3" HOLE	One or both 20"	Tier 3 ~~Rupture in~~ both 20" lines with primary valve failure
Third-party damage	Any hole size to rupture	One or both 20"	Tier 4 Rupture in one 20" line with manual valve closure Tier 5 Rupture in both 20" lines with manual valve closure

FLOW
FOR LOVE OF WATER

Protecting the Common Waters of the Great Lakes Basin
Through Public Trust Solutions

Public Comment on
Independent Risk Report
By FLOW's Executive Director, Elizabeth R. Kirkwood
August 13, 2018

- I'm Liz Kirkwood, Executive Director of FLOW (For Love of Water), a Great Lakes water law and policy center based in Traverse City.

- Thank you Dr. Meadows and the entire team for your hard work in preparing this draft risk report to evaluate the risk a Line 5 spill poses to the Great Lakes.

- In an effort to educate citizens and leaders alike about the risk and magnitude of harm from a catastrophic oil spill in the Great Lakes, my organization commissioned and released an MSU-led economic impact and damage study on a potential Line 5 spill in May of this year. This study puts credible numbers behind what common sense tells us, that a Line 5 spill could cause catastrophic economic impacts in addition to environmental destruction. It's another compelling reason for the state to take swift action to shut down Line 5

- What the FLOW report and the state's report demonstrate is this: Line 5 poses an unacceptable risk to the Great Lakes and the State of Michigan. Period.

- The message is the same. The risk and potential harm is unfairly burdens the citizens, businesses, and tribes of Michigan, and the freshwaters of the Great Lakes.

- A spill from Enbridge's Line 5 could contaminate nearby municipal drinking water intakes, devastate some of the commercial, recreational, and tribal fisheries of the Great Lakes, kill aquatic and terrestrial wildlife, impair critical ecosystem services, diminish coastal property values, and tarnish the image of the state of Michigan and perceptions of its high levels of ecological integrity. Even bigger impacts would damage Michigan's critical tourism industry.

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- The study estimates $697.5 million in costs for natural resource damages and restoration and more than $5.6 billion in total economic impacts, including:

    - $4.8 billion in economic impacts to the tourism economy;
    - $61 million in economic impacts to commercial fishing;
    - $233 million in economic impacts to municipal water systems;
    - over $485 million in economic impacts to coastal property values.

- The latest publicly available information regarding Enbridge's liability coverage for Line 5 dates back to 2015 and is capped at $700M – a far cry from the multi-billion estimates from both independent credible reports.

- It is our understanding that the Attorney General's office has not negotiated any additional liability coverage. Where does this leave Michigan citizens, communities, tribes as we brace for a Line 5 disaster every day?
- Thank you.

Liz Kirkwood, Executive Director

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Attachment to Comment 26

FLOW
FOR LOVE OF WATER

Protecting the Common Waters of the Great Lakes Basin
Through Public Trust Solutions

Public Comment on
Independent Risk Analysis for the Straits Pipelines
By FLOW's Legal Intern, Julius Moss
August 13, 2018

Hello, my name is Julius Moss and I am a Legal Intern with For Love of Water (FLOW).

I want to start by thank you all the hard work that you put into this comprehensive Risk Analysis.

First and foremost, the Risk Analysis demonstrates that Line 5 poses an unacceptable risk to the Great Lakes and the State of Michigan. My comments will focus on how the study's conservative underlying assumptions understate the harm a worst-case scenario ("WCS") Line 5 spill would cause to the Straits of Mackinac.

For example, the Risk Analysis' WCS assumes Enbridge will be able to detect a rupture in the dual pipelines immediately due to Line 5's automated leak detection systems. However, a PHMSA-funded report found that between 2010 and 2012 pipeline company employees and/or contractors detected the largest number of pipeline leaks. The public ranked second. Automated leak detection systems ranked third.

Additionally, the Risk Analysis assumes that impacts to Michigan's tourism and recreational economy will last only a year after a WCS Line 5 spill. This assumption is based on a Deepwater Horizon ("DWH") oil spill recreational study. However, the DWH spill and a potential Line 5 spill are significantly different. The DWH spill occurred approximately 41 miles offshore, while a Line 5 spill would occur two miles offshore at most. Moreover, given Line 5's proximity to the shoreline of Lake Michigan and Lake Huron, a release of oil from Line 5 would likely have greater impacts, in terms of both the scope of impacts and their duration.

Furthermore, the Risk Analysis assumes that lost amenity values to residential properties will total $2.6 million. This ignores the effects a Line 5 spill would likely have on the coastal properties of both the lower and upper peninsulas, as well as Mackinac and Bois Blanc Island. This underestimate is similar to the Risk Analysis' assumption that the commercial fishing industry will only be impacted for one season, even though the Risk Analysis states that fish stocks may face irrevocable harm and might not fully return to an altered habitat in the Straits area.

In conclusion, the Report's assumptions dramatically understate the true harm a Line 5 spill could inflict on the Great Lakes and the State of Michigan. Despite these gross underestimates, the Risk Analysis' findings still demonstrate that Line 5 posses an unacceptable risk to our Great Lakes State. We must decommission Line 5 and ensure that the Straits of Mackinac do not experience the irrevocable harm that is presented in this report.

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Thank You,
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Attachment to Comment 37

Tip of the Mitt Watershed Council
Comment Regarding the Draft Final Report
Independent Risk Analysis for the Straits Pipelines
A Multi-organizational Initiative Led by Michigan Technological University
August 19, 2018

Tip of the Mitt Watershed Council, on behalf of its 2,700 plus members, would like to thank you for the opportunity to provide comments on the Draft Final Report Risk Analysis for the Straits Pipelines (Draft Report), prepared by Michigan Technological University, released on July 16, 2018.

As a means of introduction, Tip of the Mitt Watershed Council, founded in 1979, is a nonprofit organization based in Petoskey, Michigan whose purpose is to protect, restore, and enhance water resources, including inland lakes, rivers, wetlands, groundwater, and the Great Lakes. We have staff appointed by Michigan's Governor to serve on the Michigan Pipeline Safety Advisory Board. We base all our programs on sound science and policy analysis, and have garnered respect for our work from local, state, and federal agencies, businesses, fellow environmental organizations, and citizens. Pursuant to our mission to safeguard our waters, we reviewed the Draft Report and offer the following comments.

Overall

We would like to commend Dr. Guy Meadows and his team of researchers for the hard work, time and effort that went into the completion of the draft report. Overall, the report is comprehensive and thorough and it was drafted in a timely manner. Completion of this report is essential to help guide decisions about the future of the Line 5.

We appreciate the approach taken with respect to the "worst case" scenario to attempt achieve the maximum possible loss level and using different worst case scenarios based upon the task being evaluated. The methodology used accurately captures the fact that Line 5 in the Straits of Mackinac are a low probability, high consequence scenario. However, we believe assumptions made resulted in conservative estimates. Oil spills are rarely detected immediately. In addition, the tiers of failure are based upon Enbridge Energy properly following operating procedures. History of oil spills, including Enbridge incidents in Michigan, has shown that human error comes into play more often than not and operating procedures are not always properly implemented in emergencies.

In addition, Enbridge transports synthetic crude derived from the oil sands in Western Canada through Line 5. We have little, if any at all, science on how this particular product behaves in a freshwater environment in the event of a spill. The National Academies released a report, "Spills of Diluted Bitumen from Pipelines: A Comparative Study of Environmental Fate, Effects, and Response," that concludes that bitumen, if spilled, has unique properties that affect its behavior in the environment. What we do not know is if weathering of the synthetic crude would be similar to weathering of diluted bitumen and if it would also generate a residue similar to the initial bitumen that may be more likely to submerge. This unknown could dramatically impact both the fate and transport and ability to contain and cleanup an oil spill in the Straits.

In general, the report would be improved if many of the tables were formatted in a manner that was easier for readability and public consumption.

Specific Comments

Introduction

- Correct the formal title of the owner and operator of Line 5. In legal documents with state and federal governments, including the 2016 Consent Decree and the November 2017 Agreement, the owner of Line 5 is referred to "Enbridge Energy, Limited Partnership, " as opposed to "Enbridge Energy Limited Partners.' (p. 32)
- Acknowledge that the risk to the public trust waters of the Great Lakes does not solely come from the twin pipelines located on the State-owned bottomlands in the Straits of Mackinac. The text mentions that line 5 crosses navigable waters and is located near Great Lakes shorelines, but fails to state that a leak or rupture along this portion could still result in an oil spill in Lakes Michigan-Huron and the Straits of Mackinac. This is emphasized in Task X. U.S. Coast Guard (USCG) personnel and emergency managers both pointed to the stretch of the pipeline along U.S. Highway 2 near Lake Michigan's northern shore as their worst-case scenario, citing a combination of less robust technology such as pipeline wall thickness and monitoring equipment, as well as higher vulnerability to an errant strike and potential access problems for containment and cleanup equipment, as well as difficult terrain and environment for cleanup activities. (p. 33)
- When making the comparison between the 2010 spill from Enbridge's Line 6B into the Kalamazoo River and a spill in the Straits, it is important to highlight the difference between spills in a riverine ecosystem versus an open water system. Riverine environments by their nature often allow for easier and greater containment and recovery of oil than open water spills. Unlike in open water or the Straits of Mackinac, currents in a river are generally directed downstream. This greater predictability of river currents makes it easier to forecast which way the oil will move. (p. 33)

- The tasks and scenarios are listed in Table 1. but are not provided or noted prior in the text. Tasks need to be explained or laid out in the beginning of the introduction so the table is understandable. (p. 35)

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

- Coating gaps were confirmed at more than three locations. Three locations were identified as a result of the diver inspections conducted at anchor locations. However, the biota investigation, conducted as part of the Consent Decree, identified eight additional bare spots. These coating gaps need to be acknowledged in the report. (p. 46)
- The draft report acknowledges scenarios where loss of containment is not detected by Computational Pipeline Monitoring (CPM) or a detected leak is ignored due to human error, leading to a longer than expected detection time. However, the report fails to account for these plausible scenarios in identifying the worst-case release. The total expected decision and isolation times of 3.5 minutes, if the decision to shut down is made immediately, and 13.5 minutes, allowing for the full allotted decision-making time, should be modified to account for such feasible and likely situations. (p. 49)
- The automatic valves on either sides of the Straits will only close in the event of a rupture, where there is a drop in pressure significant enough to trigger the closure. The valve on the west line automatically closes if pressure levels fall below 65 psi and the valve on the east line automatically closes if pressure drops below 45 psi. A leak would not drop pressure below this threshold to trigger the automatic closure. (p. 49)
- Tiers 4 and 5 only account for the two hour response time for a manual valve closure. The initial detection time is not included, which would be 10 minutes **IF** Enbridge procedures were properly followed and not subject to human error. In addition, based upon history of Enbridge incidents as well as other oil pipeline spills, it is not necessarily reasonable to expect that a large spill would be isolated within a two-hour window. (p. 52)

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

- Correct the formal title of the owner and operator of Line 5. In legal documents with state and federal governments, including the 2016 Consent Decree and the November 2017 Agreement, the owner of Line 5 is referred to "Enbridge Energy, Limited Partnership." (p. 62)
- In the oil dispersal simulations, particles were released on the water surface owing to specific gravities that are less than that of water. However, we have little, if any at all, science on how this particular product behaves in a freshwater environment in the event of a spill. The National Academies released a report, "Spills of Diluted Bitumen from Pipelines: A Comparative Study of Environmental Fate, Effects, and Response," that concludes that bitumen, if spilled, has unique properties that affect its behavior in the environment. What we do not know is if weathering of the

synthetic crude would be similar to weathering of diluted bitumen and if it would also generate a residue similar to the initial bitumen that may be more likely to submerge. (p. 67)

- The light synthetic commodities transported through Line 5 generally have a lower mass percentage of BTEX compounds than the other sweet or sour commodities. It would be more prudent to estimate the emissions of BTEX compounds based upon the other commodities to represent a true worst-case scenario. (p. 72)
- It is important to mention that once all the lighter compounds have evaporated, some oils can be close to the density of water. Additionally, when floating, semi submerged or dispersed oil comes into contact with suspended sediment, the sediment can bind to it causing the oil to sink. (p.82)

Task C: Analyzing how long it takes to contain and clean up the worst-case release

- The Northern Michigan Area Contingency Plan was updated in 2017. The most recent version can be accessed at https://homeport.uscg.mil/Lists/Content/Attachments/20682/NMACP.pdf. (p. 89, 96)
- The report mentions that the throughput efficiency of the Current Buster equipment was high in calm seas, and is approximately 80% in chop up to 1 ft., when towed at lower speeds. It would also be helpful to include when the Current Buster is no longer efficient or cannot be operated. (p.91)
- In Table C2, in the category "Description and limitation," "limitation" needs to be plural. (p. 94)
- Table C2 was meant to provide the description and limitations for equipment used for oil containment and recovery on shorelines. However, the table only includes a descriptions of the strategies. Limitations of the strategies were not included and should be. (p.94)
- Additional documents regarding emergency response in the Straits of Mackinac should be reviewed by the team. Enbridge's Straits of Mackinac Tactical Response Plan and the Straits of Mackinac Emergency Response Self-Assessment would have more information specific to the Straits and could provide essential information pertinent to the analysis.
- Significant effort has gone into exploring the use of in-situ burn (ISB) technology to enhance preparedness for pollution incidents on the waters of Northern Michigan. ISB is the intentional burning of floating oil as a method to remove large amounts of oil from the water's surface. The workgroup consisted of Area Committee members, including the U.S. Coast Guard, Environmental Protection Agency, National Oceanic and Atmospheric Administration, Michigan Department of Health and Human Services, U.S. Fish and Wildlife Service, Tribal sovereign nations, Michigan Department of Environmental Quality, and others. To establish a framework for the application of ISB on the Great Lakes, the workgroup reviewed hundreds of pieces of research publications and collaborated with research entities and academia including the Coast Guard Research and Development Center. The workgroup also studied information about ISB use in Alaska to gain best practices for utilization in severe cold weather

environments. The group's efforts culminated in a set of guidelines to request approval for use of ISB on the waters of the Great Lakes in Northern Michigan. In August 2017, U.S. Coast Guard, Sector Sault Sainte Marie, in partnership with member agencies from federal, state, local and tribal stakeholders, held a widely attended environmental workshop in Mackinaw City, Michigan, to determine the feasibility of using ISB as a response tactic in addition to mechanical recovery of an oil spill in the Straits of Mackinac. The Area Committee and Regional Response Team 5 (RRT 5) members discussed the risk versus reward of ISB, operational parameters necessary to conduct ISB, and public outreach. This workshop was the first of its kind in RRT 5 to evaluate the use of an alternative technology on the Great Lakes. (p. 97)

- Can the recovery rates provided by Enbridge Energy be verified by an independent third party? The rates provided seem extremely optimistic and unrealistic. (p.105/106)
- Unfortunately, not all incidents are discovered immediately and not all incidents are reported immediately. In fact, only certain incidents are reportable under current law. Therefore, not all entities, including Mackinac county emergency office, USCG Sector Sault Ste Marie and other state offices will be notified within minutes of an incident. (p.107)
- Were the Straits weather conditions taken into consideration for time estimates for deployment and staging of booms? Adverse weather conditions in the Straits region can hinder, if not prevent, deployment of boom. (p. 107)
- Two different recovery rates are provided for the response equipment available at the Straits, including the Current Buster II, Current Buster IV and Lamor bucket recovery system. One is estimated using the Genwest Estimated Recovery Systems Potential calculator and the other with no explanation (Ex. Current Buster II based on the Estimated Recovery Systems Potentials calculator is 1,551 US gallons/hr. or 36.9 bbl./hr. versus other is 3,780 gallons/hr. or 90 bbl./hr.) One recovery rate should be provided or provide an explanation to clarify the difference. (p.108)
- Note the time unit in Figures C6 and C7. (p.112/113)
- Include the original volume discharged in Table C6. (p. 113)

Task D. Analyzing the short and long-term public health and safety impacts

- There are federally recognized Indian Tribes that are not included in the populations at risk. Emmet County is home to the Little Traverse Bay Bands of Odawa Indians and Hannahville Indian Community is located in Menominee County. Based on the fate and transport simulations, both of these Tribes could be impacted by an oil spill in the Straits of Mackinac. (p. 126)
- McLaren Northern Michigan has a campus in Cheboygan, which is located directly in the affected region on the southern side of the Mackinac Bridge. (p. 128)
- Michigan Water Quality Criteria should be used rather than Oregon Water Quality Criteria or provide an explanation of why Michigan's criteria is not being used. (p. 131)
- Table D2. is missing the carcinogenic classification for both Carbon monoxide and Carbon dioxide. (p.132)

- It would be helpful to make Table D4 easier for public consumption. I would suggest color coding or some way to signify which ones are acceptable/negligible risks versus serious harm.
- Emmet County has only one "t." (p. 157)
- Make clear that the use of dispersants or other oil emulsifiers is not pre-approved anywhere in the Great Lakes. (p. 161)

Task E. Analyzing the short and long-term ecological impacts

- Michigan's Water Quality Standards should be used, if possible. If not, a justification should be provided explaining why not. (p. 183)
- According to the Great Lakes Coastal Wetland Consortium, Michigan has approximately 275,748 acres of coastal wetlands. This does not represent 73% of all coastal wetlands in the Great Lakes. (p. 194)
- In the listing of rare or endangered species located within the coastal dunes, the "t" in Lake Huron tansy and the "g" in Houghton's goldenrod do not need to be capitalized. (p. 194)
- Third full sentence, there is a typo with the word "observed." (p. 197)
- Dreissenids would include zebra and quagga mussels, not brown mussels. (p. 198)

Task F: Analyzing potential measures to restore the affected resources and mitigate adverse impacts upon ecological and cultural resources

- It would be helpful to explain the Natural Resource Damage Assessment (NDRA) process as part of the Introduction as well as defining "trustee" under NRDA. (p. 236)
- It should be noted that restoring wetlands does not produce the same functions and values as the original, natural wetland. Despite our best attempts, we cannot create nature better than nature itself. (p. 245)
- The approach for restoring wetlands is missing information regarding how to properly address threatened and endangered species. (p. 245)
- Under Macrobenthos, "straits" should be capitalized. (p. 253)

Task G: Estimating the amount of natural resource and other economic damages, public and private, that would result from a worst-case release

- It is unwise to rely on the Dynamic Risk Report. That report was highly criticized by all stakeholders because it was riddled with flawed methodologies and assumptions, had extensive data gaps, and ultimately failed to meet the scope and statement of work. (p. 310)
- According to the report "Economic Impacts of Maritime Shipping in the Great Lakes – St. Lawrence Region," released July 2018, cargo moved on the Great Lakes-St. Lawrence Seaway System totaled 143.5 million metric tons (158.3 million short tons) valued at $15.2 billion. This commerce supported 237,868 jobs and $35 billion in economic activity. (p. 307)
- Line 5 is 645 miles and transports synthetic crude, in addition to light crude. (p 308)

- The team should review and amend the section Effects on Michigan's Energy Supply, as appropriate, based upon a recent report "Assessment of alternative methods of supplying propane to Michigan in the absence of Line 5," prepared by London Economics International LLC. (p. 308)

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

- The Northern Michigan Area Contingency Plan was updated in 2017. The most recent version can be accessed at https://homeport.uscg.mil/Lists/Content/Attachments/20682/NMACP.pdf. (p. 335)
- This section needs a concluding summary, similar to the other Tasks. (p. 348)

Summary of Costs

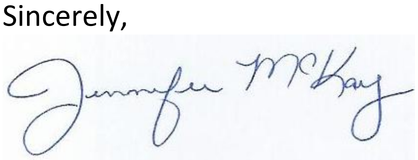
- A more detailed and comprehensive summary should be compiled. The summation should include the conclusions or results from each of Tasks providing the overall consequences of a worst-case scenario spill so the State of Michigan can establish the amount of the required financial assurance and to help guide decisions about the future of the Pipeline. (p.395)

Conclusion

We need a thorough, comprehensive and complete Risk Analysis to provide vital information to inform future decisions on Line 5. The Draft Report provides a solid foundation for this. The Watershed Council again thanks Michigan Technological University, notably Dr. Meadow and his team of researchers, for the time and expertise put forth in developing the Draft Risk Analysis Report. We urge you to give careful consideration to the comments provided and make the suggested changes to improve the final report.

Thank you for the opportunity to provide comments. If you have questions regarding these comments, please do not hesitate to contact me at 231-347-1181 or by email at jenniferm@watershedcouncil.org.

Sincerely,



Jennifer McKay
Policy Director

Tip of the Mitt Watershed Council
426 Bay Street
Petoskey, Michigan 49770

FOR LOVE OF WATER

Protecting the Common Waters of the Great Lakes Basin
Through Public Trust Solutions

August 17, 2018

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VIA ELECTRONIC SUBMISSION

RE: FOR LOVE OF WATER PUBLIC COMMENTS AND REPORT ON MICHIGAN TECHNOLOGICAL UNIVERSITY INDEPENDENT RISK ANALYSIS FOR STRAITS PIPELINES AS REQUIRED PURSUANT TO EXECUTIVE ORDER NO. 2015 – 14 AND PROCEEDINGS OF PIPELINE SAFETY ADVISORY BOARD AND GOVERNOR-ENBRIDGE AGREEMENT, NOVEMBER 27, 2017

Dear Governor Snyder, Attorney General Schuette, Michigan Department of Environmental Quality ("MDEQ") Director Grether, Michigan Public Service Commission ("MPSC") Chair Talberg, Michigan Department of Natural Resources ("MDNR") Director Creagh:

For Love of Water ("FLOW") submits the following public comments for the public record regarding the proposed decisions and actions pursuant to recommendations of the Pipeline Safety Advisory Board ("PSAB" or "Advisory Board"), Executive Order No.2015 – 14, and the Agreement entered into between Governor Snyder and Enbridge on November 27, 2017 ("Agreement" or "November 2017 Agreement").

In the spirit of this public notice and request for thoughtful comments, FLOW submits the following analysis, comments, and conclusions regarding the Independent Risk Analysis for the Straits Pipelines ("Risk Analysis"). The following analysis and comments address: (1) the methodology and assumptions

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utilized in the Risk Analysis assessments; (2) the conclusions reached in the Risk Analysis; (3) the discrepancies between the Risk Analysis' findings and Dr. Robert Richardson's report entitled, *Oil Spill Economics: Estimates of the Economic Damages of an Oil Spill in the Straits of Mackinac in Michigan* ("Economic Impact Report"), commissioned by FLOW; and (4) the lack of information regarding Enbridge's current insurance liability policies or other financial assurances covering the range of costs and damages estimated by the Risk Analysis and Economic Impact Report from a potential Line 5 oil spill.

FLOW would also like to thank Dr. Meadows and his entire team for their diligent work in preparing and completing the Risk Analysis, including the inclusion and evaluation of FLOW's previous technical reports and comments into the draft and final Risk Analysis.[1]

SUMMARY OF COMMENTS

Based on our review and analysis of the Risk Analysis, as well as several technical and legal reports and recommendations previously submitted to the Governor, Attorney General, MDEQ Director, MDNR Director, MPSC, and PSAB, we submit the following comments:

1. Three years ago, the Michigan Petroleum Pipeline Task Force ("Task Force") recommended a comprehensive and independent risk assessment and independent alternatives assessment on Line 5. Created by Governor's Executive Order No. 2015 – 14, the PSAB was charged to implement and oversee both independent assessments. Because of conflicts of interest, the risk report process was derailed until the state retained Dr. Guy Meadows and Michigan Technological University ("MTU") to assist the PSAB recommendations on Line 5. The completion of this Risk Analysis represents the first point in time that an independent risk assessment has been provided to the PSAB and State of Michigan on Line 5 and Straits of Mackinac. As a result, the Governor-Enbridge 2017 Agreement narrowing the alternatives to a replacement of Line 5 in the Straits was premature and ignored independent risk and alternative recommendations as required by the Task Force and Executive Order No. 2015 – 14.

2. The Risk Analysis' definition of a worst-case scenario ("WCS") is consistent with the federal definition of "the largest foreseeable discharge of oil" in 40 CFR 194.105, and therefore is a more accurate estimate of the potential impacts from a Line 5 spill than the less reliable spill scenario identified in the 2017 Dynamic Risk Alternatives Report ("DR Report"). The DR Report admits that it does not comply with 40 CFR 194.105 and industry standards for hazardous risk analysis. Accordingly, the state should not rely on the DR Report in any decisions concerning an adequate risk analysis or alternative analysis for the high-level or imminent ("tier 1"[2]) risks associated with Line 5 in the Straits of Mackinac.

[1] Specifically, Dr. Richardson's study *"Oil Spill Economics: Estimates of the Economic Damages of an Oil Spill in the Straits of Mackinac in Michigan"* ("Economic Impact Report") that was produced for FLOW as well as Richard Kane's memo "Defining a Worst-Case Release Scenario for the Enbridge Crude Oil Pipelines Crossing the Straits of Mackinac – Line 5." Although there are differences both in the methodology and conclusions of FLOW's previous work and the Risk Analysis performed by Dr. Meadows, both studies clearly demonstrate that Line 5's Mackinac Straits crossing poses an unacceptable risk to the Great Lakes and the State of Michigan.

[2] Line 5 is categorized as a high level "Tier 1" risk and constitutes a substantial and imminent harm or endangerment. The definition of "imminent" risk of harm for transporting hazardous materials, like crude oil, is defined as "the existence of a condition relating to hazardous material that presents a substantial likelihood that death, serious illness, seer personal injury, or a substantial endangerment to health, property, or the environment…" 49 USC §5102 (Title 49, Transportation, Subtitle III, Chpt. 51).

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3. Even though the Risk Analysis arrives at an adequate "worst-case-scenario" ("WCS"), underlying assumptions should be carefully reviewed for the final report as they relate to the conclusions about the ecological impacts (Task E), economic impacts (Task G), and broader impacts (Task X) from a worst-case scenario Line 5 spill in the Straits of Mackinac and extending across Lake Huron and Lake Michigan. For example, the Risk Analysis assumes only one year of impacts for decreased tourism expenditures. Similarly, the Risk Analysis takes a very conservative approach to commercial fishing and estimates one year of impacts of $0.5 to $1.6 million. In contrast, Dr. Richardson's Economic Impact Report estimates that commercial fishing will face a $61 million-dollar impact.

4. The Risk Analysis glosses over the complex landscape of determining when clean-up and remediation processes are complete. Baseline biological data must be incorporated into the report to fully comprehend the goals of any clean-up and remediation process and whether those goals were satisfied.

5. The Risk Analysis concedes that mental health issues and drinking water contamination are serious concerns after disasters such as a potential oil spill in the Straits. However, the Risk Analysis concludes that the public health and safety consequences following a WCS Line 5 spill would be minimal.

6. Differences in methodologies and assumptions explain the different economic outcomes posited in Dr. Richardson's Economic Impact Report and the economic damage numbers of the Risk Analysis; a careful reevaluation of assumptions in the Risk Analysis is likely to lead to more realistic economic damage estimates affecting water resources, natural resources, public and private property, tourism, and tribal interests.

7. The PSAB should utilize the Risk Analysis as well as Dr. Richardson's Economic Impact Report to conclude and finally determine that Line 5 poses an unacceptable risk to the Great Lakes, natural resources, public health, property, quality of life, and Michigan's economy.

8. Given the high-level of damage and severe disturbance to the lives of communities and citizens of Michigan, the state's current handling of Enbridge's bond and/or equivalent coverage of the potential damage falls far short of protecting the water, natural resources, public health, quality of life and economy of the state. Accordingly, the state must demand that Enbridge secure immediate liability coverage for Line 5 in the amount of $2 billion or more.

I. THE STATE OF MICHIGAN'S TROUBLED HISTORY OF IMPLEMENTING THE MICHIGAN PETROLEUM PIPELINE TASK FORCE RECOMMENDATIONS

Enbridge is known in Michigan for its catastrophic Line 6B pipeline rupture in 2010, causing the largest inland oil spill in U.S. history with clean-up costs exceeding $1.2 billion along a 40-mile stretch of the Kalamazoo River.[3] Between 2010 and 2013, Enbridge systematically and strategically expanded Line 6B's (now Line 78) pipeline average capacity from 283,000 barrels per day ("bbl") to 500,000 bbl from Flanagan, IL to Sarnia, Ontario (with ultimate design capacity at 800,000 bbl) and increased Line 5's volume over 10 percent from 490,000 bbl to 540,000 bbl. After the Kalamazoo disaster, instead of systematically examining the impacts to Michigan's air, water, and land and requiring Enbridge to

[3] See https://www.epa.gov/enbridge-spill-michigan

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evaluate feasible and prudent alternatives, the State of Michigan allowed Enbridge to expand its pipeline operations across the state in piecemeal fashion without the full public scrutiny required under law.

It wasn't until 2014 that State officials took steps to address the 65-year old Line 5 in the Straits of Mackinac. Governor Snyder established the Petroleum Pipeline Task Force ("Task Force") by executive order to make recommendations on Line 5 and other hazardous liquid pipelines in the state. A year later, the Task Force released its report with four key Line 5 recommendations to address the unacceptable risk of a release of crude oil in the Straits: (1) ban heavy crude oil; (2) demand additional information from Enbridge; (3) obtain a comprehensive independent analysis on risk (including "worst-case") and magnitude of harm; and (4) an analysis of alternatives that would lead to a removal of this unacceptable risk to the Great Lakes.

The Task Force recommendations formed the basis of the Governor's executive order that established the PSAB in September 2015 to facilitate the completion of these independent reports and make recommendations regarding decisions and actions of state officials to remove and prevent the high, unacceptable risk of Line 5. The PSAB included representatives not only from key state agencies but also from Enbridge and Marathon refineries as well as National Wildlife Federation and Tip of the Mitt.

Despite mounting evidence of Enbridge's ongoing serious violations of the easement and disclosure of evidence documenting the risk of Line 5, it took over two (2) years for completion and publication of the independent alternatives analysis. The independent risk report was not completed, because the draft submitted to the State had to be rejected and terminated because of a conflict of interest on the part of the consultant that had been hired for the report.

A circumstances surrounding the release of the DR's final Alternatives Report on November 20, 2017, also raised significant conflict of interest issues, in addition to nearly 45,000 submitted public comments that documented significant technical and legal errors and omissions, flawed assumptions, and missing data. The actions of Enbridge and handling of the reports by the consultants undermined and jeopardized the objectives of the Task Force, the PSAB, and the validity of any state actions or decisions, because of the endangerment to the waters, public health, property, quality of life and the economy.

In early October 2017, the public learned that Enbridge had failed to disclose evidence that it had in its possession for over three years concerning the condition and failing original design of Line 5 to both Michigan and federal officials. The underwater pipelines had potentially 80 bare metal spots and/or coating gaps close to the 128 total anchor locations in the Straits. Despite knowledge of Enbridge's deception about this engineering design flaw, the MDEQ and the U.S. Army Corps of Engineers ("Corps") approved an additional 22 screw anchors on Line 5 in March 2018. Enbridge's request to install another 48 anchors is pending before the MDEQ and Corps, which will bring the total to 198 anchors or almost three miles of pipeline elevated above the lakebed. The original design called for the heavy steel pipe to be placed on the bottom. The miscalculation of the powerful currents in the Straits has resulted in an original design that has failed, compromising the integrity of the line and increasing the risk even more. Enbridge's total design change that requires more and more anchor supports has never been evaluated or authorized under the Great Lakes Submerged Lands Act ("GLSLA"). This piecemeal authorization has continued because Enbridge and MDEQ have characterized and narrowed the analysis to a "repair' and "maintenance" operation, limiting evaluation to potential impacts around the footprint of each anchor, and ignoring the failing and altered pipeline design and risk from continued flow of crude oil as a whole. In fact, the GLSLA requires Enbridge to demonstrate two findings concerning the entire line: (1) no substantial likelihood of harm, impairment or pollution to public trust waters and resources; and (2)

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no feasible and prudent alternatives to locating oil pipelines in the open waters of the Great Lakes.[4] The GLSLA process is both mandatory and essential given the findings of the MTU Risk Analysis, FLOW reports, including the Economic Impact Report, and other reports that show alternatives to servicing the Upper Peninsula's propane needs and meeting regional crude oil demands within the existing pipeline system.

Just one week after DR's Report was released for public comment without knowledge by the PSAB or notice to the public, Governor Snyder unilaterally announced an agreement with Enbridge on November 27, 2017 to replace Line 5 in the Straits following a fast-track to select an alternative for such a replacement alternative by August 15, 2018.

In sum, the State of Michigan has established a multi-year, multi-phased process that has resulted in disqualifying conflicts of interest for the study consultants, delayed meaningful decisions to protect the paramount interests of the Great Lakes, and allowed Enbridge to continue to profit by transporting 540,000 barrels ("bbl") per day through an aging asset that threatens our public water, property, health, safety, economy and environment. It has taken three years since the Task Force's recommendations for an independent assessment to be completed on risks Line 5 poses to the Great Lakes and the State of Michigan. State decision makers must act now to decommission Line 5, as the Risk Analysis clearly demonstrates that Line 5 poses an unacceptable risk to the people, water, and natural resources of the state. In light of the Risk Analysis and Economic Impact Report's clear evidence that the magnitude of harm and risk are "tier 1" (a high, unacceptable risk of harm), at a minimum, state officials should temporarily suspend crude oil transport in Line 5, pending a directive to Enbridge to comply with the requirements and standards of the GLSLA, or, in the alternative, permanently terminate use of Line 5 in Straits, and implement another alternative that avoids the high risk to the Great Lakes, communities, businesses, and citizens.

II. THE RISK ANALYSIS' DEFINITION OF WORST-CASE SCENARIO

The Risk Analysis sets out to study the potential and likely effects and impacts of a "worst-case scenario" ("WCS") Line 5 spill in the Straits of Mackinac. The Risk Analysis' definition of a WCS is based on the accumulation of worst-case assumptions. The Risk Analysis' approach of determining the WCS is also consistent with the federal government's definition of a "worst-case discharge", which is defined as "the largest foreseeable discharge of oil, including discharge from fire or explosion, in adverse weather conditions" in 49 CFR 194.105.[5] This definition of a WCS leads to a scientifically accurate estimate of the potential impacts from a Line 5 spill or release that would occur as the result of an Enbridge automation or personnel failure, similar to Enbridge's 2010 Line 6B spill in Marshall, Michigan.

The Risk Analysis starts with the above definition and considers several plausible scenarios of primary causes and secondary failures to ultimately determine the WCS for a Line 5 spill in the Straits of Mackinac. The Risk Analysis correctly utilizes only passive protection controls such as fixed secondary containment in arriving at the WCS, properly excluding active controls such as automated block valves that may not work due to mechanical or personnel failure. This approach differs greatly from the DR Report.

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[4] MCL 324.32502

[5] Dr. Guy Meadows, *Independent Risk Analysis for the Straits Pipelines*, July 16, 2018, Michigan Petroleum Pipelines Safety Advisory Board, https://mipetroleumpipelines.com/document/risk-analysis-straits-pipelines, pg. 34 [hereinafter Risk Analysis].

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The state-contracted 2017 DR Report, which did not follow 49 CFR 194.105, utilized active and tertiary controls that it assumed would reduce the magnitude of harm from a release.[6] Because the DR Report evaluated alternatives to Line 5 in the Straits, it chose the Pipeline and Hazardous Materials Safety Administration ("PHMSA") WCS for emergency response planning, which allows a lower level spill or alternative release scenario ("ARS") based on assumptions of no personal or automated controls. For example, the ARS allowed the DR Report to assume shut-down valves would be closed by remote control operations. This assumption allowed the DR Report to drastically reduce the extent of a Line 5 spill. Moreover, the DR Report fell short of the defined ARS by subjectively selecting ideal or optimal results for active control measures, rather than a range based on history of Enbridge or the industry with other spills and releases. As a result, because of an appearance of a conflict of interest described above in section one and these improper assumptions, the DR Report is not credible and should not be relied on for any WCS, risk, or alternatives action or state decision.

However, it should be noted that both the Risk Analysis and the DR Report made assumptions about physical processes, which depending on the time of the year, weather, winds, and temperature, can result in a reduction of the extent of the effects of a spill.[7] Yet, even with this assumption that the extent of harm could be reduced by physical processes, the Risk Analysis concludes that a WCS Line 5 spill in the Straits would result in 58,000 bbl of oil spilling into the Great Lakes, affecting 441 miles of shoreline and creating a potential $1.37 billion economic impact and up to a $1.3 billion dollar price tag to contain and clean-up discharged oil.[8] Dr. Robert Richardson's Economic Impact Report concludes that that impact and damage to a similar Line 5 spill could over $6.2 billion.[9] While the Risk Analysis may understate damage to tourism, property values, and restoration costs, both reports estimate massive damage and harm, which point to an extremely high "tier 1" risk category. These reports, with other documented evidence, point to only one conclusion: the risk and harm of a potential Line 5 spill are unacceptable. The potential effects and impacts from a WCS Line 5 spill are far more than "minimal" and would violate legal standards under the GLSLA, public trust common law, and the Michigan Environmental Protection Act ("MEPA").

III. THE BASELINE ASSUMPTIONS AND METHODOLOGIES THAT SIGNIFICANTLY AFFECT THE RISK ANALYSIS' FINDINGS

The Risk Analysis explicitly states that the analysis utilizes several assumptions in reaching its conclusions on the amount and dispersion of oil spilled, as well as the impact and damage that a spill would likely cause to public trust uses, such as fishing, shipping, drinking water, swimming, boating, tourism, public and private coastal property, and other losses and costs to the state, local communities, public health, and sensitive environments.[10] While the use of assumptions is common in economic forecasting and other scientific studies such as economic and natural resource impact modeling, it is essential to understand the Risk Analysis' underling the assumptions to fully understand how Dr. Meadows and his team came to the final conclusions. In reviewing the Risk Analysis' assumptions, it is readily apparent that the Risk Analysis uses baseline assumptions that help provide an accurate estimate

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[6] *Risk Analysis* at 39.
[7] *Id*. at 38.
[8] *Id.* at 277.
[9] Dr. Robert Richardson, *Oil Spill Economics: Estimate of the Economic Damage of an Oil Spill in the Straits of Mackinac in Michigan*, May 2, 2018, flowforwater.org/wp-content/uploads/2018/05/FLOW_Report_Line-5_Final-release-2.pdf, pg. 32 [hereinafter Economic Impact Report].
[10] *Risk Analysis* at 38.

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of the amount of oil dispersed from WCS Line 5 spill in the Straits. However, other assumptions utilized in the Risk Analysis estimates of WCS' economic impact demonstrate how assumptions can clearly compromise the reliability of the conclusions reached in the Risk Analysis.

The following baseline assumptions underpin the amount of oil dispersed: that a Line 5 leak would be detected immediately, that it would take Enbridge personnel 13.5 minutes to determine the nature and magnitude of the leak and isolate the leak, and that Enbridge personnel could be deployed to Line 5 in the Straits area and manually shut the secondary valves to the dual Line 5 pipelines in the Straits within two hours of leak detection. [11] All of these assumptions are key to determining how much oil is likely dispersed into the Great Lakes during a WCS Line 5 spill in the Straits.

These assumptions about Enbridge's rapid response to a Line 5 leak or rupture affect the predicted volume of oil released and subsequently the distance of shoreline that would be oiled from a WCS spill in the Straits. However, the assumptions employed in the Risk Analysis lead to a rational conclusion that a WCS Line 5 spill would cause approximately 58,000 bbl of oil to be released into the Great Lakes. Although there are scenarios that could produce higher estimates of oil spilled, the Risk Analysis baseline assumptions are reasonable given the vast number of factors that could influence these critical findings.

Although the assumptions that contribute to the Risk Analysis' findings on the amount of oil spilled during a WCS Line 5 spill are reasonable, the same cannot be said for the Risk Analysis' assumptions pertaining to the economic impact a WCS Line 5 spill would cause. The assumptions employed in the Risk Analysis' economic impact analysis greatly underestimate the likely economic impact that would follow a WCS Line 5 spill. Specifically, the Risk Analysis operates under the assumption that an oil spill in the Straits will only have a short-term effect on the region's tourism and recreational economies, commercial shipping industry, commercial fishing, and coastal property values.[12]

For example, the Risk Analysis assumes that the impact to the Michigan's recreational and tourism economy will only last one (1) year from a WCS Line 5 spill in the Straits.[13] This includes impacts to: the number of day-trips to state and national parks, the number of overnight camping trips, and the economic benefits from recreational boating and fishing. The Risk Analysis bases this assumption of a short-term economic impact on a recreation assessment for the Deepwater Horizon ("DWH") oil spill.[14] The recreational assessment for the DWH spill found the number of shoreline visitations had recovered in most areas after one year and recovered in all areas after two years.[15] However, the Risk Analysis does not recognize that the DWH spill and a Line 5 spill are drastically different scenarios. Mainly, that the DWH spill occurred roughly 41 miles off the coast of Louisiana, while a potential Line 5 spill would occur approximately two miles offshore at most.[16] This proximity to the shoreline and coastal communities drastically amplifies the immediate and long-term impacts that a WCS Line 5 spill would likely cause to the recreational and tourism economies of northern Michigan. Moreover, the Risk Analysis does not provide definitions of what constitutes a determination that the recreational economy is no

[11] *Id.* at 48.
[12] *Id.* at 289.
[13] *Id.*
[14] *Id.*
[15] *Id*.
[16] Richard Pallardy, Deepwater Horizon Oil Spill of 2010, Encyclopedia Britannica (April 13, 2018), https://www.britannica.com/event/Deepwater-Horizon-oil-spill-of-2010.

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longer affected, and a lack information regarding how long the loss in economic multiplier effect would last.

In addition, the Risk Analysis grossly underestimates the amount of time it will likely take to remove the dispersed oil and start restoring the water and shorelines of Lake Michigan and Lake Huron. If a WCS Line 5 spill were to occur, and approximately 441 miles of shoreline were affected, then clean-up crews would have to restore over a mile of beach every day to ensure the shoreline would be in adequate condition for the next summer season, when the majority of Michigan tourism and recreational activities take place. Moreover, the Risk Analysis does not provide a clear definition of what constitutes "restoration", "recovery", or "clean-up", and makes no mention of baseline data or measurements that independently verify the effects and impacts are no longer present in the water, shoreline, or affected environment. Without an understanding of when clean-up and remediation may be deemed adequate, the estimate to recreational impacts is difficult to accurately quantify.

The Risk Analysis' assumption of a short-term economic impact does not account for any lingering stigma effects that a catastrophic environmental disaster would likely have. The long-term taint and diminution of property values from a release of hazardous substances and water pollution are well documented.[17] The Risk Analysis' assumption that the reduction in the value of lakefront properties would only amount to $2.6 million is an underestimate of the effects an environmental catastrophe would have on the residential housing market. Furthermore, a WCS Line 5 spill would significantly influence the general public's perception about the quality of recreational activities available in Michigan, such as boating, swimming, and fishing. The Risk Analysis fails to address how a Line 5 spill would affect the "Pure Michigan" brand that helped spur $2.1 billion in visitor spending last year.[18]

The Risk Analysis also assumes that the effects to commercial fishing from a WCS Line 5 spill would only persist for one (1) year. The Risk Analysis concludes that reduction in whitefish, trout, walleye, yellow perch, and chinook salmon harvests would not be impacted in the second season after a WCS Line 5 spill.[19] This assumption contradicts the Risk Analysis previous conclusion that there would likely be irreversible harm to fish populations and fish habitat in the Straits area.[20] Additionally, studies of prior oil spills, such as the Exxon Valdez spill, have determined that these spills significantly affected marine wildlife and habitat for over a decade.[21] Therefore, the Risk Analysis assumption that commercial fishing will only be impacted for a year after a WCS Line 5 spill is highly unlikely.

In conclusion, the assumptions made in the Risk Analysis significantly affect the Risk Analysis' ability to accurately estimate the natural resource damage, impacts to coastal and adjacent property values, and impacts to the Straits and "Pure Michigan" economy from a WCS Line 5 spill in the Straits. The Risk Analysis fails to assess the long-term damages from a WCS Line 5 spill in the Straits, and ultimately

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[17] *Economic Impact Report* at 31.
[18] Lansing State Journal Editorial Board, *Editorial: Who Knew Michigan was a Tourist Destination? Everyone Apparently*, Lansing State Journal (May 24, 2018), https://www.lansingstatejournal.com/story/opinion/editorials/2018/05/24/editorial-medc-statistics-show-pure-michigan-gaining-momentum/641696002/.
[19] *Risk Analysis* at 307.
[20] *Id.* at 211.
[21] Justin Gillis and Leslie Kaufman, *After Oil Spills, Hidden Damage Can Last for Years*, New York Times (July 17, 2010), https://www.nytimes.com/2010/07/18/science/earth/18enviro.html.

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underestimates the risk Line 5 poses to the State of Michigan, Wisconsin, Canada, and the Great Lakes. Therefore, the Risk Analysis assumptions must be reevaluated and revised to ensure the final report accurately represents the risk Line 5 posses to the Great Lakes and the State of Michigan.

IV. THE RISK ANALYSIS LACKS CLEAR DEFINITIONS AND STANDARDS FOR THE CLEAN-UP AND REMEDIATION PROCESS OF A WCS LINE 5 SPILL

The Risk Analysis estimates that time to clean up oils on the shorelines of Lake Michigan and Lake Huron will take anywhere from one (1) to two (2) years.[22] The Risk Analysis briefly explains that "the decision for when cleanup is complete is made by the [Federal On-Site Coordinator] FOSC."[23] This brief explanation does not adequately describe the complex process of determining when clean-up and remediation efforts are complete, and what standards and/or processes must be completed or met before such a critical decision is made.

While there is no singular federal or state guideline for oil spill clean-up standards, the Federal On-Site Coordinator ("FOSC") is guided by several key factors, including the results from net environmental benefit analysis ("NEBA") and mass balance calculations that determine the percentage of oil recovered. Understanding how the FOSC and appropriate state officials determine when water resources or shoreline are "clean" or "remediated" is fundamental to evaluating the potential duration of the clean-up process after a WCS Line 5 spill.

The final Risk Analysis should articulate the complex nature of clean-up standards and guidelines in the event of a catastrophic oil spill. Without an explanation of how the FOSC and coordinated state officials determine when a segment of shoreline is deemed "clean" or "remediated," the Risk Analysis fails to fully describe how shoreline clean-up would be completed within 12 to 24 months.[24] Furthermore, the Risk Analysis also should explain how baseline biological data can help evaluate the remediation process. If no such baseline biological data currently exists for the Straits area that could be impacted by a WCS Line 5 spill, the Risk Analysis should recommend that baseline data be acquired as soon as possible so that if a Line 5 spill were to occur, the FOSC and appropriate state officials can utilize this baseline information to efficiently determine when the necessary clean-up and remediation processes are complete.

V. UNDERSTANDING THE DIFFERENCES BETWEEN THE RISK ANALYSIS AND DR. RICHARDSON'S ECONOMIC IMPACT REPORT

The Risk Analysis and Dr. Richardson's Economic Impact Report both seek to quantify the economic and ecological impacts from a Line 5 catastrophic oil spill in the Straits of Mackinac. Despite differences in economic impact costs, both reports demonstrate that Line 5 poses as an unacceptable and imminent risk to a complex dynamic and vulnerable ecosystem. This section, however, details what assumptions contributed to numerical differences between the reports.

One fundamental difference between the reports is that the State of Michigan tasked Dr. Meadows' team to conduct a worst-case-scenario risk analysis, where as Dr. Richardson's Economic Impact Report

[22] *Risk Analysis* at 120.
[23] *Id.* at 118.
[24] *Id.*

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constructed a high impact spill scenario. Interestingly, the amount of oil discharged in both reports is approximately the same. The Risk Analysis maintains that 58,000 bbl (2,436,000 gallons) of oil would be discharged under a WCS Line 5 spill in the Straits, while the Economic Impact Report applies approximately 59,500 bbl (2,499,000 gallons) of oil under a high impact spill scenario.[25] Therefore, the differences between the Risk Analysis and the Economic Impact Report do not concern the amount of oil discharged from a Line 5 spill in the Straits, but rather the extent, magnitude, duration, and impacts that a Line 5 spill would have on water, natural resources, public health and safety, property values, tourism, recreation, fishing, shipping, taxes, and other costs.

The main reason for the difference in economic impact estimates between the two reports is that the Economic Impact Report assumes tourism expenditures would be affected on a declining basis for five (5) years. This amount represents the majority of the total estimate ($4.8 billion of a total of $5.6 billion). By contrast, the Risk Analysis assumes that fewer counties would be affected under a WCS, and further assumes only one (1) year of impacts to Michigan's tourism economy.

Although, the Risk Analysis did not use the same method, it estimates lost utility or satisfaction accruing to recreation users, represented as foregone "willingness-to-pay for recreation."[26] The Risk Analysis estimates only $7 to $20 million in foregone 'net willingness to pay' for recreation day trips. This does not include foregone spending at local businesses (economists refer to the difference between 'willingness to pay' and actual spending as the net economic benefit, or in this case, net economic loss), but not lost spending. It only reflects lost satisfaction to visitors to state parks, state recreation areas, Mackinac state historic parks, national parks, and national forests.[27]

By contrast, Dr. Richardson's Economic Impact Report assumes lost expenditures accruing to tourism businesses. The Economic Impact Report considered tourism to include visitors beyond this narrow context of outdoor recreation on public lands. The Economic Impact Report also cited evidence that previous oil spills had tourism impacts that endured beyond one year.[28]

The Risk Analysis also estimates recreational fishing and boating impacts separately, with only one (1) year of impacts. On the other hand, the Economic Impact Report includes these categories under tourism and estimates that impact will last for five (5) years on a declining basis. Additionally, the Risk Analysis estimates that impacts to the commercial fishing industry will only occur for one (1) year after a spill. As a result of this conservative approach to commercial fishing and rebound of resources, the Risk Analysis estimates impacts of $0.5 to $1.6 million to the commercial fishing industry. The Economic Impact Report yields larger losses due to its assumption that commercial fishing will experience three (3) years of declining impacts, totaling a present value of $61 million.[29]

Additionally, the Risk Analysis estimates that the commercial shipping industry would face a $42 million impact if a WCS Line 5 spill were to occur.[30] Although the Economic Impact Report does not quantify the economic impact to the commercial shipping industry, the Economic Impact Report's inclusion of

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[25] *Risk Analysis* at 41; *Economic Impact Report* at 1,4.
[26] See *Risk Analysis,* Table GI4 on p.294 for a summary of the estimates.
[27] *Risk Analysis* at 293.
[28] *Economic Impact Report* at 13, 24-25.
[29] *Id.* at 29.
[30] *Risk Analysis* at 308.

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secondary economic impacts would demonstrate the ripple effect a delay in commercial shipping would cause. There are many manufactures that rely on Great Lakes shipping to provide raw materials for their production processes. Therefore, the Risk Analysis' $42 million impact is likely an underestimate of the overall impact a delay in commercial shipping would cause.

There are also drastic differences between the approaches to coastal property values, as Dr. Richardson's report assumed five (5) years of declining impacts for the $485 million estimate; the Risk Analysis uses "lost amenity value" to generate estimates of only about $2 million. For other comparisons, see the Economic Impact Report's summary table[31] and the Risk Analysis' summary of impacts.[32]

Despite the discrepancies mentioned above, the Risk Analysis and the Economic Impact Report both demonstrate that Line 5 poses an imminent and unacceptable risk to the Great Lakes and the State of Michigan. State officials should utilize the findings of both reports to ensure that the state upholds its duties as public trustees of the Great Lakes and natural resources of Michigan.

VI. THE RISK ANALYSIS CONCLUSION ON PUBLIC HEALTH AND SAFETY CONSEQUENCES ARE NOT CONSISTENT WITH ITS FINDINGS REGARDING MENTAL HEALTH ISSUES AND DRINKING WATER CONTAMINATION

The Risk Analysis acknowledges that "mental health issues are a significant concern after disasters such as a potential oil spill at the Straits of Mackinac."[33] This finding is consistent with mental health studies conducted after the DWH spill which found individuals experienced symptoms such as mistrust, anger, anxiety, as well as acute stress with symptoms of posttraumatic stress disorder.[34] These symptoms demonstrate that adverse mental health impacts a WCS Line 5 spill could cause. Additionally, tribal members have significant and sacred connections with the water, natural resources, and wildlife that would be directly impacted by a WCS Line 5 spill. The Risk Analysis indicates that "restrictions of access to cultural heritage sites, recourse allocation, and equitable compensation issues may include legal proceedings, and these could potentially lead to post-traumatic chronic stress disorder."[35] As significant as the effects to mental health on residents and tribal members, the Risk Analysis fails to discuss the potential costs of long-term mental health counseling, therapy, and other services that needed to prevent or treat the mental health symptoms caused by a WCS Line 5 spill.

In addition to the mental health concerns a WCS Line 5 spill presents, the Risk Analysis also demonstrates that a Line 5 spill presents risks to drinking water supplies in the Straits area. [36] The Risk Analysis identified 12 municipal drinking water intakes within the Straits area, as well as 306 private water wells that are located within approximately 200 feet of the shoreline within the Straits channel that are at potential risk of oil contamination.[37] These private and public drinking water sources would have to be monitored and possible closed after a WCS Line 5 spill to ensure that drinking water sources were not

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31 *Economic Impact Report* at 2.
32 *Risk Analysis* at 321.
33 *Id.* at 160.
34 *Id.*
35 *Id.* at 161.
36 *Id.* at 156-158.
37 *Id.*

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contaminated and met federal and state drinking water quality standards pursuant to the Safe Drinking Water Act ("SDWA").

The potential for drinking water contamination on Mackinac Island is high in the event of a WCS Line 5 oil spill. The Island's public water supply draws directly from Lake Huron, in an area that is predicted to be covered by oil during a WCS Line 5 spill.[38] However, the Risk Analysis fails to evaluate the risks to the public drinking water supply on the island as well as the emergency response plan that would have to be implemented to ensure Mackinac Island residents and visitors have adequate drinking water supplies following a WCS Line 5 spill.

Despite the significant risks laid out in the Risk Analysis, the report concludes that the short- and long-term risks to public health and safety due to a WCS Line 5 spill are relatively low.[39] This conclusion contradicts the Risk Analysis findings concerning the potential effects to resident's mental health and public and private drinking water supplies within the Straits area. The Risk Analysis conclusion to Task D – evaluating risk to public health and safety, must be revised to accurately reflect the Risk Analysis' findings concerning mental health impacts and drinking water contamination.

VII. THE RISK ANALYSIS' FINDINGS DEMONSTRATE THAT LINE 5 POSES AN UNACCEPTABLE RISK TO THE GREAT LAKES AND THE STATE OF MICHIGAN

The Risk Analysis concludes that a WCS Line 5 spill in the Straits of Mackinac could cause up to 58,000 bbl (2,436,000 gallons) of oil to be released into the Great Lakes.[40] This released oil would disperse over 1,000 square miles of Great Lakes surface water and affect approximately 441 miles of shoreline.[41] This potential environmental disaster would cost approximately $1.3 billion to contain and clean-up and would also leave permeant impacts that could change the character of the Straits indefinitely.[42]

The State of Michigan is the trustee of the public's irrevocable interest in the waters and bottomlands of the Great Lakes. Thus, the state has a paramount duty to protect the natural resources found within the Straits area and ensure that the public's interest in the Straits for such activities as boating, fishing, and swimming are not impaired. The State's paramount duty to protect natural resources is also incorporated into Michigan's constitution which expressly holds that, "the legislature shall provide for the protection of the air, water, and other natural resources of the state from pollution, impairment and destruction."[43]

The Michigan legislature must acknowledge the unacceptable risk the Line 5 poses to the air, water, and natural resources of this state and decommission the flow of oil through the heart of the Great Lakes before a WCS spill occurs. Line 5 like any other piece of infrastructure cannot operate indefinitely and will eventually fail. Therefore, it is not a matter of if a Line 5 spill will occur, but when. Our state leaders must be proactive about this critical issue, and ensure that the Straits of Mackinac are swimmable, navigable, and fishable for current and future generations.

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[38] *Id.* at 100-101.
[39] *Id.* at 164.
[40] *Id.* at 345.
[41] *Id.* at 41,75 -77.
[42] *Id.* at 277.
[43] MI. CONST. ART. 4, §52.

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The Risk Analysis also demonstrates that a WCS spill would also have a $1.37 billion impact to the State of Michigan's economy.[44] The significant amount of the $1.37 billion economic impact would directly affect northern Michigan communities that depend on the summer tourist and recreational season to support them through the winter months[45] with potential beach closures up to 24 months, these local economies would miss two critical summer seasons. Such a drastic impact to the region's tourism and recreational economies could potentially initiate indirect economic effects that would ripple into industries that might not be directly affected by a Line 5 spill in the Straits. With unemployment rates as high as twenty percent in Mackinac County, it is critical that the coastal communities of northern Michigan continue to generate economic revenue through the recreational and tourism industries.

In addition to the unacceptable risks to natural resources and Michigan's economy, the Risk Analysis also demonstrates that Line 5 poses an intolerable risk to the federally recognized tribes' cultural and historic traditions. In 1836, the tribes reserved the right to fish the Straits of Mackinac.[46] This reserved right to fish is not a reserved right to the actual fish population within the waters of the Straits, but rather is a reserved right to have a connection with the fish, to pray for the fish, to dance with the fish, to harvest the fish, as well as preserve and pass down these culturally significant acts from one generation to the next. A WCS Line 5 spill will undoubtedly affect tribal members' ability to engage in the act of fishing and the sacred connection to the waters and fish that are essential to their way of life.

Overall, the Risk Analysis demonstrates that Line 5 poses an unacceptable risk to the Great Lakes, coastal communities, tribes, and the State of Michigan. State officials have a duty under public trust common law and Michigan's Constitution to protect the Great Lakes and other natural resources of this state. Therefore, state officials must take immediate action and stop the flow of oil through Line 5 to ensure the protection of our environment, our economy, and our way of life.

VIII. THE RISK ANALYSIS SHOULD BE EVIDENTIARY PROOF THAT ENBRIDGE DOES NOT POSSESS ADEQUATE INSURANCE OR OTHER FINANCIAL ASSURANCES TO SUFFICIENTLY COVER ALL LIABILITY FOR ALL DAMAGES AND/OR LOSSES RESULTING FROM A LINE 5 SPILL IN THE STRAITS OF MACKINAC

The Risk Analysis estimates that the likely costs for containing and cleaning-up dispersed oil from a WCS Line 5 spill in the Straits would likely cost Enbridge $1.3 billion.[47] Furthermore, the Risk Analysis also establishes that the economic impact from a WCS Line 5 spill in the Straits is also approximately $1.3 billion.[48] Therefore, the total amount of liability for a WCS Line 5 spill is estimated at $2.6 billion.

As significant as this liability is, the 1953 Easement authorizing Enbridge to operate Line 5 in the waters and the bottomlands of the Straits of Mackinac only requires Enbridge to possess a "comprehensive bodily injury and property damage liability policy . . . in the sum of at least one million dollars, covering the liability herein imposed upon [Enbridge]."[49] This binding provision of the 1953 Easement is beyond

[44] *Risk Analysis* at 324.
[45] *Id.* at 127 ("According to a Tourism Economy study (2016), visitor spending contributed $89.91 million, $363,39 million and $219.98 million to the economies of Cheboygan, Emmet, and Mackinac counties respectively")
[46] *People v. LeBlanc*, 399 Mich. 31 (Mich. 1976).
[47] *Id.* at 277.
[48] *Id.* at 324.
[49] State of Michigan's 1953 Easement with Lakehead Pipeline Company, Inc., pg. 10.

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outdated and is wholly inadequate for the significant liability that Enbridge will face in the event of a Line 5 spill.

Although the 1953 Easement's liability provision has been inadequate for many years, the State of Michigan finally recognized its inadequacies and inquired about Enbridge's insurance policies in a March 2015 letter to Enbridge.[50] Enbridge responded to the State of Michigan in an April 2015 letter verifying that Enbridge possess a global liability insurance policy that covers sudden and accidental pollution events, in the total amount of $700 million.[51] Although, the $700 million-dollar policy is much greater than the 1953 easement's million-dollar requirement, it still is inadequate to cover the Risk Analysis' estimate of $2.6 billion in liabilities stemming from a WCS Line 5 spill. In addition, it should be noted that insurance policies contain multiple exemptions and exclusions for various occurrences or damages and costs, which are not covered by such insurance policies. For example, state regulators in Minnesota recently concluded "that Enbridge's current general liability policies for its entire U.S. mainline oil pipeline system, which would include new Line 3, has 'significant exclusions for insurance coverage related to damages caused by a crude oil spill.'"[52]

State officials, as well as the public, must be ensured that Enbridge can financially cover the liabilities associated with a WCS Line 5 spill in the Straits. State officials must demand that Enbridge demonstrate that its current insurance policies and financial statements show it can and will cover the liabilities and estimated worst-case scenario costs and damages associated with the risks that are presented in this Risk Analysis and Dr. Richardson's Economic Impact Report.

IX. CONCLUSION AND RECOMMENDED ACTIONS

The Risk Analysis and the Economic Impact Report clearly demonstrate that Line 5 in the Straits of Mackinac poses an unacceptable risk to the Great Lakes and the State of Michigan. Michigan should not put the Great Lakes, our economy, health, drinking water, fisheries, and way of life at risk from a catastrophic oil spill any longer. Now armed with this latest report on risk, the State of Michigan should exercise its legal duty as public trustee and revoke the 65-year-old Easement that authorizes Enbridge to conditionally occupy our public waters.

The Governor's 2017 agreement with Enbridge to find a replacement alternative for Line 5 was severely premature and does not address the imminent and unacceptable risks that are presented in the Risk Analysis' findings. State officials should not be evaluating far-off alternatives to Line 5, but determining what steps need to be taken to mitigate the imminent and unacceptable risks Line 5 poses today.

It is time for the state to stop delaying action with more studies, but rather exercise its legal duty as public trustee, and revoke Line 5's easement. As public trustee of the waters, the state should then require Enbridge to submit and demonstrate through comprehensive alternative analysis that there are no other feasible and prudent alternatives to the continued operation of Line 5 in the Straits of Mackinac.

At the very minimum, state officials must demand that Enbridge demonstrate that they possess sufficient liability coverage for all liabilities and/or damages stemming from the WCS Line 5 spill outlined in the

[50] State of Michigan's March 12, 2015 letter to Enbridge.
[51] Enbridge's April 17, 2018 letter to the State of Michigan.
[52] Star Tribune, "Enbridge oil spill insurance inadequate, Minnesota regulators say," August 15, 2018, Minn., MN https://insurancenewsnet.com/oarticle/enbridge-oil-spill-insurance-inadequate-minnesota-regulators-say

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Risk Analysis. Without proof that Enbridge maintains sufficient liability coverage, the state may face lengthy litigation and negotiations with Enbridge to ensure that the company is held fully responsible for the costs associated with a Line 5 spill in the Straits.

Again, FLOW thanks Dr. Meadows and his team for all their hard work on this comprehensive Risk Analysis, as well as the PSAB for this opportunity to comment on the draft report. We hope our comments are seriously considered, and the revisions to the Risk Analysis are made to address some of the flaws highlighted in our comments. Should you have any questions or desire further information, we are willing to meet with you and technical experts to discuss the above.

Sincerely yours,

James Olson	Elizabeth R. Kirkwood
President	Executive Director

cc: U.S. Senator and Hon. Gary Peters
U.S. Senator and Hon. Debbie Stabenow

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August 19, 2018

Michigan Department of Environmental Quality
Attn: Heidi Grether

Michigan Department Natural Resources
Attn: Mr. Keith Creagh

Re: Comments on MTU Risk Assessment Systems, Inc. Draft Report – Alternatives Analysis for the Straits Pipeline

Dear Directors Creagh and Grether

Enbridge has read and reviewed the Draft Independent Risk Analysis of Straits Pipelines prepared by the team of researchers led by Michigan Technological University and directed by professor Guy Meadows of Michigan Tech's Great Lakes Research Team. It is our understanding that data from this report will be considered when determining the future of Line 5 and how best to enable the region to continue to safely receive the energy on which everyone depends.

Based upon the worst-case conditions that the team of researchers was directed to follow, the scenarios that are presented in the report are purely hypothetical and the probability of the events actually occurring is extraordinarily unlikely. That being said, Enbridge has the plans, the people, the expertise, the training and the equipment to respond quickly and effectively in the unlikely event of any incident on Line 5 in the Straits.

Enbridge pipelines operate with multiple layers of safety in mind. These layers include a 24-hour control center that constantly monitors all of our lines and can initiate a shutdown in minutes; automatic shut-off valves located on either side of the Straits that would minimize the amount of product that could be released; and well-trained local personnel with emergency response equipment who could be onsite quickly.

For more than 60 years, Line 5 has safely and reliably transported the energy families and businesses require each day in a manner that also protects Michigan's natural resources and supports the region's economy.

We all agree that the State's natural resources are a treasure that must be protected. Enbridge is working with the State of Michigan to evaluate and implement measures that will improve pipeline safety.

As part of our robust maintenance program, we are exploring new technologies to ensure Line 5 – and our entire pipeline system – remains a reliable part of the nation's energy system, and a critical link in the Straits of Mackinac that connects Michigan's two peninsulas to the energy that people need each day.

Looking to the future, two feasible alternatives to the existing dual pipeline crossings have been identified to help ensure the continued safety and protection of the Great Lakes for future generations, and we look forward to our continued collaboration with the State to further explore the viability of these options.

Sincerely,

John Gauderman
Enbridge Energy, Limited Partnership
Director, Great Lakes Region

Attachment A – Technical Comments

Attachment A – Technical Comments

Table A1: Comparison of assumptions for this and previous estimates of spill volumes at the Straits. (Pages 37/38)

The identified information extracted from the Dynamic Risk report for the 3" leak case is not consistent with the information provided in the 2017 Dynamic Risk report. Both the "Equipment Design Standards" and the "Values Assumed for Calculations" in Table 2-9 (p. 2-75) of the DRAA report provide different values than those in Table A1 of the MTU Risk Analysis report. There are inconsistencies in terminology and uncertainties in the alignment of the MTU extracted information.

Task A.2.6 Tiers of Failure (Pages 49/50)

Enbridge takes exception that the response time to manually close valves is being reported as two hours, as suggested in Tier 4 and Tier 5 scenarios. A more realistic time would be one hour and, in practicality, may be less as noted below. Regarding response timing for manual closure of isolation valve(s) in the event of communication loss during an incident, Enbridge has a number of employees based in the area of the Straits, and has an on-call rotation to cover nights and weekends. One of the stipulations for being on-call is that on-call employees must remain in the local area while on-call, so as to maintain the capacity to respond within one hour.

Loss of communication and control of multiple remote control valves would most likely involve a loss of control / communication with all remote equipment on Line 5. This loss of communication would enforce local station logic that is independent of the Enbridge Control Centre SCADA system.

Local logic at initial pumping station of the pipeline at Superior Terminal would initiate a shutdown of booster pumps after 10 minutes of continuous loss of communications / control. The loss of boosters would cause the shutdown of Line 5 mainline units at Superior. Superior Terminal is manned 24/7 so if the local logic did not shutdown boosters and mainline units, local operations personnel would be directed to stop both booster and mainline pumps at Superior.

Control Centre process would be to initiate contact with Regional Operations Management to identify the need for a coordinated field response versus an on-call technician response due to the magnitude of the outage. Management would determine who could be contacted to minimize travel response times for each station and valve location.

Task A.2.5.1 Spill/Leak Detection Time (Pages 45)

The report states, "Operators install a combination (hybrid) of these systems because the pipeline is used to transport various products such as crude, refined and Natural Liquid Gas (NLG) using the same conduit according to seasonal needs." This is not an accurate statement. A combination of internal and external systems does not make up a "hybrid" system. Operators like Enbridge employ a Leak Detection strategy which employs several complementary layers. The strategy encompasses several primary leak monitoring methods, each with a different focus and featuring differing technology, resources and timing. Used together, these methods provide an overlapping and comprehensive leak detection capability. These methods include:

Attachment A – Technical Comments

- Visual surveillance and reports - Enbridge has people, processes and infrastructure established that facilitate the reporting of oil or oil odors from third parties and from Enbridge's aerial and ground line patrols. Enbridge manages third-party reports through its emergency telephone line, and communicates with affected public and local emergency officials through its public awareness program. Aerial pipeline patrols are conducted in accordance with regulatory requirements and risk based approaches.

- Controller monitoring - Enbridge's Pipeline Controller monitors pipeline conditions (such as pipeline pressure) through the Supervisory Control And Data Acquisition ("SCADA") system, which is designed to identify unexpected operational changes, such as pressure drops along the pipeline, that may indicate a leak. Additional sensors at facilities are monitored through SCADA such as concentrations of explosive vapor, pump seal failures, equipment vibration levels and sump levels are used by the controller to identify potential leaks.

- Computational Pipeline Monitoring Systems (CPM)

  - Enbridge employs computer-based pipeline monitoring systems that utilize measurements and pipeline data to detect and alarm on anomalies that could indicate possible leaks. The Enbridge primary computational pipeline monitoring system (or Material Balance System, aka "MBS") is a sophisticated real-time transient model (RTTM) representative each individual Enbridge pipeline. The system continuously monitors changes in calculated volume of liquids to alert the operator and analyst on shift of potential leak conditions.

  - Rupture Detection – Enbridge employs complementary computer-based pipeline monitoring systems that utilize pump station pressure and flow measurements to identify and alarm on pipeline rupture events. The control center procedures require immediate shutdown of the pipeline upon receipt of a rupture alarm.

  - Automated Pressure Deviation – Enbridge employs complementary computer-based pipeline monitoring system that utilize pressure measurements during pipeline shut-in conditions and generate alarms if a significant pressure drop occurs.

  - Automated Volume Balance - Enbridge employs complementary computer-based pipeline monitoring system that determines a time-averaged volume imbalance using injection and delivery flow meters during running conditions. If the imbalance exceeds a pre-set threshold, it will generate an alarm.

  - Acoustic Inline Inspection - Acoustic inline inspection tools are specially designed to confirm the integrity of the pipeline and for the detection and localization of very small leaks through unique acoustic signatures. Deployment of these tools is focused on pipeline risk profile such as high consequence areas.

Attachment A – Technical Comments

- Enbridge has installed an additional, internal hybrid CPM system on L5 Straits. This hybrid system combines two leak detection methodologies: volume balance calculations and pressure wave functionality. The internal hybrid CPM system is described in the Consent Decree Alternative Leak Detection report, and in Enbridge's State of Michigan Additional Available Leak Detection technologies report. Also, Line 5 does not carry refined products as (incorrectly) stated.

The report also states, "These detections systems are only accurate for steady-state operations. A pipeline under transient conditions (start-up and shut-down) produce additional background noise which results in inaccurate detection." This statement is incomplete and inaccurate. It is not true that these systems are only accurate for steady-state operations. CPM sensitivity can be degraded by certain transient conditions, but the basic functionality for leak detection continues. In general, external leak detection systems are not affected by transient pipeline operations.

Task B.2.3 Oil Dispersal Simulation (Page 64)

It should be noted that there is a difference between particle tracking (used in this section) and fate/trajectory modeling of hydrocarbons. Because particle tracking treats oil as an inert and neutrally buoyant there are many chemical and physical fates that this model does not include or may incorporate inaccurately therefore likely exacerbating the impacts of the oil.

Task B.2.3 Oil Dispersal Simulation (Page 65)

Report states, "Evaporation or weathering of oil is one of the most important processes…" This statement makes it sound like evaporation is the only weathering process that can occur to oil and that is incorrect. We recommend other weathering processes including dissolution, degradation, emulsification, biodegradation, etc. be noted and included in the analysis.

Task B.3.1 Hydrodynamic Modeling Results – Oil Beaching (Page 71)

The report states that the single greatest distance of oiled shoreline was predicted from the release event in February. This is contradictory to what is stated in the ice season (from January to late April). Ice reduces the impacts of currents and wind on a spill therefore this suggest that the model does not accurately predict how a spill will act during ice conditions.

Task C Time to contain and cleanup the worst-case release (Page 84)

Although this section, in general, attempts to address response actions, there is analysis to show how these response actions will impact the modeling. Response actions will reduce the potential impacts and fate of the oil.

Attachment A – Technical Comments

Task C.2.1 Overview of Spill Response – SCAT methodology (Page 84 and again on 104)

The phases listed for SCAT are not consistent with the practices employed NOAA or Enbridge. Below are the simplified steps in SCAT:

1. Conduct reconnaissance survey(s).
2. Segment the shoreline.
3. Assign teams and conduct SCAT surveys.
4. Develop cleanup guidelines and endpoints.
5. Submit survey reports and shoreline oiling sketches to the ICS Planning Section.
6. Monitor effectiveness of cleanup.
7. Conduct post-cleanup inspections.
8. Conduct final evaluation of cleanup activities

Most important of these is that endpoints are agreed upon early in the process not at the end.

C.2.2 Incident Command System and the Unified Command Structure (Pages 86)

Enbridge, USCG, MI DEQ, local EM, and Tribal would form a Unified Command using ICS. A JFO would not be used.

C.2.3 Tactics to Respond to and Clean Up Oil Releases (Pages 87)

Report states that oil responses can be broken down into two different categories, Enbridge believes there are three; Open Water Recovery, Near Shore Recovery, and Shoreline clean up.

Near shore would be similar to inland water course as deflection, protective, containment boom, could be used to allow skimmer recovery without oil beaching. Near shore is addressed in the report in Section C.2.3.2.1 page 89.

C.2.3.2.2 Near-shore recovery and removal Table C1 (Page 91)

Related to the exclusionary booming wave height information, the EPA manual referenced does not recognize the larger boom "Sea Sentry" or "Ocean Boom". The Sea Sentry boom has 21 inch freeboard and 21 inch draft. Tinsel strength in excess of 40,000 lbs. The design is to military standards and is the choice of the US Navy. The boom can be deployed and anchored or held in place in 8 foot waves or greater. Enbridge has 10,000 ft. of this boom, 5000 ft. at the Straits, 5000 ft. in Escanaba. This has a positive impact on Enbridge's ability to respond.

Attachment A – Technical Comments

C.2.4 Reviews of Documents for the Straits of Mackinac (Page 92)

Report mentions the Great Lakes Region ICP but neglects to include other ER plans (Straits of Mackinac Tactical Response Plan, Great Lakes Field Emergency Response Plan and the Control Point Mapping Site Sheets).

C.2.4 Reviews of Documents for the Straits of Mackinac (Page 94)

This section only partial summarizes the Integrated Contingency Plan (ICP). Missing is information for the specific region and a high level summary of the Tactical Response Plan (TRP): The purpose of the TRP is to provide Enbridge with a response plan to provide the necessary information to respond quickly and effectively to an incident, which may occur at or near the pipeline crossing. The TRP is developed to maximize the protection of the public's health and safety, and environmentally sensitive areas that could potentially be affected.

C.2.4.4 Programmatic Agreements Among Agencies (Page 94)

There is no mention of Enbridge's participation in regional/area activities, including exercises. This facilitates an understanding among all parties on capability to respond together.

C.3.1 Fate of Oil in the Worst Case Scenario – Figure C4 (Page 97)

As shown in Figure C4, the concept that 20,000 bbls of oil would remain steady on water from 144 to past 216 hours without change is not logical as effects of emergency response would remove oil from the water.

C.3.4 Interviews with Enbridge representatives (Pages 101)

There is no recognition that Enbridge would engage other Enbridge resources from neighboring regions. These resources would be able to be at site within the 5 day window of response. This excludes Enbridge resources in Canada, USCG boom caches, or boom in Sault Ste. Marie Ontario.

C.3.5 List of Equipment Identified (Pages 104)

MTC should be MPC. It also should be noted that they are the two closest OSRO's but additional resources would be mobilized as necessary.

C.4.1 Containment and Recovery on Water (Pages 105)

Although there is extensive research done to create this section, this addresses only response equipment available in the first 6 hours and then extrapolate that into 106 hours of response. Enbridge's response would be considerably greater.

C.4.1 Containment and Recovery on Water Table C5 (Page 107)

The analysis focuses on a small sample of equipment, a sample that is considerably less than what Enbridge would deploy in such a situation. Over a 5-day period, Enbridge would deploy equipment from across its system across the United States, including various OSROs under contract to Enbridge, and not just ER equipment in the vicinity of the Straits. For example, Enbridge facilities in the states of Illinois, Minnesota and Wisconsin are approximately a 6-12 hours from the Straits (including crew activation). These facilities can bring an additional 21,000 ft. of boom, 16 boats, and 33 skimmers. Taking into account similar Enbridge capability across the US, including our contracted OSROs, brings our estimated total recovery capability to over 500,000 bbls over 5 days. This was calculated using the following assumptions:

- A response of Enbridge and contracted OSRO resources in most of the United States;
- 2 hours was assumed to notify and activate crews prior to departing their home locations
- 12 hours driving time/day and 8 hours sleep/day
- Deployment at the Straits assumed 2 hours to deploy
- Recovery was based on USCG d-rating of skimmers;
- A work day of 8 hours (for safety, Enbridge does not deploy on water at night, though some shoreline activities may occur). The 8 hour work day was also based on the sunrise/sunset data for the Straits in December.

Not included are regions in Canada, which have similar resources as regions in the United States but crews do not have HAZWOPER qualifications. Canadian crews could be trained to the 40 hour HAZWOPER standard; however, qualification would only take affect by the end of day 5. This assumes the requirement for HAZWOPER 40 hrs. includes the need to do post ER recovery and remediation. Should the crews from Canada take HAZWOPER 24, it would allow additional response capabilities in days 4 and 5, especially for those crews deploying from Sarnia and Southwestern Ontario where there are considerable resources, as well as an additional Oil Spill Response Contractor (ERMC).

C.5.1 Time to Contain and Recover Oils on Water Figure C9 (Page 113)

The figure heading states that there is limited oil recovery with increasing wind speed. The Current Buster design creates a quiescent area within the apex such that any skimmer can be used with relatively high efficiency. This also limits the impact of environmental conditions on skimmer recovery efficiency.

C.5.2 In situ Burning (Pages 114)

A much greater amount of oil would be burned than stated as regular boom and even a current buster could be used to supply oil to the containment area surrounded by the 500 feet of fire boom (Enbridge have a total of 1000' of fire boom). By continually feeding product to the burning area greater amounts will be burned.

C.7 References ROC Users Guide (Pages 119)

Reviewing the Recovery System Performance (User's Guide, p26), a 10-knot wind leads one to predict recovery efficiency of 20 to 25% for Group C (weir skimmers family), 25 to 55% for Group B (paddle belt, fixed and moving submersion plane), and 55 to 85% for Group A (oleophilic devices). This is very conservative for weir devices in particular, and somewhat conservative for oleophilic devices. It would be helpful to know the precise algorithms to confirm the accuracy of these calculations.

There are similar problems with the broad conclusions one could infer from Recovery System Performance (User's Guide, p27), which purports to relate skimmer efficiency with ranges of oil type. For example, Group B skimmers are estimated to have only 65 to 85% efficiency, and Group C devices (i.e., weir skimmers) could be as low as 25%. Again, it would be helpful to know the precise algorithms.

Appendix A-1 Leakage Calculations (Page A-2)

Comments to this section are with regards to the detailed calculation of Leakage after Valves closed for Base Case of Rupture/Pin-hole. Exchange flow of oil and underwater must be taken into account when calculating potential oil spill volumes from leaking underwater pipelines, which highly depends on hydrostatics pressure and pipeline geometry. The study did not take account pipe geometry or the elevation into consideration while estimating the potential drain down volume for each release location. The study took the distance from release location to lowest elevation point and measured the available product inside the pipe based on this particular length of distance of pipe.

The study also assumed all products inside the pipe will drain out in same amount of time for all five types of tier failures considered in estimating the WCD volume, which over estimates the volume for the pinhole leaks which will take significantly longer to drain.

Appendix D3.7.1 Considering the worst-case scenario (Page 46)

The release base frequency considered in the Individual Risk calculation does not match with the scenario, which is the worst case discharge (WCD). The report uses the pipeline average release frequency, which includes all sizes of releases from very small leaks to large rupture and interprets this frequency as WCD. This assumption skews the average to a higher magnitude and derives higher individual risks for the concerned locations.

For HVL products, explosion occurs due to the delayed ignition of the cloud. The event tree did not take consideration of this event in calculating outcome event probabilities.

The calculation assumes that the probability of traveling or dispersion of the release product to the populated area is 100%, which is not realistic since it is highly dependent on metrological conditions, such as wind speed/direction and water flow direction.

An underwater release should not be modelled the same as a release from exposed pipe on land. This overstates the entire individual risk calculation. As the temperature underwater is less than atmospheric temperature, an underwater release takes longer to transform the released product into gas.

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August 19, 2018

Michigan Department of Environmental Quality
Attn: Heidi Grether
Michigan Department Natural Resources
Attn: Mr. Keith Creagh

Re: Comments on MTU Risk Assessment Systems, Inc. Draft Report – Independent Risk Analysis for the Straits Pipeline

Dear Director Creagh and Director Grether,

API has read and reviewed the Draft Independent Risk Analysis of Straits Pipelines prepared by the team of researchers led by Michigan Technological University and directed by Professor Guy Meadows of Michigan Tech's Great Lakes Research Team. We welcome the opportunity to comment on the draft report.

While we appreciate the authors' statements regarding the low-probability of occurrence when referring to the events representing the 'worst-case scenarios' described in the draft report, these statements do not adequately analyze the risk, as implied by the title of the draft report. To properly analyze the risk associated with these events, we urge the authors to evaluate the probabilities of these events so that the impacts described may be put in the proper context. Without that frame of reference readers are not able to conceptualize the likelihood a spill will have the described effects on the region. If this analysis cannot be performed, it is suggested that the title of the report be modified to better capture the scope of the report, as 'risk-analysis' is not appropriate due to the lack of consideration of probability.

Further to the worst-case scenarios, we also ask that authors be more explicit in their descriptions that are associated with each Task and its associated scenario. Please see the following excerpt from Page 32:

> "For example, a winter spill would be the most difficult to respond to safely and effectively; a spring spill would generate the highest economic costs, as outlined in the report for Tasks G and I; and a summer spill would pose the highest risks to public health and safety due to the seasonal changes in population in the Straits area, as described in the report for Task D. To effectively capture the worst foreseeable scenario for each of these areas that the State described as a subtask in the assessment scope of work, the same spill volume and location was carried

> across all tasks, but the spill timing assumed for evaluation varied depending on the worst outcome for that particular task's focus area."

Because of this approach, a distinct and separate scenario was used for each analysis. However, a general reader could reasonably conclude that the analyses performed on the worst-case impacts from the different Tasks and subject areas are the result of a singular scenario. We ask that the authors include a detailed description of this wherever possible to ensure readers are aware that the different outcomes evaluated in each Task cannot be considered cumulative in nature due to them being wholly separate events and scenarios.

Finally, API works diligently with our response partners in industry, government and the spill response community to ensure spill response preparedness and response capabilities exist in the event a spill occurs. API posts all spill preparedness and response guidance to the Response Library of oilspillprevention.org and works with government to ensure this guidance is incorporated into Regional Response Team guidance, when requested.

API is the only national trade association representing all facets of the oil and natural gas industry, which supports 10.3 million jobs and eight percent of the U.S. economy. API's more than 625 members include large integrated companies, as well as exploration and production, refining, marketing, pipeline, and marine businesses and service and supply firms. We thank you for your consideration of these comments and are available if ever questions arise the authors' think we can help answer.

Sincerely,

Colin M. Frazier
Policy Advisor
Midstream and Industry Operations
American Petroleum Institute

August 18, 2018

RE: PUBLIC COMMENTS AND REPORT ON MICHIGAN TECHNOLOGICAL UNIVERSITY INDEPENDENT RISK ANALYSIS FOR STRAITS PIPELINES AS REQUIRED PURSUANT TO EXECUTIVE ORDER NO. 2015 – 14 AND PROCEEDINGS OF PIPELINE SAFETY ADVISORY BOARD AND GOVERNOR SNYDER-ENBRIDGE AGREEMENT, NOVEMBER 27, 2017

VIA ELECTRONIC SUBMISSION

Dear Governor Snyder, Attorney General Schuette, Michigan Department of Environmental Quality Director Grether, Michigan Public Service Commission Chair Talberg, Michigan Department of Natural Resources Director Creagh:

I am submitting the following public comments for the public record regarding the proposed decisions and actions pursuant to recommendations of the Pipeline Safety Advisory Board ("PSAB" or "Advisory Board"), Executive Order No.2015 – 14, and the Agreement entered into between Governor Snyder and Enbridge on November 27, 2017

I would like to begin by complimenting Dr. Meadows and the team that assembled the MI Tech Independent Risk Analysis (draft) report. While it was done in a very short period of time, it is thorough, well thought out, and considering the complexity of the topic, relatively easy to read and comprehend.

Nevertheless, I would like to offer the following comments for consideration in the finalized version.

Worst Case Spill

Per the MI Tech Independent Risk Analysis (draft), on p. 58, the Worst-Case Spill is roughly 58,000 bbls. If the scenario that involves two phase flow (vaporizing NGLs due to a sudden loss of downstream pressure) is set aside, I have independently calculated the Worst-Case Spill to be 65,000 bbls. Given the approximations and assumptions that must be made to do the calculation, I regard the amount two amounts to be equivalent.

"Pinhole" Leakage

Per the MI Tech Independent Risk Analysis (draft), on p. 52……….

In the case of a pinhole leak, using the flow rate assumed for this analysis, a leak of 500 bbl/h is the largest flow rate, based on Enbridge-provided information that might go undetected by their CPM system. For such a leak to exceed our Tier 5 scenario volume, it would have to continue undetected for 116 hours, or approximately 5 days. Even assuming ice cover, the assessment

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team felt that it would not be plausible for such a leak to continue for longer than that with no visual observation of surface oil.

While the above statement is subjective, I agree.

Impact on Gasoline in Michigan

Brad Shamla, Enbridge Vice President of U.S. Operations, has stated that Line 5 provides enough crude to Michigan to fuel 120,000 cars and light trucks per day. While this sounds impressive, per MDOT (2018) there are 7,817,182 such vehicles in MI. Thus, while 120,000 of the vehicles in Michigan depend on gasoline derived from Line 5, it is only 1.5% of the total vehicles in the State. Shutting down Line 5 would have virtually no impact on the supply of gasoline to Michigan.

Impact on Propane in the U.P.

A recent report sponsored by the NWF, and authored by the London Economics Institute states if Line 5 were shut down, the impact on the price of propane in the U.P. only would be $0.05 per gallon. This is within the daily price fluctuations and "would be lost in the noise of typical price variability." As with gasoline, the impact of shutting down Line 5 on the price of propane in the U.P. would go unnoticed.

Regardless of whether Line 5 is shutdown or not, it is unacceptable that a large number of customers in the U.P. are dependent on a single source for their propane. A recent Op Ed in the Marquette Mining Journal (July 18, 2018) by Bishop Rayford Ray (Episcopal Bishop for Northern Michigan) and I outlined several means by which this dependency could be corrected. (See **Appendix 1**)

Corrosion by Zebra and Quagga Mussels

The impact of zebra and quagga mussels on an underwater pipeline was not an issue in 1953 when Line 5 was constructed. They are an invasive species, and did not appear in the Great Lakes until 1991. They are now pervasive in the Straits.

Why is this important? The excrement from the mussels is slightly acidic. The U.S. Army Corps of Engineers and several universities have confirmed it corrodes bare steel because it is acidic.

Turning to the pipeline, it has been recently confirmed there is bare steel at 42 of the 48 locations that divers visited, with the largest being 16 inches long and 10 inches wide. 87.5 % of the supports have created bare spots on the steel. And this is just for those inspected.

Some of the supports were installed in 2003. Pitting Corrosion, which is caused by the zebra and quagga mussels, may have caused the thickness of the pipe wall to be reduced by as much as 40-50% since that time. Even for the supports installed in 2014, the pipe wall thickness could be reduced by 15%.

Such possible reductions in pipe wall thickness are cause for alarm. This issue must be addressed in the MI Tech Risk Analysis. (See **Appendix 2)**

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Shoreline Affected

The report is inconsistent regarding the km of shoreline affected by a spill. On page 85, the maximum oiled shoreline is said to be 711 km (442 miles). On page 343, it is said to be 996 km (619 miles). But on page 345, the maximum oiled shoreline is stated as 2,007 km (1247 miles).

Obviously, the range of cleanup costs would be drastically different, depending on which of the oiled shoreline distances is used.

The various oiled shoreline distances must be better explained or corrected to a single, agreed upon value, involving the individuals who were responsible for the various sections of the report.

Clean Up Costs and Economic Impact

In 1989 the Exxon Valdez incident resulted in at least $7 billion of cleanup costs. It contaminated 1300 miles of shoreline. The MI Tech Risk Analysis shows a wide variation in the miles of oiled shoreline, the minimum number is 442 miles (see Shoreline Affected above). If we roughly compare Line 5 to Exxon Valdez, the shoreline involved is 442/1300 = 34%, Thus, 0.34 x $7 billion = $2.38 billion (in 1989). Escalating to 2018, the cost would be $9.3 billion. However even this number does not include loss of property value and subsequent loss of property tax income by local government, as well as the many local businesses that would be forced to permanently shut their doors.

A report on the same subject by Dr. Robert Richardson of MSU put these costs at $6.3 billion.

Based on the above, I believe the cost would be at least $10 billion, and perhaps significantly more.

It is difficult to accept the approximate estimate of $1.8 billion that appears in the MI Tech Risk Analysis. It almost certainly is 3 to 5 times that amount.

Task X of the MI Tech Risk Analysis

Task X of the MI Tech Risk Analysis presents a view of Line 5 that goes beyond legal, technical and economic considerations. It introduces the concept of Social License to Operate (SLO). The discussion and considerations presented in Task X are very meaningful, and must be regarded as key inputs when deciding the future of Enbridge Line 5.

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Appendix 1

THE MINING Journal

Enbridge Line 5: Is it worth the risk all of us will take?

JUL 15, 2018

Rayford Ray & Gary Street

Faith groups gathered recently on the steps of the Capital in Lansing to call for a shutdown of Enbridge's Line 5.

Because we believe that all of humanity is called by God to love and care for all of creation, the issue of the danger of Pipeline 5 is of grave importance to the entire Great Lakes ecosystem and our communities in the Basin.

There is a growing concern among many over the lack of adequate upkeep and questions about the necessity of continuing operation of the Line 5. Line 5 is 65 years old. It runs under, over and through the entire state of Michigan. It is showing signs of decomposition and has a history of 29 documented leaks totaling over 1 million gallons.

The line's rising potential for rupture jeopardizes the future water quality, ecosystem health, commercial fisheries, tourism, and livelihood of those across and beyond Michigan.

A rupture would mean environmental and economic risk to the Straits, as well as the entire northern shorelines of Lake Michigan and Lake Huron. Tourism would nearly vanish. Commercial fishing by Native

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Americans at the Straits would cease. Mackinac Island and Bois Blanc Island would need to be evacuated and remain so for several months. Thousands of seasonal jobs would be lost. Local businesses such as restaurants, hotels, motels, arts and crafts shops, micro-breweries, gas stations, marinas, etc., would face economic ruin. Ferry boats to Mackinac Island could not operate. Property values, and the taxes they generate, would plummet.

A recent study by Dr. Robert Richardson of Michigan State University conservatively estimated the cost to Michigan of an oil spill at the Straits to exceed $6 billion.

In a full page ad that appeared on March 28, 2018, in The Marquette Mining Journal, Enbridge boasted they supply propane to 65 percent of the residents in the Upper Peninsula via Line 5.

Assuming this is true, it would be important to note that two-thirds of the propane users in the U.P. are dependent on a multibillion-dollar Canadian company, whose primary goal is to transport crude oil and unrefined propane from Alberta to Ontario, using Michigan as a convenient shortcut.

This raises an overriding concern about the high degree of dependence the U.P. has on Line 5 with no apparent backup plan if a sudden shutdown occurs due to equipment failure or worse yet, a rupture.

This was recently confirmed by Enbridge's communications strategist and community engagement official, Ryan Duffy: *"We've been trying to convey the importance of Line 5. If you lose 65 percent, that's a big deal."*

Unfortunately, Mr. Duffy got it right. It is a big deal! The answer, however, is not to continue repeating the mantra that Line 5 can never be shut down. Rather, we call for the implementation of alternatives for providing propane to the U.P. as quickly as possible.

Before a disaster occurs, we maintain there are straight forward alternatives that can be readily implemented, at a cost that is a small

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fraction of the proposal (by Enbridge) of building a tunnel under the Straits. They include:

- A new 4-inch pipeline to transport propane from Superior, WI to Rapid River, or
- 1 rail car per day to transport propane from Superior, WI to Rapid River, or
- 3-4 tank trucks per day to transport propane from Superior, WI to Rapid River, or
- Increasing the rail deliveries of propane to the existing facility at Kincheloe.

But wouldn't a shutdown of Line 5 result in a substantial price increase for propane? No. According to an independent consulting report, *"The cost impact ....is not expected to substantially impact local/regional pricing dynamics......although profit margins may be impacted."* In other words, the Enbridge profit margin for propane in the U.P. may not be quite as lucrative.

Many Michiganders continue to pray over this issue. We stand with the majority of people who lovingly show compassion for this planet - our island home - we only have one.

Editor's note: Rt. Rev. Rayford Ray, Bishop in the Episcopal Diocese of Northern Michigan.

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Appendix 2

Zebra and Quagga Mussels and their Impact on Bare Steel

By: Gary Street, M.S., P.E.
July 20, 2018

VIA ELECTRONIC SUBMISSION

Overview:
Enbridge has acknowledged there are several large areas of the pipeline where the protective coating is missing. We know that pseudo-feces from zebra mussels and quagga mussels are corrosive to bare steel. However, we do not know for certain what caused the bare spots. Enbridge has said they may have occurred when the new supports were being installed. Even more uncertain, we do not know how long the various bare spots have been exposed to corrosion by the presence of the zebra mussels.

Given the lack of precise knowledge, and the extreme environmental hazard posed by a rupture of Line 5 at the Straits, the prudent scenario is to assume that damage to the coating originally began in 2003 when the first of the new supports were installed. That being the case, it is very possible that the Line 5 pipe wall has suffered serious Pitting Corrosion beginning at that time. Making the matter worse, Pitting Corrosion is difficult to detect.

Introduction
On September 14, 2017, it was reported[1] that sections of the coating on Enbridge Line 5 are missing – gone! The sections missing are as large as dinner plates - and larger.

> *Several holidays are larger than the "Band-Aid"-sized areas Enbridge initially described when the gaps were revealed. The largest patch of exposed pipeline metal is 16 inches long and 10 inches wide. Others are narrower but also exceed a foot in length.*
>
> *Also detailed in the reports is a "disturbed" coating area that's more than 3 feet long, a "dislodged" coating area that's 13 feet long and a mysterious 8-inch "white deposit" of unknown origin that Enbridge says "remains under investigation."*

The reported damage to the pipeline coating doesn't stop there[2]. In a follow up news report issued on November 25, 2017, the situation was revealed to be much worse:

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[1] http://www.mlive.com/news/index.ssf/2017/09/line_5_coating_inspection.html#incart_river_home

The document shows "a majority" of the 48 inspection sites were found to have gaps in the pipe's coating, according to a joint statement from the Michigan Department of Natural Resources, Department of Environmental Quality, Attorney General and Agency on Energy.

The report shows divers found 37 of the 48 anchor locations surveyed had calcareous deposits. The deposits, state officials say, amount to a degradation of the coating in that area and equate to 37 gaps in the pipeline's coating.

With two of the deposits found in areas where divers had also identified bare steel pipe, some issue was found at 42 of the 48 anchor locations divers visited.

"A year ago, Enbridge said there were no coating gaps in the Straits pipeline," {former} Michigan Agency for Energy Executive Director Valerie Brader said in a statement.

"Now, there are dozens," Brader said, "When will we know the full accounting of what Enbridge knows about Line 5?"

This news is very disturbing. 87.5% of the locations visited by the divers had damage to the protective coating. How many additional areas has the protective coating been damaged?

Enbridge attributes the bare spots to the installation of pipeline supports. If we accept the Enbridge explanation, we need to remember the first of these supports were installed in 2003[3] – fourteen years ago. As will be discussed later, this length of time is very important.

Impact of Zebra and Quagga Mussels on Bare Steel

The presence of bare steel raises the very real possibility of corrosion of the steel by zebra (and quagga) mussels. While the mussels were not present when Line 5 was constructed in 1953, they are a reality today.

By September of 1991, zebra mussels were found in all five of the Great Lakes[4].

Numerous sources have documented the corrosive impact of zebra mussels on bare steel[5,6,7,8,9]. Thus, there can be no doubt both zebra mussels and quagga mussels are corrosive to bare steel.

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[2] https://www.mlive.com/news/grand-rapids/index.ssf/2017/11/enbridge_finds_issues_with_42.html

[3] Letter from Enbridge, dated May 20, 2003, by Adam Erickson, to John Arevalo, Michigan Department of Environmental Quality, titled "Enbridge Energy's Joint Permit Application for Repair Work to be Completed on Crude Oil Transmission Pipelines Located in the Straits of Mackinac. MDEQ Permit Number: 01-24-0046-P.

[4] https://www.oneonta.edu/academics/biofld/PUBS/OP/Biology,%20Invasion,%20and%20Control%20of%20the%20Zebra%20Mussel%20in%20North%20America%20OP%2024.pdf, p. 9

[5] Zebra Mussel Research Technical Notes, Prepared and published by the Zebra Mussel Research Program, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS, 39180-6199, Technical Note ZMR-2-07, and Section 2, Revised January 1998, p. 2.

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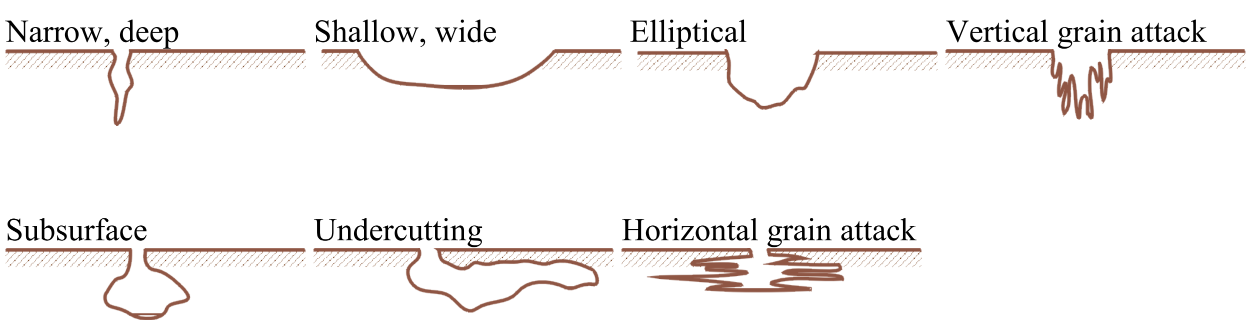
The cause of their corrosiveness is the excrement[10,11,12,13] from the mussels, which is acidic. **An acidic deposit on bare steel leads to corrosion.**

Are all types of corrosion equally harmful? NO! Some forms are far worse than others. **Pitting corrosion** is a localized form of **corrosion** by which cavities or "holes" are produced in the material. While corrosion of bare steel can take many forms, the most insidious, and the one we must be especially concerned with is pitting corrosion. Pitting corrosion is more dangerous than Uniform Corrosion because it is more difficult to detect, predict, and design against. Corrosion products often cover the pits.

Quoting the National Association of Corrosion Engineers (NACE)[14],

> *"Pitting is considered to be more dangerous than uniform corrosion damage because it is more difficult to detect, predict and design against. Corrosion products often cover the pits. A small, narrow pit with minimal overall metal loss can lead to the failure of an entire engineering system."*

Typical examples of Pitting Corrosion are shown below[15]:



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[6] Zebra mussel migration to inland lakes and reservoirs: A guide for lake managers. Ohio Sea Grant, Published by Ohio State University. Author: Robert Heath, Dept. of Biological Sciences Water Research Institute, Kent State University, 1994, p. 2.

[7] USGS: https://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=5, See "Impact of Introduction", paragraph 1.

[8] U.S. Fish and Wildlife Service, Zebra Mussel (Dreissena polymorpha), Ecological Risk Screening Summary, published February, 2011, Revised July 2015, p. 7.

[9] USGS: Nonindigenous Aquatic Species: Benson, A.J., D. Raikow, J. Larson, A. Fusaro, and A.K. Bogdanoff. 2015. Dreissena polymorpha. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=5 Revision Date: 6/26/2014

[10] https://www.livescience.com/27415-shipwreck-alley-threatened-by-invasive-mussels.html
[11] https://www.michigan.gov/documents/deq/wrd-ais-dreissenids_499881_7.pdf, p. 5.
[12] http://www.aquaticnuisance.org/wordpress/wp-content/uploads/2009/01/FCRPS-foul-release-coating-cost-estimate.pdf, p. 1 – under the heading "Background".
[13] https://www.fws.gov/nevada/nv_species/invasive_species/mussels.htm
[14] https://www.nace.org/Pitting-Corrosion/
[15] https://www.nace.org/Pitting-Corrosion/

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Limitations to the Detection of Pitting Corrosion by Smart Pigs

Enbridge relies on "Smart Pigs" to monitor corrosion in their pipelines. However, "Smart Pigs" are not 100% reliable.

Quoting a recent article in the Wall Street Journal[16],

> *"…. smart pigs might not be enough. Enbridge……….a major Canadian pipeline company, has spent over $4.4 billion to upgrade pipeline safety. It is spending big bucks after one of its pipelines spilled oil into the Kalamazoo River in 2010 – a corrosion breach that Enbridge's smart pigs failed to detect ahead of time." "………. **despite recent advances, smart pigs aren't terribly accurate.**"*

The Impact of Mussels on Bare Steel

Corrosion rates in the U.S. are expressed in mils per year (mpy), a mil being a thousandth of an inch. So, how much corrosion can be tolerated before it becomes alarming?[17]

> *Mils per year or mpy, is used to give the corrosion rate in a pipe, a pipe system or other metallic surfaces. To calculate the material loss or weight loss of a metal surface, there is a formula using the type of metal, the size of the sample area and the time of exposure, giving the value of mils per year. The expression mpy is mostly used in the United States. One Mil is equal to one thousandth of an Inch. In metric, one mil per year equals to 0.0254 mm/y.*
>
> *In an open water system a corrosion rate of around 1 mpy is normal. Having corrosion rate of around 10 mpy, you should take action. **Corrosion rates of 20 MPY and above, you should be concerned, as the corrosion is eating the metal rather fast.***

The 1998, the US Army Corps of Engineers issued a definitive report that addresses how much corrosion, in mpy, can be caused by the impact of zebra mussels on bare steel[18]. **Their report concludes the pitting corrosion rate would be in the range of 10-30 mpy. This is within the "you should be concerned" range of the reference cited above.**

A "Most Probable Scenario" regarding Pitting Corrosion on the Exterior of Line 5:

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[16] Fowler, Tim, and Gilbert, Daniel, "Oil-Pipeline Cracks Evading Robotic Smart Pigs", Wall Street Journal, August 16, 2013.

[17] http://www.merusonline.com/gl-mpy

[18] Zebra Mussel Research Technical Notes, Prepared and published by the Zebra Mussel Research Program, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS, 39180-6199, Technical Note ZMR-2-07, and Section 2, Revised January 1998, p. 2-3.

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- US Army Corp of Engineers pitting corrosion rate on bare steel by zebra mussels: 30 mpy
- Possible years of exposed bare steel for Line 5: 14 years

30 mpy = 30/1000 inches per year = 0.03 inches per year
For 14 years, this amounts 0.03*14 = 0.42 inches of pitting corrosion.

Original wall thickness of Line 5 at the Straits = 0.812 inches (schedule 60 pipe, 20 inches O.D.)

Probable wall thickness in 2017 due to pitting corrosion since 2003 = (0.812-0.42) = 0.392 inches!

To say it another way, where pitting corrosion due to the impact of zebra mussels on bare steel has occurred, **the wall of the pipeline may be only 48% as thick as it was in 1953 when it was originally installed.**

In addition, it must be remembered that **corrosion never stops. Every year Line 5 remains in service, pitting corrosion will increase by 0.03 inches. While this may seem small, the cumulative affect spells disaster.**

Conclusions

- Enbridge has admitted that large areas of the coating are missing, exposing the bare steel to the underwater environment.
- Zebra mussels had arrived in all five Great Lakes by 1991[19].
- The excrement of zebra mussels is acidic, and corrosive to bare steel.
- The U.S. Army Corps of Engineers has stated the corrosion rate caused by zebra mussels can be as much as 30 mpy. (mpy = mils per year. One mil per year = 1/1000 of an inch per year)
- The type of corrosion caused by zebra mussels would be pitting corrosion.
- Pitting corrosion is very difficult to detect.
- If damage to the coating took place in 2003 when the initial supports were installed, pitting corrosion has occurred for 14 years.
- Regardless of whether the damage to coating took place in 2003, or some time thereafter, where there is bare steel, pitting corrosion has occurred and continues to occur.

Epilogue

The original draft of this report was done in late in 2017.

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[19] http://www.mlive.com/news/index.ssf/2017/09/line_5_coating_inspection.html#incart_river_home

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However, since that time a new development has entered the picture. Enbridge is now proposing to install a new single 36 inch diameter pipe at the Straits to replace the two existing 20 inch diameter pipelines. The new pipeline would be a "pipe within a pipe". The outer pipe would provide additional protection in the event of a rupture of the inner pipe, which would carry the crude oil and the Natural Gas Liquids (NGLs).

The pipeline described above would be assembled on shore and pulled across the Straits. It would be "covered" with 6-8 feet of "material" (the exact description of the cover was not disclosed by Enbridge).

This raises three important concerns:

- In the course of burying the line and placing the "cover", there is a very good chance the coating on the outer line will be damage, leading to the corrosion scenario described above.

- If the line is buried, exterior inspection of the inner or the outer pipeline will not be possible. As mentioned earlier, inspection of the thickness of the inner pipeline will depend entirely on "smart pigs" which are far from 100% reliable.

- Further, there does not appear to be a technically feasible manner in which to inspect the outer pipeline from the inside.

In short, the pipeline would be subject to external corrosion, but there would be no visual means to inspect for it. This is not an acceptable situation.

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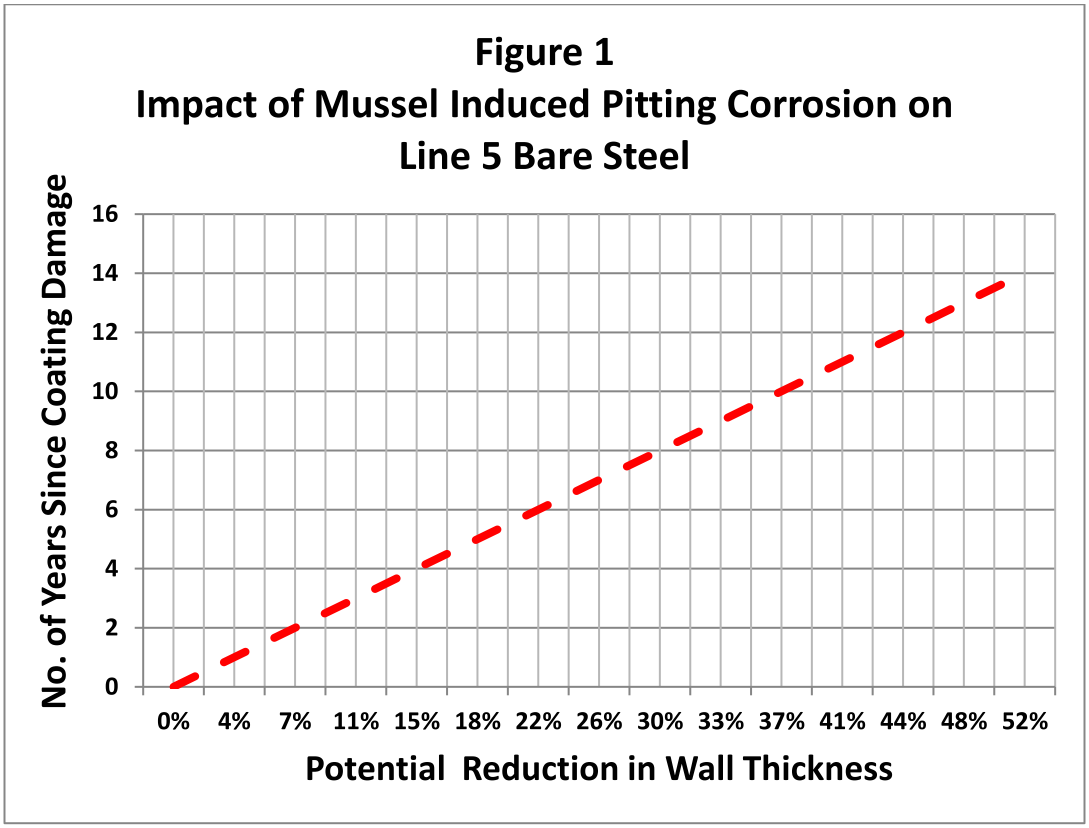
Figures 1 & 2 portray the impact of corrosion on bare steel caused my mussels.



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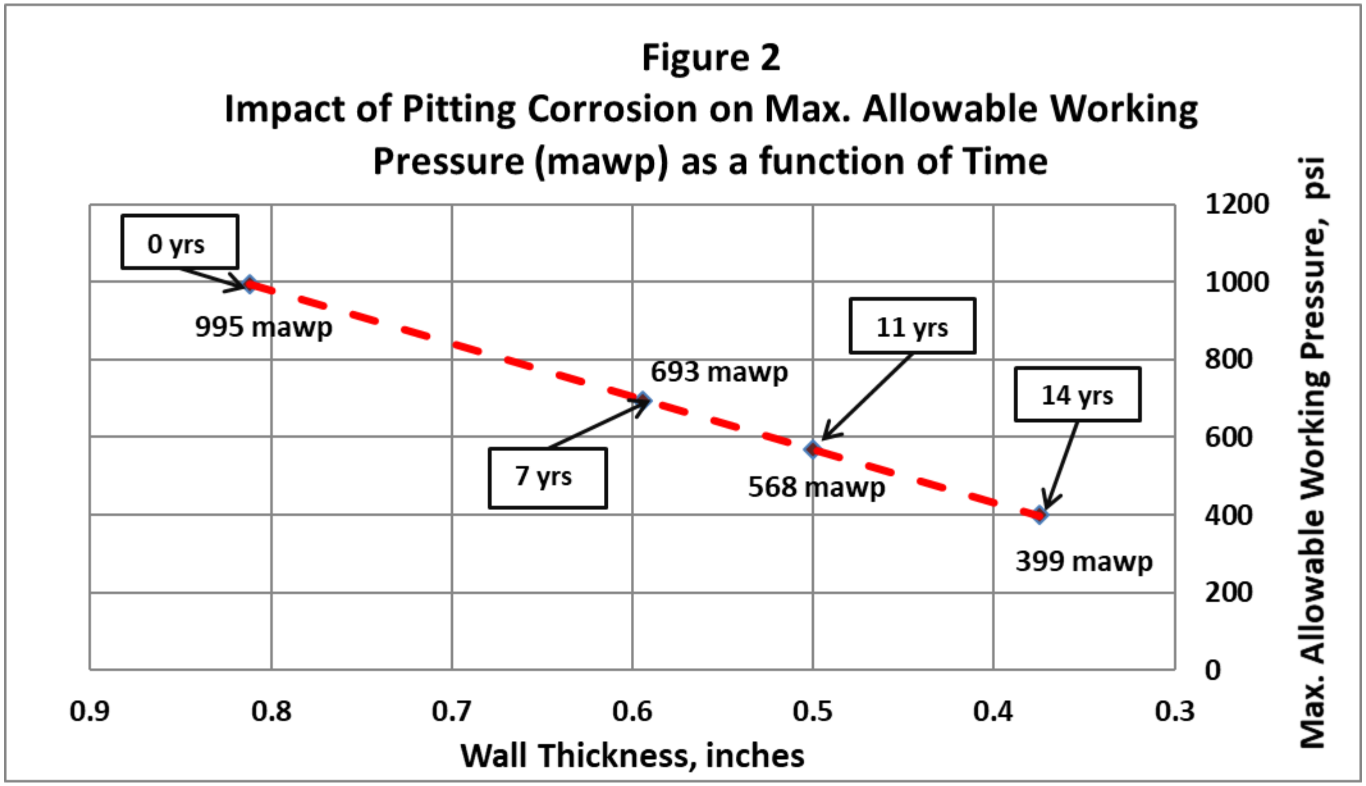

Figure 2 is a plot of Maximum Allowable Working Pressure (mawp) for schedule 60, 20 inch outside diameter, seamless carbon steel pipe[20]. This is the pipe that was installed at the Straits of Mackinac in 1953.

For example, the chart tells us that in 7 years, pitting corrosion will cause the MAWP to decrease from 995 psi to 693 psi; in 14 years (the period of time from 2003 to 2017), the MAWP can decrease to 399 psi.

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[20] Stritt and Priebe, 37 Clyde Avenue, Buffalo, New York, 14215, www.strittandpriebe.com

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Figure 2 assumes that pitting corrosion did not occur prior to 2003. Enbridge has recently admitted that damage has occurred to the pipeline coating while the new supports were being installed[21]. They apparently have been aware of this since 2014, but only recently acknowledged it. While Enbridge claims to have discovered the damage in 2014, we do not know when it actually occurred, so have assumed that at least some of the damage to the coating took place in 2003.

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[21] http://www.mlive.com/news/index.ssf/2017/10/enbridge_line_5_damage_2014_de.html

Joint Agency Comments on the Draft Independent Risk Analysis for the Straits Pipelines

August 30, 2018

These comments are submitted on behalf of the Department of Natural Resources (MDNR), the Department of Environmental Quality (MDEQ), and the Michigan Agency for Energy (MAE) and were developed by technical staff with expertise in a variety of areas.

Introduction

- Page 32, last paragraph – The discussion of multiple worst case scenarios is potentially confusing when compared to the single, representative worst case scenario selected in the report and its associated financial impacts. We suggest reiterating this distinction throughout the report and ensure there is clarity when referring to the single worst case liability versus the various circumstantial worst case scenarios. In addition, any dollar figures relating to scenarios other than the single worst case should be denoted accordingly to avoid confusion.

Task A

- Section A.2.2 presents information regarding primary and secondary valves. For clarity, the distances between the primary and secondary valves should be shown.
- Section A.2.3, Page 42: For clarity, the elevation profile should identify the areas of the Straits pipelines which are generally buried and those which are not. If possible, it may be beneficial if the elevation can be provided relative to the nearest valves as well.
- Section A.2.4: We suggest deleting the phrase, "with fatigue being the most likely." This statement is not fully justified and may be irrelevant if there are several plausible causes for a pinhole leak.
- Section A.4.5 recognizes that a shutdown of manual valves could occur in either 120 or 60 minutes and provides the volume differences. The cost assumption presented later in the report uses a 120-minute shut down time. A cost assumption using 60 minutes should have also been presented.

Task B

- In section B.3.1 it would be helpful to identify the sensitivity/threshold which, when met, would designate a given area of shoreline as being oiled (e.g. grams/meter squared or other like units).

Task C

- Suggest replacing term "Beach" with Shoreline. The majority of shorelines in the straits would not be considered a beach.

Section C.2.3.1 On water oil response strategies

- The text should expand on examples of physical response efforts in addition to the already provided examples of chemical or biological response.
- In Section C.2.3.1.2, in situ burning is described as requiring approval from the Federal On-Scene Coordinator (FOSC) to be used on the Great Lakes. The FOSC will also need to get approval from the Regional Response Team (RRT) (EPA Region 5), which held a workshop in Mackinaw City, MI, in August of 2017 on the potential use of this technique in response to a spill in the Straits area. It is not clear how approval for burning oil would be provided (e.g. permit, exemption, EPA waiver, RRT, Governor's proclamation of state of disaster or emergency)
- Michigan air pollution control regulations do not allow open burning of oil without proper evaluation of emissions and issuance of an air permit. Part 55 of NREPA does not give anyone in the DEQ authority to waive the requirements of an air permit. Air Quality Division of MDEQ maintains the position there may need to be a declaration by the Governor to grant approval, unless there is some type of Memorandum of Understanding (MOU) or other agreement between the state and federal agencies pre-approving the activity under specified circumstances.
- The statement in Section C.2.3.2.1. that a "limitation of the large-scale use of sorbent booms is the creation of large amounts of contaminated wastes" is not appropriate. In the high consequence area of the Straits utilizing sorbent booms is a reasonable trade off in that it removes oil/contaminants from the environment and proper contaminated waste handling is an anticipated part of any spill response.
- In Section C.2.4.1 there is a need to define "UCG."
- The last 4 paragraphs in Section C.2.4.4. are not needed and should be deleted.

Section C.3.2 Interview with Mackinac County Emergency Managers

- There needs to be a short description of what occurred during the "ATC Incident" to provide necessary context for further discussion. It is not accurate to state that notification occurred within minutes (the Anchor drag took place on April 1 it was reported by ATC at 4:30 April 2). We suggest taking a critical look to determine if all of the information in this section is necessary and/or relevant.
- The sentence "In the event of a spill in the Straits area, a similar procedure would be used" does not make sense as the ATC incident did involve a spill.
- Reference to space shuttle landing strip is unnecessary. There is no reason to assume that only the National Guard could bring equipment to the local airstrip near the Mackinac Bridge.
- The reference to the "MICEMS" database should be corrected to read Michigan Critical Incident Management System (MI CIMS). Please include MI CIMS in the list of acronyms.

- It is not clear whether the last four paragraphs Section C.3.2 refer to information gleaned from interviews with Mackinac County Emergency Managers or to information acquired elsewhere.

Section C.3.3 Interview with the US Coast Guard Sector Sault Sainte Marie

- The reference to “2mm oil thick” in the third paragraph appears to be a typo. The word "oil" should be removed, as the reference is to the thickness of ice.

Section C.3.4 Interviews with Enbridge Representatives

- The second paragraph at bottom states that Enbridge has: “an incident management plan including various documents and guidelines.” We suggest adding details about the documents and guidelines or deleting this statement.

Section C.3.4.1 Equipment and recovery rate provided by Enbridge

- The first paragraph references “locally available equipment listed above”, however the report does not provide a concise list of locally available response equipment.

Section C.4.1 Containment and Recovery on Water

- The second paragraph on page 106 discusses how the Response Options Calculator simulates treatment of oil by dispersant application, among other things. It is worth noting that dispersant application may not be authorized for use in the Great Lakes, so using this method as part of the calculator’s estimate for response time may not be appropriate.

Section C.5.2 In situ Burning

- See above comments on Section C.2.3.1.2 – It is not clear how ISB will be allowed.

Task D

- Section D.2.5 discusses contaminants of potential concern and a reference to a water quality criterion for the State of Oregon is used. Michigan Water Quality standards are more relevant. If a discussion of the Oregon criteria remains in the report, there should be an explanation of their relevance to the State of Michigan and the Great Lakes.
  - Michigan Water Quality Standards (Part 4 Rules) are available at: https://www.michigan.gov/deq/0,4561,7-135-3313_3681_3686_3728-350340--,00.html

Task E

- General comment: the overall feel of the section is that it was authored by multiple authors with varying degrees of attention to detail and sentence structure/grammar.

- In E3.1 reference is made to an Alaska water quality standard. Again, Michigan water quality standards are more relevant. If a discussion of the Alaska standard is retained in the report, there should be an explanation of its relevance to Michigan and the Great Lakes.

Table E.4. Michigan's natural communities at risk following a rupture in the Line 5 pipeline in the Mackinac Straits

- The word "birds" should be inserted after "migratory" in the section describing the importance of Limestone Bedrock Lakeshore. See https://mnfi.anr.msu.edu/communities/community.cfm?id=10717 "Limestone bedrock lakeshore provides stopover and feeding corridors for migratory songbirds, including many warbler species." In addition to "songbirds", shorebirds, raptors and other types of birds use this area.

Section E.3.3.1 Habitats

- Page 190, paragraph 1- MNFI natural community classification recognizes 76 rare and natural communities native to Michigan (remove the word "rare". Not all of the 76 communities are considered rare). In addition, there are other plant communities that are NOT recognized by MNFI because they are not considered "Natural"; for example, Aspen stands.

  "These habitats have been designated critical by MNFI…." Only S1 habitats are considered "Critically imperiled"; the other ranks don't use the word critical in their definition and the examples given are all S2 and S3 communities. Wording could be changed to say, "critically imperiled, imperiled, and rare".

- Page 191- examples of conservation areas of greatest risk should include DEQ Environmental Areas, DNR Ecological Reference Areas, and non-profit coastal reserves.

- Coastal Wetlands and Dunes page 194, paragraph 2- regarding wetland monocultures this data set is from 2008 and significant time and money has been spent over the past decade reducing the amount of European Phragmites on the landscape which is not reflected in the Bourgeau-Chavez et al., dataset. Although in principle diverse wetland complexes are better than monocultures, some rare species seek out Typha and Schoenoplectus dominated systems such as Black Tern, Least Bittern, Marsh Wren, etc.
  - It would be useful to have a similar bulleted list of species that use coastal wetlands as was provided for dunes.

  - First bullet under freshwater dunes discusses the piping plover, which should state that it is referring to the Great Lakes population (the Great Plains and Atlantic Coast population are not endangered).

  - For the listed plants; both Houghton's Goldenrod and Pitcher's Thistle have the same distribution (Houghton's Goldenrod is a bit narrower) and are considered Great Lakes Endemic species. Pitcher's Thistle is found throughout the Great Lakes region.

Section E.3.3.2 "s" is missing from impacts.

- Submerged Aquatic Vegetation- "ecosystem important services" should read "important ecosystem services"
- Page 197- first full sentence- "The" should be "They".
- Page 198- Mollusks. There is no mention of rare and listed mussel species in this section, otherwise the invertebrate's section is thorough.

Section E.3.3.3 Invertebrates

- On page 196-197, Crustaceans, Annelids, and Ciliophora, etc. should be given their own headings instead of being imbedded in the description of Mollusks.
- Please clarify that the references to response of annelids and polychaetes to oil spills on page 197 are from spills in salt water; thus, leaving even greater uncertainty as to whether annelids and polychaetes are capable of biodegrading oil spilled in freshwater.

Section E.3.3.5 Fish

- The second paragraph reads "Those species with status under Endangered Species Act (ESA) include Burbot, Coho, Chinook, Rainbow Trout and the Long-Nose Sucker (Table E6)." While these species may have status under the ESA in other states, they do not have status in Michigan. See https://mnfi.anr.msu.edu/data/specialanimals.cfm#grp15.
- The second paragraph refers to "Important fish spawning habitat in the Straits have been identified for other species, including Alewife, Rainbow Smelt, and Walleye (Table E6)." Note that the Straits area also holds important spawning habitat for Lake Trout, See https://www.glahf.org/explorer/.
- Table E6. Fish species in Lakes Michigan and Huron that are most vulnerable to oil exposure following rupture of the Line 5 pipeline in the Mackinac Straits
  - What does Commercial Value for Fisheries mean as related to the Straits? Not all species marked with an X under the "Fisheries" column are considered commercial species by the State of Michigan.
  - What does Commercial Value for Aquaculture mean as related to the Straits?
- Page 209, explain how the properties of bunker C oil relate to oil transported by Line 5.

- In the paragraph describing Yellow Perch on page 209, the mention of Walleye, Largemouth Bass, and Northern Pike does not make sense.
- In the paragraph describing Lake Sturgeon on page 209, it should be clarified that they are listed as Threatened under the Endangered Species Act of the State of Michigan (Part 365 of PA 451, 1994 Michigan Natural Resources and Environmental Protection Act).

Section E.3.3.6 Birds

- The section “Oil Toxicity to Birds” does not clearly relate marine or other regional bird research to birds likely to be found in Michigan.
- In general, much attention is given to federally listed threatened and endangered species, while State listed T&E species aren’t mentioned in the text (though they are acknowledged in the table).
- Page 221- the piping plover section probably should have been the last paragraph in this section as it interrupts the flow of the discussion and other species could have been mentioned as well. Piping plover is an important coastal species, mentioning others as examples (colonial nesting water birds such as Common Tern) would strengthen the discussion.
- Page 222- Timing of Waterbird Migration- “For example, the breeding piping plover arrives on its breeding territories”. Remove the first “breeding” as it is redundant, and some of the piping plover that return aren’t breeding.

Section E.3.3.7 Mammals

- Page 222- these species are also of cultural importance to Native Americans.
- MNFI “Biotic” data should read “Biotics.”
  The phrase “impacts from chronic exposure to oil were also seen” is the first mention of impacts to chronic exposure to oil so the word “also” doesn’t fit.

Section E.3.4 Overall Ecosystem Impacts

- There isn’t any mention about the impacts to rare plant species and rare natural communities.

Section E.3.5 Summary

- This section does not address secondary resource impacts caused by response efforts such as vegetation removal, wetland disturbance, increased boat and pedestrian traffic, disturbance or destruction of habitat, or potential introduction of invasive species. The sentence just before the summary reads “It is, therefore, possible that the extent of risk on natural resources could be reduced given clean-up activities and time of year of an event.”

Task F: Analyzing potential measures to restore the affected natural resources and mitigate adverse impacts upon ecological and cultural resources

- This section does not address measures to mitigate affected natural resources, including the availability, effectiveness, and costs of potential mitigation measures. The authors appear to erroneously assume that compensatory restoration costs under Natural Resource Damage Assessment authorities or mitigation costs cannot be estimated.

F.1 Introduction

- In the first sentence, "Damage Assessment and Restoration Plan" and "DARP" should be deleted.
- The first paragraph states that "scientists" believe … please provide a reference to this as it suggests that "all scientists" believe…
- Figure F1- Articulating Cultural and Natural Resources Laws in the US. The figure caption should have the word "Federal" placed within. In Paragraph 1, all the laws mentioned are Federal laws, any relevant state laws and policies should be included.
- The second paragraph includes a statement that compensatory restoration "cannot be determined until the losses have been inventoried and full recovery has occurred." This needs additional explanation or clarification as it is not true that full recovery must have occurred for trustee agencies to estimate losses over time and make a claim for compensatory restoration.
- The second paragraph includes a sentence that says, "We will discuss injuries to examples of resources that may require both primary and compensatory restoration, but the latter costs cannot be included." This needs additional explanation or clarification as we understand relevant examples of compensatory restoration and associated costs do indeed exist.
- The paragraph on page 236 about primary restoration mischaracterizes the cleanup work that was conducted after the first year as primary restoration. Most of the work described was still cleanup work being conducted pursuant to orders from the U.S. EPA using their response authorities. The boundary between cleanup and primary restoration is more a legal one than a practical one. "Cleanup" is conducted under response authorities and "primary restoration" is conducted under NRDA authorities. Practically speaking, a cleanup operation may accomplish all the goals that the trustee agencies would seek under their authorities to make claims for primary restoration. In the case of the Enbridge Line 6B oil discharges, significant work to restore habitats impacted by the oil and the response activities was required by the U.S. EPA and MDEQ under their response authorities. The definition of "primary restoration" used throughout Task F seems to be confusing long-term cleanup actions with primary restoration under NRDA. This should be clarified.

F.2.1. Definition of Worst-case Scenario

- The last sentence of the first paragraph ends with "the restoration of baseline and that timeline cannot be simulated", but NRDA trustee agencies routinely estimate trajectories for return to baseline and calculate the lost levels of ecological services over acres and years (see https://darrp.noaa.gov/economics/habitat-equivalency-analysis).

F.3 Analysis

- In the first paragraph, the statement "yet, it could be claimed that the natural resources damaged in the case of Deepwater Horizon were of greater significance than those in the case of Line 6B spill in Marshall MI." should be deleted.

Table F1. Oil Spill Comparison

- While use of the term "Primarily wetland" for types of shoreline impacted because of the Enbridge Line 6B spill is correct, given that the impacted area was primarily floodplain, it does not account for the wooded floodplain, emergent marshes, rare fen, areas of submerged and floating vegetation, and riverine riffles and pools that were also impacted.

Section F.3.1.1 Wetlands

- Under limitations or plantings; care must also be taken not to introduce non-native invasive species.

Section F.3.1.1.2 Approach for restoration- Sediment Removal

- In addition to limited manual cleanup, another alternative to addressing oil in sensitive wetland habitats is to monitor for natural recovery and not employ direct intervention.

Section F.3.1.4.1

- Page 251"Habits" should be "habitats" "13 unique terrestrial communities- the examples include coastal fens and Great Lakes marshes and gravel cobble shoreline which are not considered terrestrial but are palustrine communities.

Section F.3.2.4.1

- Page 255- last sentence refers to endangered reptiles and amphibians in the straits. There aren't any species listed as endangered; species of conservation concern or rare would cover it though.

Section F.3.2.6 Birds Page 258

- "Waterbirds such as loons, grebes and cormorants many of which have both high ecological value and Economic value as important game species"- None of the examples are game species so including waterfowl in the list would be important especially as the

Straits is a high migratory waterfowl staging area. Many would disagree with the statement that cormorants have high ecological value.

- Does Migratory bird hunting include woodcock? The report should state that "Migratory waterfowl hunting" or water fowl hunting instead of "migratory bird hunting".
- Page 259 "Sediment removal and replacement will take place in sand environments typically used by these nesting shorebirds". What nesting shorebirds is this referring to?
- Page 259 "Restore lost birds by facilitating additional reproduction and/or reduce mortality of injured bird species"." It is unclear how seasonal waterfowl closures will help mitigate loss during oiling; the assumption is that seasonal waterfowl closures refer to closures for waterfowl hunting? Waterfowl hunting is typically considered compensatory mortality instead of additive mortality so further clarification would be helpful.

Section F.3.2.6.3 Monitoring

- "Observation and collection of bird species will take place…" What does "collection" refer to?
- "there are a number of monitoring systems in place to collect the number and distribution of birds in Michigan". Should "Collect" read Estimate?
- National Audubon IBAs is not a monitoring system but a designation of important habitat.
- MNFI information can be used to report on presence or absence of species but it wouldn't be useful for population monitoring.

Section F.3.2.7 Terrestrial Mammals

- Page 260 "these species are considered of economic importance…" they are also culturally significant species to tribal members.
- Monitoring- "MI DNR monitors mammal populations through the issuance of trapping permits". The issuance of a fur bearer license cannot be used to monitor mammal populations. The only species listed in this section that requires mandatory registration is river otter, so some information could be gleaned for that species about distribution. There is a trapper harvest survey that asks questions about harvest that could also provide information about distribution, but it would be hard to assess populations from this.

Section F.3.4.2.2. Marshall MI

- The reference to $62,000,000 for primary shoreline restoration is incorrect as it included restoration costs beyond what occurred along the shoreline (e.g., wetlands), payments for compensatory restoration projects, mitigation projects, and provisions for agency cost reimbursement among other things. Much of what the report is referring to as primary restoration was instead conducted under cleanup actions that were not part of the monetized value of the compensatory restoration included as the bulk of the $62 million reported in the press releases for the NRDA settlements. Instead of using shoreline restoration as a surrogate for all potential restoration and mitigation measures, it would be more accurate to use the $62 million over 112.6 km as a surrogate for estimating compensatory restoration and mitigation than for primary restoration.

<u>Task G</u>

Section G.I.2.2 Assessing Losses

- The third paragraph starts with “Our assessment of natural resource damages estimates economic losses for injuries to recreational uses of natural resources.” The report should clarify why the analysis focused on injuries to recreational uses and what other types of damages to natural resources have not been estimated. The report should also clarify the distinctions between the scope of the analysis presented and a full natural resource damage assessment under the Oil Pollution Act.

Section G.I.5 Conclusions

- The first sentence on page 322 says “Our estimates do not include dollar values – such as use and non-use values – lost due to injuries to habitat and wildlife that are not manifested through recreational uses.” This limitation should be explained and clarified in relation to Task II-G (2) in the Statement of Work which includes analyzing "the economic value of the natural resources destroyed or impaired".
- Also, on page 322, the last sentence in the first bullet reads “If the restoration of habitat and wildlife services from section F does not compensate for the lost services during the injury period, the standard approach in NRDA would be to assess these losses via habitat-scaling approaches such as habitat equivalency analysis, which is beyond the scope of our assessment and outside the expertise of economists.” This should be explained and clarified in relation to Task II-G (3) in the Statement of Work which includes analyzing "The economic value of the public uses and ecological services . . . that would be lost until a final cleanup and restoration is complete", as well as Subtasks II-G 2 and II G 3-4

<u>Task H</u>

Section H.1.2 The Line 5 Oil Spill “Policy Network”

- On page 330, please note that the Office of the Great Lakes is now located within the Michigan Department of Natural Resources. Regardless, this parenthetical statement should be deleted as the Office of the Great Lakes does not have a specific role in oil response efforts.

Section H.2.2 Government Benefits: Gain in State and Federal Tax Revenues

- The assumption that total oil-spill cleanup costs will be $500,000,000 paid by responsible parties as referenced in Section F.3.4.3 may be inaccurate based on concerns with using shoreline restoration as a surrogate for all potential restoration and mitigation measures and an incorrect dollar amount used in the case of the Marshall spill.

<u>Task X</u>

- Task X and the rest of the main report fail to discuss in detail any of the broad impacts relating to energy supply disruptions to Michigan and the region following a worst case spill. A report detailing such impacts was included as Appendix GI-2, but neither Task X nor any other section of the main report references or makes consequential use of the information contained in this appendix.