NPR-A AND HARRISON BAY HYDROGRAPHIC SURVEY 2003

Prepared by:
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ConocoPhillips

Anadarko
Alaska

POLARIS
APPLIED SCIENCES, INC.

NPR-A AND HARRISON BAY HYDROGRAPHIC SURVEY - 2003

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EXECUTIVE SUMMARY

Field studies were conducted in July 2003 to obtain water depth data in order to facilitate small-boat access (i) for the southern part of Harrison Bay between the Sakoonang/Tamayagiaq Channel, the Nigliq Channel, and the entrance to the Iqalliqpik River (Fish Creek-Judy Creek system), and (ii) for the Sakoonang, Tamayagiaq, and Ulamnigiaq Channels within the Colville delta.

The data are presented in a variety of formats that include:

- bathymetric survey track lines,
- track lines color-coded with water depth data,
- detailed charts with plotted water depth data,
- contoured bathymetry maps, and
- River Channel Navigation Charts that show recommended "safe passage" routes between waypoints.

During an exercise or response operation, it is important to be able to navigate quickly and safely to a destination. As boat operators may not be familiar with the channels of the region, the River Channel Navigation Charts were created from survey data to provide a simplified set of navigation charts that enable a boat operator to transit to a site easily and safely. The set of charts includes primary waypoints that can be entered into a GPS for navigation, and intermediate waypoints that locate specific channel or other features, such as shoal areas. Depth contour(s) indicate the approximate channel width so that a boat operator is aware if it is necessary to stay close to the waypoint navigation lines. River Channel Navigation Charts and navigation waypoint data are presented for:

- the area of southern Harrison Bay between the Sakoonang/Tamayagiaq Channel and the Nigliq Channel,
- the Nigliq Channel between Harrison Bay and CD-2,
- the lower Iqalliqpik River between Harrison Bay and the lake that is in reach E-35.

Figure E-1 shows on an orthophoto base the generalized bathymetric contours of the area of southern Harrison Bay that was surveyed in 2003.

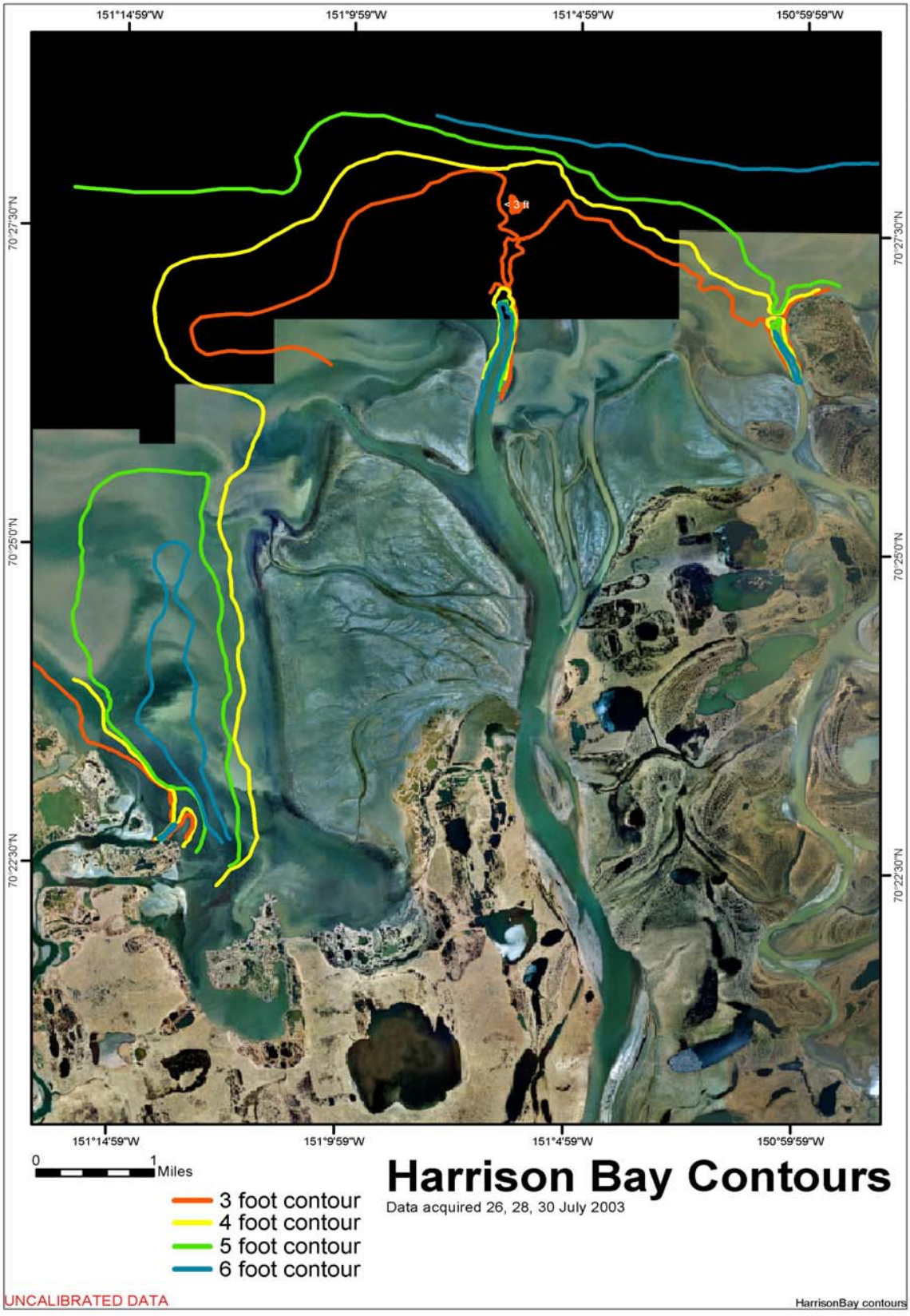

Figure E- 1 Generalized bathymetric contours of the area of southern Harrison Bay surveyed in 2003.

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1 INTRODUCTION

SUMMARY

- The objective of this study was to obtain water depth data for the southern part of Harrison Bay in order to facilitate small-boat access between the Sakoonang/Tamayagiaq Channel, the Nigliq Channel, and the entrance to the Iqalliqpik River (Fish Creek-Judy Creek system)[1].
- Field data were collected using an integrated water depth and Geographical Positioning System (GPS) system for the Sakoonang Channel, the Tamayagiaq Channel, the Ulamnigiaq Channel, the Nigliq Channel south to reach NK-5, the East Channel of the lower Iqalliqpik River as far west as reach E-35, and in the nearshore waters of Harrison Bay between approximately 70º 22.4' to 70º 28.2' N and 151º 17.0' to 150º 57.0' W.
- Data reduction involved the generation of the bathymetric survey track lines and examples of uncalibrated representative water depth data for: (1) the nearshore waters of Harrison Bay between the entrances to the Sakoonang/Tamayagiaq Channel and the Nigliq Channel; (2) the ACS pre-staging site # 267 on the east bank of the Nigliq Channel in reaches NK-7 and NK-8; and (3) the lower Iqalliqpik River delta.
- The astronomical tide component in the coastal waters of Harrison Bay is on the order of 0.3 feet. During periods of calm winds inspection of the predicted tide tables for Prudhoe Bay to determine the approximate times of high and low tides may provide a small advantage for passage through known very shoal areas. However, during periods of strong winds, the meteorological effects have a greater impact on overall water depths in terms of navigation,
- Water level changes on the order of 4 feet due to meteorological effects have been measured in southern Harrison Bay and up to 3 feet in the channels of the Colville delta. These changes have a significant impact on navigation particularly at the mouths of the Kupigruak, Sakoonang/Tamayagiaq, and Nigliq distributary channels in the Colville delta, and at the entrance to the Iqalliqpik River (Fish Creek).

[1] Inupiaq names recognized by the Inupiat people living in the area are used for waterways, with the USGS mapped names following in parentheses.

1.1 OBJECTIVES

The overall purpose of the oil spill response strategy study for the Alpine and NPR-A oil fields development project is to:

(a) develop an understanding of the physical character of the project area, and

(b) generate an information database that will enable practical and effective response strategies to be developed for potential spills on land, for spills adjacent to the lakes, rivers, or stream channels in the operational area, and for spills that might affect the nearby coast of Harrison Bay.

A key element of effective oil spill response operations in this coastal area is the ability for boats to move between the different channel systems that characterize the Colville delta and adjacent areas The nearshore waters of southern Harrison Bay and many of the river channels have shoals that limit boat traffic. As these depth limitations vary depending on changes in water levels associated with the meteorological and astronomical tides, it is critical to have data on the minimum water depths that are likely to occur in shoal areas at any given time. The maximum range of the predicted astronomical tides for this region is on the order of 1.0 foot, whereas the range of recorded meteorological, or wind-induced, tides has been as high as 4.5 feet[2].

One specific objective of the 2003 survey was to locate recommended "safe passage" transit routes in southern Harrison Bay between the Sakoonang/Tamayagiaq Channel, in the lower Nigliq Channel, and in the lower Iqalliqpik River.

The integration of the water depth, or bathymetry, data collected during this study with real-time data on water-level changes provides the basis for informed decisions on which boats are appropriate for response operations at a particular moment in time.

[2] Owens E.H., Taylor, E., and Hale, B., 2003. Oceanographic Studies in Harrison Bay and the Colville River Delta, Alaska, to Support the Development of Spill Response Strategies. *Proceedings 26th Arctic Marine Oilspill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa ON, 253-269.

1.2 FIELD STUDY METHODS

The field study was conducted between 26 and 31 July 2003 (Table 1.1) using the two Alaska Clean Seas (ACS) pontoon boats Nechelik and Sakoonang (see report cover photograph). These boats have a draft of approximately 1.5 feet with water-jet propulsion outboard motors and are suitable for shallow-water operations.

Table 1-1 Summary of 2003 Field Activities

26 July	transit Sakoonang Channel and survey the bathymetry of the entrance/exit channel in Harrison Bay (HB) to the north and northeast
27 July	helicopter over flight to obtain GPS waypoints for potential Nigliq Channel routes - transit the Sakoonang/Tamayagiaq Channel to HB en route Nigliq Channel – rough choppy seas and winds >25 knots so no work possible in HB – return to Sakoonang and survey the Tamayagiaq Channel between the Colville River and the Sakoonang Channel
28 July	transit Sakoonang to HB and survey approximate east-west bathymetry lines en route to the Nigliq Channel – locate outer end of main (north) channel and survey inbound to the south – continue channel survey south to reach NK-5 – on outbound (northern return) follow east and west channel margins to end and then survey approximate east-west bathymetry lines to the Sakoonang/Tamayagiaq Channel entrance
29 July	Doreen A. Nukapigak (DAN) joins field party - winds 35+ knots so no work possible in HB - transit Sakoonang to Ulamnigiaq – survey Ulamnigiaq Channel between Tamayagiaq and Sakoonang – survey Sakoonang Channel from Ulamnigiaq south to Alpine
30 July	Jobe Woods and DAN with field party – bathymetry survey transit to the entrance to the Nigliq and then to the mouth of the Iqalliqpik River – survey Iqalliqpik River East Channel west-southwest to the lake in reach E-35 – bathymetry survey transit from the Iqalliqpik River to the entrance to the Nigliq and then to the Sakoonang/Tamayagiaq Channel
31 July	PAS crew with Rob Murray and Tad Smith (ACS) – northeast from the Sakoonang/Tamayagiaq Channel around the Colville River delta to Kupigruak Channel and then to Colville Village – return to Alpine by helicopter

Water depth and location were measured using two continuous-recording Lowrance LCX-15MT systems, with a 50-200 kHz transducer mounted on the transom of the boats. The instrument has a 7-inch high-resolution black-and-white screen that enables the operator to view both the boat track(s) and the sea or riverbed profile on a split screen. Instrument sensitivity was set to a low range and depth/position data were recorded every second. Data were recorded on Multi-Media Cards (MMC), which were downloaded at the completion of each day's survey.

Water depth measurements were made at a fixed location, a navigation buoy in the Sakoonang Channel, to monitor water level changes between the beginning and the end of the survey each day. In addition, water level observations from a graduated staff at the Alpine boat dock were also obtained from ACS and were observed on departure and return at the dock each day.

Latitude and longitude coordinates were recorded on the NAD 27 (Alaska) datum.

1.3 DATA REDUCTION

Data files were downloaded from the MMC and converted to text files using software provided by Lowrance. Erroneous depth and position fixes were flagged by the software and deleted. The position fixes were originally recorded on the MMC in a format specific to Lowrance equipment and this format was converted to latitude and longitude (WGS 84 datum) by a formula provided by the company. The product of this data processing was a spreadsheet with latitude, longitude, depth, and a time differential based on the start of the data set for each data point recorded.

For analysis, the data was inserted into ArcMap™ (ESRI), which plotted and labeled each point with the corresponding depth. Additionally, data points were manually binned according to set depth ranges (0-2 feet, 2-4 feet, etc.) and these bins were then plotted and color-coded to provide bathymetric relief.

1.4 WATER LEVELS AND WATER DEPTHS

Water levels change constantly in the survey area as a results of the predictable astronomical tides and the unpredictable meteorological tides. At this time, no attempt has been made to correct or calibrate the water depth data.

The predicted astronomical tides for Prudhoe Bay, #2 Dock, during the study period are provided in Table 1.2. Visual inspection of water level data obtained during the 2002 oceanographic study of southern Harrison Bay indicates that the times of the tides are between a half hour and one hour earlier off the Colville delta as compared to Prudhoe Bay. In a region with such a low tidal range (maximum range of 0.8 feet during the 2003 study period) this timing offset would be barely discernable in the coastal waters. The predicted water levels for the daily survey periods are shown in Table 1.3. This information indicates that the astronomical range for the first two days (July 26 and 27) was lower (0.2 and 0.4 feet respectively) than during the following four days (0.8 feet).

Table 1-2 Predicted 2003 Tides for Prudhoe Bay, # 2 Dock (see also Appendix B)

	HIGH		**LOW**		**HIGH**		**LOW**	
	time	**height (feet)**	**time**	**height (feet)**	**time**	**height (feet)**	**time**	**height (feet)**
26 July			05:45	0.1	13:08	0.7	19:50	0.2
27 July	00:32	0.4	06:40	0.0	13:53	0.7	20:21	0.2
28 July	01:13	0.5	07:27	0.0	14:31	0.8	20:46	0.2
29 July	01:52	0.5	08:12	-0.1	15:05	0.7	21:09	0.2
30 July	02:32	0.6	08:56	-0.1	15:36	0.7	21:30	0.2
31 July	03:12	0.7	09:40	-0.1	16:05	0.7	21:52	0.1

Table 1-3 Predicted Water Levels during the 2003 Field Surveys

	SURVEY START		**MAXIMUM**		**SURVEY END**		**RANGE**
	time	**height (feet)**	**time**	**height (feet)**	**time**	**height (feet)**	**feet**
26 July	12:00	0.7	13:08	0.7	16:00	0.5	- 0.2
27 July	10:00	0.3	13:53	0.7	17:30	0.4	+ 0.4 / - 0.3
28 July	08:15	0.0	14:31	0.8	17:00	0.6	+ 0.8 / - 0.2
29 July	08:50	-0.1	14:00	0.7	14:00	0.7	+ 0.8
30 July	09:30	-0.1	15:36	0.7	19:15	0.4	+ 0.8 / - 0.3
31 July	09:00	-0.1	16:05	0.7	18:30	0.5	+ 0.8 / - 0.2

As a comparison between observed water levels in Harrison Bay and predicted tides at Prudhoe Bay, Table 1.4 presents the field measurements at two locations in Harrison Bay at a time of calm winds when it would be expected that there were few or no meteorological effects. These data show that the actual times of the low and high tides occur up to one- and one-half hours later in southern Harrison Bay than the predicted tides at Prudhoe Bay (Table 1.5) and that the measured water levels changes in Harrison Bay were considerably lower than the predicted Prudhoe Bay tidal water level ranges (Table 1.6). Inspection of the same predicted tide data for Point Barrow shows a similar relationship, with later tides and a smaller range in Harrison Bay.

Table 1-4 Prudhoe Bay (PB) Predicted Tides and Observed Water Levels at a Location in Southern Harrison Bay (HB-B) during a Calm Wind Period in 2001

		HIGH		**LOW**		**HIGH**		**LOW**	
		time	**height (feet)**	**time**	**height (feet)**	**time**	**height (feet)**	**time**	**height (feet)**
6 July	PB	02:08	0.5	08:22	-0.1	15:12	0.7	21:19	0.2
	HB-B	03:39	5.73	10:00	5.44	15:40	5.62	21:30	5.49
7 July	PB	02:41	0.6	09:01	-0.1	15:47	0.7		
	HB-B	04:20	5.77	10:00	5.56	16:40	5.78		

Table 1-5 Time Difference between Predicted Tides at Prudhoe Bay and Observed High and Low Water Levels in Southern Harrison Bay

	Time Difference (hours: minutes)			
6 July	+ 1:31	+ 1:38	+ 0:28	+ 0:11
7 July	+ 1:39	+ 0:59	+ 0:53	

Table 1-6 Elevation Differences between Predicted High and Low Tides at Prudhoe Bay and Observed Water Levels in Southern Harrison Bay

		Range (feet)			
		High to Low	**Low to High**	**High to Low**	**Low to High**
6 July	PB	- 0.6	+ 0.8	- 0.5	+ 0.4
	HB-B	- 0.3	+ 0.2	- 0.1	+ 0.3
7 July	PB	- 0.7	+ 0.8		
	HB-B	- 0.2	+ 0.2		

The conclusion drawn from this brief review of predicted versus measured tides is that the astronomical tide component in the coastal waters of Harrison Bay is on the order of 0.3 feet and is so small that it has little effect on water depths in terms of navigation. During periods of calm winds, however, inspection of the predicted tide tables for Prudhoe Bay to determine the approximate times of high and low tides may provide a small advantage for passage through known very shoal areas.

Superimposed on the astronomical tides are meteorological effects that frequently result in water level changes of greater magnitude. In a previous study, the range of long-term water level observations at Colville Village was on the order of 3.0 feet, whereas nearshore water level changes in southern Harrison Bay over the same time period were on the order of 5.0 to 5.5 feet (Table 1.7).

Table 1-7 2001 Water Level Data Summary

	Harrison Bay Site A (feet)	**Harrison Bay Site B (feet)**	**Colville Village* (feet)**
Dates of Measurement	4 Aug. 2001 to 29 Sept. 2001	18 July 2001 to 16 Sept. 2001	19 June 2001 to 30 Sept. 2001
Minimum	13.35	16.83	-0.13
Maximum	18.93	21.95	2.82
Average	16.27	19.06	0.72
Range	5.6	5.1	3.0
Range <1.0 ft. Astronomical Tide	4.6	4.1	2.0

*measurements post-flooding (actual measurements began June 1)

A graduated water-level staff at the Alpine boat dock has been surveyed in to the 0.0-foot datum (MLLW). This staff gauge provides reliable and real-time calibration data for this section of the Sakoonang Channel. The observations on this staff made during the study period are provided by ACS and are presented as Table 1.8. Additional water depth measurements made at the Alpine boat dock and at channel buoys to the north of Alpine in the Sakoonang Channel are provided in Table 1.9.

The meteorological effects on water levels are a critical element in controlling recommended "safe passage" in a few key areas, particularly the mouths of the Kupigruak, Sakoonang/Tamayagiaq, and Nigliq distributary channels in the Colville delta, and at the entrance to the Iqalliqpik River (Fish Creek). Water level changes on the order of 4 feet have been measured in southern Harrison Bay and up to 3 feet in the channels of the Colville delta.

Table 1-8 Observed Alpine Boat Dock Staff Water Levels (Time and Height) during the 2003 Field Surveys

	TIME	HEIGHT (feet)	CHANGE
26 July	06:00	1.6	
	12:00	1.8	+ 0.2
	18:00	2.2	+ 0.4
27 July	06:00	1.9	- 0.3
	12:00	2.2	+ 0.3
	18:00	3.0	+ 0.8
28 July	06:00	3.0	0
	12:00	2.7	- 0.3
	18:00	2.6	- 0.1
29 July	06:00	1.9	- 0.7
	12:00	2.6	+ 0.7
	18:00	3.2	+ 0.6
30 July	06:00	3.1	- 0.1
	12:00	2.5	- 0.6

Table 1-9 Observed Alpine Boat Dock Staff Water Levels (Time and Height) during the 2003 Field Surveys, Additional Depth Range Observations in the Sakoonang Channel ("Other Obs."), and the Predicted Prudhoe Bay Tidal Range over that Same Time Period (From Table 1.3)

	SURVEY START		SURVEY END		STAFF RANGE	OTHER OBS.	TIDE RANGE
	time	height (feet)	time	height (feet)	feet (+ = increase)	feet	feet
26 July	12:00	1.8	16:00	2.2	+ 0.4		- 0.2
27 July	10:00	1.95	17:30	2.95	+ 1.0	+ 0.7	+ 0.1
28 July	08:15	2.9	17:00	2.6	- 0.3	+ 0.4	+ 0.6
29 July	08:50	1.8	14:00	2.7	+ 0.9	+ 0.6	+ 0.8
30 July	09:30	2.75	19:15	2.2	- 0.55	- 0.9	+ 0.4

2 2003 SURVEY TRACK LINES

SUMMARY

- Water depth data have been organized into the following six geographical data sets:
    - Harrison Bay
    - Nigliq Channel
    - Sakoonang Channel
    - Tamayagiaq Channel
    - Ulamnigiaq Channel
    - Iqalliqpik River

- Track-line charts at scales of approximately 1:30,000 for Harrison Bay and approximately 1:12,000 for the river channels have been superimposed on an orthophoto base for each data set and are presented in Appendix A.

2.1 DATA MANAGEMENT

The water depth data have been organized into the following six geographical data sets (the letter prefix for the sets is provided in parentheses):

- Harrison Bay (HB)
- Nigliq Channel (N)
- Sakoonang Channel (S)
- Tamayagiaq Channel (T)
- Ulamnigiaq Channel (U)
- Iqalliqpik River (IQ)

2.2 TRACK-LINE CHARTS

The section includes:

- a general orthophoto map that shows a composite of all the track lines that were surveyed in 2003 (Section 2.2.1),
- an index map of the individual track-line charts (Section 2.2.2), and
- details on the set of thirty track-line charts organized into the six data sets (Sections 2.2.3 through 2.2.8) that are presented in Appendix A.

For charting purposes, the Harrison Bay data are presented at a scale of approximately 1:30,000 and the river channel data at approximately 1:12,000.

2.2.1 Composite Tracks

Figure 2-1 shows all the track lines that were surveyed in July 2003 superimposed on an orthophoto of the area.

2.2.2 Chart Index

Figure 2-2 is an index map of all of the charts that have been created to present the individual track-lines for each data set. The data have been organized into six geographical data sets with the following letter prefixes:

- Harrison Bay (HB)
- Nigliq Channel (N)
- Sakoonang Channel (S)
- Tamayagiaq Channel (T)
- Iqalliqpik River (IQ)

Figure 2- 1 Composite map of all surveyed track lines, July 2003.

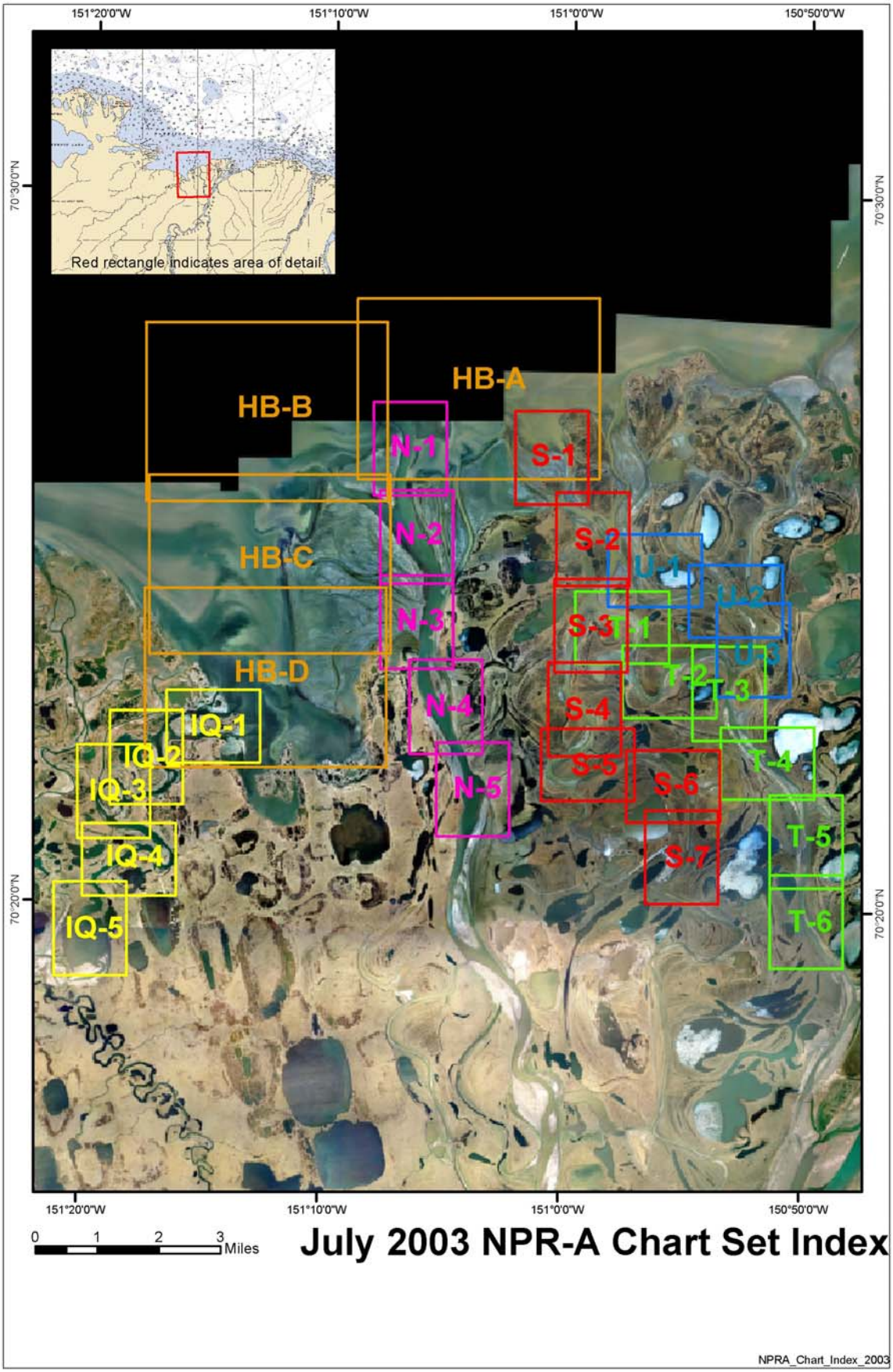

Figure 2- 2 Index map of all charts.

2.2.3 Harrison Bay Track Charts

Figures A-1 through A-4 in Appendix A show the tracks lines of Harrison Bay on a set of four charts at a scale of approximately 1:30,000. The area covered by each chart is shown in Figure 2-2. The focus of this part of the survey was to: (a) establish a navigation route into and out of the Sakoonang and Nigliq Channels; (b) define the extent of the coastal shallow waters between the Sakoonang and Nigliq Channels, and (c) define the extent of the coastal shallow waters between the Nigliq Channel and the Iqalliqpik River.

The results for the first two parts of the survey (a) and (b) are provided in Section 3 of this report; the results for part (c) are shown in the bathymetric map (Figure E-1) in the Executive Summary.

The depth data coverage between the Nigliq Channel and the Iqalliqpik River as shown in Figure E-1 is useful as a general indication of depths in the region, but further data are required before a recommended "safe passage" navigation route can be defined.

2.2.4 Nigliq Channel Track Charts

Figures A-5 through A-9 in Appendix A show the tracks lines of the Nigliq Channel on a set of five charts at a scale of approximately 1:12,000. The area covered by each chart is shown in Figure 2-2. The focus of this part of the survey was to establish a recommended "safe passage" navigation route in the Nigliq Channel between Harrison Bay and CD-2. Some of the data generated by this part of the survey are provided in Section 4 of this report.

2.2.5 Sakoonang Channel Track Charts

Figures A-10 through A-16 in Appendix A show the tracks lines of the Sakoonang Channel on a set of seven charts between Alpine and Harrison Bay at a scale of approximately 1:12,000. The area covered by each chart is shown in Figure 2-2. The focus of this part of the survey was to establish a recommended "safe passage" navigation route in the Sakoonang Channel between Harrison Bay and Alpine. The data generated by this part of the survey have not been processed at this time.

2.2.6 Tamayagiaq Channel Track Charts

Figures A-17 through A-22 in Appendix A show the tracks lines of the Tamayagiaq Channel between the Colville River and the Sakoonang Channel on a set of six charts at a scale of approximately 1:12,000. The area covered by each chart is shown in Figure 2-2. The focus of this part of the survey was to establish a recommended "safe passage" navigation route in the Tamayagiaq Channel. The data generated by this part of the survey have not been processed at this time.

2.2.7 Ulamnigiaq Channel Track Charts

Figures A-23 through A-25 in Appendix A show the tracks lines of the Ulamnigiaq Channel between the Tamayagiaq Channel and the Sakoonang Channel on a set of three charts at a scale of approximately 1:12,000. The area covered by each chart is shown in Figure 2-2. The focus of this part of the survey was to establish a recommended "safe passage" navigation route in the Ulamnigiaq Channel. The data generated by this part of the survey have not been processed at this time.

2.2.8 Lower Iqalliqpik River Track Charts

Figures A-26 through A-30 in Appendix A show the tracks lines of the Lower Iqalliqpik River between Harrison Bay and the lake in reach E 35 on a set of five charts at a scale of approximately 1:12,000. The area covered by each chart is shown in Figure 2-2. The focus of this part of the survey was to establish a recommended "safe passage" navigation route in Iqalliqpik River. The results of this part of the survey are provided in Section 5 of this report. The bathymetry data for the mouth of the river are inadequate at this time to establish a recommended "safe passage" navigation route into and out of the river from Harrison Bay.

3 SAKOONANG/TAMAYAGIAQ TO NIGLIQ TRANSIT

SUMMARY

- One specific objective of the 2003 survey was to locate a recommended "safe passage" transit route in southern Harrison Bay between the Sakoonang/Tamayagiaq Channel and the Nigliq Channel.

- The results of this component of the survey are presented as a schematic bathymetric map that indicates the most direct route between these two distributary systems and as a table that provides the latitude and longitude coordinates with the uncorrected depth data.

- The data are provided in a format that can be entered into a GPS as a series of waypoints for navigation.

3.1 INTRODUCTION

In keeping with the overall purpose of the study program (Section 1.1), one specific objective of the 2003 survey was to locate a transit route in southern Harrison Bay between the Sakoonang/Tamayagiaq Channel and the Nigliq Channel. This information would provide a potential recommended "safe passage" route from the Alpine ACS oil spill response base into the Nigliq Channel.

Both the Sakoonang/Tamayagiaq Channel and the Nigliq Channel have shoals at their mouths due to the deposition of river-borne sediment as the channels discharge into Harrison Bay. This deposition results from a reduced flow velocity as the river waters escape the confines of the channels upon entering the coastal waters of Harrison Bay. No data for the Sakoonang channel existed prior to this survey but the presence of channel-mouth shoals is well known. Bathymetric data for the channel-mouth of the Nigliq were obtained for Arco Alaska Inc. on 17-18 August 1996 by Shannon & Wilson, Inc.[3] and again on 2-3 September 1997 by Coastal Frontiers Corp.[4].

The results of this component of the 2003 survey are presented as a schematic bathymetric map (Figure 3.1) that indicates the most direct route between these two distributary systems and as a table (Table 3.1) that provides the latitude and longitude coordinates with the uncorrected depth data. This table presents data in a format that can be entered into a GPS as a series of waypoints for navigation.

The results of the 1996 and 1997 surveys at the mouth of the Nigliq Channel have been inspected to visually compare that data with the bathymetric data collected during this 2003 survey (Section 3.5).

3.2 BATHYMETRY

The generalized contours that were hand-drawn from the uncorrected water depth and track-line data (Figure 3.1) show several key features:

[3] Memo from Shannon & Wilson to ARCO Alaska, Inc. dated August 24, 1996.
[4] Memo from Coastal Frontiers Corp. to Michael J. Baker, Jr. Inc. dated January13, 1998.

- **The exit from the northern end of the Sakoonang/Tamayagiaq Channel** is a 5- to 6-feet deep channel that is very narrow, approximately 25- to 50-feet wide.
- A section immediately to the north of this channel shoals to water depths as little as 4 feet for a distance of approximately 750 to 1000 feet (250 to 300 yards).
- This shoal area gives way northwards to a long, narrow, curved channel with water depths up to 7 feet that provides access to Harrison Bay.
- The most direct route between the two channels is a general WNW heading from the northwestern end of the curved channel for approximately 3 miles to a point due north of the Nigliq Channel Entrance. This part of southern Harrison Bay has a very gradual seaward slope and the route lies between the 5- and 6-foot depth contours.
- **The entrance to the Nigliq Channel** is characterized by a narrow, shallow, and slightly sinuous channel that runs approximately north-south for a distance of just over 1 mile. This channel is approximately 25- to 50-feet wide and cuts through shoals that have 2-feet or less water on either side. Water depths in the channel vary between 4 and 5 feet with several sections that shoal to less than 4 feet. At times of lower water levels, these depth values could be reduced by as much as 2 feet (see following paragraph).
- A wide, deep channel with depths over 6 feet that provides direct access into the Nigliq Channel begins at approximately 70º 27' N.

No correlation has been established between water level changes at the Alpine boat dock in the Sakoonang Channel and those that take place in southern Harrison Bay (see footnote # 2 and Section 3.4 – Navigation Advisory). It is not possible, therefore, to state at this time if the water level data from the boat dock can be used to evaluate access and navigation conditions at the mouths of the Sakoonang/Tamayagiaq and Nigliq Channel, where the depths constraints are most critical. Taking a conservative approach and assuming that there is a direct relationship between water levels at these three locations, it is possible that:

- when measured water levels at the Alpine boat dock are 2.0 feet, then the depth-limiting shoals in the channel at the mouth of the Nigliq Channel would be approximately 2.5 feet, and
- for an Alpine boat dock value of 1.0 feet, the same depth-limiting shoals at the mouth of the Nigliq would be approximately 1.5 feet.

Similarly, it is possible that:

- when measured water levels at the Alpine boat dock are 2.0 feet, then the depth-limiting shoals in the channel at the mouth of the Sakoonang/Tamayagiaq Channel would be approximately 3.5 feet, and
- for an Alpine boat dock value of 1.0 feet, the same depth-limiting shoals at the mouth of the Sakoonang/Tamayagiaq would be approximately 2.5 feet.

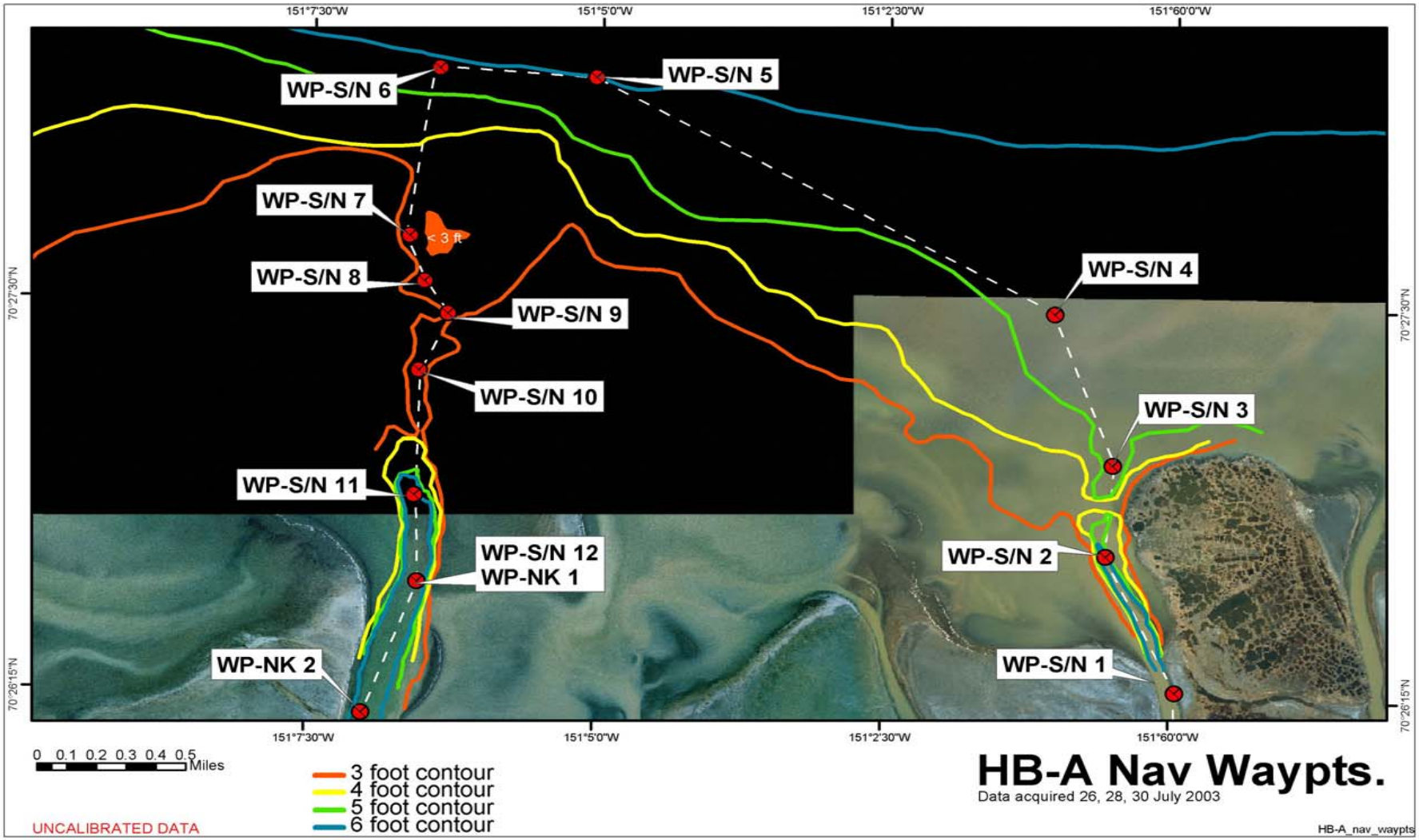

Figure 3- 1 Bathymetric map of the coastal area between the Sakoonang and Nigliq Channels, with navigation waypoints marked (see Table 3.1).

3.3 WAYPOINT DATA

Table 3.1 provides a set of coordinates that can be used as waypoints to navigate along a route between the Sakoonang/Tamayagiaq Channel and the Nigliq Channel. The table includes (1) primary waypoints intended for navigation with a GPS unit and (2) intermediate waypoints with uncorrected and uncalibrated water depths that indicate shoal areas and channel depths. As noted elsewhere, these depth values have not been calibrated against a chart datum and represent actual measured depths on the date of the survey.

Table 3- 1 Waypoint Data in Harrison Bay between the Sakoonang and Nigliq Channels (see Figure 3-1) (NAD 27 (Alaska) datum)

WAYPOINT NUMBER	LONGITUDE		LATITUDE		DEPTH (ft)
	degrees	minutes	degrees	minutes	
S/N 1	-150	59.748	70	26.302	11.2
S/N 2	-151	0.484	70	26.917	5.5
S/N 3	-151	0.448	70	27.121	6.4
S/N 4	-151	0.833	70	27.514	6.0
S/N 5	-151	4.839	70	28.251	5.5
S/N 6	-151	6.205	70	28.274	5.5
S/N 7	-151	6.438	70	27.736	4.5
S/N 8	-151	6.318	70	27.593	4.5
S/N 9	-151	6.106	70	27.489	3.5
S/N 10	-151	6.350	70	27.303	4.6
S/N 11	-151	6.457	70	26.733	6.7
S/N 12 = NK 1	-151	6.331	70	26.631	8.8

3.4 NAVIGATION ADVISORY

Although the route presented here is based on the best available data, care must be taken, particularly in the shoal areas at the mouths of each channel.

- The majority of the depths used in this analysis for the mouth of the Sakoonang/Tamayagiaq Channel were measured on 26 July 2003, at a time of relatively "normal" water levels in the Sakoonang Channel at Alpine. The depth gauge data at the boat dock on that date ranged between 1.6 and 2.2 feet.

- The majority of the depths used in this analysis for the transit route in Harrison Bay and for the mouth of the Nigliq Channel were measured on 28 July 2003, at a time of relatively high water levels in the Sakoonang Channel at Alpine. The depth gauge data at the boat dock on that date ranged between 2.6 and 2.9 feet. These values are on the order of 1.0 to 1.5 feet above a "normal" water level.

At times of strong east or northeast winds, a water-level setdown would likely reduce depths across the entire nearshore area and the effects of this drop in sea level , in terms of navigation and accessibility, would be greatest in these shoal areas. At times of strong west or southwest winds, a water-level setup would likely increase depths across the entire nearshore area, but it is recommended that the proposed recommended "safe passage" route be adhered to rather than attempt a shorter inshore route.

3.5 COMPARISON WITH 1996 AND 1997 BATHYMETRIC DATA

The two prior surveys in 1996 and 1997 attempted to define the shoal areas at the entrance to the Nigliq Channel. Depth contours derived from these two surveys are presented in Figures 3-2 and 3-3 respectively. These charts show a similar trend with deep water (greater than 8 feet) in the northern part of the Nigliq Channel that shoals to less than 2 feet Harrison Bay. The channel shown in the two 1996 and 1997 surveys curved to the west in the vicinity of waypoint S/N 10. Our survey did not locate this westerly extension of the channel even though our track lines (Figure 2-3: HB-A, and Figure 2-7: N-1) are closely spaced in that area. It is important to note that this westerly channel shoaled to depths of less than 3 feet in 1996 and 1997 and so, if it still exists, may not provide a better recommended "safe passage" navigation route into and out of the Nigliq Channel that the one presented in Figure 3-1.

Further analysis of and comparison between the three data sets may yield more information regarding the shoals, and possible future field work in this area could attempt to locate the curved channel.

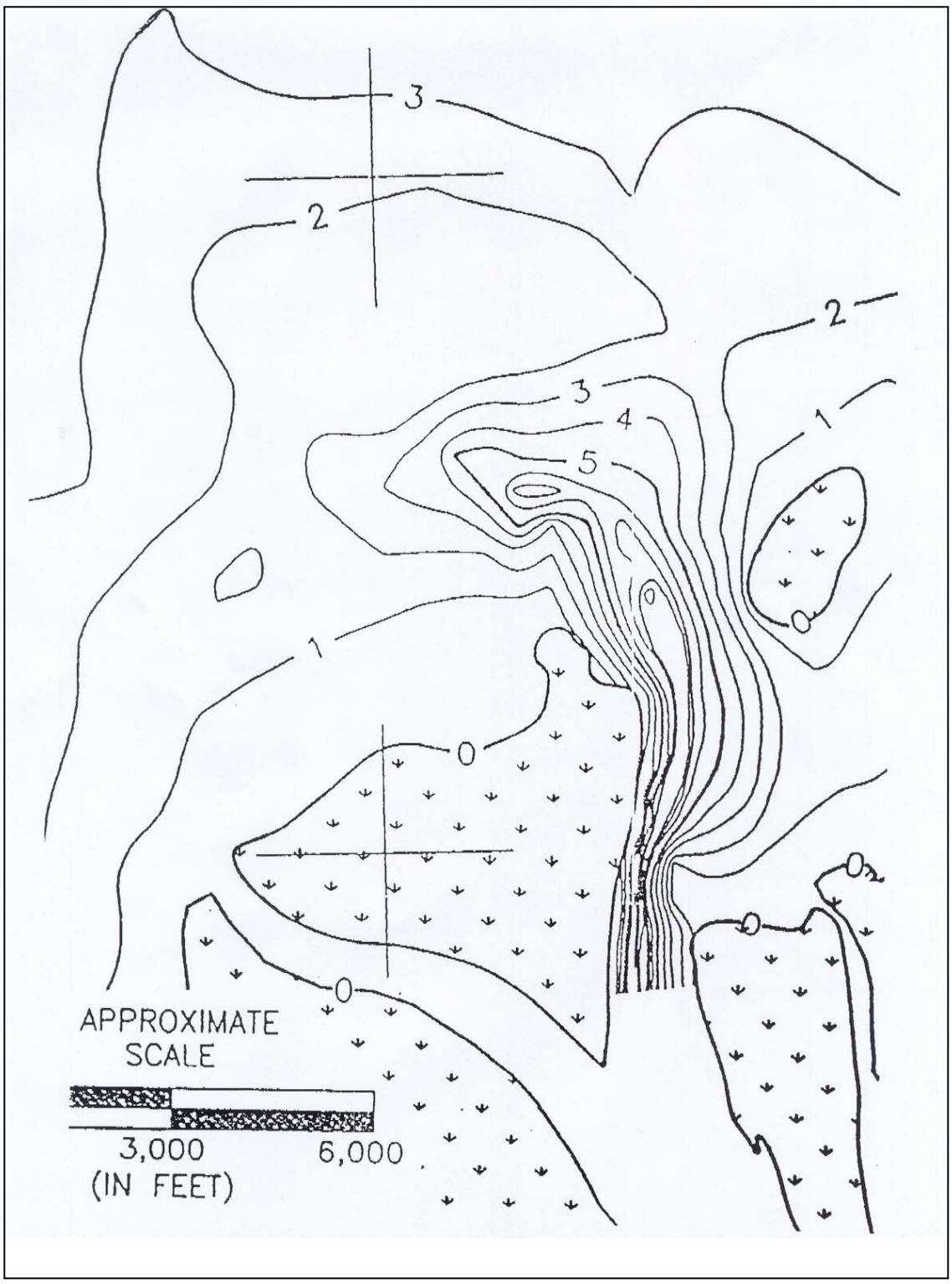

Figure 3- 2 1996 survey of Nigliq Channel entrance.

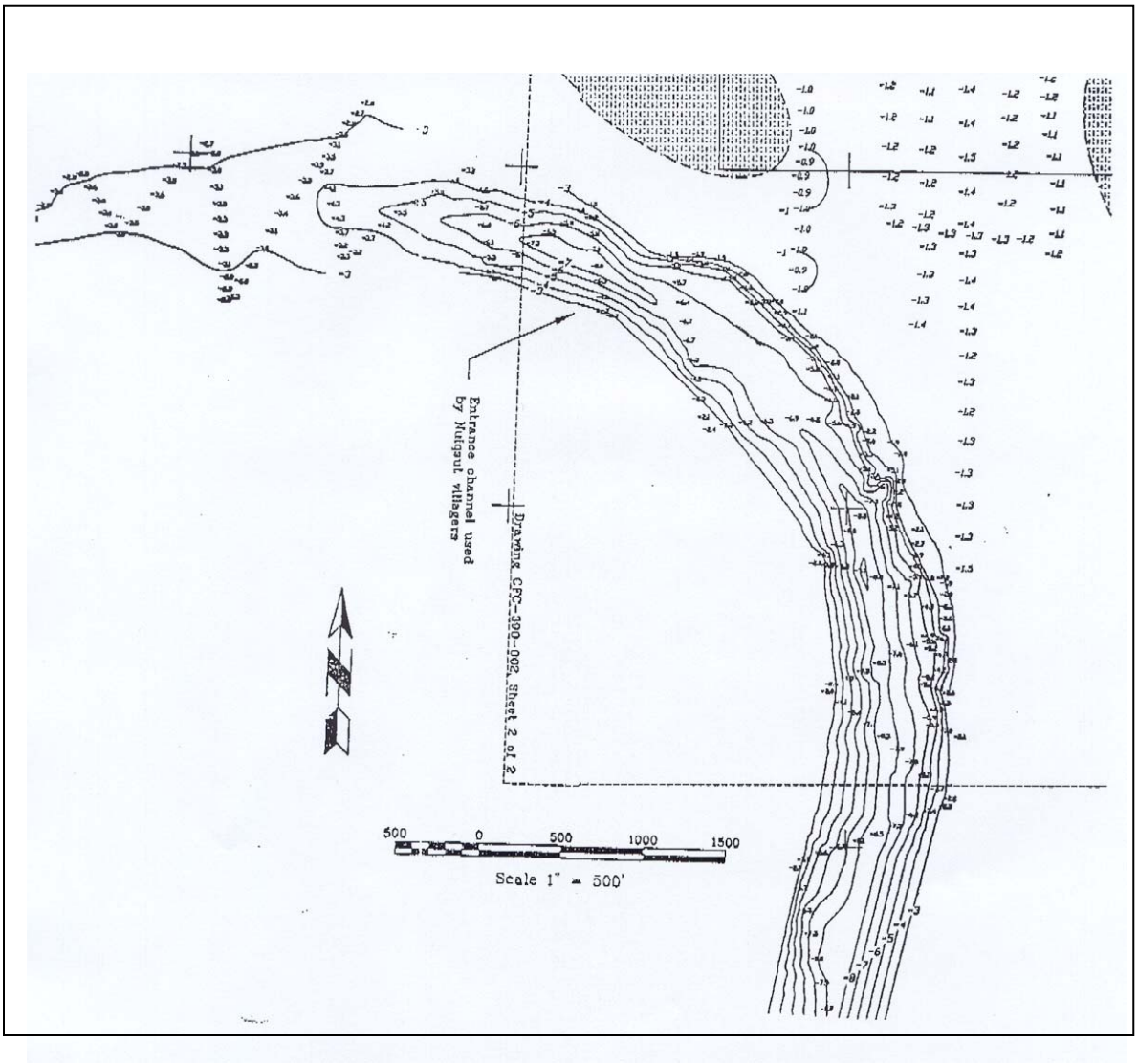

Figure 3- 3 1997 survey of Nigliq Channel entrance.

4 NIGLIQ CHANNEL AND ACS SITE # 267

SUMMARY

- One specific objective of the 2003 survey was to locate a recommended "safe passage" transit route in the Nigliq Channel between Harrison Bay and CD-2.

- The results of this component of the survey are presented as an overall bathymetric map that indicates the most direct route in the Nigliq Channel and as a set of strip charts the provide a more detailed location of the channel and the waypoints.

- The waypoint data are provided in a format that can be entered into a GPS as a series of waypoints for navigation.

- One data subset has been reduced for the area of the ACS pre-staging site # 267 on the east bank of the Nigliq Channel in reaches NK-7 and NK-8. For this site the following data are presented:
  - the bathymetry survey track lines on the orthophoto base
  - color-coded water depth data on the orthophoto base
  - a detailed chart of a section of the channel at the riverbank with water depth data on the orthophoto base
  - a River Channel Navigation Chart intended to show recommended "safe passage" through this section of the Nigliq Channel.

  These data are intended to demonstrate other potential presentation formats.

4.1 INTRODUCTION

In keeping with the overall purpose of the study program (Section 1.1), one specific objective of the 2003 survey was to locate a recommended "safe passage" route in the Nigliq Channel between Harrison Bay and CD-2. The results of this component of the survey are presented as a single schematic navigation map (Figure 4.1); a set of five larger-scale strip charts that show the channel in greater detail are presented in Section 4.5. This map and these charts show navigation waypoints and the uncalibrated 10-foot depth contour in the Nigliq Channel. Table 4.1 provides the latitude and longitude coordinates of the waypoints with the uncorrected depth data. This table presents data in a format that can be entered into a GPS as a series of waypoints for navigation. (NOTE: *The navigation waypoints do not necessarily represent the deepest part of the channel at the location*).

One subset of the Nigliq Channel data has been reduced for the area of the ACS pre-staging site # 267 on the east bank of the channel in reaches NK-7 and NK-8. These data were selected as they are representative of the other data sets for the Sakoonang Channel, the Tamayagiaq Channel, the Ulamnigiaq Channel, and the lower Iqalliqpik River. The intent of this section is to present examples of the types of reduced data that can be produced as a result of these channel surveys. These examples include:

Section 4.2 – Bathymetry Survey Track and Water Depth Chart. This chart indicates the level of detail that is available and the location of water-depth data for a channel as well as some of the depth data that is available for planning or for operations in a particular reach of the river channel.

Section 4.3 - Color-coded Water Depth Chart. This chart provides a visual representation of depth categories for a rapid review of the bathymetry of an area.

Section 4.4 – Detailed Navigation Chart. This chart provides detailed site-specific recommended "safe passage" information for a particular reach or reaches. Information on the chart can include waypoint locations, channel boundary contours, and the location and character of mid-channel or channel margin shoals.

Section 4.5 - River Channel Navigation Charts. This five-chart series provides recommended "safe passage" routes for transit within the Nigliq Channel between Harrison Bay and CD-S at a scale of approximately 1:12,000. The charts show the 10-foot depth contour and the location of the waypoint coordinates that can be entered into a GPS for navigation (Table 4-1).

Table 4- 1 Waypoint Data in the Nigliq Channel
(see Figure 4-1) (NAD 27 (Alaska) datum)

WAYPOINT NUMBER	LONGITUDE		LATITUDE		DEPTH (ft)
	degrees	minutes	degrees	minutes	
NK 1	-151	6.331	70	26.631	8.8
NK 2	-151	6.802	70	26.210	14.4
NK 3	-151	6.830	70	25.698	11.4
NK 4	-151	5.493	70	24.960	11.8
NK 5	-151	5.187	70	24.537	12.0
NK 6	-151	5.699	70	23.983	14.8
NK 7	-151	5.878	70	23.119	15.0
NK 8	-151	4.730	70	22.627	15.7
NK 9	-151	3.866	70	21.998	29.0
NK 10	-151	3.816	70	21.614	10.0
NK 11	-151	3.794	70	21.135	14.0

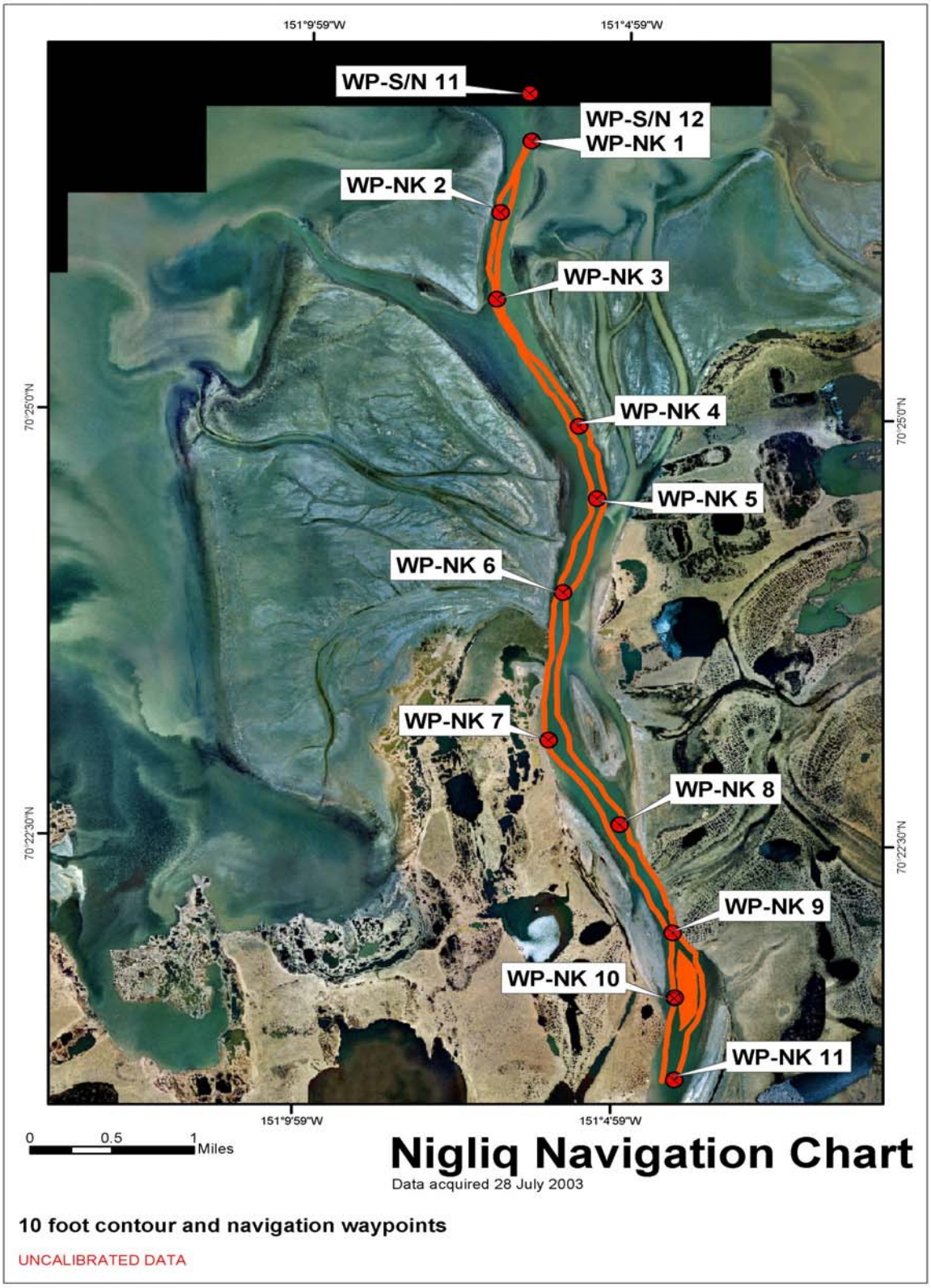

Figure 4- 1 Map showing the 10-foot depth contour of the Nigliq Channel between Harrison Bay and CD-2, with navigation waypoints marked (see Table 4.1).

4.2 BATHYMETRY SURVEY TRACK LINES

The track lines for which depth and position data have been recorded are plotted directly onto an orthophoto base in order to indicate the level of detail that is available and the location of water depth data. For the area of Harrison Bay that has been surveyed, these tracks would be presented on a set of four overlapping charts at a scale of approximately 1:30,000 (Appendix A, Figures A-1 through A-4). For each of the five river channel areas, they would be presented as a series of overlapping strip charts at a scale of approximately 1:12,000 (Figures A-5 through A-30). The example given is from the Nigliq Channel for the area covered by reaches NK-7 and NK-8 and is at a scale of approximately 1:6,000 (Figure 4.2). This area is the location of the ACS pre-staged equipment (ACS site # 267); the three dark blue oil spill equipment containers are visible on the orthophoto and are marked by the blue arrow.

This example shows that the two survey boats attempted to maintain a standard overlapping zigzag pattern on the southward tracks. On the northward portion of the survey the boats attempted to follow the 5-foot depth contour on each side of the channel. This latter pattern is clear in the uppermost part of the figure.

For locations where detailed information or actual depth values are required, these data can be displayed. The example depicts a portion (on the order of 15 %) of the depth values that were recorded by the Lowrance LCX-15MT system. The density of depth values displayed is selected on the basis of clarity and legibility. As noted elsewhere, these depth values have not been calibrated against a chart datum and represent actual measured depths on the date of the survey.

The depth data in Figure 4-2 show that:

- the area of deep water immediately adjacent to the ACS equipment containers has a maximum recorded water depth of 37.6 feet,
- water depths within a few yards of the east bank adjacent to the containers are in the range of 7 to 10 feet, and
- the minimum depth recorded on the large mid-channel shoal in the lower half of the figure was 3.3 feet.

Figure 4- 2 Bathymetry survey track lines and depth data in reaches NK-7 and NK-8 (28 July 2003).

4.3 COLOR-CODED TRACK LINES OF WATER DEPTHS

The survey method produces a large volume of water depth data. If all of the data point values are plotted, the numbers are either too small to be legible or overlap so that one value cannot be distinguished easily from another. A method was developed that groups depth values in order to show all of the data for an area. This format presents the depth categories as color-coded track lines (Figure 4-3).

These color-coded water depth charts provide a visual representation of depth categories for a rapid review of the bathymetry of an area. The depths along a track line are grouped into seven categories in the data spreadsheet. The code categories have been selected to emphasize the shallow-water areas with a red line for tracks where depths were less than 2.0 feet and an orange line for depths of 2.0 to 4.0 feet at the time of the survey.

For the area of Harrison Bay that has been surveyed, these data would be presented on a set of four overlapping charts at a scale of approximately 1:30,000. For each of the five river channel areas, they would be presented as a series of overlapping strip charts at a scale of approximately 1:12,000. The example given in Figure 4-3 is from the Nigliq Channel for the area covered by reaches NK-7 and NK-8 adjacent to the ACS pre-staged equipment (ACS site # 267) and is at a scale of approximately 1:6,000. As noted elsewhere, these depth values have not been calibrated against a chart datum and represent actual measured depths on the date of the survey.

The color patterns in Figure 4-3 clearly show:

- an area of deep water (20+ feet) immediately adjacent to the ACS equipment containers,
- shallow water (< 2 feet) in the eastern part of the Nigliq Channel to the southeast of the containers, and
- a large mid-channel shoal with minimum depths of 2-4 feet in the lower half of the figure (the extent of this shoal is shown on the detailed navigation chart in Figure 4-4 and on strip-series navigation chart N-5 in Figure 4-9).

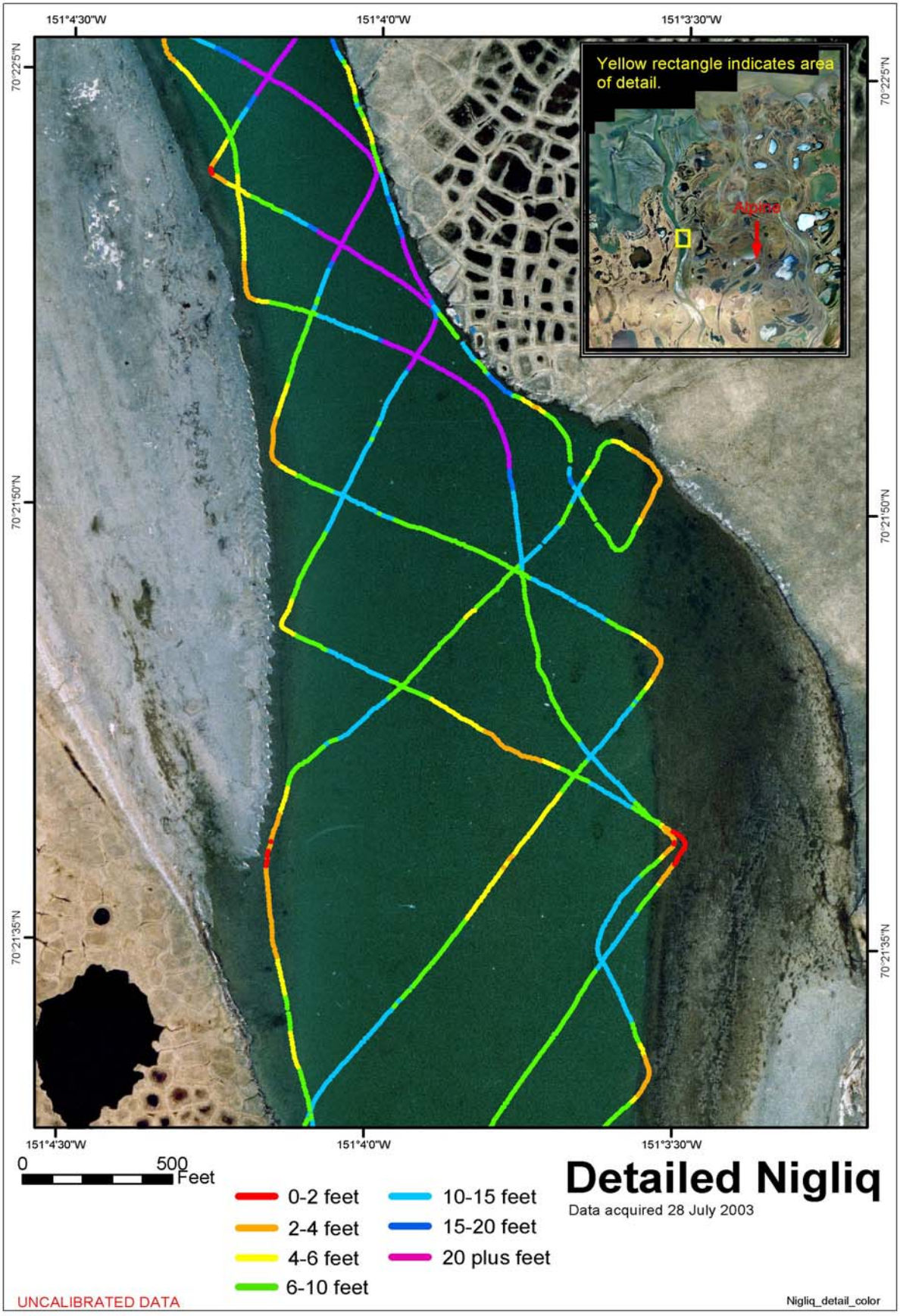

Figure 4- 3 Color-coded track lines of water depths in reaches NK-7 and N-8.

4.4 DETAILED NAVIGATION ADJACENT TO ACS # 267

Site-specific charts can be prepared for areas where particular navigation hazards are present or for locations of specific interest, such as pre-selected oil spill control sites. The example given in Figure 4-4 is from the Nigliq Channel for the area covered by reaches NK-7 and NK-8 adjacent to the ACS pre-staged equipment (ACS site # 267) and is at a scale of approximately 1:6,000, whereas the navigation strip chart for this area (N-5, Figure 4-9) is at a scale of approximately 1:12,000. In this chart the channel boundary is shown by the 10-foot depth contour, the way points (Table 4-1) are marked, and the large mid-channel shoal is characterized by the 4- and 6-foot depth contour. As noted elsewhere, these depth values have not been calibrated against a chart datum and represent actual measured depths on the date of the survey.

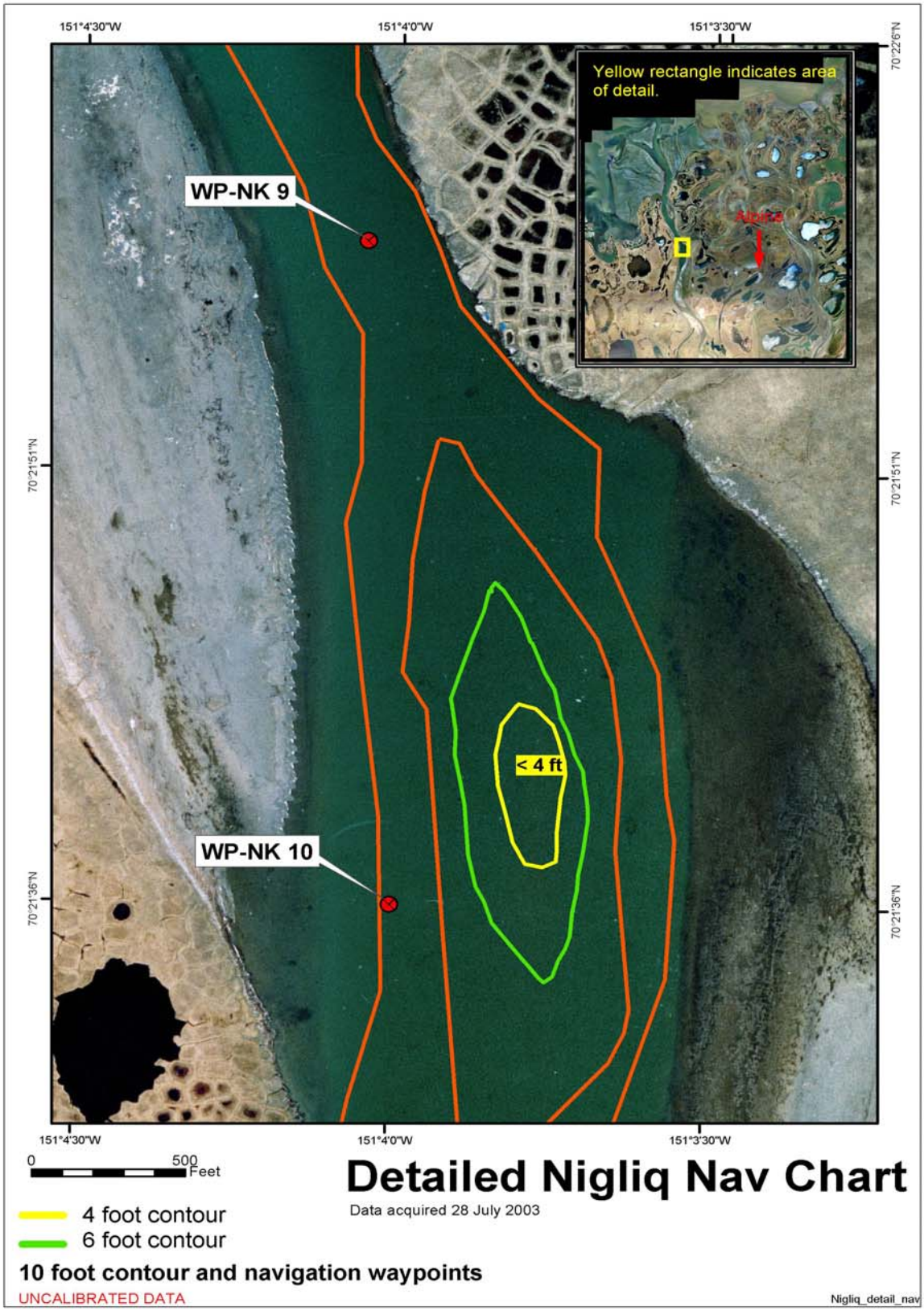

Figure 4- 4 Detailed navigation chart and waypoints for reaches NK-7 and N-8.

4.5 RIVER CHANNEL NAVIGATION CHARTS

During an exercise or response operation, it is important to be able to navigate quickly and safely to a destination. As boat operators may not be familiar with the channels of the region, this series is intended to provide a simplified set of navigation charts that will enable a boat operator to transit to a site easily and safely. The set includes primary waypoints (Table 4.1) that can be entered into a GPS for navigation and intermediate waypoints that locate specific channel or other features, such as shoal areas. A depth contour(s) indicates the approximate channel width so that a boat operator is aware if it is necessary to stay close to the waypoint navigation lines.

For each of the five river channel areas, the navigation information and recommended "safe passage" routes would be presented as a series of overlapping strip charts at a scale of approximately 1:12,000. A general chart of the channel between Harrison Bay and CD-2 is presented as a single chart in Figure 4-1. The set of five charts for the Nigliq Channel (Figures 4-5 through 4-9) provide a more detailed recommended "safe passage" navigation route from Harrison Bay to CD-2. Site-specific charts can be prepared for areas where particular navigation hazards are present or for locations of specific interest, such as pre-selected oil spill control sites (Figure 4-4). As noted elsewhere, these depth values have not been calibrated against a chart datum and represent actual measured depths on the date of the survey.

Figure 4- 5 Nigliq Channel navigation chart N-1.

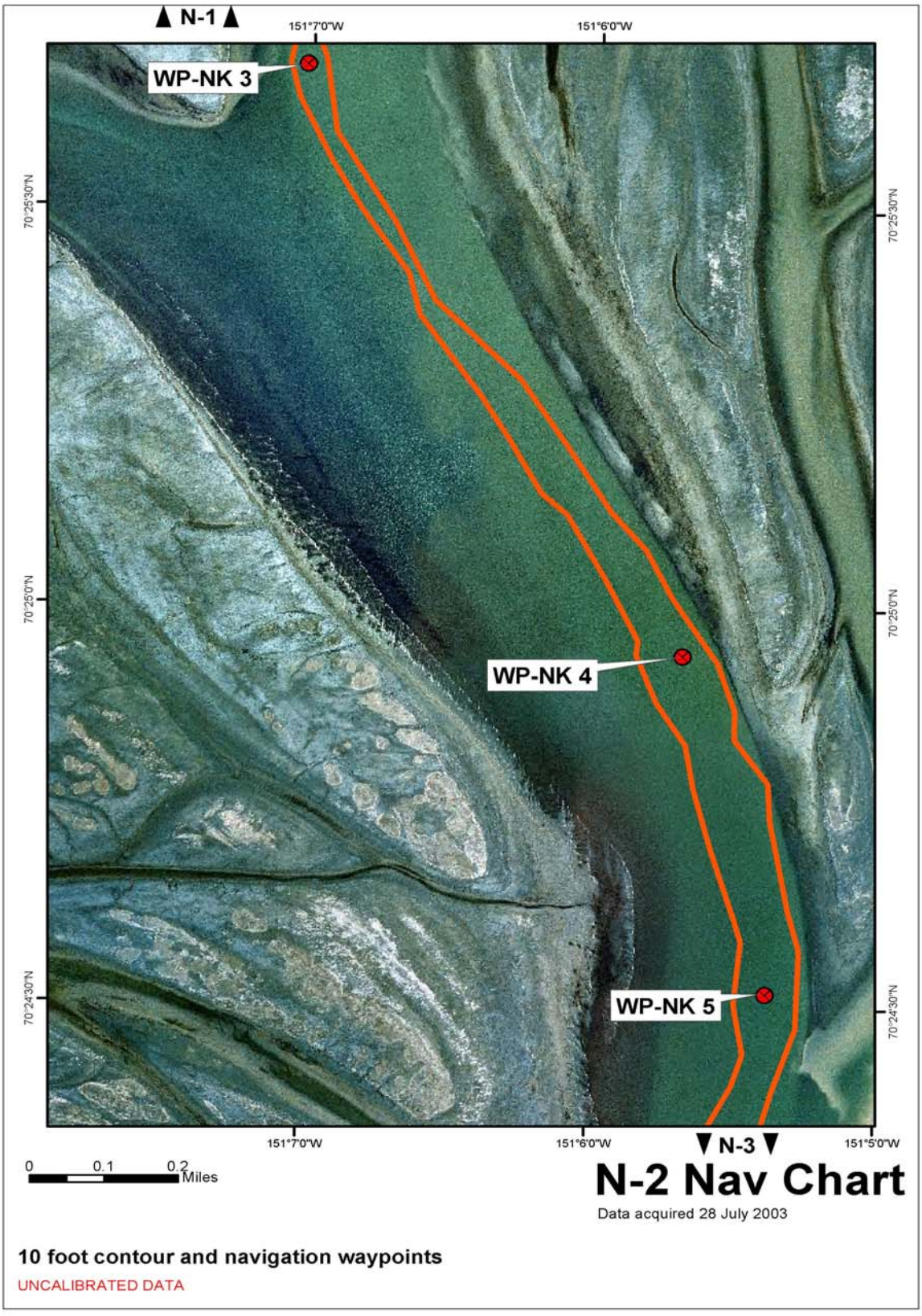

Figure 4- 6 Nigliq Channel navigation chart N-2.

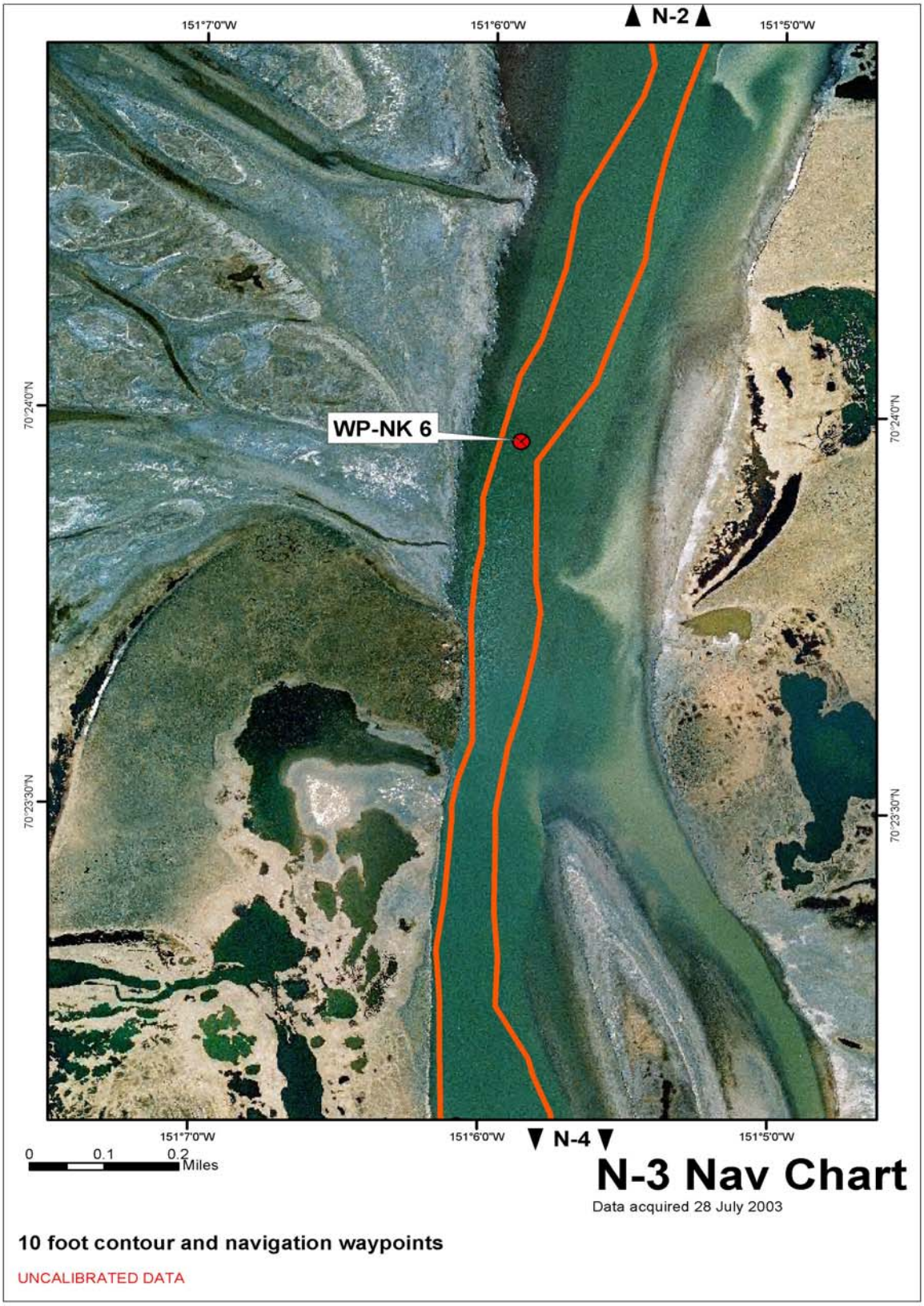

Figure 4- 7 Nigliq Channel navigation chart N-3.

Figure 4- 8 Nigliq Channel navigation chart N-4.

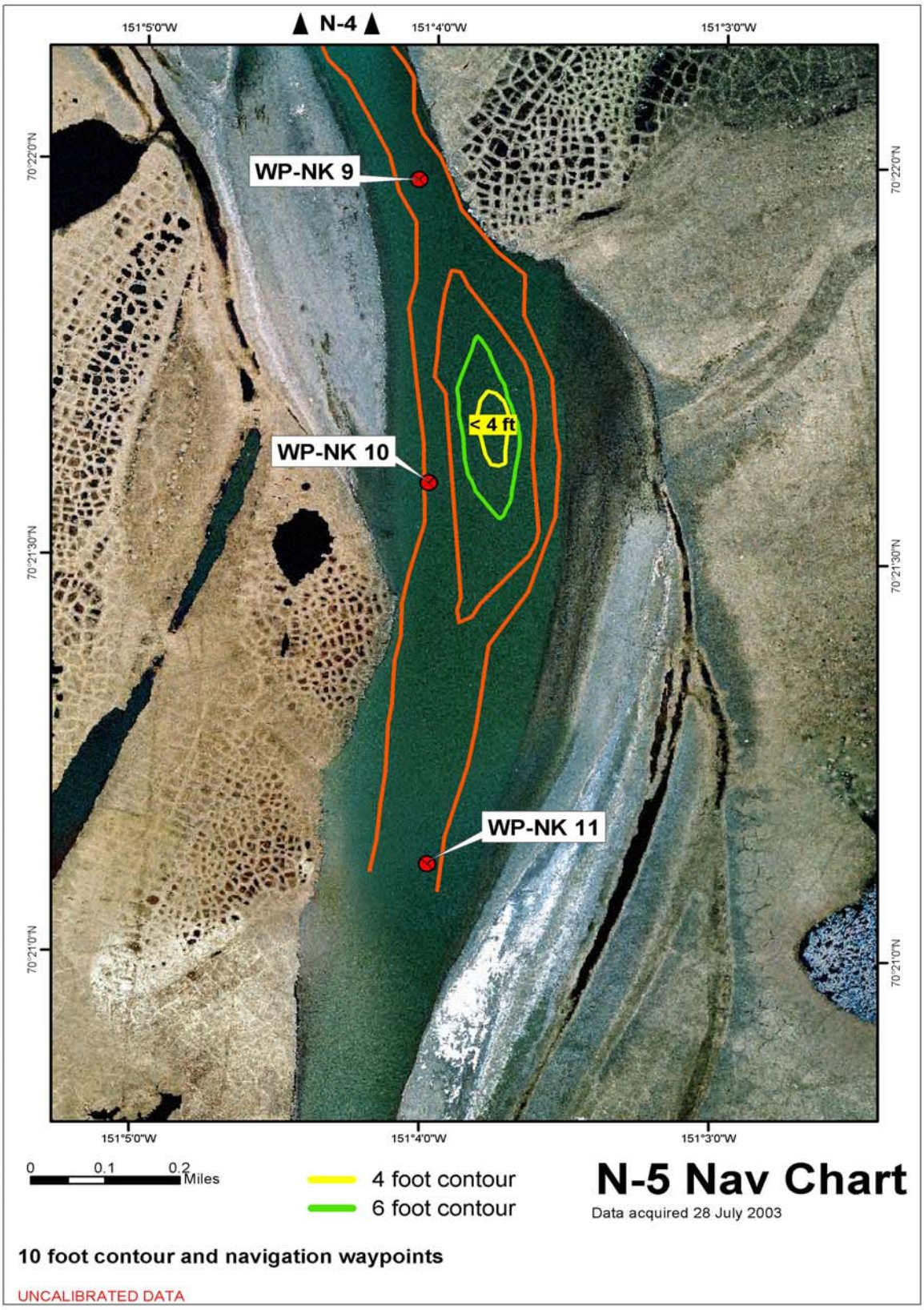

Figure 4- 9 Nigliq Channel navigation chart N-5.

5 LOWER IQALLIQPIK RIVER NAVIGATION CHARTS

SUMMARY

- Water depths in the lower Iqalliqpik River were surveyed from the mouth at Harrison Bay to the lake that is Reach E 35

- This sections presents: (a) five color-coded depth track line maps, (b) a single navigation chart that show the entire area surveyed with the 5-foot contour, (c) five River Channel Navigation Charts intended to show recommended "safe passage" through this section of the Iqalliqpik River, and (d) a set of waypoints that can be entered into a GPS for navigation.

5.1 INTRODUCTION

In keeping with the overall purpose of the study program (Section 1.1), one specific objective of the 2003 survey was to obtain water depth data in the lower Iqalliqpik River that would provide a potential "safe passage" route. The results of this component of the survey are presented as follows:

1. a set of five color-coded track line charts at a scale of approximately 1:12,000 that show measured water depths in the area surveyed (Figure 5-1 through Figure 5-5);
2. a single navigation chart of the area surveyed that shows the location of the main channel and a set of navigation waypoints (Figure 5-6);
3. a set of five navigation charts at a scale of approximately 1:12,000 that show the 5-foot contour depth on 30 July 2003 (Figure 5-7 through Figure 5-11); and
4. a table (Table 5.1) that provides the latitude and longitude waypoint coordinates with the uncorrected depth data. This table presents data in a format that can be entered into a GPS as a series of waypoints for navigation.

5.2 BATHYMETRY

The color-coded track lines of the uncorrected water depth data show several key features:

- The two survey boats entered the river by different channels but both exited through the northern most of the two. Water depth data for the northern channel are used in the navigation charts.
- Water depths at the mouth of the river in Harrison Bay are 2 to 4 feet and increase upriver to greater than 4 feet to the west of the river-mouth bar.
- Both survey boats had difficulty navigating into the river mouth and, as noted in Section 2.2.8, the bathymetry data for the mouth of the river are inadequate at this time to establish a recommended "safe passage" navigation route into and out of the river from Harrison Bay.

- The channel in the lower Iqalliqpik River is well-defined as far as the lake in reach E-35 with water depths in most sections greater the 6 feet. The 5-foot contour was selected to define the channel margins for the navigation chart set.

No correlation has been established between water level changes at the Alpine boat dock in the Sakoonang Channel and those in the water of Harrison Bay near the mouth of the Iqalliqpik River. It is not possible, therefore, to state at this time if the water level data from the boat dock can be used to evaluate access and navigation conditions at the mouths of the Iqalliqpik River, where the depths constraints are most critical.

The depth values have not been calibrated against a chart datum and represent actual measured depths on the date of the survey.

Table 5- 1 Waypoint Data in the lower Iqalliqpik River (see Figures 5-6 through 5-11 (NAD 27 (Alaska) datum)

WAYPOINT NUMBER	LONGITUDE		LATITUDE		DEPTH (ft)
	degrees	minutes	degrees	minutes	
IQ 1 (N)	-151	13.359	70	22.848	4.0
IQ 2 (N)	-151	13.909	70	22.678	9.7
IQ 3 (N)	-151	14.113	70	22.666	9.8
IQ 4 (N)	-151	14.656	70	22.668	7.8
IQ 5 (N)	-151	15.064	70	22.714	9.0
IQ 6 (N)	-151	15.585	70	22.694	5.0
IQ 7 (N)	-151	15.668	70	22.674	6.5
IQ 8 (N)	-151	16.111	70	22.634	9.0
IQ 9 (N)	-151	16.479	70	22.509	9.0
IQ 10	-151	16.627	70	22.434	16.0
IQ11	-151	16.838	70	22.263	9.0
IQ 12	-151	16.550	70	21.946	8.9
IQ 13	-151	16.261	70	21.883	17.7
IQ 14	-151	15.973	70	21.858	18.0
IQ 15	-151	16.000	70	21.785	13.0
IQ 16	-151	16.510	70	21.589	11.0
IQ 17	-151	17.645	70	21.492	9.8
IQ 18	-151	17.873	70	21.429	24.9
IQ 19	-151	18.105	70	21.435	10.0
IQ 20	-151	18.199	70	21.662	9.2
IQ 21	-151	18.410	70	21.709	10.0
IQ 22	-151	19.039	70	21.678	7.3
IQ 23	-151	19.300	70	21.468	10.0
IQ 24	-151	19.253	70	21.389	9.0
IQ 25	-151	18.816	70	21.198	9.2
IQ 26	-151	18.244	70	21.105	12.0
IQ 27	-151	17.767	70	21.081	6.7
IQ 28	-151	17.361	70	21.029	11.0
IQ 29	-151	17.223	70	20.986	7.0
IQ 30	-151	17.046	70	20.984	9.0
IQ 31	-151	16.767	70	20.958	5.0
IQ 32	-151	16.356	70	20.837	12.0
IQ 33	-151	16.006	70	20.673	18.0
IQ 34	-151	16.058	70	20.574	11.0
IQ 35	-151	16.318	70	20.514	8.0
IQ 36	-151	16.632	70	20.568	14.0
IQ 37	-151	16.822	70	20.733	17.0

WAYPOINT NUMBER	LONGITUDE		LATITUDE		DEPTH (ft)
	degrees	minutes	degrees	minutes	
IQ 38	-151	17.085	70	20.801	11.4
IQ 39	-151	18.193	70	20.618	10.0
IQ 40	-151	19.242	70	20.374	15.0
IQ 41	-151	19.296	70	20.277	20.7
IQ 42	-151	19.008	70	20.133	35.0
IQ 43	-151	19.138	70	20.053	9.9
IQ 44	-151	19.188	70	19.996	14.0
IQ 45	-151	19.668	70	19.865	7.0
IQ 46	-151	19.787	70	19.786	10.5

Figure 5- 1 Color-coded track lines of water depths for the lower Iqalliqpik River – chart IQ-1.

Figure 5- 2 Color-coded track lines of water depths for the lower Iqalliqpik River – chart IQ-2.

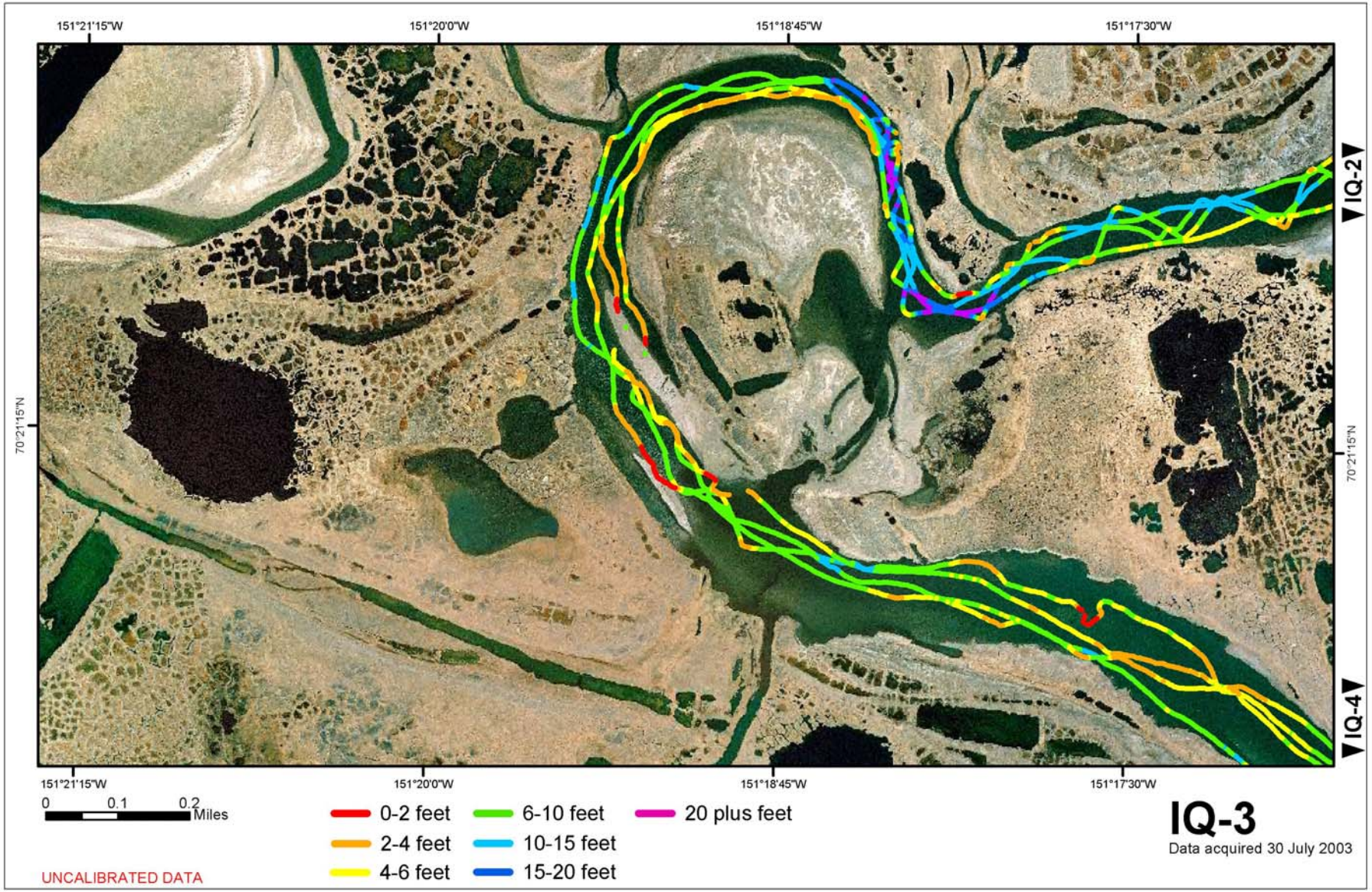

Figure 5- 3 Color-coded track lines of water depths for the lower Iqalliqpik River – chart IQ-3.

Figure 5- 4 Color-coded depth track lines for the lower Iqalliqpik River – chart IQ-4.

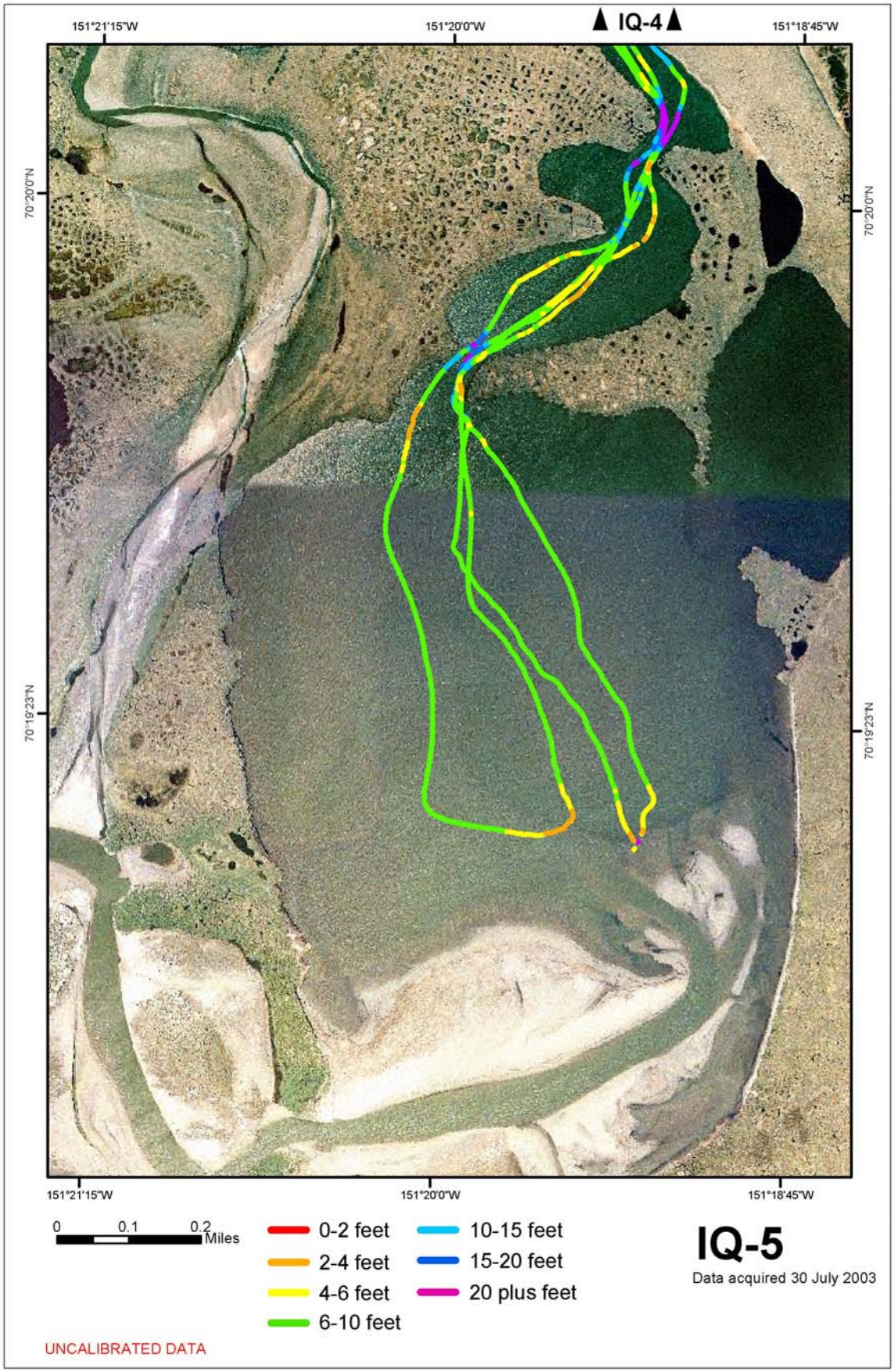

Figure 5- 5 Color-coded depth track lines for the lower Iqalliqpik River – chart IQ-5.

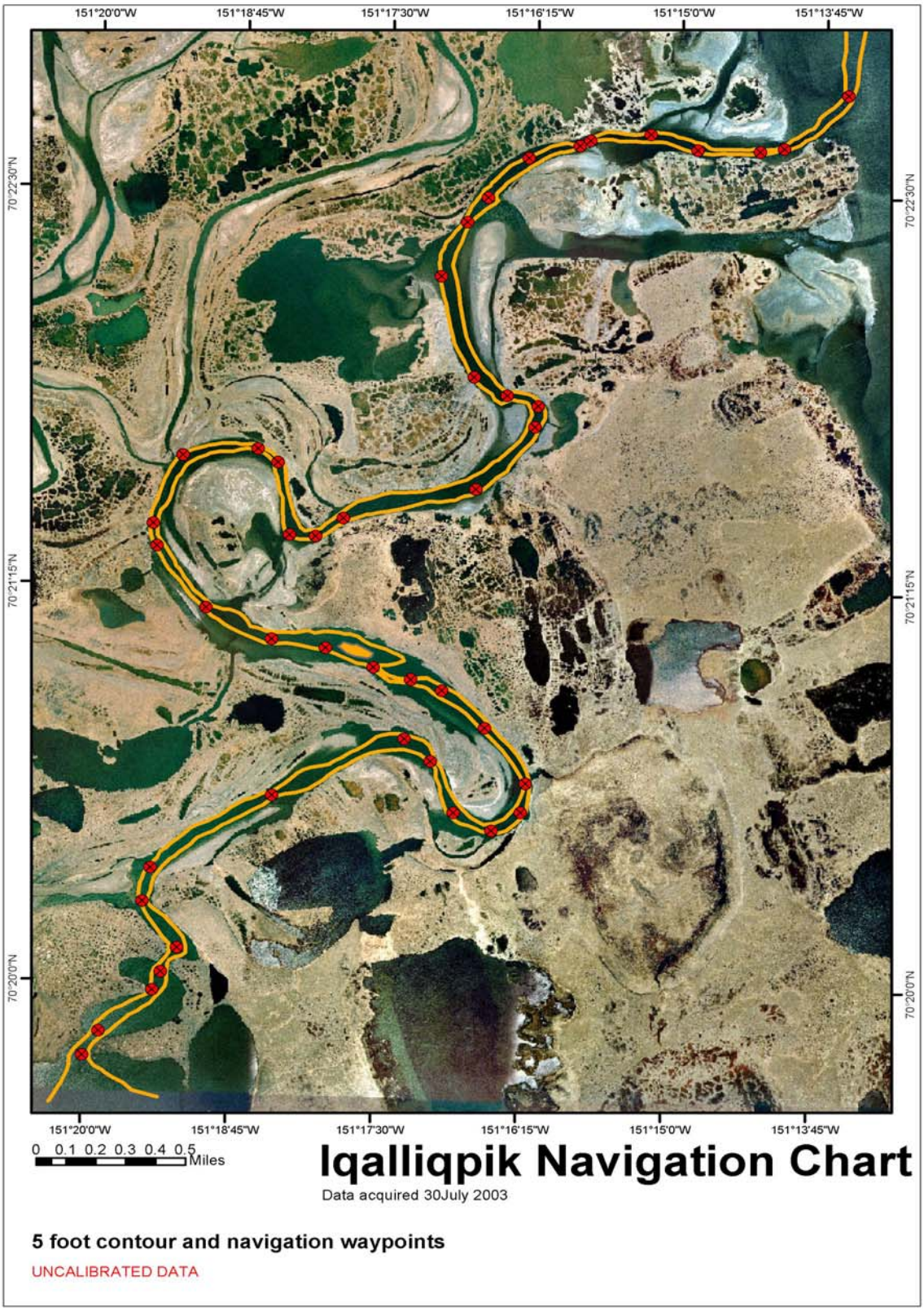

Figure 5- 6 General navigation chart of the lower Iqalliqpik River with navigation waypoints marked (see Table 5.1 and Figures 5-7 through 5-11).

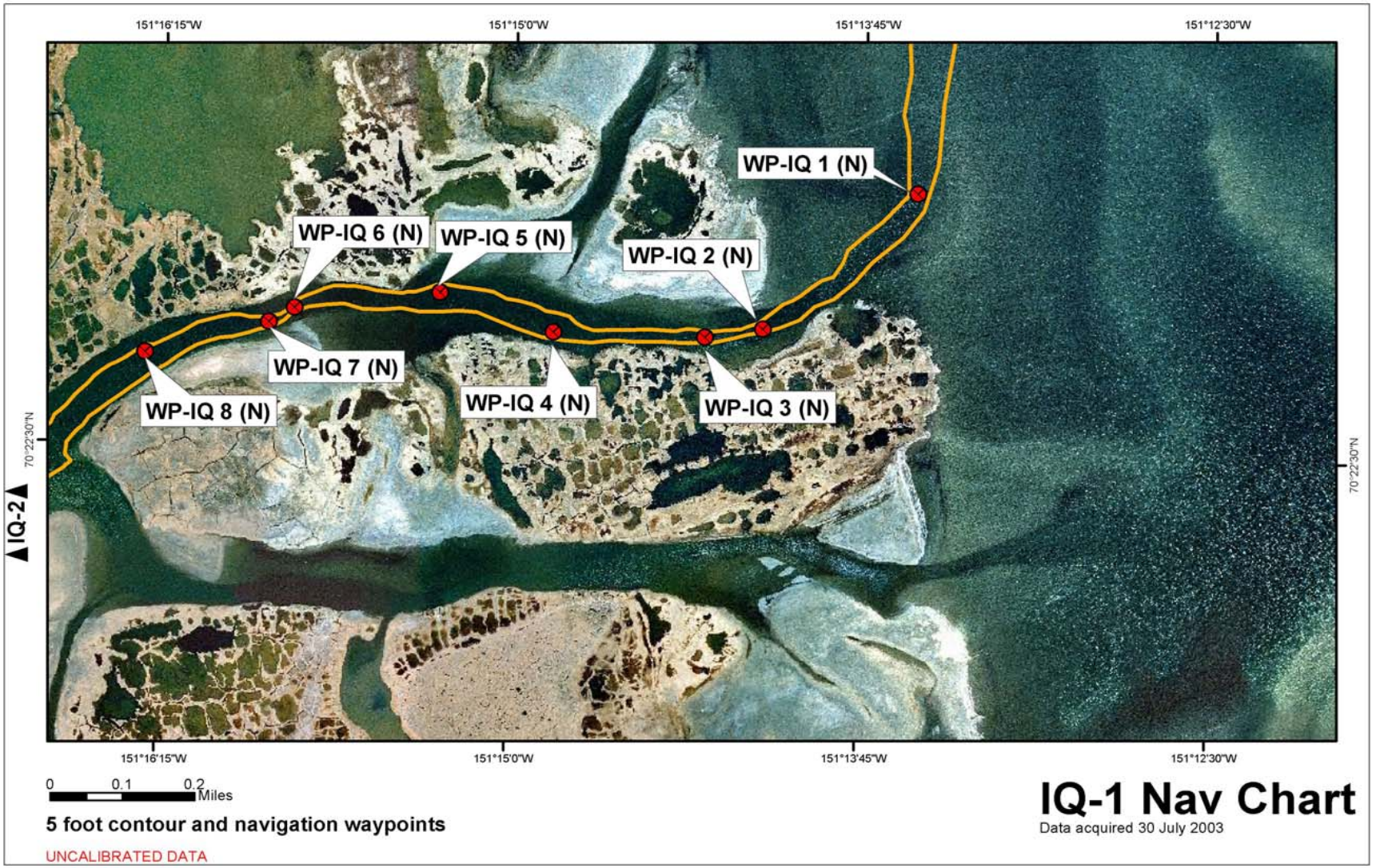

Figure 5- 7 Navigation chart of the lower Iqalliqpik River with navigation waypoints marked - Nav Chart IQ-1 (see Table 5.1).

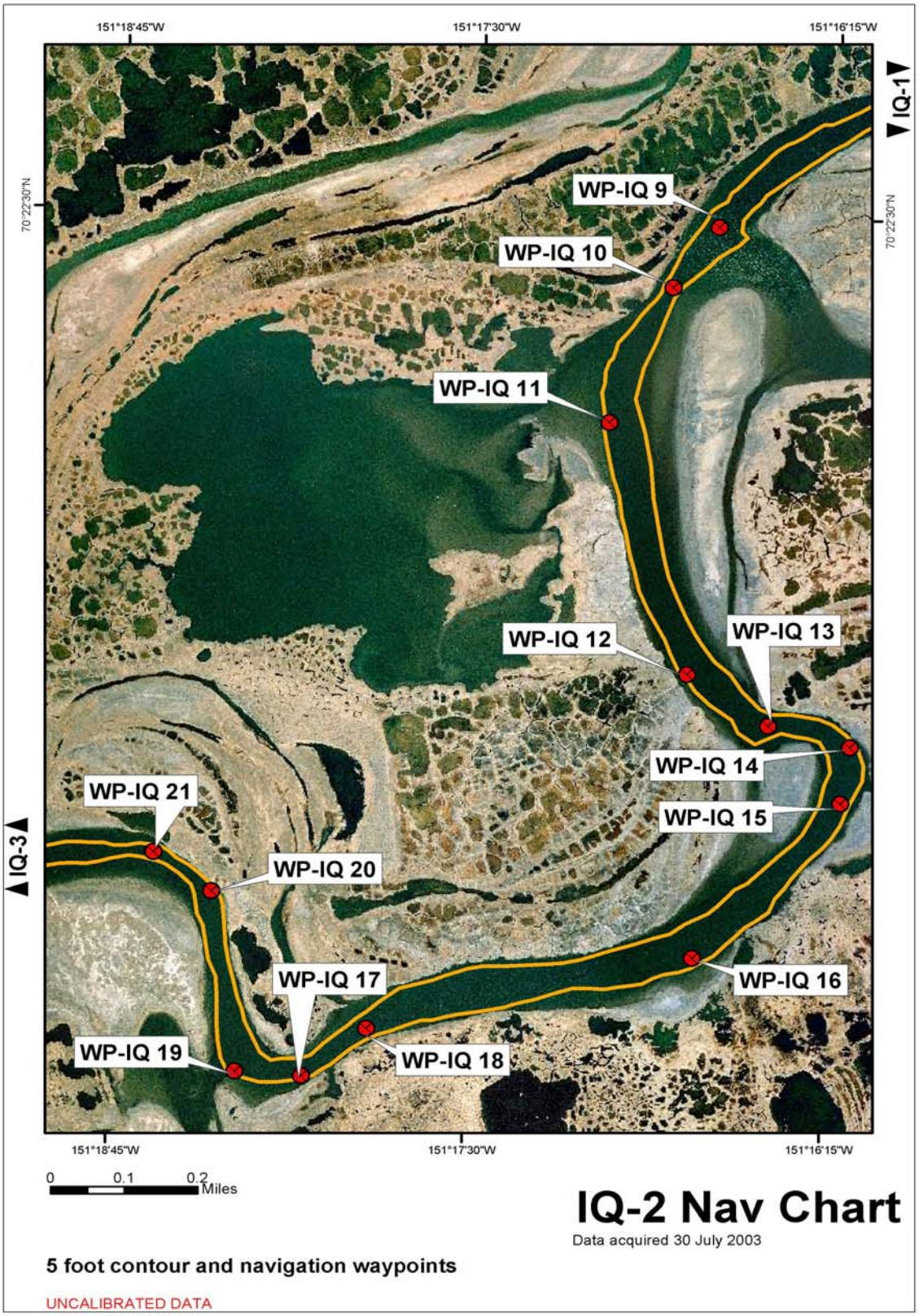

Figure 5- 8 Navigation chart of the lower Iqalliqpik River with navigation waypoints marked - Nav Chart IQ-2 (see Table 5.1).

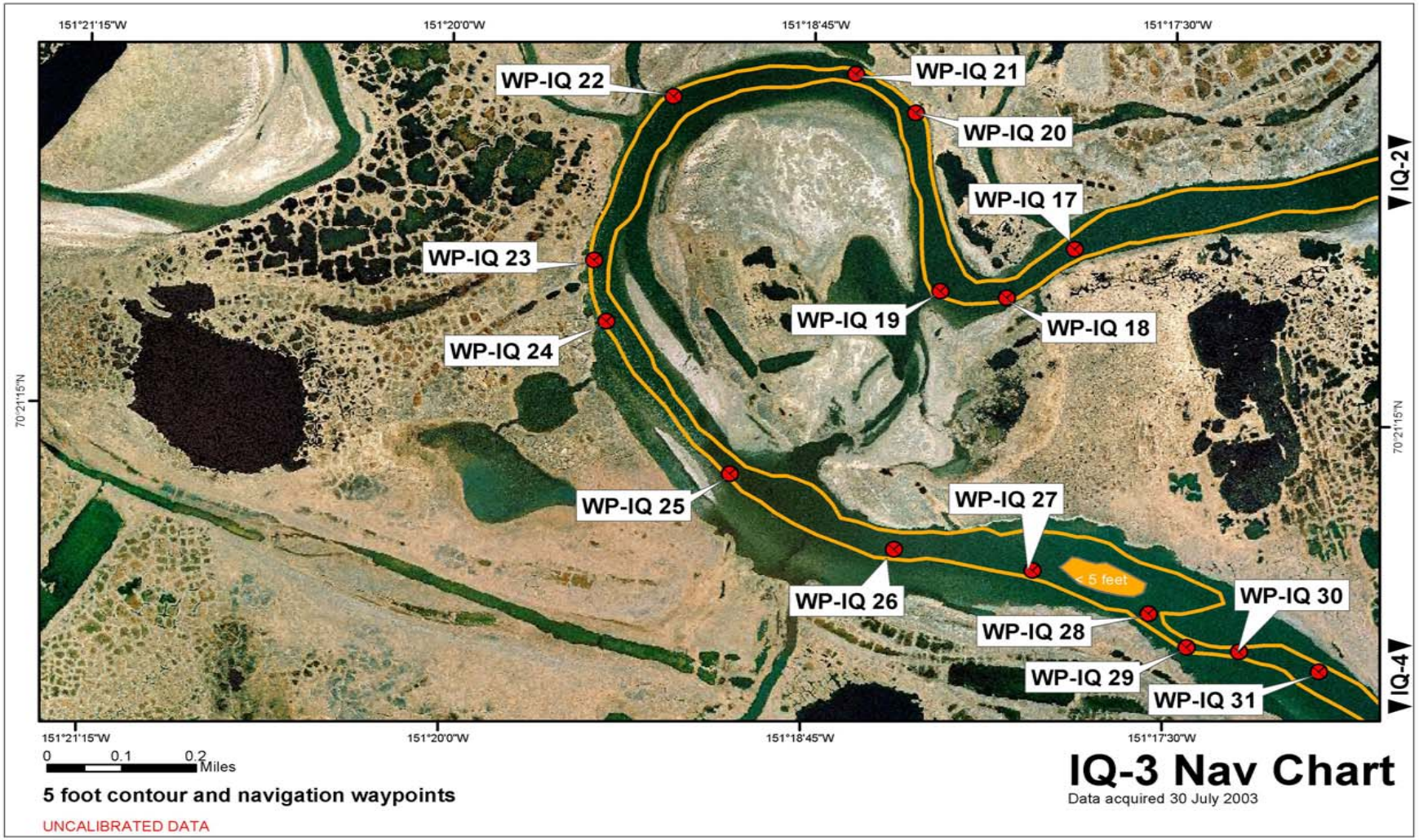

Figure 5- 9 Navigation chart of the lower Iqalliqpik River with navigation waypoints marked - Nav Chart IQ-3 (see Table 5.1).

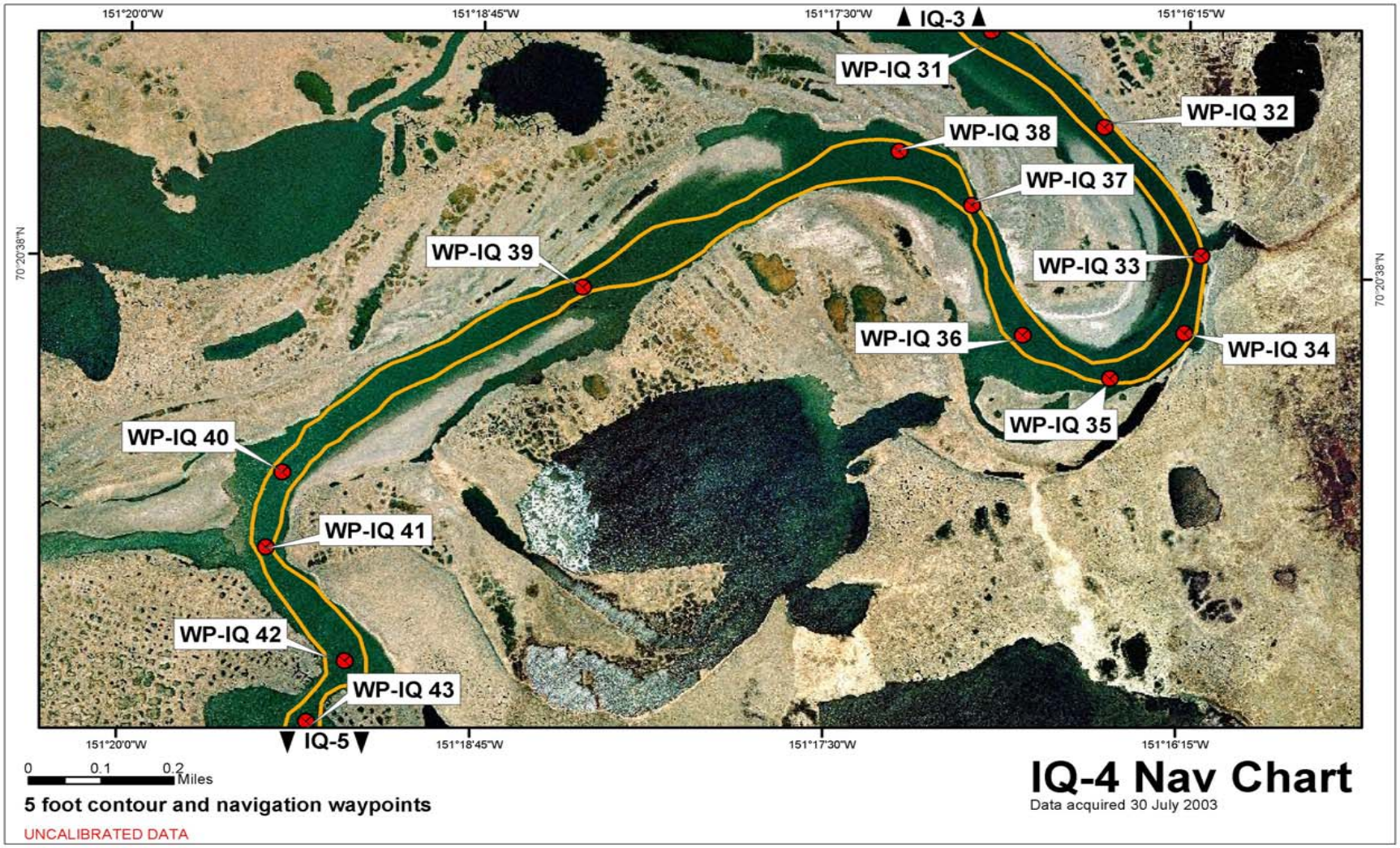

Figure 5- 10 Navigation chart of the lower Iqalliqpik River with navigation waypoints marked - Nav Chart IQ-4 (see Table 5.1).

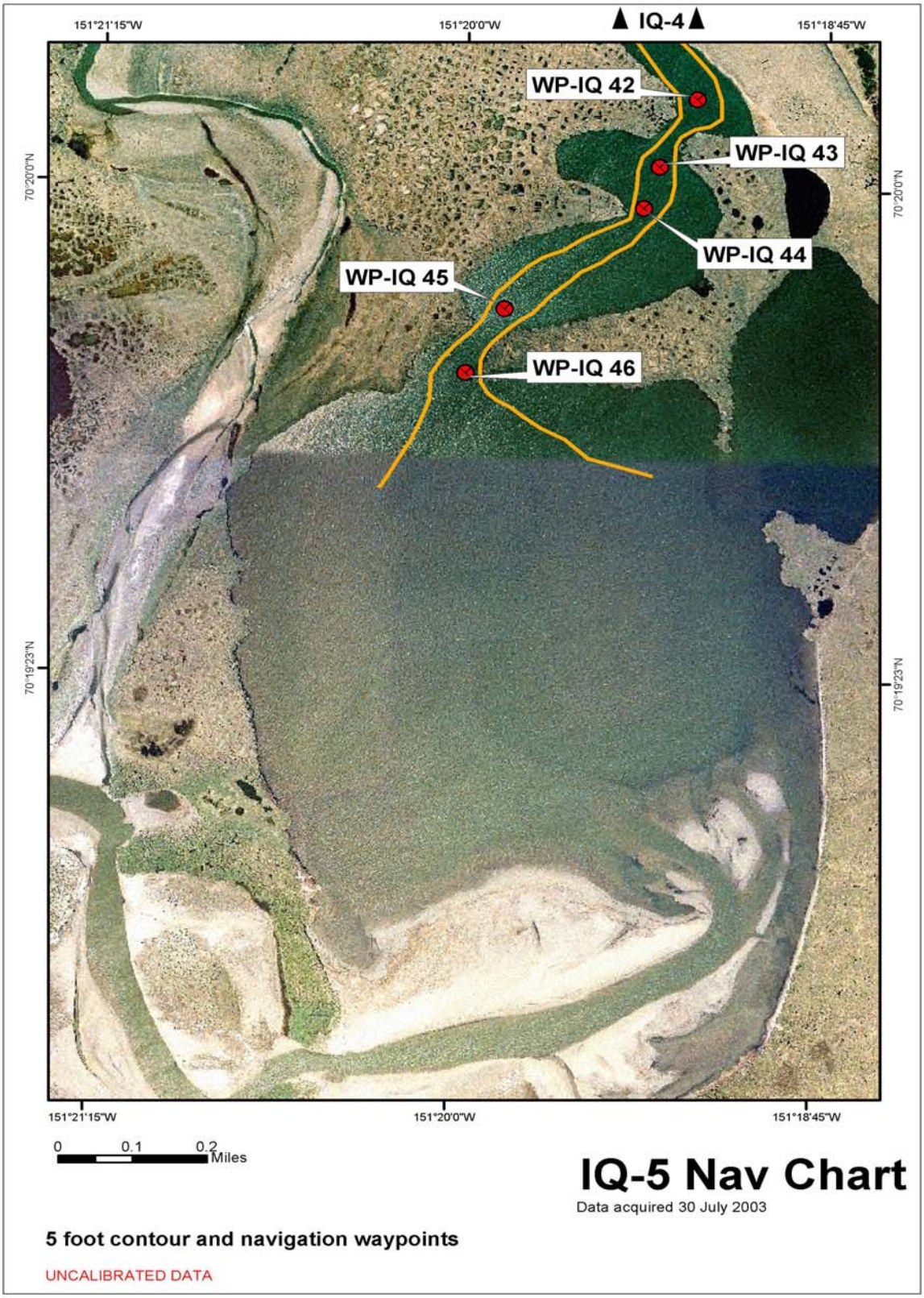

Figure 5- 11 Navigation chart of the lower Iqalliqpik River with navigation waypoints marked - Nav Chart IQ-5 (see Table 5.1).

6 RECOMMENDATIONS

The data and charts presented in this report were generated in response to the need to produce navigational information between the Sakoonang/Tamayagiaq Channel, the Nigliq Channel, and the Iqalliqpik River as soon as practical. These data and the charts have been produced with the knowledge and understanding that not all of the data could be processed and that the depth values have not been calibrated to a known datum or to water-level data. This section identifies five recommended future activities to maximize the knowledge that is contained in the data already collected and to complete the data for key areas.

1. The depth values have not been calibrated against a chart datum or water levels (such as MLLW) at the time of the surveys and represent actual measured depths on the date of the survey. We recommend that the depths be corrected and calibrated to a common datum. Data at locations where track lines cross on the same day at different times or on different days could be cross-checked as part of this calibration process.
2. The data for the Sakoonang, Tamayagiaq, and Ulamnigiaq Channels have not been processed at this time. The data exist to produce channel depth and navigation charts for these three channels similar to the Detailed Navigation Charts presented in this report.
3. The depth data for the area between the Nigliq Channel entrance and the mouth of the Iqalliqpik River (Figure E-1) is useful as a general indication of depths in the region, but further data are required before a recommended "safe passage" navigation route can be defined. Additional field survey work could generate this data.
4. The bathymetry data for the mouth of the Iqalliqpik River is inadequate at this time to establish a recommended "safe passage" navigation route into and out of the river from Harrison Bay. Additional field survey work could generate this data.
5. A data comparison between the 1996, 1997, and the 2003 data would yield more details on the character of the shoals and channels at the entrance to the Nigliq Channel. Possible future field work in this area could attempt to locate the curved east-west channel across the entrance to the Nigliq Channel.

APPENDIX A – TRACK LINE CHARTS

Page

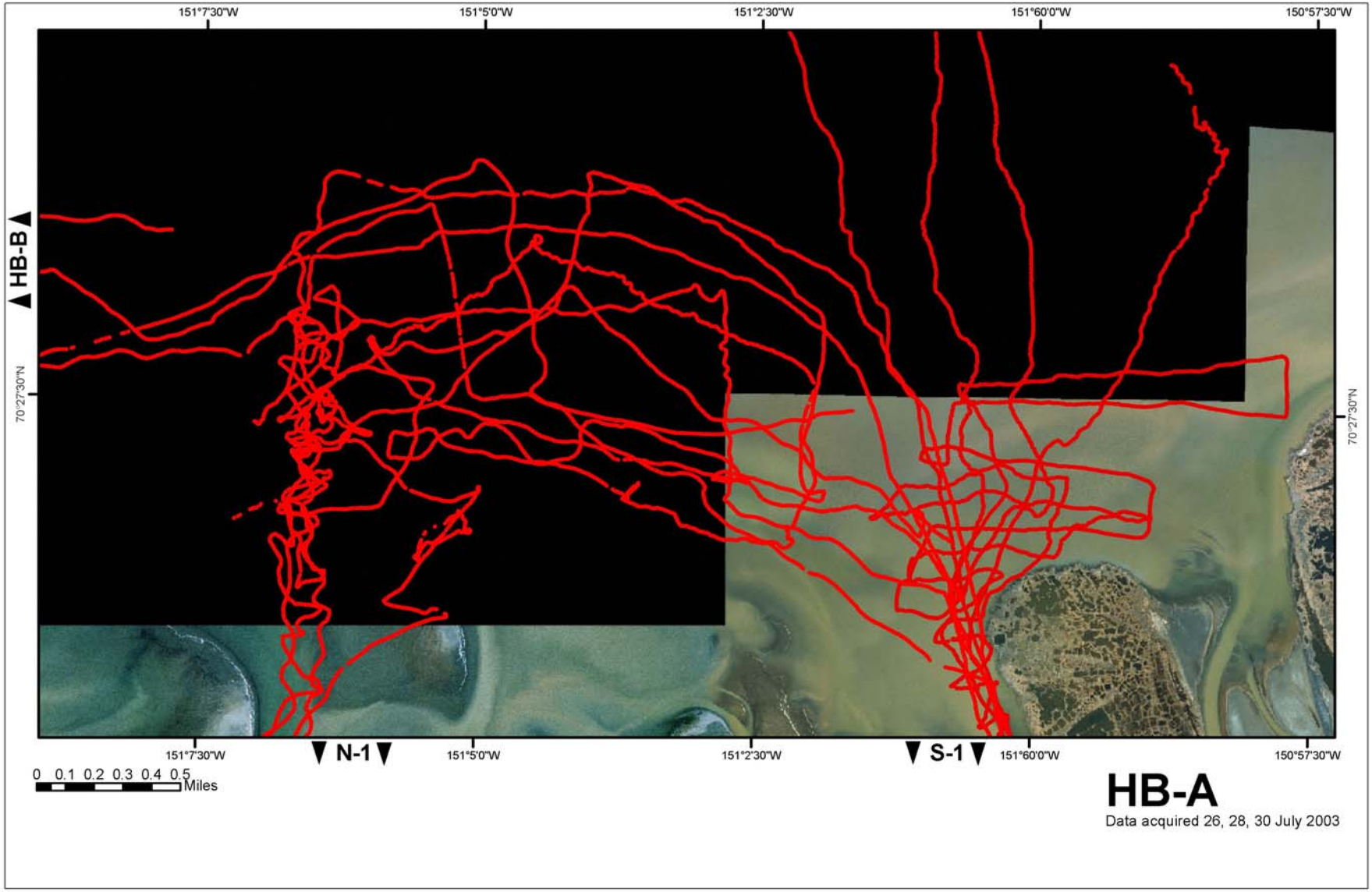

Figure A- 1 Track lines in Harrison Bay: HB-A

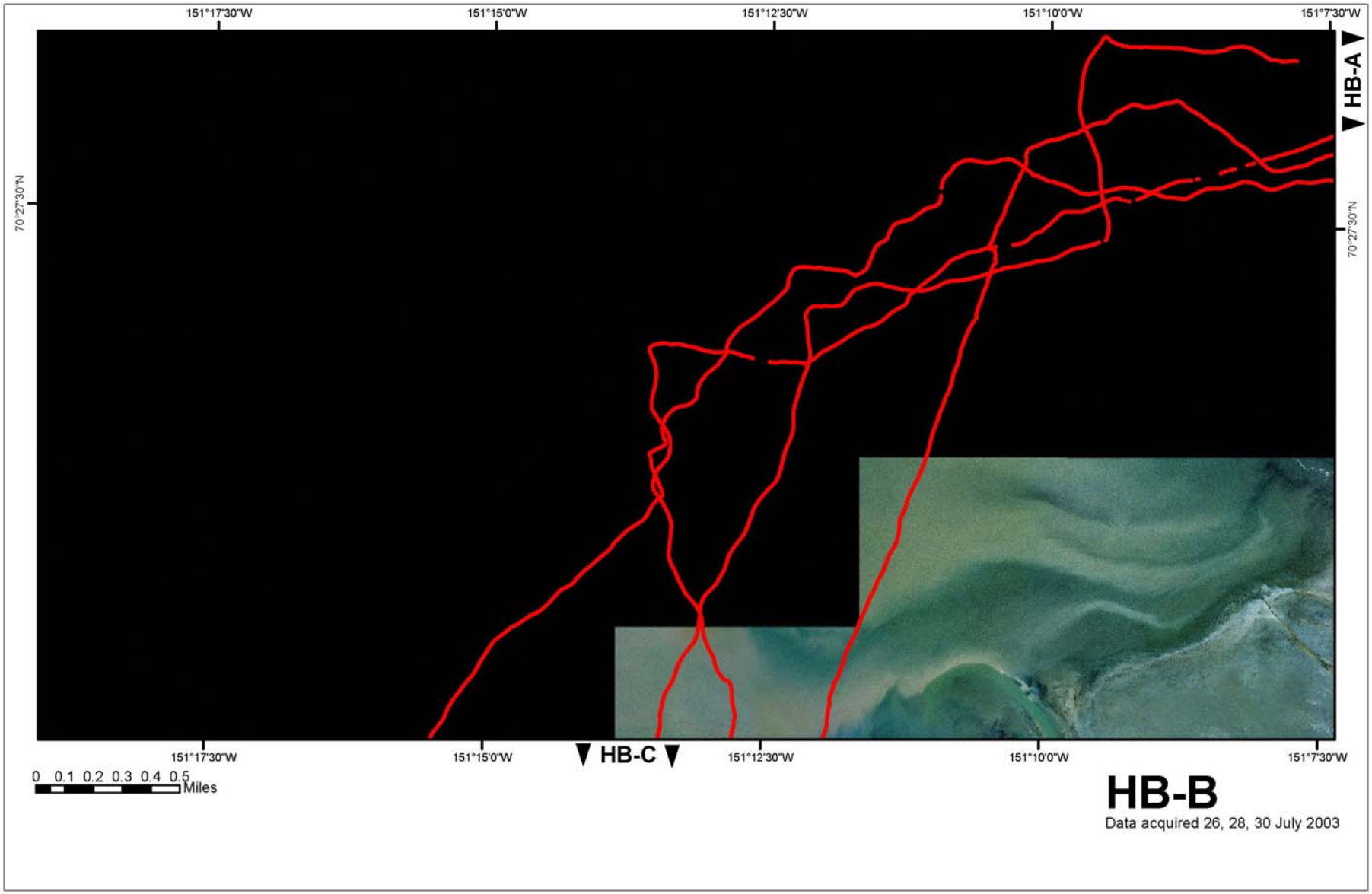

Figure A- 2 Track lines in Harrison Bay: HB-B

Figure A- 3 Track lines in Harrison Bay: HB-C

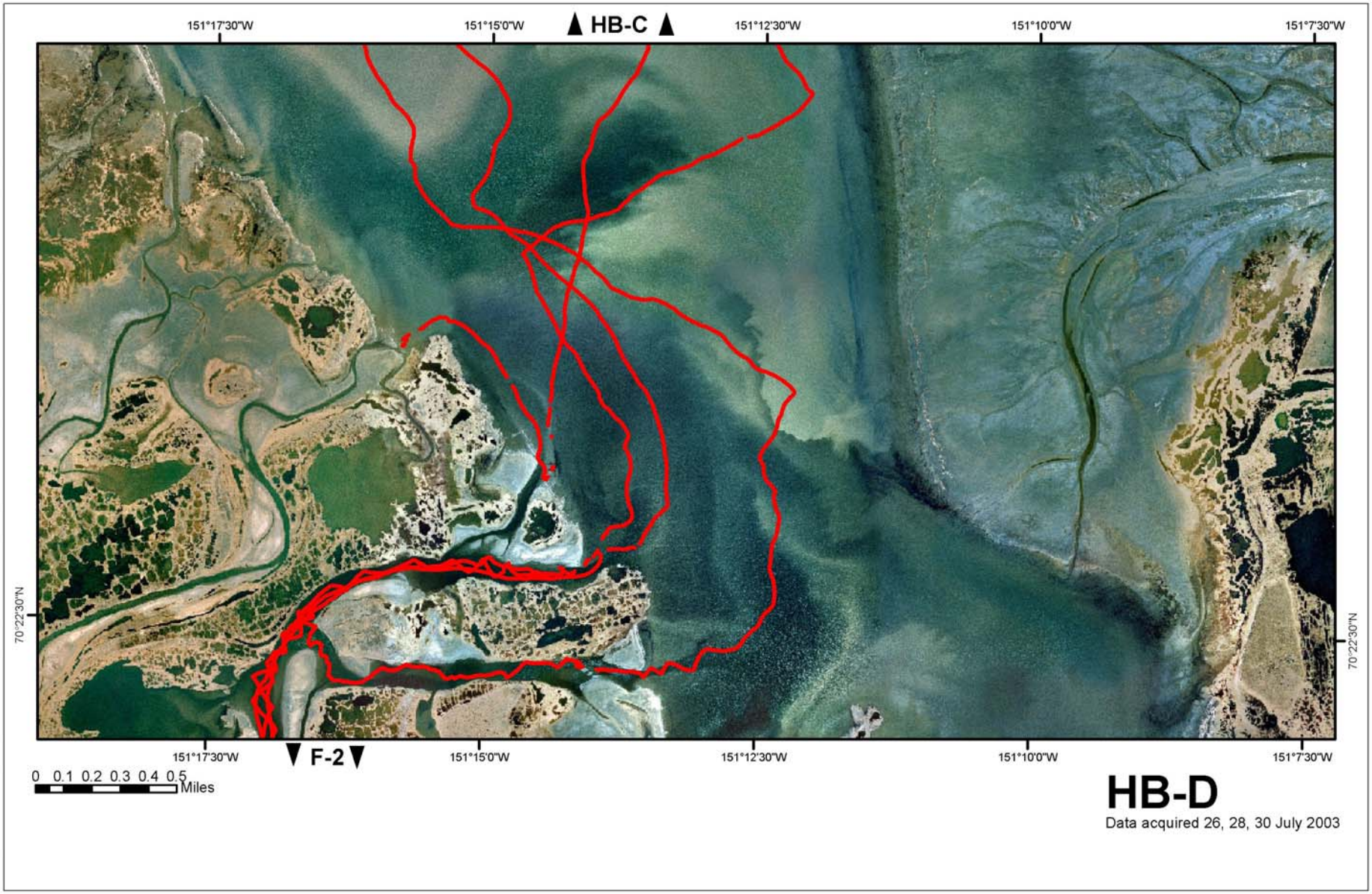

Figure A- 4 Track lines in Harrison Bay: HB-D

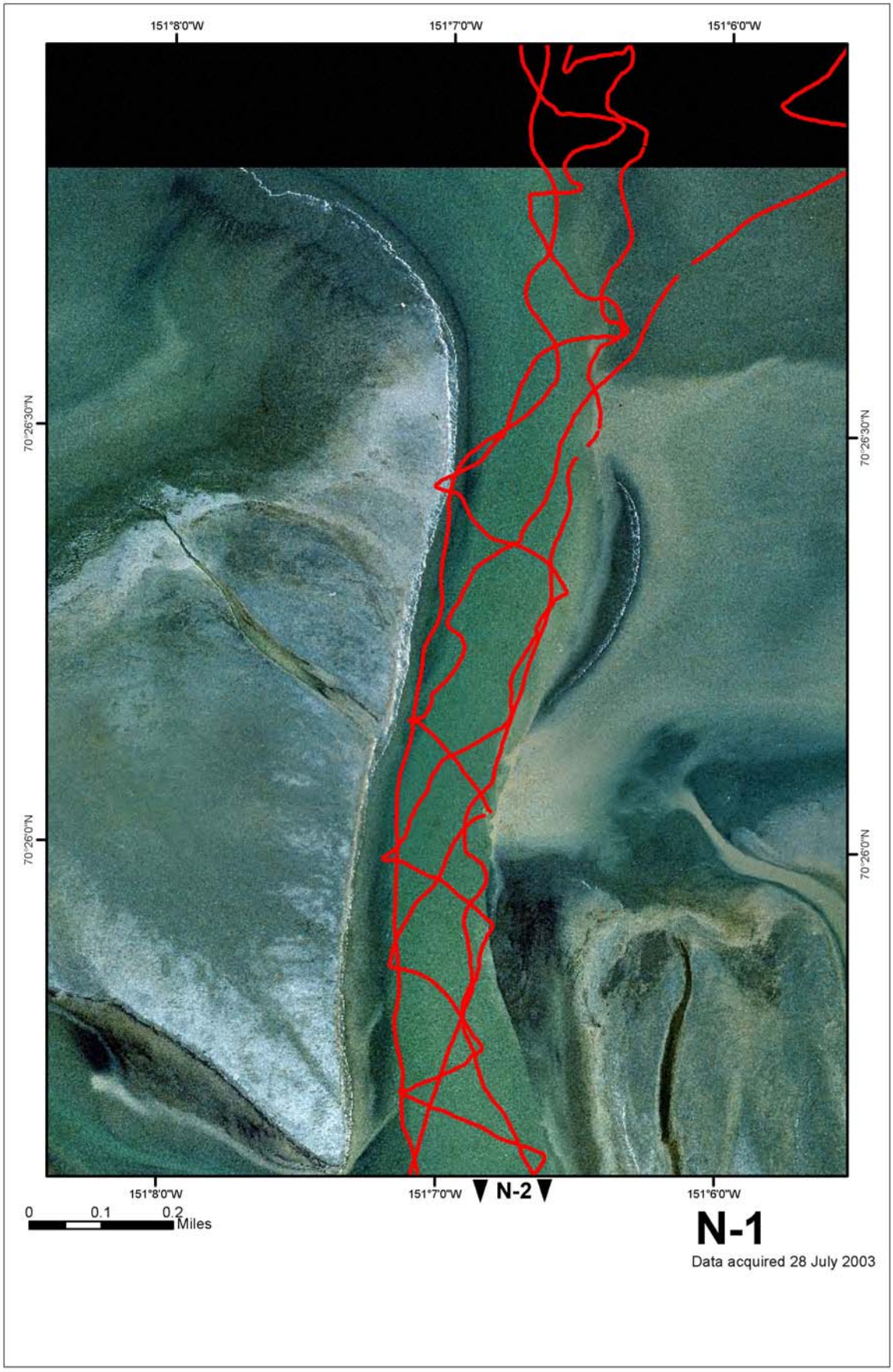

Figure A- 5 Track lines in the Nigliq Channel: N-1

Figure A- 6 Track lines in the Nigliq Channel: N-2

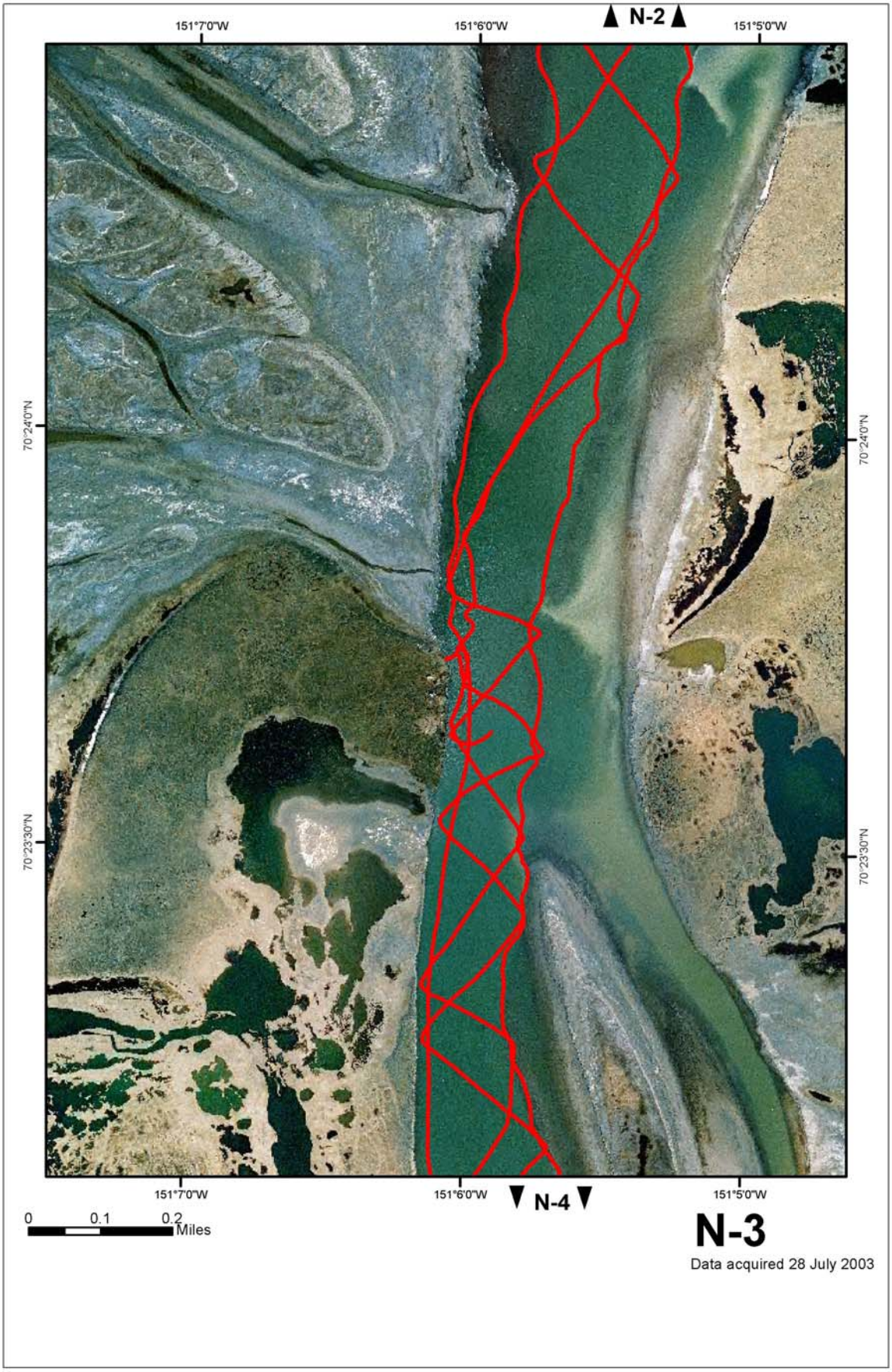

Figure A- 7 Track lines in the Nigliq Channel: N-3

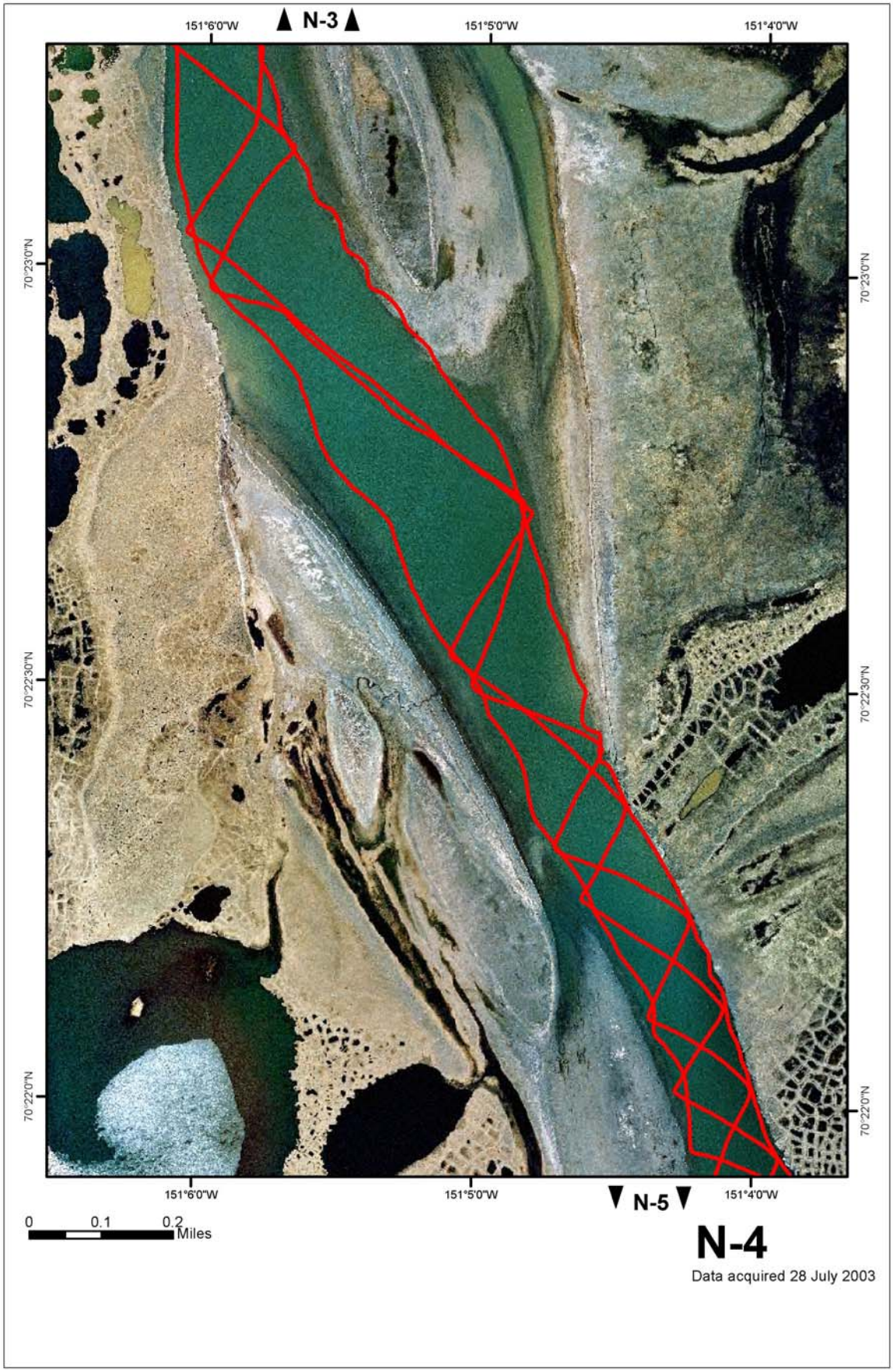

Figure A- 8 Track lines in the Nigliq Channel: N-4

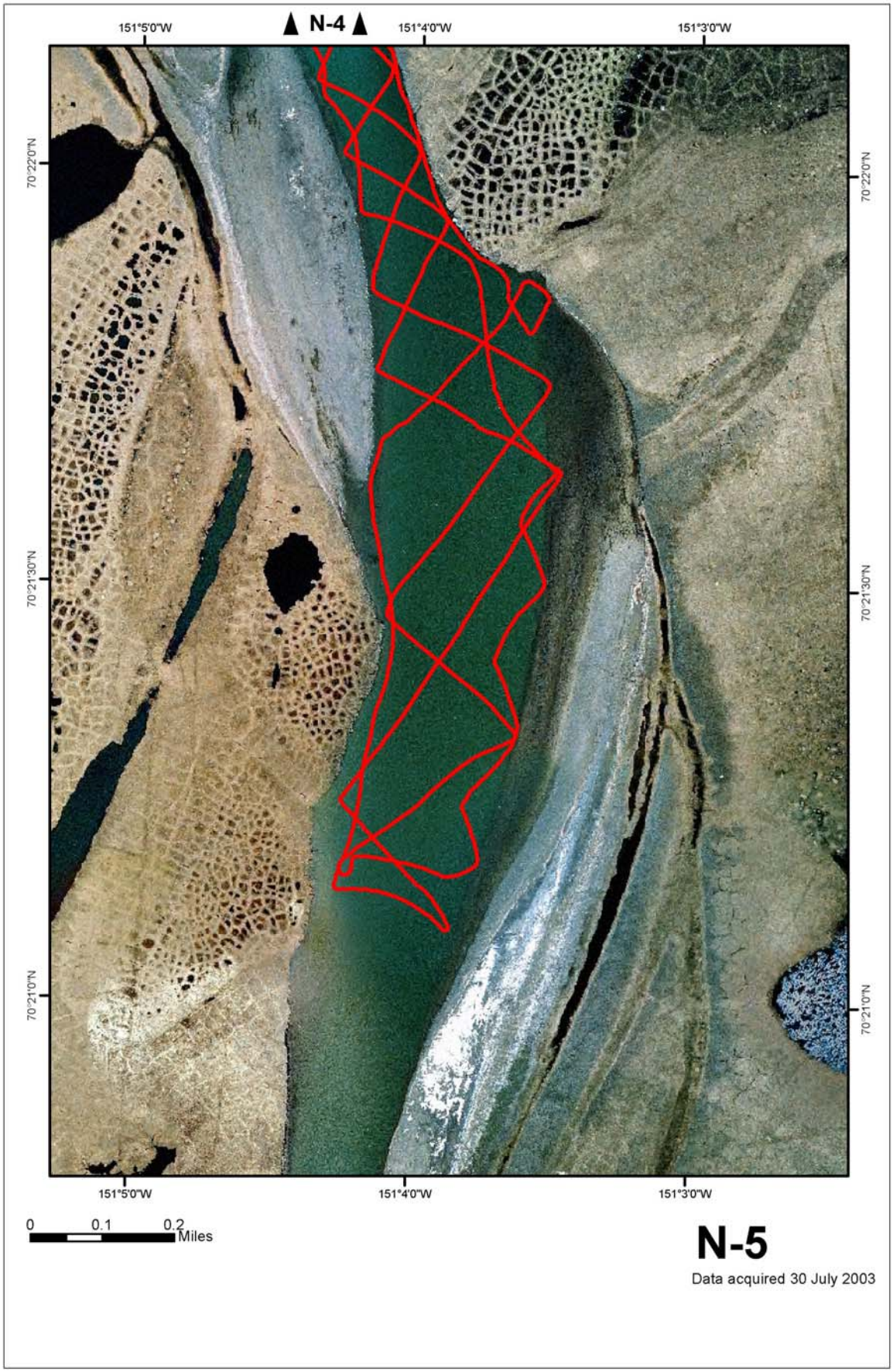

Figure A- 9 Track lines in the Nigliq Channel: N-5

Figure A- 10 Track lines in the Sakoonang Channel: S-1

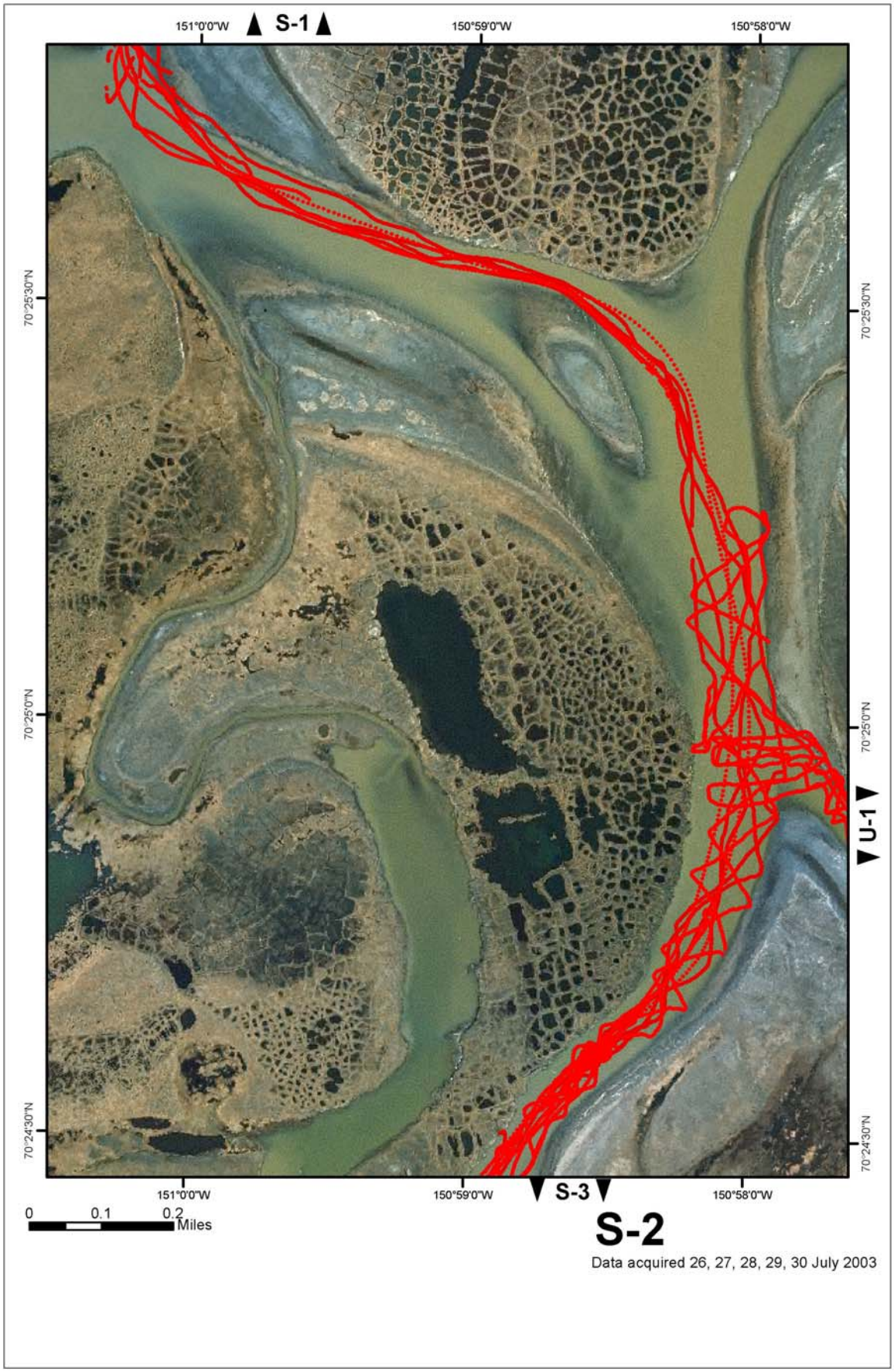

Figure A- 11 Track lines in the Sakoonang Channel: S-2

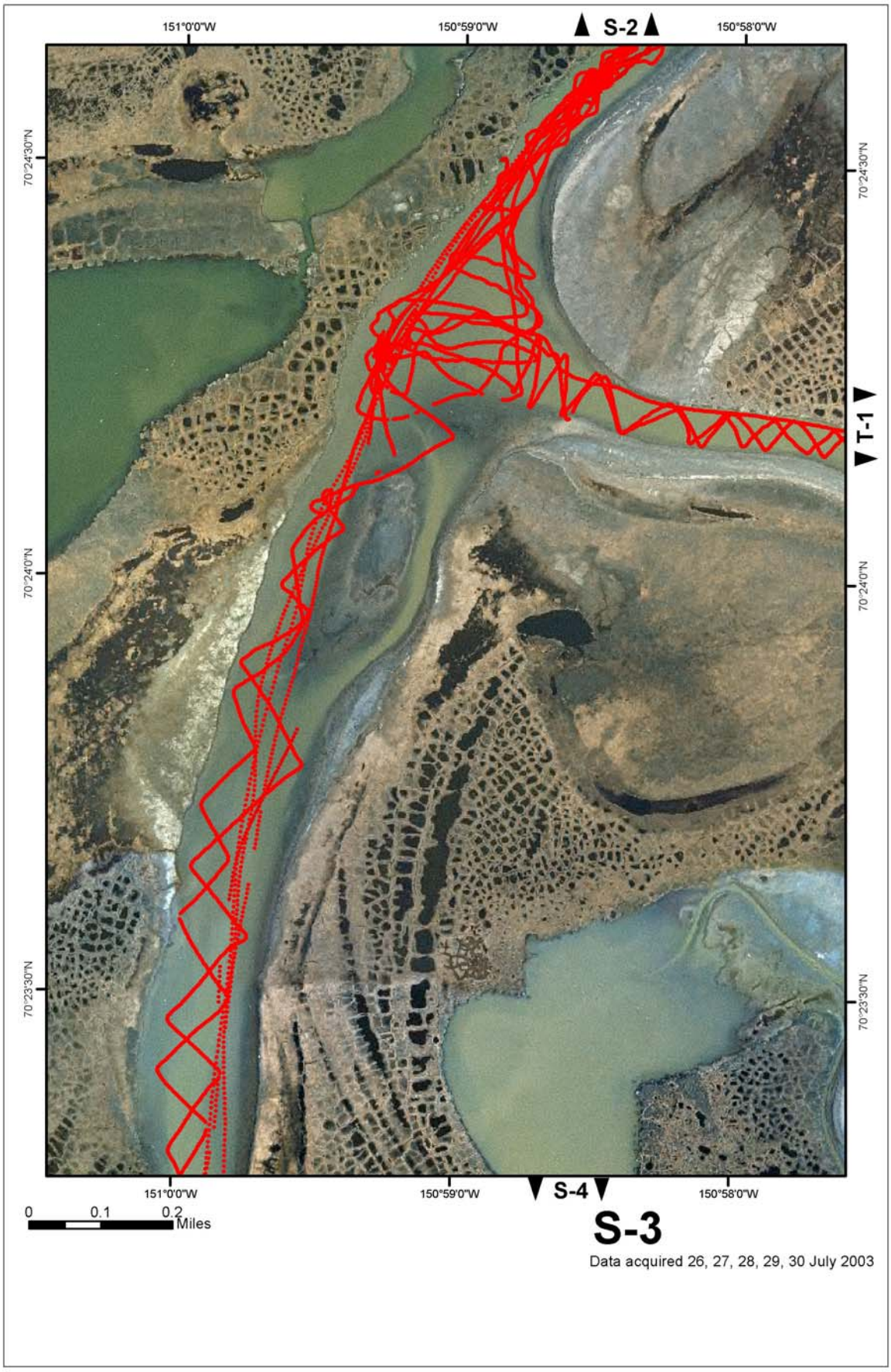

Figure A- 12 Track lines in the Sakoonang Channel: S-3

Figure A- 13 Track lines in the Sakoonang Channel: S-4

Figure A- 14 Track lines in the Sakoonang Channel: S-5

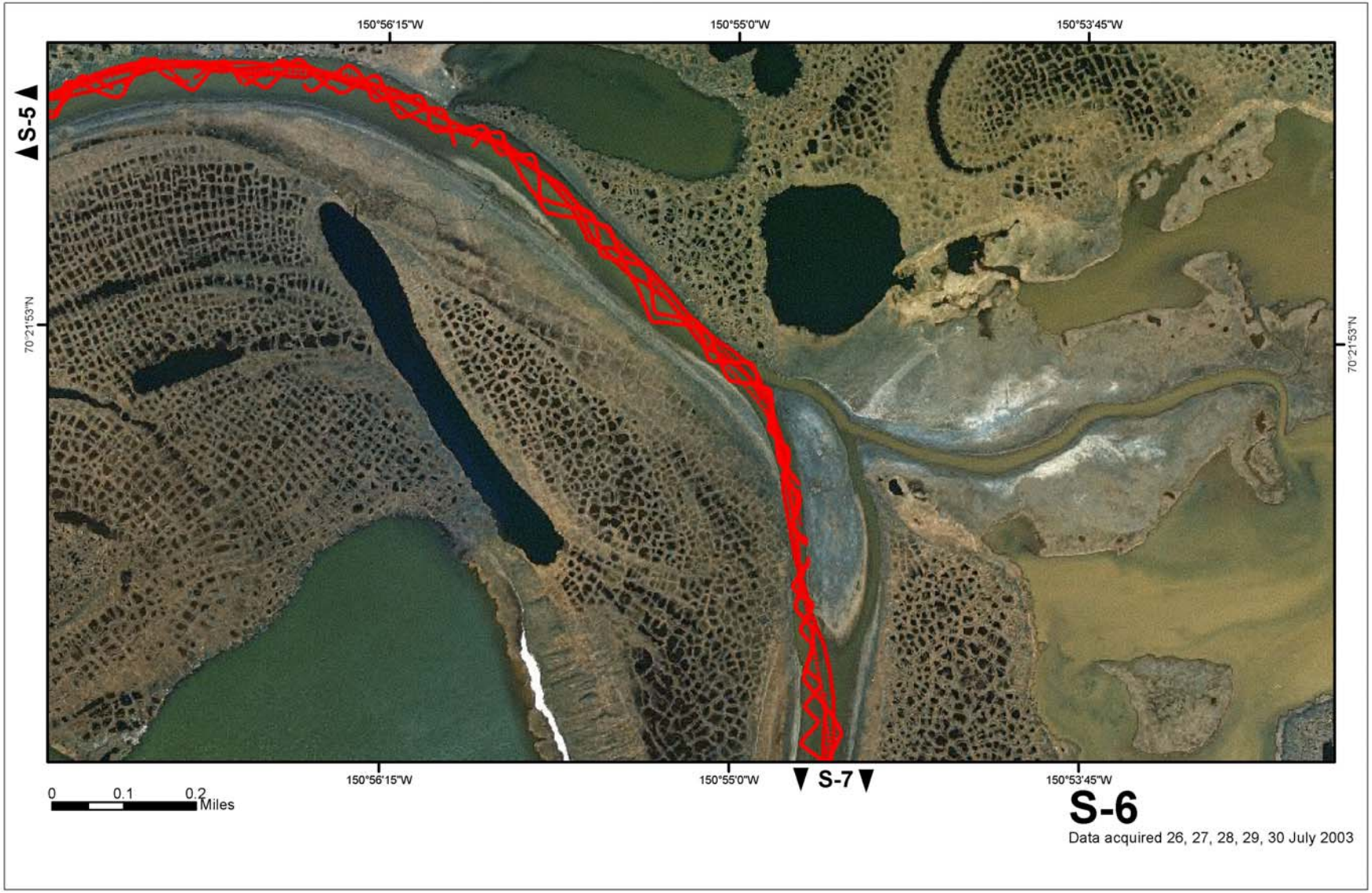

Figure A- 15 Track lines in the Sakoonang Channel: S-6

Figure A- 16 Track lines in the Sakoonang Channel: S-7

Figure A- 17 Track lines in the Tamayagiaq Channel: T-1

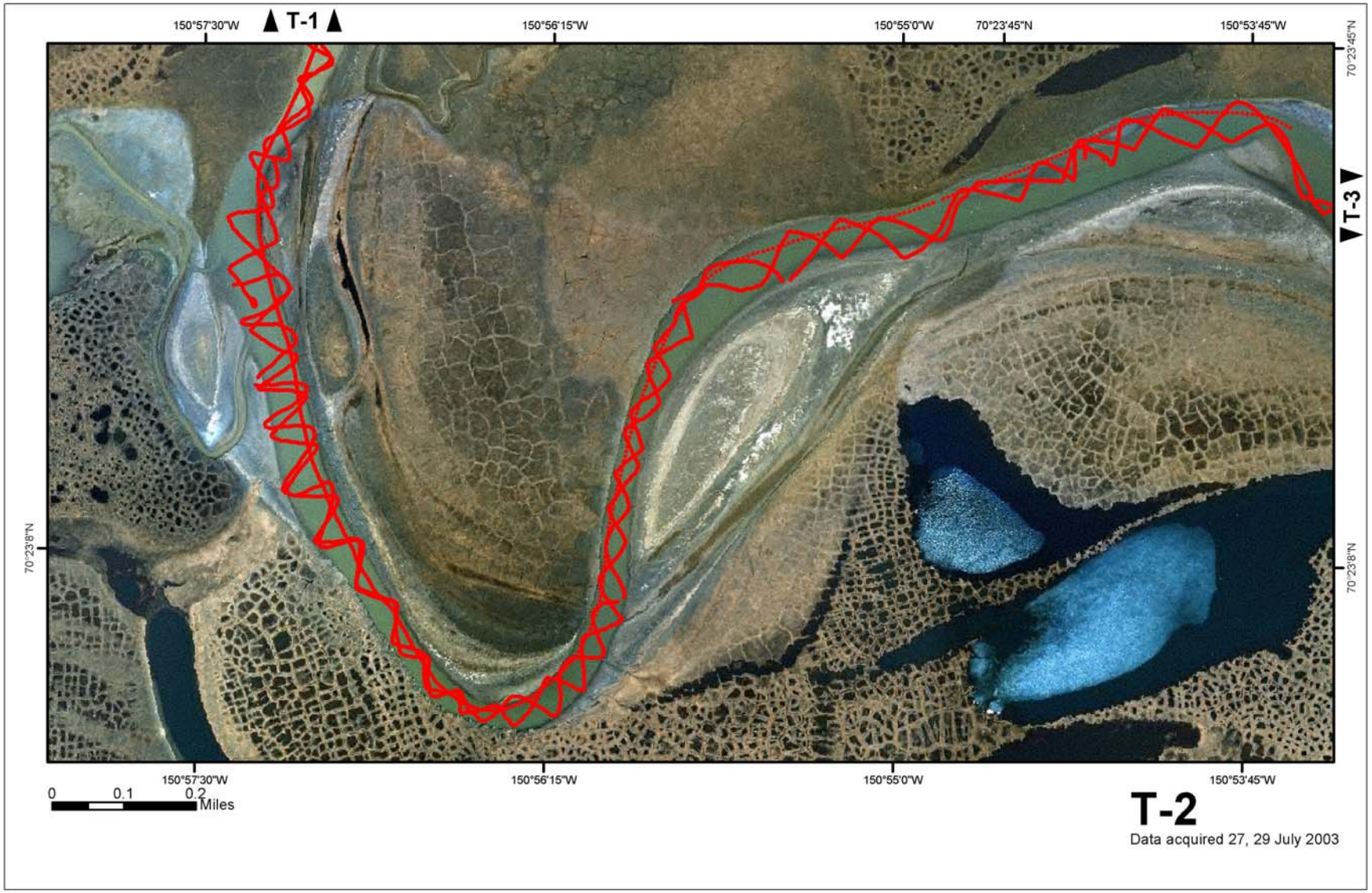

Figure A- 18 Track lines in the Tamayagiaq Channel: T-2

Figure A- 19 Track lines in the Tamayagiaq Channel: T-3

Figure A- 20 Track lines in the Tamayagiaq Channel: T-4

Figure A- 21 Track lines in the Tamayagiaq Channel: T-5

Figure A- 22 Track lines in the Tamayagiaq Channel: T-6

Figure A- 23 Track lines in the Ulamnigiaq Channel: U-1

Figure A- 24 Track lines in the Ulamnigiaq Channel: U-2

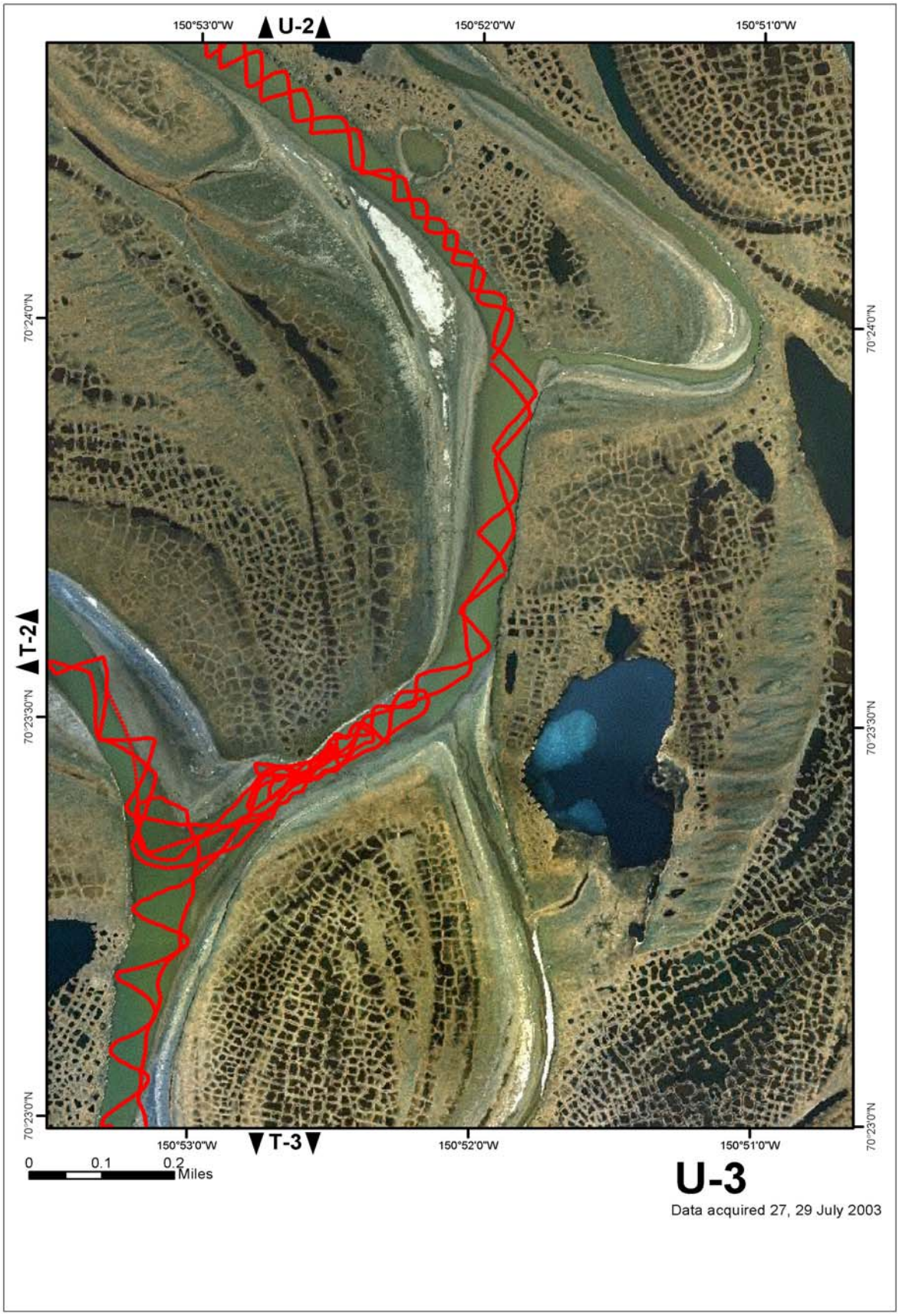

Figure A- 25 Track lines in the Ulamnigiaq Channel: U-3

Figure A- 26 Track lines in the Lower Iqalliqpik River: IQ-1

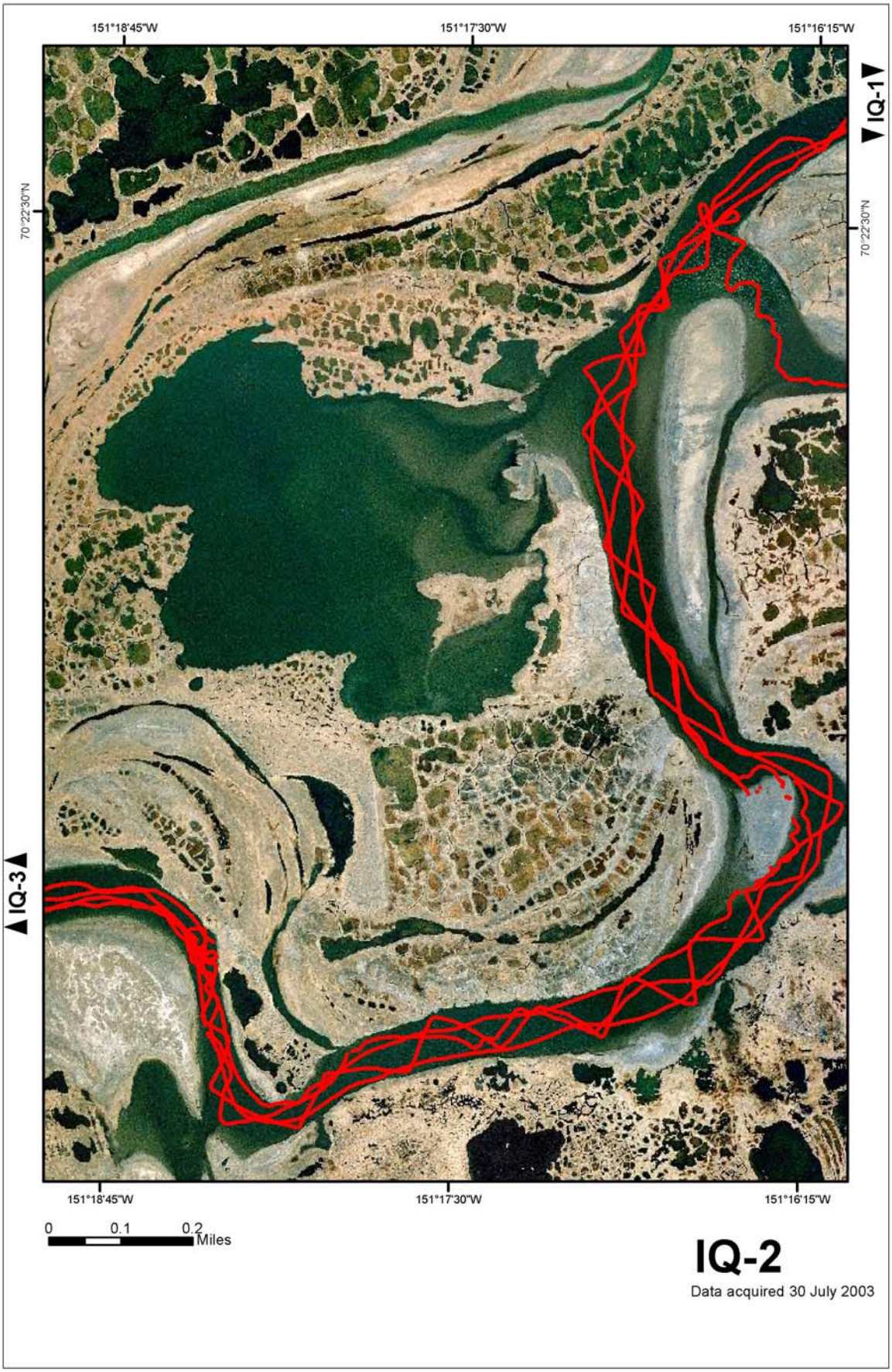

Figure A- 27 Track lines in the Lower Iqalliqpik River: IQ-2

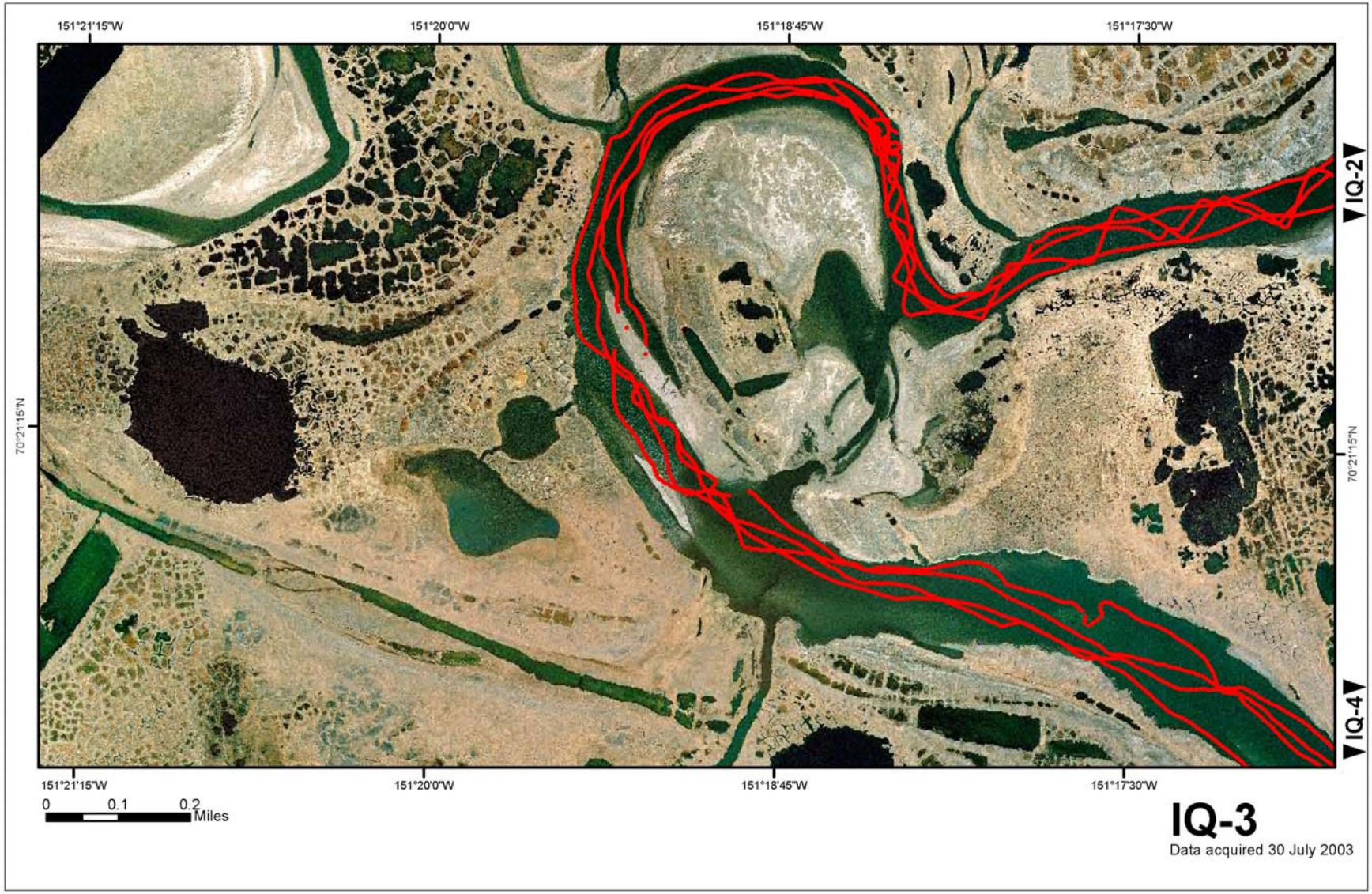

Figure A- 28 Tracks line in the Lower Iqalliqpik River: IQ-3

Figure A- 29 Track lines in the Lower Iqalliqpik River: IQ-4

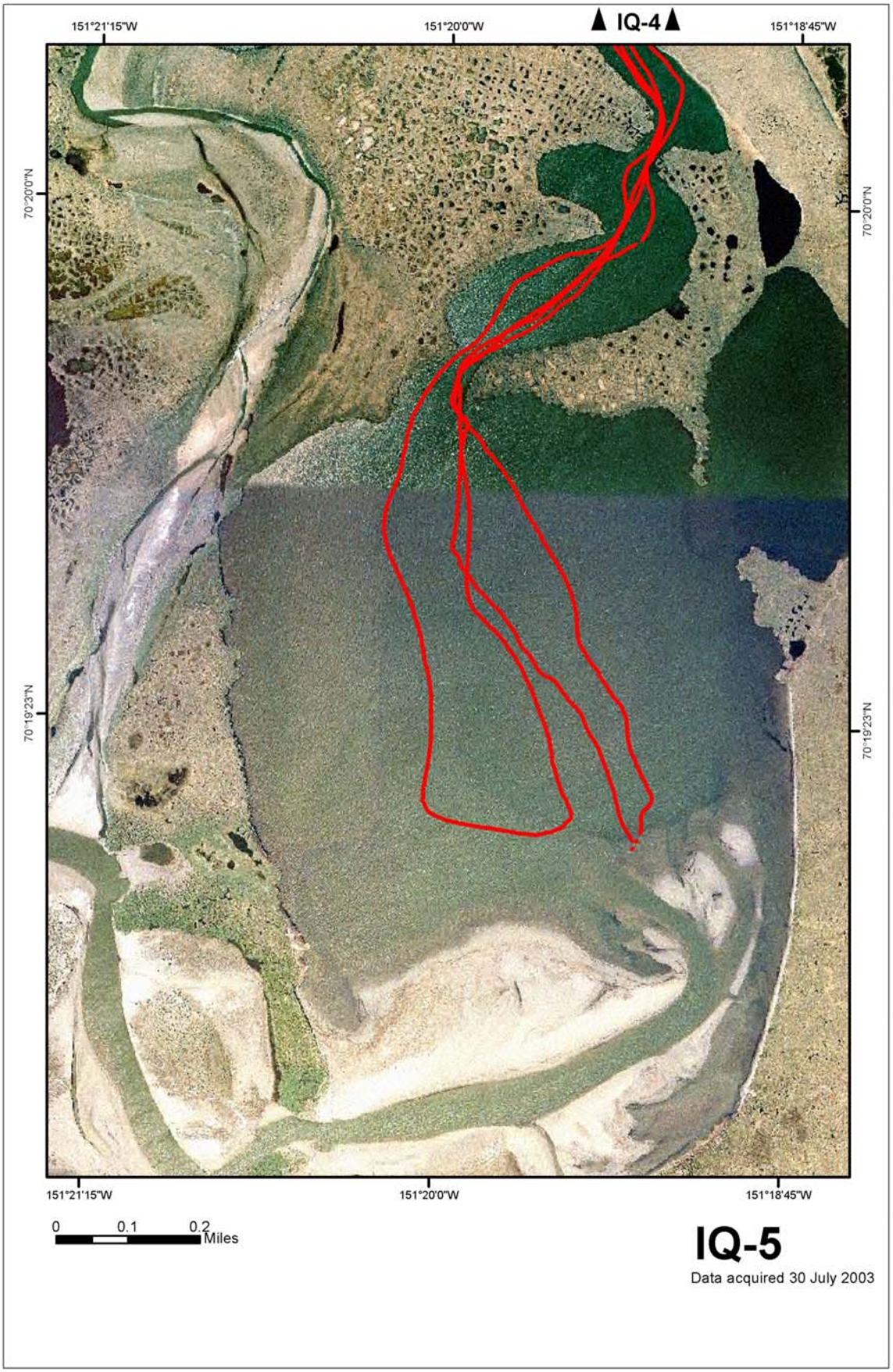

Figure A- 30 Track lines in the Lower Iqalliqpik River: IQ-5

APPENDIX B – PREDICTED TIDES

Prudhoe Bay, Dock #2

Saturday July 26, 2003
Sunday July 27
Monday July 28
Tuesday July 29
Wednesday July 30
Thursday July 31