ENBRIDGE ENERGY
2001 PIPELINE CROSSING INSPECTIONS

Project Overview

Onyx - Superior Special Services, Inc. was contracted to perform underwater inspections of navigable pipeline water crossings in the states of North Dakota, Minnesota, Wisconsin, Illinois, Michigan, and New York. Because of the difference in methods and equipment used to complete the contract, the work was divided into two portions:

- The Straits of Mackinac
- River Crossings.

The survey and inspection of The Straits of Mackinac was performed between July 30th and September 15th, 2001. The report for The Straits of Mackinac portion of the work (titled 2001 Hydrographic Survey of Pipeline and Subsequent Emergency Repairs) was submitted in November of 2001. This report deals primarily with the River Crossings portion of the work; which was performed between October 9th and October 30th, 2001.

Combinations of sonar, total station, global positioning, video and dive equipment were used in the field to collect bathymetric data and inspect the pipeline crossing routes. The River Crossings inspections began in Duluth, MN with a safety briefing at the Enbridge Energy office. The River Crossings were then completed in the following order:

1. Nemadji River - Superior, WI;
2. Red River of the North – Drayton, ND;
3. Pembina River – Neche, ND;
4. Cass Lake & Cass Lake Channel – Cass Lake, MN;
5. Mississippi River – Ball Club, MN;
6. Bad River – Ashland, WI;
7. Wisconsin River – Wisconsin Rapids, WI;
8. Rock River – Fort Atkinson, WI;
9. Des Plaines River – Joliet, IL;
10. St. Joseph River – Niles, MI;
11. Indian River – Indian River, MI;
12. Saginaw River – Bay City, MI;
13. Niagara River – Grand Island, NY; and
14. Buffalo River – Buffalo, NY.

Each site's accessability, water depth, pipeline location aids and surrounding terrain determined the methods and equipment employed to complete the field work. The data and information collected in the field was used to create plan and profile plot for each crossing, along with this report. If you have any questions about the 2001 Pipeline Crossing Inspections or this report, please direct them to the following address and contact:

Onyx-Superior Special Services, Inc.
Company Headquarters
P.O. Box 1323
100 W. Larsen Drive
Fond du Lac, WI 54937
(800) 688-4005 phone (920) 923-9010 fax

Contacts
Trent Nedens - Engineering/Hydrographics Manager
Fond du Lac, WI Office - ext. 515
TJNEDENS@SUPERIORSERV.com
Mark Berge – Operations Manager
Fond du Lac, WI Office - ext. 508
MGBERGE@SUPERIORSERV.com

General Equipment & Methods

Due to the unique conditions present at each of the River Crossings, Onyx – SSS had to employ a variety of different surveying and inspection equipment in order to complete the work. The following is a list of the equipment used on the various crossings, including model and serial numbers.

➢ **Multibeam Sonar System:**				
• Reson Multi-beam Sonar	Model	Seabat 9001	Serial #	4697020
• TSS Motion Reference Unit	Model	DMS 2	Serial #	032003
• Trimble DGPS	Model	AG 132	Serial #	0224008190
• HyPack Software	Version	8.9		
➢ **Single-beam Sonar System:**				
• Odem Echotrac	Model	DF3200	Serial #	H110889
• See Trimble DGPS Mobile Unit				
➢ **Trimble DGPS Mobile Unit**	Model	AG 132	Serial #	0224017816
➢ **Applied Microsystems** (Sound Velocity Meter)	Model	SV Smart Sensor	Serial #	
➢ **Radiodetection System (Pipeline Locator):**				
• Receiver	Model	PXL-2	Serial #	400628
• Transmitter (*Active*)	Model	HPTX-2	Serial #	302008
➢ **Topcon Total Station**	Model	GTS-210	Serial #	LJ2495

In addition to the equipment listed above, the following equipment was used to complete the Straits of Mackinac portion of the work.

➢ **Deep Ocean Engineering ROV**	Model	HD2	Serial #	HD368
➢ **ORE Acoustic Positioning System (Trackpoint 2):**				
• Topside Unit	Model	4410D-01	Serial #	483
• Hydrophone	Model	4211A	Serial #	461OB
• Beacons	Model	4330MN0003	Serial #	1550 & 1659
➢ **Side Scan Sonar System**				
• Marine Sonic Side Scan Sonar	Model	150/600	Serial #	H110891
• Trimble DGPS	Model	AG 132	Serial #	0224017816

Additional information and specifications for the equipment listed can be found in Appendix B. Procedures and methods for the equipment used exclusively for the Straits of Mackinac portion of the work are outlined in the 2001 Hydrographic Survey of Pipeline and Subsequent Emergency Repairs document.

For the River Crossing portion of the work, the survey team used either the Multi-beam sonar, Single-beam sonar, or Total Station survey system to obtain the bathymetric (depth contour and bottom profile) data over and around the pipelines. The DGPS mobile unit was used at every site to obtain coordinates for the benchmark used, the position the total station was placed to obtain datum and/or collect depth points, and to depict the shoreline and high banks around the crossing. Divers and/or video documentation were used to inspect every pipeline route at each crossing site. Subsurface object Location Equipment was also used at every site to locate the pipelines along shorelines.

A Survey Log was completed for each crossing site inspected. The log contains general survey information, as well as weather conditions, equipment used, calibration results, survey geodesy, dive survey notes, and matrix (survey area) coordinates. In addition, a Pipeline Crossing Information Log was also completed for most of the crossing sites. This log contained information specific to this job; including pipeline identification (diameter, color-code, and line number), critical coordinates (shoreline, high bank, benchmark, total station), vertical datums (benchmark, water surface), and site sketches. A photo log documenting the crossing, benchmark, and other details of interest was also maintained for the majority of the sites. Refer to Appendix C for copies of the Survey Logs for each crossing site.

Multi-beam Sonar Survey

At sites where the Multi-beam sonar system was used, the survey began with the design of a collection matrix within the HyPack collection/navigation software. A matrix is a geo-referenced area around the site which enables the surveyor to see the coverage of the system in real-time. Matrices for the River Crossings were defined to encompass all of the pipelines crossing at a particular site, while maintaining a minimum of 50' of area upstream and downstream of the outermost pipelines. The Multi-beam system is housed in the survey vessel Miss Geodesy, and limited to areas with a minimum of 3' of water depth and reasonable access.

Miss Geodesy >



Once the matrix was created, the sonar was deployed at a minimum depth for site conditions (2' for all the sites covered in this inspection). Once deployed, a series of calibration tests were conducted to assure the sonar and its components are performing properly. Water velocity measurements were obtained at 5' intervals, averaged, and then inputted into the sonar software. The final calibration was a lead line check of the corrected sonar reading within HyPack, the results of which were recorded on the Survey Log.

The survey technicians attained nearly 100% coverage of the survey matrix areas, with minimum data densities of 1 to 4 points per square foot of survey area. The system collected a minimum of 20 thousand raw data points per minute of survey, with sub-meter horizontal accuracy and vertical accuracy between ± 0.15' and ± 0.30'. All raw data was recorded to CD and edited by technicians at the Fond du Lac, WI office.

Single-beam Sonar Survey

The Single-beam sonar system was used at sites where access was limited to small boats or water depths were between 5' and 1.5'. In these areas, the pipeline routes were plotted in HyPack, and displayed on a laptop computer aboard the shallow water vessel. Additional lines were replicated parallel to the pipeline route at 10' intervals, extending to a minimum of 50' upstream and downstream of the pipeline.



< Shallow Water Vessel

The sonar was deployed at a minimum depth for site conditions (0.5' for all the sites covered in this inspection). Once deployed, a series of calibration tests were conducted to assure the sonar and its components were performing properly. Water velocity measurements were obtained and inputted into the sonar software. The final calibration was a lead line check of the corrected sonar reading within HyPack, the results of which were recorded on the Survey Log.

The survey technicians piloted the shallow water vessel along the each pipeline route and along the replicated survey lines around them. The system collected a minimum of 40 thousand raw data points per hour of survey, with sub-meter horizontal accuracy and vertical accuracy within ± 0.1'. All raw data was recorded to CD and edited by technicians at the Fond du Lac, WI office.

Trimble DGPS Mobile Unit

A Differential Global Positioning System (DGPS) mobile unit was used at all of the crossing sites. The unit will attain sub-meter horizontal accuracy when it can capture 5 or more satellites and a correction signal (the correction signal provides the differential component of the position solution). When in use for this project, the unit was activated and allowed to 'settle' for 5 minutes. The unit was then checked to see if it had the required number of satellites and correction signal needed to achieve sub-meter accuracy

(the unit was not used until these criteria were met). The unit was used as a stand-alone device to obtain coordinates for selected targets and as the positioning unit for the Single-beam sonar system.

Sound Velocity Meter
Because the velocity of sound through water can change dramatically with temperature and other site conditions, the Sound Velocity Meter was used at each site to measure the specific speed of sound during the survey. Measurements were taken at 5' intervals and averaged before entering the value into the HyPack software. This procedure is an important step in the calibration process completed before every survey.

Radiodetection System (Pipeline Locator)
Location equipment was needed to determine the pipelines' positions along the shorelines of the various river crossings. The equipment used for this survey was rented from Telco Sales, a licensed distributor of Radiodetection equipment. Steve Bogenholm, a representative from Telco Sales, met the survey crew on site in Superior, WI for field training in the operation of the rental equipment. The training course lasted 8 hours and covered operation, troubleshooting, and usage based on site conditions.

During a survey, the first step was to locate the pipelines on site. The number, color-code, size and approximate position of the pipelines was determined through the use of previous survey maps, local assistance, current information from Enbridge Energy representatives, and crossing markers. If test caps were present, the transmitter was hooked to the test leads and activated (usually set between 100 & 350 millivolts).

The pipelines were located by walking perpendicular to their route along the shorelines of the crossing with the receiver. If the transmitter was used, the pipelines were first located and flagged in the *Active Mode* setting on the receiver. Then the receiver was set to *Passive Mode* and the positions were either verified against the *Active Mode* positions or simply located in *Passive Mode* alone. Once completed, the final positions were checked against any pipeline markers present at the crossing site.

Topcon Total Station
The Total Station was only used at sites where boat accesses and/or water depths were less than 1.5' deep. It has a visual range of ~3,500 feet and is calibrated bi-annually in-house. The system consists of the collection unit with the laser and focal optics and a prism attached to a waterproof telescoping staff. For obtaining datum, the unit was leveled and then calibrated to a new or existing benchmark on site, setting the relative elevation of the benchmark to 0.00'. Then the prism staff was held at the water surface and datum was recorded. This process was repeated every hour and averaged.

When bathymetry had to be collected, the diver would walk along the pipeline with the prism staff; holding it on the river bottom or on the top of the pipeline (if exposed). The surveyor would take depth measurements at 5' intervals along the pipeline routes and along routes parallel to the pipelines up to 50' away.

Please refer to the individual River Crossings section of this report for more detailed information on the equipment, procedures, findings, and recommendations associated with each crossing site.

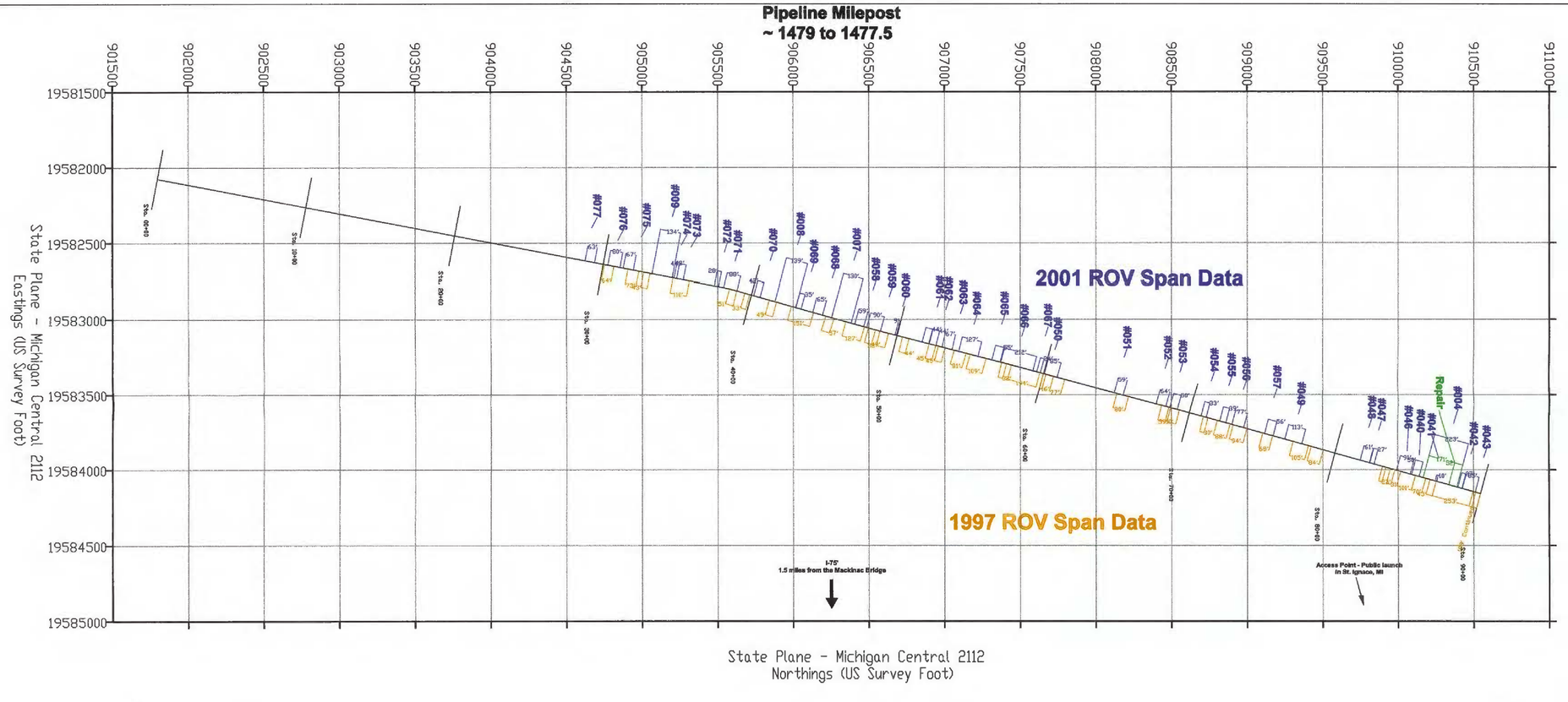
Straits of Mackinac Crossing

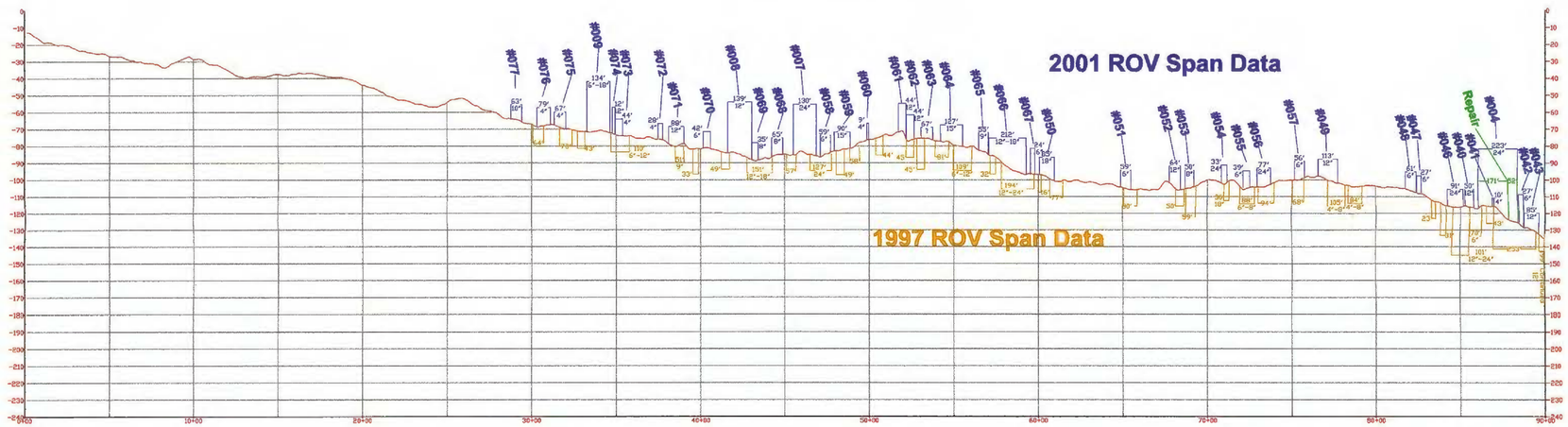


General Information

Location:	Mackinac Straits, MI; approximately 1.5 miles west of the bridge Access from public launch (St. Ignace, MI)	
Nearest Cities:	St. Ignace, MI & Mackinaw City, MI	
Pipeline Milepost:	MP 1479 through 1476	
Date of Inspection:	July 30 through September 15, 2001	
Weather Conditions:	Variable	
	Air Temps. (High / Ave. / Low)	= 85° / 60° / 35°
	Wind (Speed & Direction)	= Variable 5 – 20 mph
Water Conditions:	Current Speed	= Variable 1 - 3 fps
	Visibility	= Excellent (10' to 50')
	Datum	= Variable
Personnel Involved:	Trent Nedens – Lead Surveyor & Dive Tender Darrell Martin – Surveyor & Lead ROV Technician Lance Birdsall – Crew Chief & Survey Technician Matt Volpe – Deckhand Adam Vandenhouten – Diver & Survey Technician Jim Howard & Adam Erickson– Enbridge Energy Representatives United States Coast Guard – St. Ignace, MI Group	
Equipment Used:	Side Scan Sonar Package	Multi-beam Survey Package
	DGPS/Trackpoint Integrated Units	ROV Package
Inspection Time:	210 hours	
Pipelines Present:	Twin Lines: Line 5	30" Diameter Red Line
Reference Drawings:	**Enbridge # D-5.84-13039-0-0**	**Onyx-SSS # 021**
	Enbridge # D-5.84-13040-0-0	**Onyx-SSS # 022**
	Enbridge # D-5.84-13041-0-0	**Onyx-SSS # 023**
	Enbridge # D-5.84-13042-0-0	**Onyx-SSS # 024**
	Enbridge # D-5.84-13043-0-0	**Onyx-SSS # 025**

See 2001 Hydrographic Survey of Pipeline and Subsequent Emergency Repairs report for more information on this crossing.





LEGEND

Red Pipeline - Profile View Facing West
Line 5 (30" Diameter)

Eastern Pipeline (Center to South)

1997 ROV Span Data

2001 ROV Span Data

2001 Span Repair Data

Enbridge Drawing # D-5.84-13040-0-0

NOTES:

1) Survey data was collected by Superior Special Services - Hydrographic Survey Team. Data was collected using a multibeam sonar system from 07/31 thru 08/02, 2001. The multibeam system uses electronic instrumentation to correct for heave, pitch, and roll; and applies DGPS horizontal positioning in real time.
2) Reference data was collected with DGPS in Geographic Coordinates (NAD 83), using DDM format.
3) Bathymetric and Cross-sectional data is referenced to the State Plane (NAD 83), MI Central (2112) coordinate system.
4) Vertical scale of profile views exaggerated 10X to show detail.
5) NOAA tide data was used to correct for variance in datum throughout the survey. Water elevation was referenced to 577.5' NAVD 88 (NAVD is equal to IGLD in this area, < 0.1' difference).
6) Details on the pipeline condition are outlined in the drawing and final report.
7) **2001 Span data collected with a Phantom HD2 ROV; utilizing the Trackpoint 2 acoustic positioning system and a Trimble AG 132 DGPS unit.**

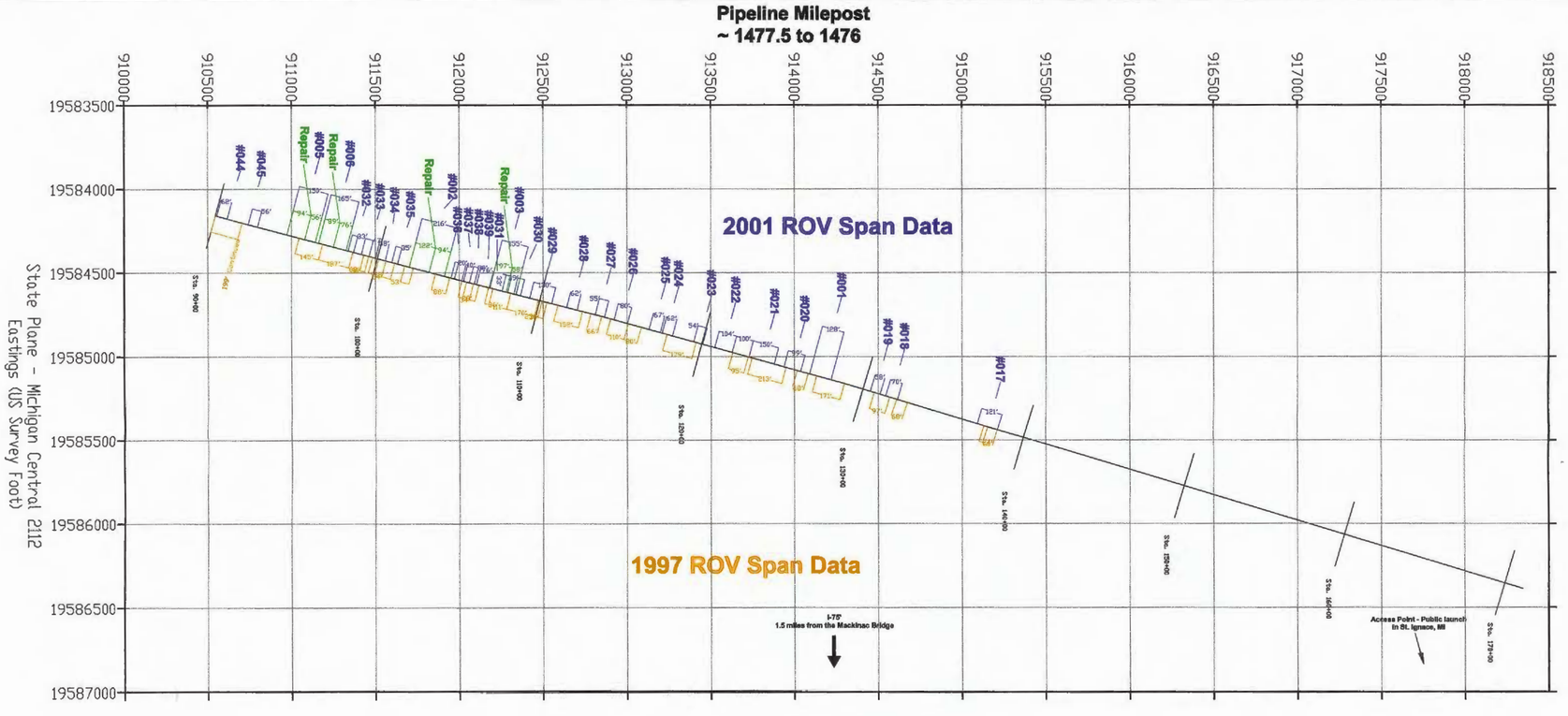
MACKINAC STRAITS
EASTERN PIPELINE - SOUTH END

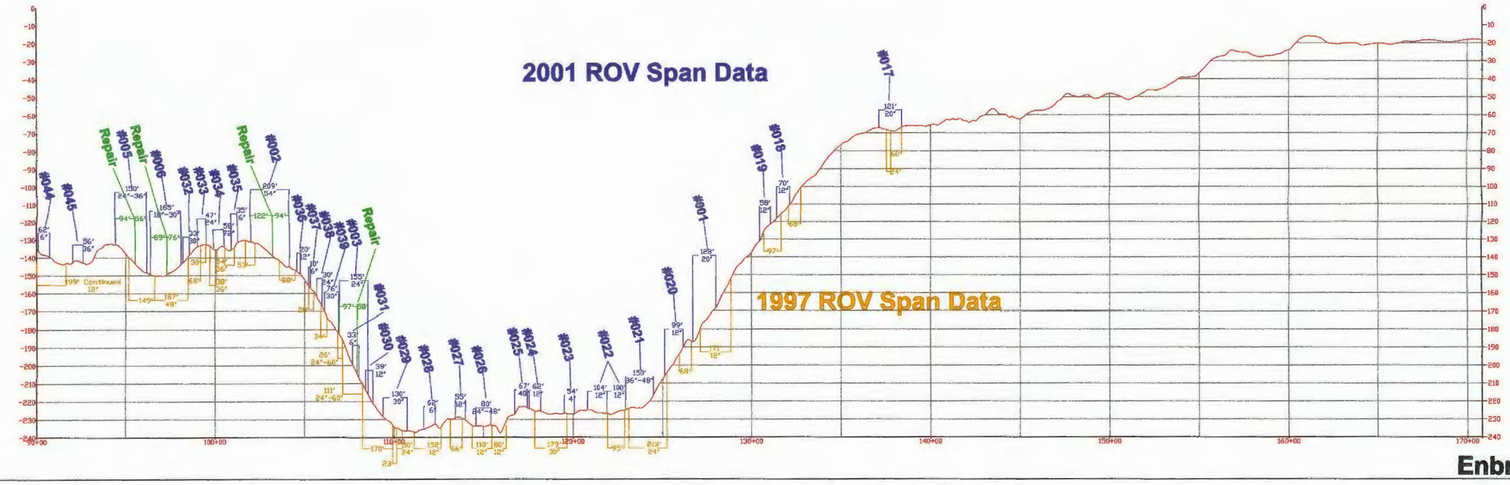
2001 Navigable Waterway Inspection
Mackinac Straits

Plan and Profile Views
2001 vs. 1997 Surveys
Eastern Pipeline - South End
Mackinac Straits near Mackinaw City, MI
July 30 thru September 14, 2001

ONYX
100 W. Larsen Dr. - P.O. Box 1323
Fond du Lac, WI 54936-1323
Phone: (920) 923-9000
Fax: (920) 923-9010

Drafter:	Duane Peterson
File Name:	2001 vs 1997 E. S. S. F.
Job #:	490159C.01.071
Date:	12/20/01
Drawing:	022





LEGEND

Red Pipeline - Profile View Facing West
Line 5 (30" Diameter)

Eastern Pipeline (Center to South)

1997 ROV Span Data

2001 ROV Span Data

2001 Span Repair Data

Enbridge Drawing # D-5.84-13041-0-0

NOTES:

1) Survey data was collected by Superior Special Services - Hydrographic Survey Team. Data was collected using a multibeam sonar system from 07/31 thru 08/02, 2001. The multibeam system uses electronic instrumentation to correct for heave, pitch, and roll; and applies DGPS horizontal positioning in real time.
2) Reference data was collected with DGPS in Geographic Coordinates (NAD 83), using DDM format.
3) Bathymetric and Cross-sectional data is referenced to the State Plane (NAD 83), MI Central (2112) coordinate system.
4) Vertical scale of profile views exaggerated 10X to show detail.
5) NOAA tide data was used to correct for variance in datum throughout the survey. Water elevation was referenced to 577.5' NAVD 88 (NAVD is equal to IGLD in this area, < 0.1' difference).
6) Details on the pipeline condition are outlined in the drawing and final report.
7) **2001 Span data collected with a Phantom HD2 ROV; utilizing the Trackpoint 2 acoustic positioning system and a Trimble AG 132 DGPS unit.**

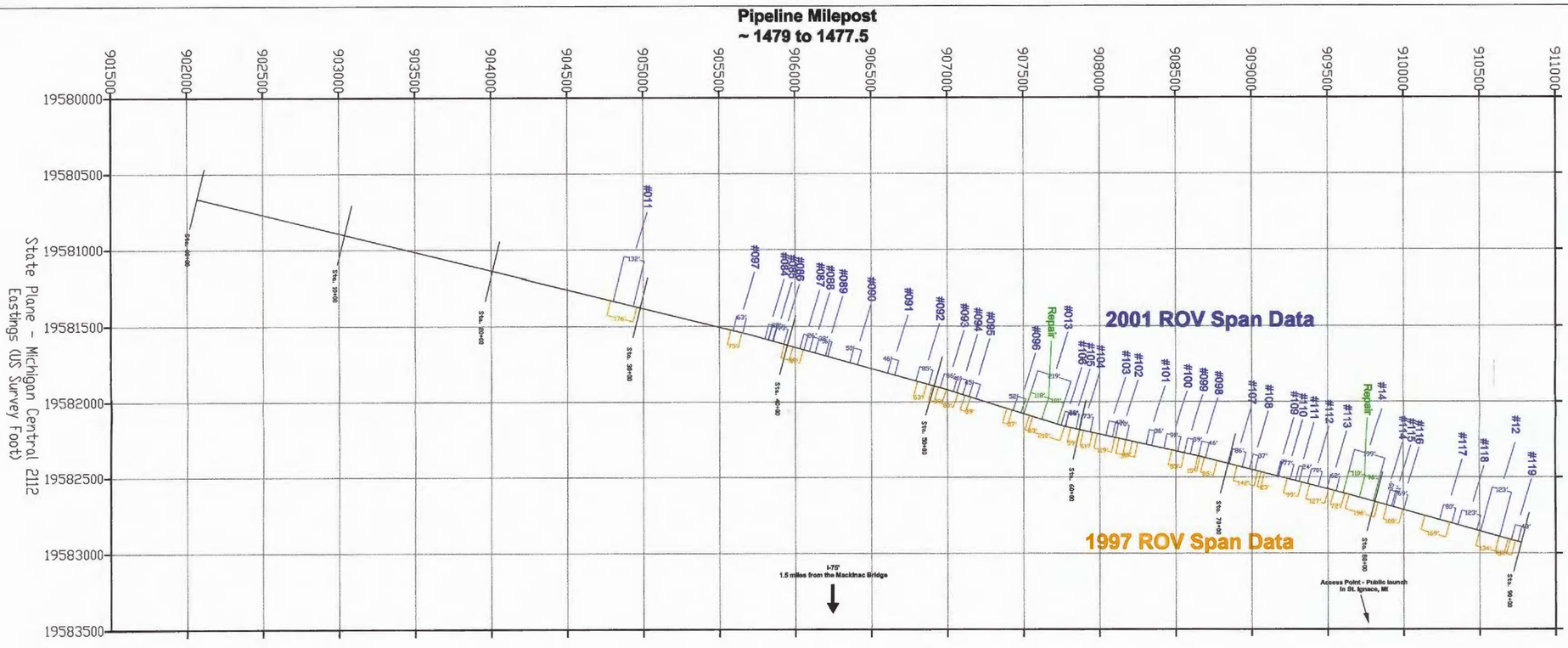
MACKINAC STRAITS
EASTERN PIPELINE - NORTH END

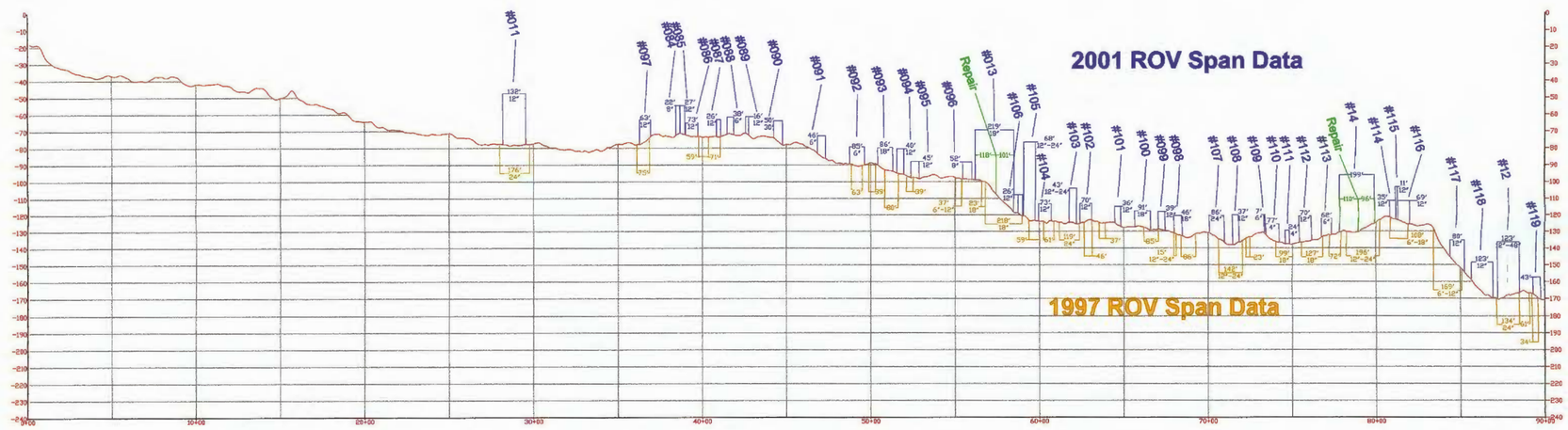
2001 Navigable Waterway Inspection Mackinac Straits

Plan and Profile Views
2001 vs. 1997 Surveys
Eastern Pipeline - North End
Mackinac Straits near Mackinaw City, MI
July 30 thru September 14, 2001

ONYX
100 W. Larsen Dr. - P.O. Box 1323
Fond du Lac, WI 54936-1323
Phone: (920) 923-9000
Fax: (920) 923-9010

Drafter:	Duane Peterson
File Name:	2001 vs 1997 E. S. N. F.
Job #:	490159C.01.071
Date:	12/20/01
Drawing:	023





LEGEND

Red Pipeline - Profile View Facing West
Line 5 (30" Diameter)

Eastern Pipeline (Center to South)

1997 ROV Span Data

2001 ROV Span Data

2001 Span Repair Data

Enbridge Drawing # D-5.84-13042-0-0

NOTES:

1) Survey data was collected by Superior Special Services - Hydrographic Survey Team. Data was collected using a multibeam sonar system from 07/31 thru 08/02, 2001. The multibeam system uses electronic instrumentation to correct for heave, pitch, and roll; and applies DGPS horizontal positioning in real time.
2) Reference data was collected with DGPS in Geographic Coordinates (NAD 83), using DDM format.
3) Bathymetric and Cross-sectional data is referenced to the State Plane (NAD 83), MI Central (2112) coordinate system.
4) Vertical scale of profile views exaggerated 10X to show detail.
5) NOAA tide data was used to correct for variance in datum throughout the survey. Water elevation was referenced to 577.5' NAVD 88 (NAVD is equal to IGLD in this area, < 0.1' difference).
6) Details on the pipeline condition are outlined in the drawing and final report.
7) **2001 Span data collected with a Phantom HD2 ROV; utilizing the Trackpoint 2 acoustic positioning system and a Trimble AG 132 DGPS unit.**

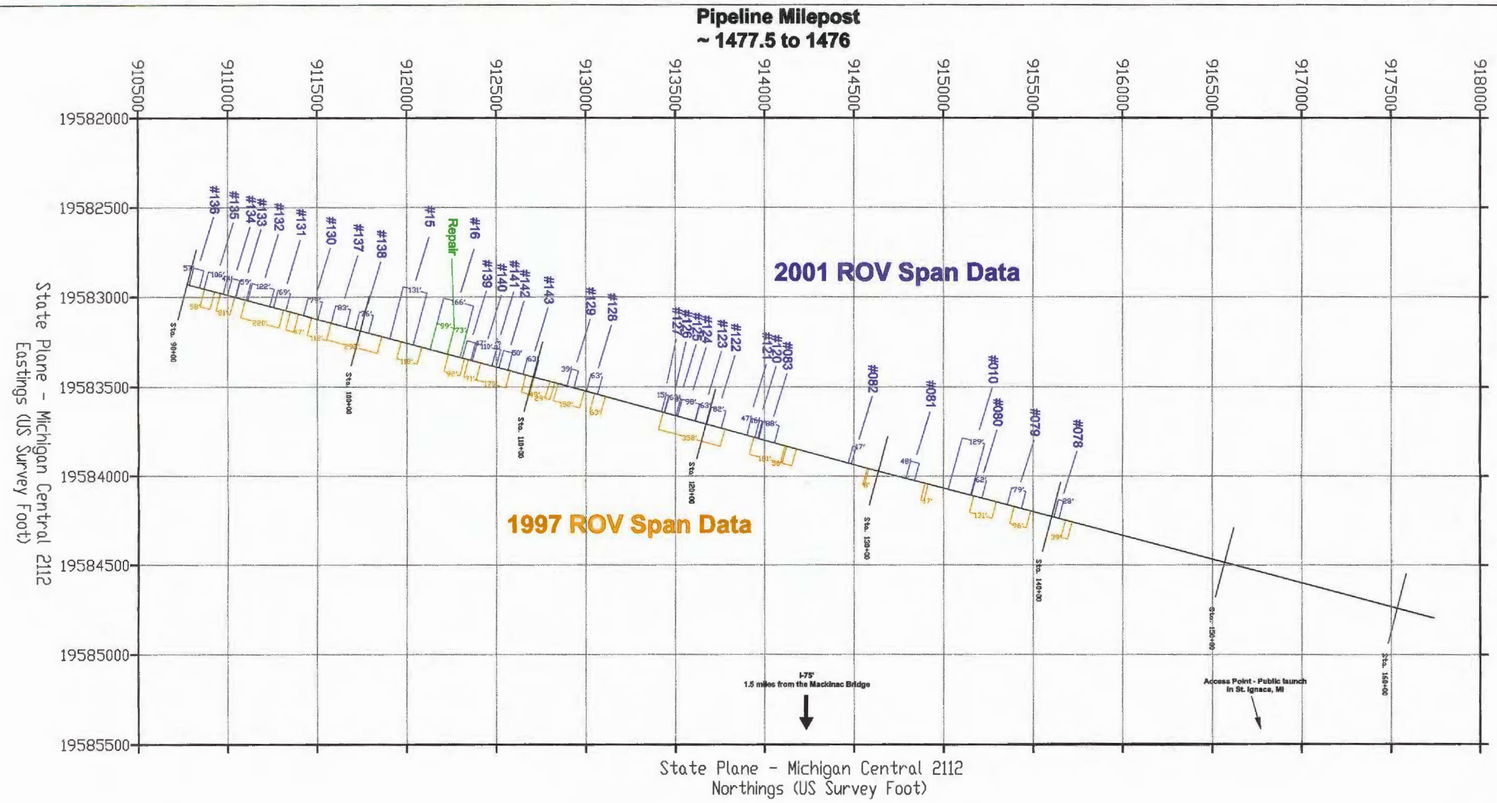
MACKINAC STRAITS
WESTERN PIPELINE - SOUTH END

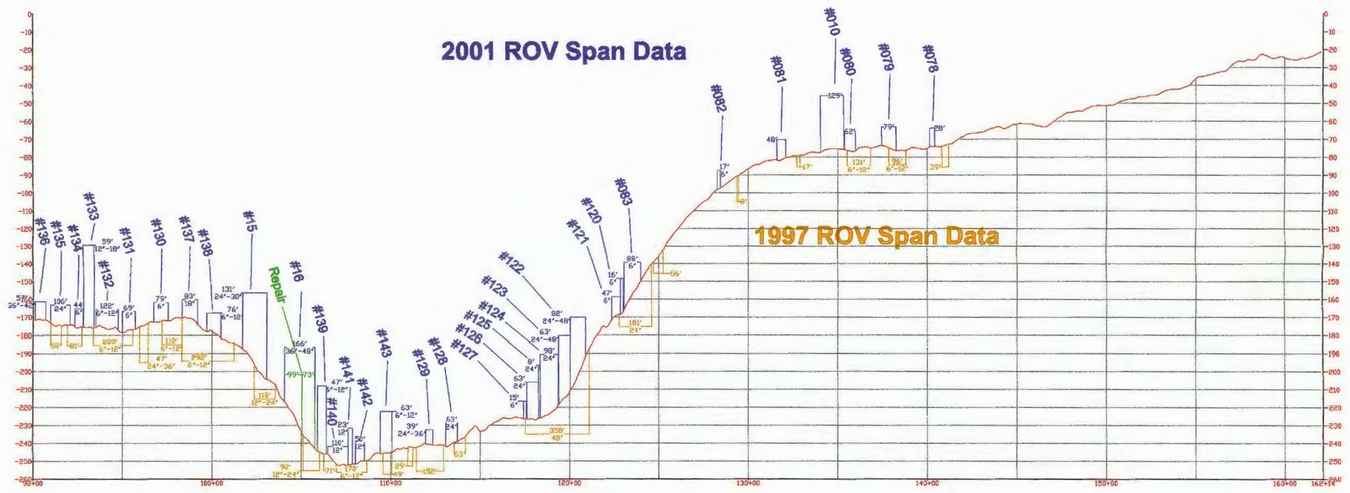
2001 Navigable Waterway Inspection Mackinac Straits

Plan and Profile Views
2001 vs. 1997 Surveys
Western Pipeline - South End
Mackinac Straits near Mackinaw City, MI
July 30 thru September 14, 2001

ONYX
100 W. Larsen Dr. - P.O. Box 1323
Fond du Lac, WI 54936-1323
Phone: (920) 923-9000
Fax: (920) 923-9010

Drafter:	Duane Peterson
File Name:	2001 VS 1997 W. S. S. F.
Job #:	490159C.01.071
Date:	01/17/01
Drawing:	024





LEGEND

Red Pipeline - Profile View Facing West
Line 5 (30" Diameter)

Eastern Pipeline (Center to South)

1997 ROV Span Data

2001 ROV Span Data

2001 Span Repair Data

Enbridge Drawing # D-5.84-13043-0-0

NOTES:

1) Survey data was collected by Superior Special Services - Hydrographic Survey Team. Data was collected using a multibeam sonar system from 07/31 thru 08/02, 2001. The multibeam system uses electronic instrumentation to correct for heave, pitch, and roll; and applies DGPS horizontal positioning in real time.
2) Reference data was collected with DGPS in Geographic Coordinates (NAD 83), using DDM format.
3) Bathymetric and Cross-sectional data is referenced to the State Plane (NAD 83), MI Central (2112) coordinate system.
4) Vertical scale of profile views exaggerated 10X to show detail.
5) NOAA tide data was used to correct for variance in datum throughout the survey. Water elevation was referenced to 577.5' NAVD 88 (NAVD is equal to IGLD in this area, < 0.1' difference).
6) Details on the pipeline condition are outlined in the drawing and final report.
7) **2001 Span data collected with a Phantom HD2 ROV; utilizing the Trackpoint 2 acoustic positioning system and a Trimble AG 132 DGPS unit.**

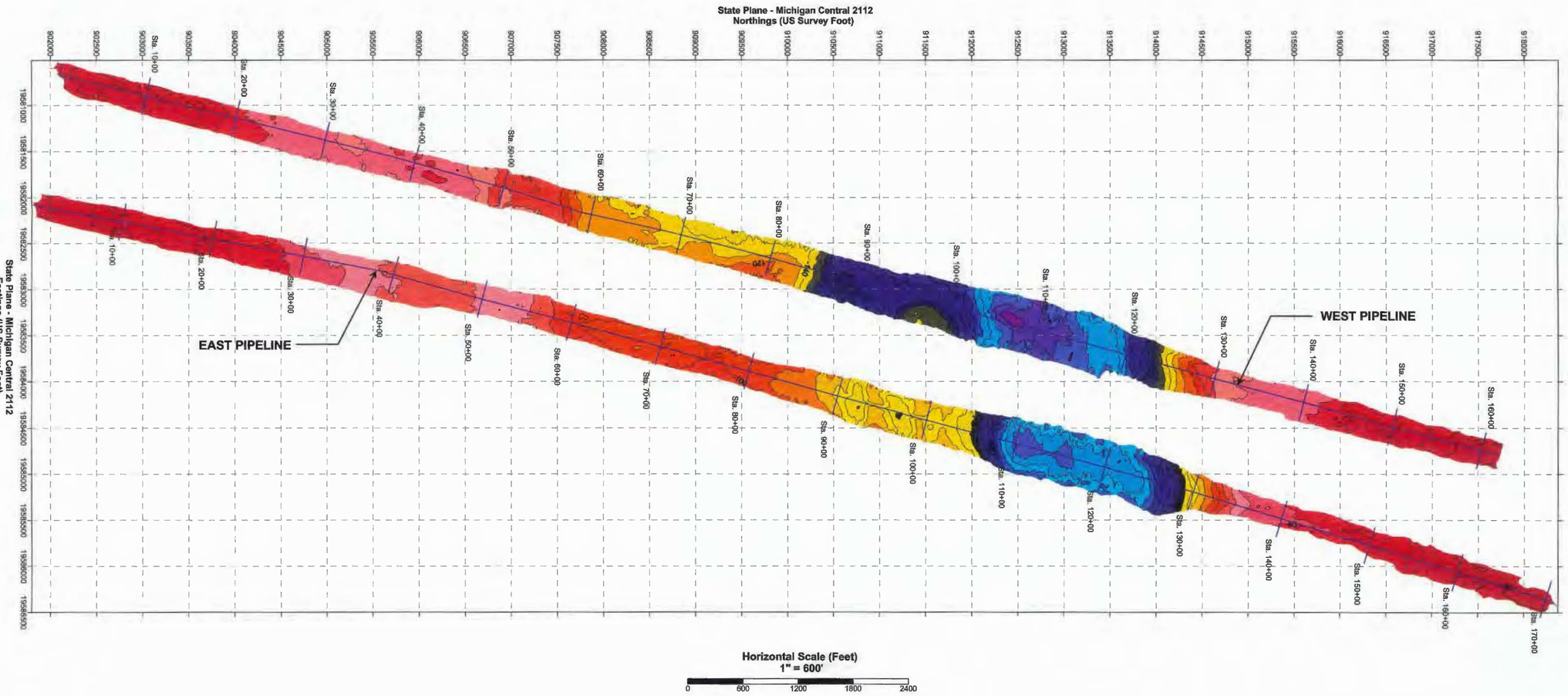
MACKINAC STRAITS
WESTERN PIPELINE - NORTH END

2001 Navigable Waterway Inspection Mackinac Straits

Plan and Profile Views
2001 vs. 1997 Surveys
Western Pipeline - North End
Mackinac Straits near Mackinaw City, MI
July 30 thru September 14, 2001

ONYX
100 W. Larsen Dr. - P.O. Box 1323
Fond du Lac, WI 54936-1323
Phone: (920) 923-9000
Fax: (920) 923-9010

Drafter:	Duane Peterson
File Name:	2001 VS 1997 W. S. N. F.
Job #:	490159C.01.071
Date:	01/17/01
Drawing:	025



Enbridge Drawing # D-5.84-13039-0-0

NOTES:
1) Survey data was collected by Superior Special Services - Hydrographic Survey Team. Data was collected using a multibeam sonar system from 07/31 thru 08/02, 2001. The multibeam system uses electronic instrumentation to correct for heave, pitch, and roll; and applies DGPS horizontal positioning in real time.
2) Reference data was collected with DGPS in Geographic Coordinates (NAD 83), using DDM format.
3) Bathymetric and Cross-sectional data is referenced to the State Plane (NAD 83), MI Central (2112) coordinate system.
4) Vertical scale of profile views exaggerated 10X to show detail.
5) NOAA tide data was used to correct for variance in datum throughout the survey. Water elevation was referenced to 577.5' NAVD 88 (NAVD is equal to IGLD in this area, < 0.1' difference).
6) Details on the pipeline condition are outlined in the drawing and final report.

MACKINAC STRAITS - EASTERN & WESTERN PIPELINES
PLAN VIEW COLOR FILLED CONTOUR MAP

2001 Navigable
Waterway Inspection
Mackinac Straits

Plan View Color Filled Contours
2001 Bathymetric Survey
Eastern & Western Pipelines
Mackinac Straits near Mackinaw City, MI
July 30 thru September 14, 2001

ONYX
Superior Special Services, Inc.
100 W. Larsen Dr. - P.O. Box 1323
Fond du Lac, WI 54936-1323
Phone: (920)923-9000
Fax: (920)923-9010

Drafter:	Duane Peterson
File Name:	COLORCONTOURDONE
Job #:	490159C.01.071
Date:	11/16/01
Drawing:	021