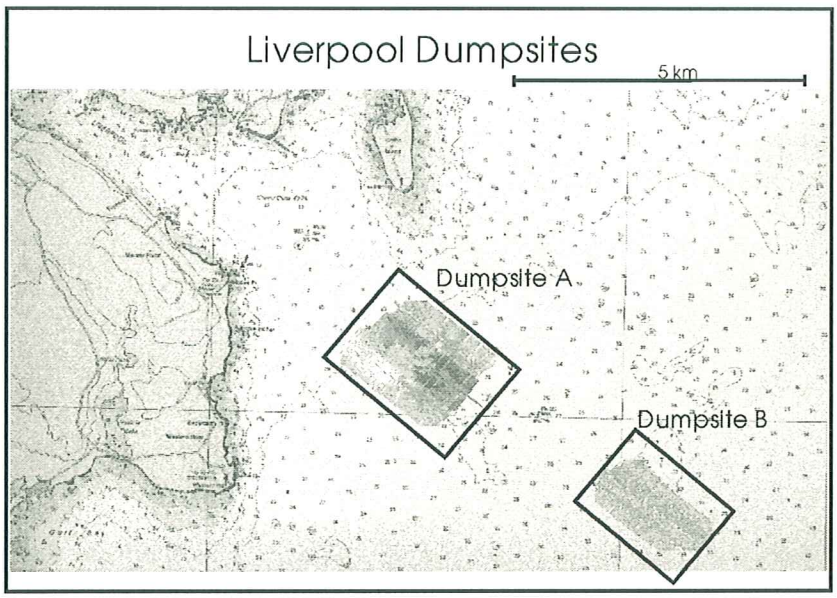
Sidescan Sonar Survey of the Liverpool Offshore Dumpsites

13-16 May 1994



for
Public Works and Government Services Canada
A&ES, Atlantic Region
and
Transport Canada
Marine Navigational Aids

by
D. Russell Parrott
Geological Survey of Canada
Box 1006, Dartmouth NS Canada, B2Y 4A2

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Natural Resources Canada Ressources naturelles Canada

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Survey Summary

Survey DPW94001 was undertaken as part of a joint project by the Geological Survey of Canada (GSC) and Public Works and Government Services Canada (PWGSC) to determine existing seafloor conditions in the approaches to Liverpool Harbour, Nova Scotia, prior to new dumping of materials dredged from the inner harbour. Two detailed sidescan surveys were performed (dumpsites A and B) and 10 grab samples were taken to provide groundtruth for the sidescan sonar data. See Figure 1 for locations of dumpsites A and B and Figure 2 for the sample locations.

The geophysical portion of the survey was performed by the Geological Survey of Canada. The following equipment was used on the geophysical survey as part of a research project to study the stability and mobility of dredge spoil deposits: a Simrad MS992 dual frequency (120 and 330 kHz) sidescan sonar; a 3.5 kHz sub-bottom profiler system, and a GeoAcoustics SE880 4 channel digital data acquisition system. Data from the attitude sensor package on the Simrad MS992 sidescan sonar were logged on a portable computer to allow analysis of the towfish motion during the survey. Ten grab samples were taken in Dumpsite A to assist with the interpretation of the sidescan sonar and sub-bottom profiler data, and to provide information on the potential for sediment transport in the area.

Continuous coverage bathymetry data were collected at the dumpsites by Public Works and Government Services Canada, using a 14 channel Navitronics sweep bathymetry system mounted on the 10 metre vessel Miramichi Surveyor. Navigation for the survey was provided by PWGSC using a differential GPS system.

Survey Objectives

Survey DPW94001 was organized to:

1. Collect sidescan sonar and 3.5 kHz subbottom profiler data over a proposed offshore dumpsite in the approaches to Liverpool harbour to study seafloor conditions prior to dumping of material dredged from the inner harbour.
2. Collect swath bathymetry data over the site to determine water depths prior to dumping of dredged material
3. Obtain samples of the various sediments found on the seafloor to provide groundtruth for the interpretation of the geophysical data.

Preliminary Results

About 20 km of sidescan sonar, and sub-bottom profiler data were collected during the geophysical survey portion of Cruise DPW94001. A preliminary interpretation of the sidescan and sub-bottom profiler data was made in the field to pick sample sites. Ten van Veen grab samples were taken to test interpretations made from the acoustic data. Digital mosaics of the sidescan sonar data have been produced to show the current distribution of surficial sediments at the seafloor, and to establish a baseline for further work after material has been dumped in the area.

Examples of the various sidescan sonar mosaics and records have been included in this report to provide a quick overview of the results. High resolution copies have also been produced and provided under a separate cover as a series of large sheets.

Geological Setting

Haggis Geophysics and King Associates (1992) describe the geological setting of Liverpool Harbour in an 1992 report to PWGSC. Their description of the local geological setting for Liverpool Harbour is applicable to the offshore areas near the harbour and is summarized here. Haggis and King report that Liverpool Harbour is underlain by Meguma Group metamorphic rocks (dominantly quartzose schists) of Cambro-Ordivician age. The bedrock is overlain by surficial sediments that have been reworked by recent glaciations, and changes in sea-level.

Haggis and King describe a patchy cover of glacial till, left by the last glaciation, which is generally composed of sandy or silty gravel with numerous boulders and cobbles. These sediments have been modified during subsequent changes in sea level, which subjected the marine areas to beach-zone reworking of the glacial sediments. The beach-zone reworking produced sandy, gravely and cobbly deposits (basal transgressive lag). The following rise in sealevel locally left littoral (sub-marine beach related) sandy and shelly deposits. As sea level rose, the energy level at the seafloor decreased and sediment supply became much lower but steadier, resulting in ponded deposition only in the lower-lying marine areas. These are usually organic and microfossil rich silts and clays.

Deposits within Liverpool Harbour reflect this general history. Borehole data (Maritime Testing, 1992) indicate that in much of the area a very competent unit of variable thickness lies directly on the bedrock. It comprises boulders, cobbles, and often sand and gravel. Haggis and King referred to this unit as the "Cobble Unit" (see table below). Generally overlying the Cobble Unit is a grey, sorted, usually fine sand with shells, which Haggis and King referred to as the "Sand Unit". Locally overlying the Sand Unit is a green, soft, sandy to silty unit with abundant organic content. This represents the post-glacial to present accumulation, primarily from the Mersey River, which Haggis and King referred to as the "Organics Unit". Much of the dredged material is expected to consist of fine material from the "Organics Unit" with some coarse material from the "Sand Unit and the "Cobble Unit"

Haggis and King summarize the local stratigraphy for the Liverpool Harbour as:

Unit	Description
Organics Unit	Sands and silts with abundant organics
Sand Unit	Sorted, sometimes, stratified, grey sand, generally fine sand with shell fragments and some organics
Cobble Unit	Boulders and cobbles, sometimes with sand and gravel
Bedrock	Meguma Group schists

The seafloor in the area of dumpsites A and B appear to be comprised of the same material as those described by Haggis and King for the inner harbour. The seafloor sediments in the area around the dumpsites show signs of modern day reworking, possibly by wave action during storms.

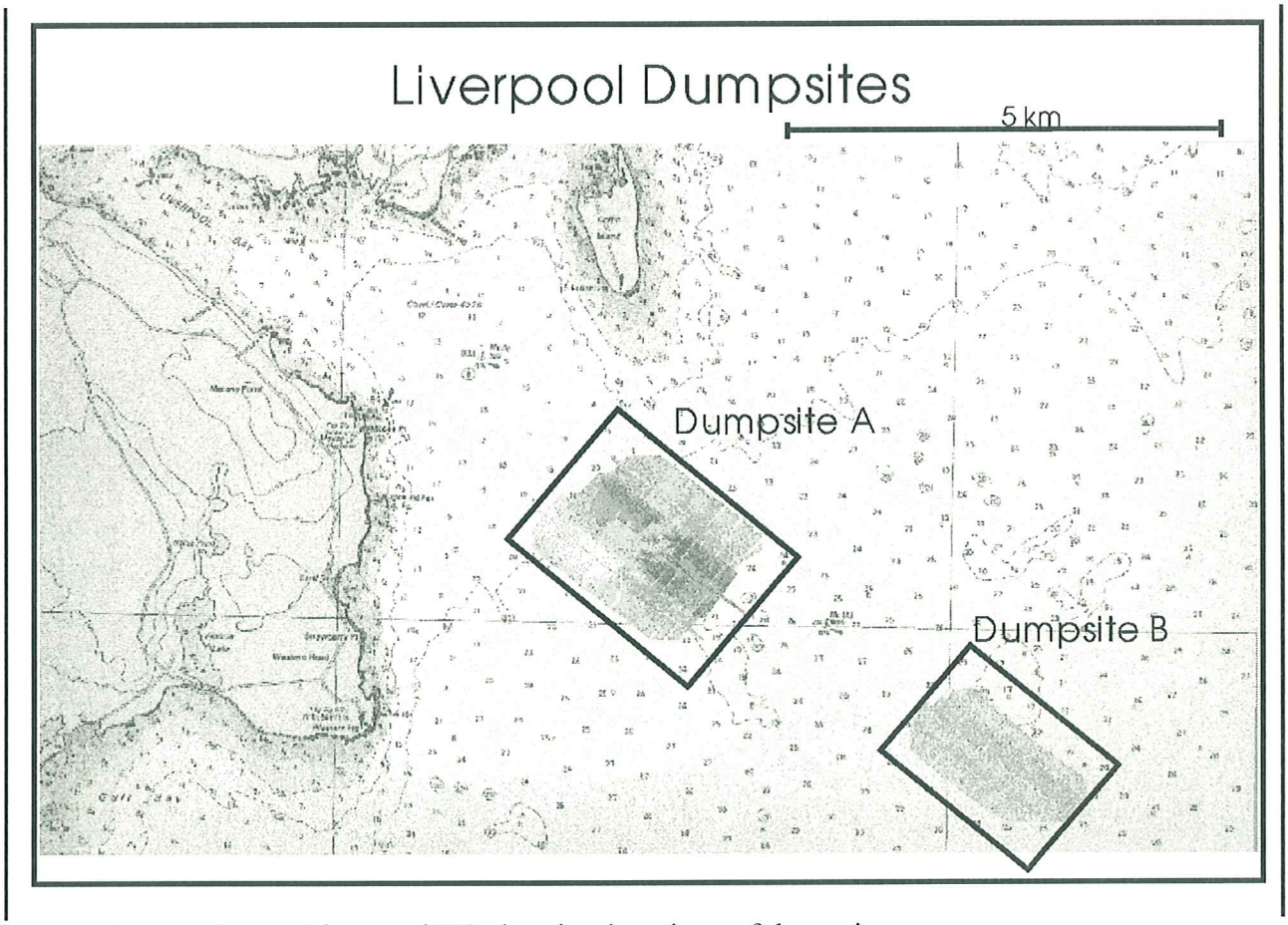

Figure 1 Approaches to Liverpool NS showing locations of dumpsite surveys.

Dumpsite A

Overview

Dumpsite A, shown in the location map in Figure 1, is situated in the approach to Liverpool Harbour, NS, at location 44° 00.2'N 64° 38.0'W. Water depths in the area range from about 30 to 45 metres. Sidescan sonar and sweep bathymetry data were collected over the dumpsite, and a series of 10 grab samples were taken to assist with the interpretation of the acoustic data.

Survey Procedure

A two step procedure was used to collect sidescan sonar data in Dumpsite A. A preliminary series of three lines with a spacing of 500 metres were run at a 300 metres range (each side) to provide a quick overview of the distribution of surficial sediments and seafloor conditions. Then a series of more closely spaced lines (75 metres) were run at a 100 metre range (each side) to provide overlapping data for use in building a digital sidescan sonar mosaic. Subbottom profiler and sweep bathymetry data were collected concurrently with the sidescan sonar data. Additional sweep bathymetry data were collected by PWC, at a later date, to provide 100 percent bathymetry coverage of the seafloor as shown in Figure 6.

Seafloor conditions

Interpretation of the sidescan sonar data from Dumpsite A (shown below in Figures 2 and 3) confirms the presence of the same units as described by Haggis and King for the inner harbour. Bedrock is seen to outcrop in several areas and is predominately located in the south east corner of the survey area.

The bedrock outcrops are surrounded by large areas of high backscatter (dark records) with many discrete reflectors on the sidescan sonar data. These areas have been interpreted as the coarse sand, gravel, cobbles and boulders of the Cobble Unit of Haggis and King.

Overlying the Cobble Unit are areas with more uniform, high backscatter. These areas generally show the presence of large ripples on the seafloor and have been interpreted as a deposit of coarse sand - the Sand Unit of Haggis and King. This material has been formed into sand waves and large ripples. Sub-bottom profiler data indicate that the sand reaches a thickness of 2-3 metres. An area of low backscatter (light records) in the centre of the surveyed area and has been interpreted as mainly a fine sand - and is probably a fine sand sub-unit of the Sand Unit. It appears to occur as a veneer which overlays the coarse sand of the Sand Unit and the Cobble Unit. In the water depths found in this dumpsite, 30-45 metres, the sands found at the seafloor would probably be reworked by wave action during the more severe storm events.

A large area of low backscatter (light records) in the western portion of the record is associated with a wedge of material seen on the sub-bottom profiler records. This unit overlies both the Cobble Unit and the Sand Unit in this area. One of the grab samples (#10) in this unit showed abundant fines and woodchips, indicating that this deposit is related to the Organics Unit of Haggis and King.

Separate mosaics have been produced using the data from surveys performed with swaths of 600 metre (300 metres range each side) and 200 metres (100 metre range each side). Both are presented below in Figures 2 and 3. The data collected with the wide range, shown in Figure 2, provides an overview of the seafloor conditions in the area. The mosaic presented in Figure 3 was collected at a 200 metre swath, and an offset between lines of 75 metres and provides a more detailed picture of the seafloor. The mosaics provide a convenient method to visualize the location of features on the seafloor. The details of these features can be seen in the individual sidescan sonar graphic records on file at the Geological Survey of Canada in Dartmouth, NS.

Figure 2 Digitally processed sidescan sonar mosaic of Dumpsite A showing data collected at a swath of 600 metres (300 metres each side)

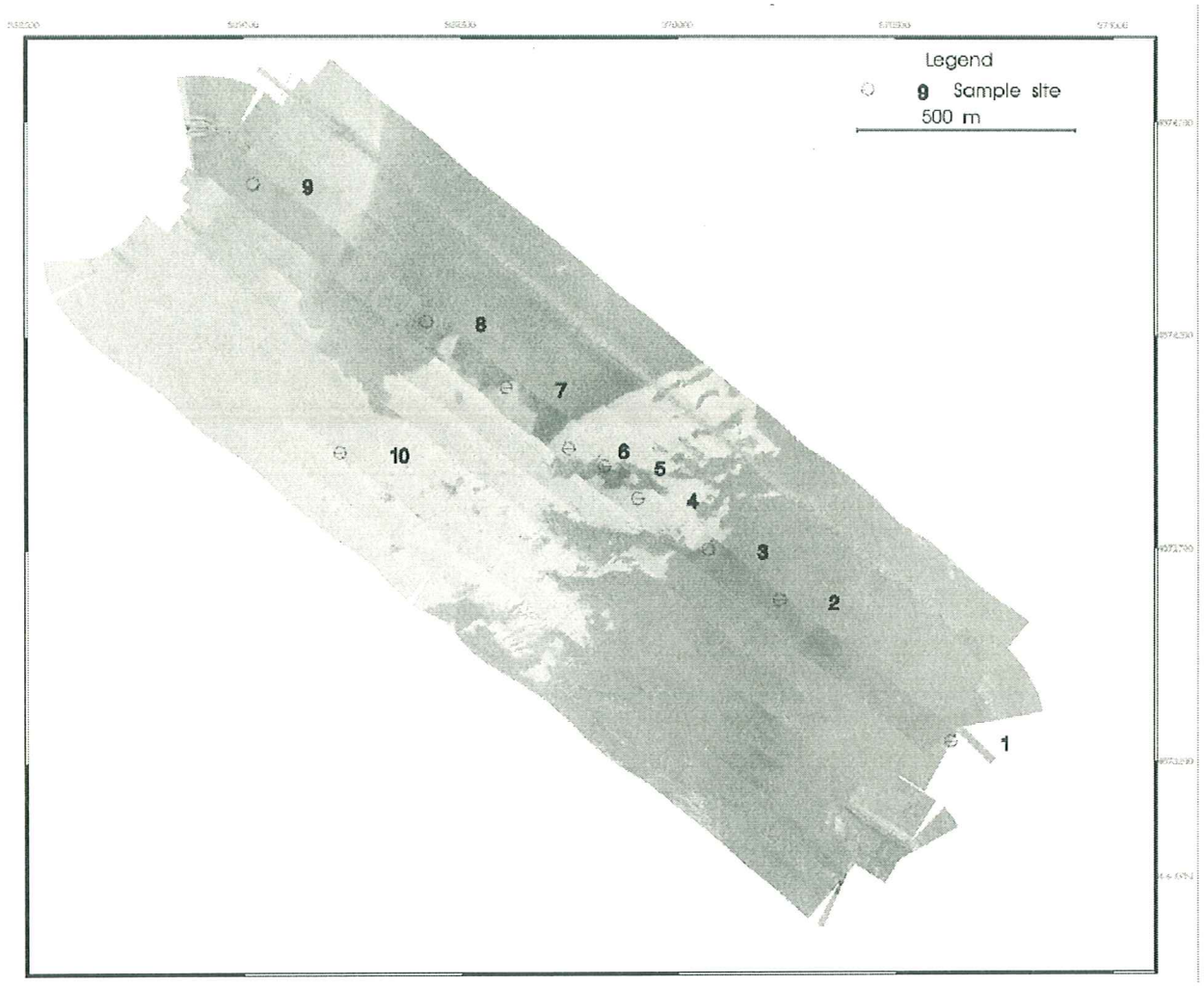

Figure 3 Digitally processed sidescan sonar mosaic of Dumpsite A showing data collected at a swath of 200 metres (100 metres each side)

Recent events

Several recent events have been interpreted from the sidescan sonar data.

1. Several sites, characterized by a doughnut shaped area of high backscatter (dark record) about 12-20 metres in diameter, are visible in the sidescan sonar data collected over Dumpsite A. These features can be seen in Figures 2 and 3 about 300-450 metres southwest of grab sample five (which is located at the centre of the present dumpsite). A detailed picture of the feature is shown in Figure 4. Each of the sites probably represents a single discharge of coarse grained material by a barge.

2. Zones of large sand ripples with a wavelength of about 1-2 metres and sand waves can be seen in the coarse sands which occur near the contact with the Cobble Unit, as shown the dark sediments in the northeast corner of Figure 5. Interpretation of the original records show that these ripples are generally oriented with their long-axis in a northeast/southwest direction. The ripples appear to be symmetrical in nature and may represent reworking of the sediments on the seafloor by wave induced motion. The orientation of the ripples suggests that the waves would have come from the southeast.

3. The 200 metre long linear feature visible just south of the location of grab samples 5 and 6 was probably caused by an anchor being dragged across the seafloor. The feature is shown in Figure 5.

Figure 4 Example of previously dumped materials at dumpsite A

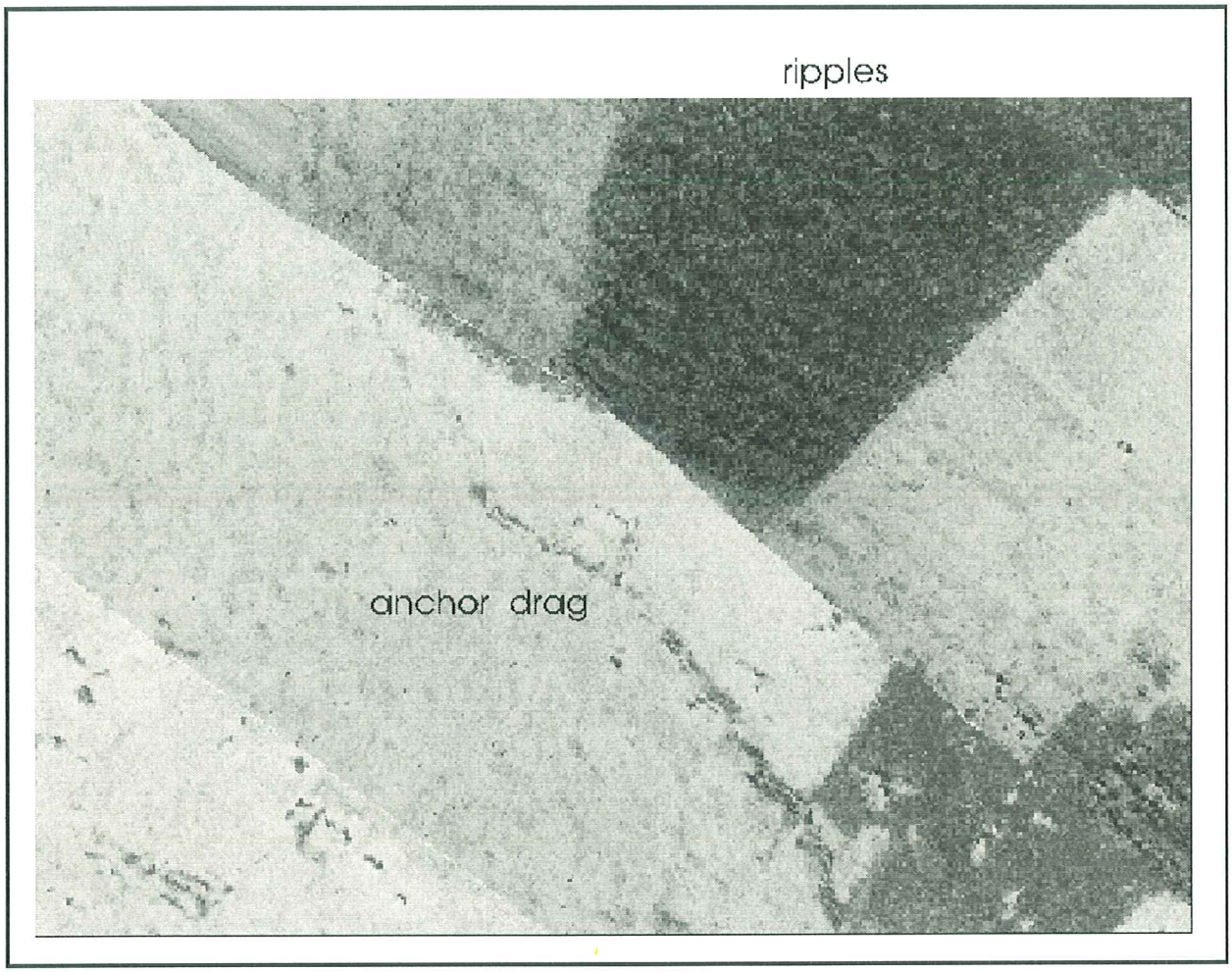

Figure 5 Evidence of an anchor drag and wave formed sand ripples in Dumpsite A. The ripples indicating recent reworking of seafloor sediments by wave action during storms.

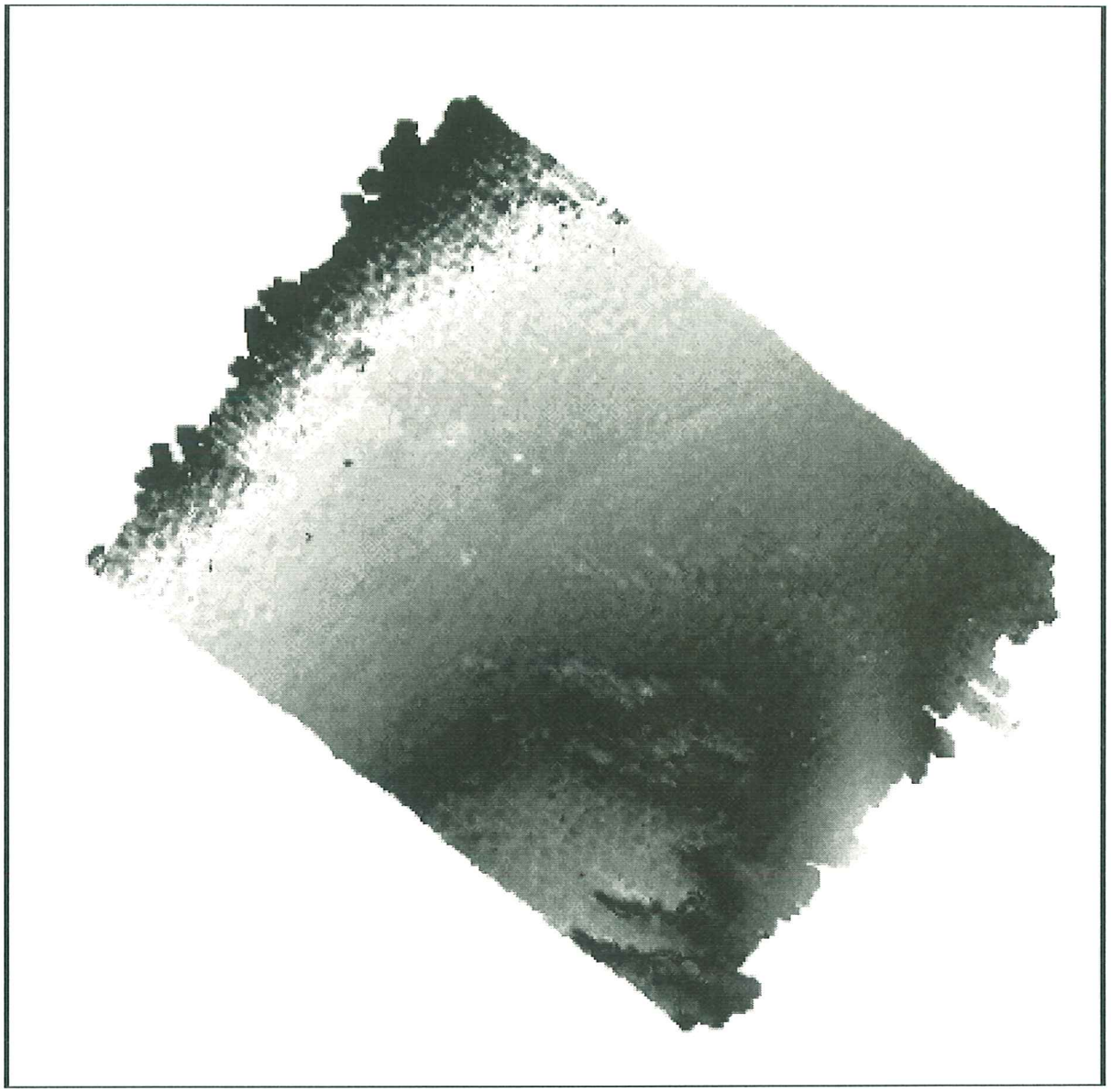

Figure 6. Bathymetry data collected at Dumpsite A by PWGSC. Darker colours represent shallow depths. The full data set is available from PWGSC.

Dumpsite B

Overview

Dumpsite B, shown in the location map in Figure 1, is situated in the approach to Liverpool Harbour, NS, at location 43° 59.5'N 64° 34.5'W. Water depths in the area range from about 30 to 45 metres. Sidescan sonar and sweep bathymetry data were collected over the dumpsite. No grab samples were taken at this site.

Survey Procedure

A series of lines with a spacing of 250 metres were run at a 300 metres range (each side) to provide information on the distribution of surficial sediments and seafloor conditions in Dumpsite B. Subbottom profiler and sweep bathymetry data were collected concurrently with the sidescan sonar data. Due to wave conditions at the site, it was only possible to collect partial bathymetry coverage of the seafloor.

Seafloor Conditions

Must of the sidescan sonar data of the seafloor at Dumpsite B is characterized by areas of high backscatter (dark records) with many discrete reflectors on the sidescan sonar data, as shown in Figure 7. These areas have been interpreted as the coarse sand, gravel, cobbles and boulders of the Cobble Unit of Haggis and King. This may occur as a thin veneer over the bedrock surface.

Overlying the Cobble Unit are areas with more uniform, high backscatter. These have been interpreted as being a coarse sand, the Sand Unit of Haggis and King. In places it appears to reach a thickness of several metres. An area of low backscatter (light records) occurs in the centre of the surveyed area and has been interpreted as mainly a fine sand - and is probably a fine sand sub-unit of the Sand Unit. It appears to occur as a veneer which overlays the coarse sand of the Sand Unit.

Figure 7 Digitally processed sidescan sonar mosaic of Dumpsite B

Access to Geophysical Data

The sidescan sonar, subbottom profiler and grab samples collected during this survey are archived at the Geological Survey of Canada, in Dartmouth Nova Scotia. For access to the geophysical data and samples contact the senior scientist for the survey, Russell Parrott (902-426-7059) or Susan Merchant of the GSC Curation group (902-426-3410). Available data consist of the field collected graphical records for the sidescan sonar and subbottom profiler, digitally processed sidescan sonar mosaics, ExaByte tapes containing the sidescan sonar data in SEG-Y format, and a CD-ROM containing the (compressed) sidescan sonar data in SEG-Y format.

Proposed Future Work

This present survey has defined the seafloor conditions at Dumpsite A and B before the commencement of a large scale dumping program. The presence of several sediment types has been interpreted. Indications of reworking of the seafloor sediments by modern seafloor processes have been found - probably by wave action during storms. Evidence of previous dumping of dredged material at site A has been found.

In order to determine the net effect of dumping in this area it is necessary to perform repetitive sidescan sonar mapping on the dumpsites, using the same techniques as used in this survey. A sidescan sonar mosaic should be run immediately at the finish of the dumping to establish seafloor conditions at that time. This would establish the boundaries of the most recent dumping and serve as a baseline for monitoring of reworking and transport of the dredged material with time. This survey should then be repeated, at intervals of 1-2 years to determine the net effect of current seafloor processes on the dumped materials.

The 3.5 kHz sub-bottom profiler records obtained during the survey operations were generally contaminated by noise and did not allow full resolution of the structure of the sediments or penetration into the seafloor required to map sediment thicknesses in these sediments. During any future surveys, the use of a small sparker, boomer, or chirp source should be considered.

References

Haggis Geophysics and Edward L. King and Associates, Investigation for Liverpool Harbour Dredging: Surficial Geological Conditions as Mapped from Seismic Data, 29 July 1992

Maritime Testing (1985) Limited, Geotechnical Drilling/Sampling/Testing Liverpool Channel Dredging and Containment Ponds Liverpool, Nova Scotia, Service Contract No. 2106316, July 1992

Appendix A

Survey Particulars

Name of Vessel:	Miramichi Surveyor
Name of Master/Hydrogopher:	Robert Murphy
Dates of Survey:	13-16 May 1994
Area of Operation:	Liverpool, Nova Scotia
Senior Scientist:	Russell Parrott, GSC

Personnel

Geological Survey of Canada	Public Works and Government Services Canada
Russell Parrott	Robert Murphy
Austin Boyce	
Fred Jodrey	

Equipment Specifications and Performance

The Liverpool offshore dumpsites were surveyed with sidescan sonar and sub-bottom profiler equipment between 13-16 May 1994 by the Miramichi Surveyor, a 10 metre aluminum boat owned and operated by PWGSC. The area was subsequently surveyed using a Navitronics 12 channel sweep bathymetry system by PWGSC. The sidescan sonar and sub-bottom profiler survey equipment were positioned on the afterdeck of the vessel.

SIMRAD MS992 SIDESCAN SONAR

The Simrad MS992 digitally controlled sidescan sonar was used to generate high resolution acoustic images of the seabed at 100 and 300 metre ranges each side of the survey track (200 and 600 metre swaths). Lines run at the 100 m range were typically 75 metres apart for dumpsite A. A 300 metre range with 125 metre spacing was used for the sidescan sonar survey of Dumpsite B. About 75 metres of towcable were deployed for Dumpsite A and 80 metres for Dumpsite B. Data (both 120 and 330 kHz) were digitized and stored on a GeoAcoustics SE880 digital recorder. A hardcopy graphic record of the sidescan sonar data was produced on an Alden 9315CTP thermal recorder. The sidescan sonar system was capable of resolving objects down to a size of about 25 cm. The digital gain settings for the system were logged on field sheets. The Simrad sidescan sonar was deployed from the port side of the vessel.

DIGITAL DATA ACQUISITION

The sidescan sonar data were digitized and logged on a GeoAcoustics SE880 data acquisition system. The clock in the SE880 was synchronized to the DPW navigation data logger. All four channels of sidescan sonar were acquired at a sample interval of 60 microseconds. No gains or geometric corrections were applied to the raw lagged data. Channel configurations for the logged data were:

Channel	Use
0	120 kHz port
1	120 kHz starboard
2	330 kHz port
3	330 kHz starboard

BATHYMETRY

Bathymetry data were collected by PWC using a 12 channel Navitronics sweep bathymetry system using arrays of pressure transducers mounted on booms. Data were processed by DPW and provided to GSC as a file with positions and water depths. Coverage of dumpsite A was 100%.

SAMPLING EQUIPMENT

Samples of the surficial sediment in the area were obtained using a small van Veen grab sampler deployed by hand from the port side of the Miramichi Surveyor.

SUB-BOTTOM PROFILER

A 3.5 kHz sub-bottom profiler system was used to determine the thickness of the sediments in the survey area. The system was capable of penetrating to the base of these sediments and showing the location of the underlying harder material, typically glacial deposits and bedrock. The subbottom profiler was deployed from the starboard side of the afterdeck. The records were generally contaminated by engine noise from the survey vessel.

NAVIGATION

Navigation was by a differential Global Positioning System owned and operated by PWGSC, This system utilized a shore station placed on Moose Pt. Accuracy of the navigation was about 4 m.

Data processing

The sidescan sonar and sub-bottom profiler records were interpreted in the field to provide an overview of the surficial geology of the survey area, and sites were selected for sample coverage. Proposed positions for grab samples were identified in terms of offset from the position of the dumpsite.

Digital sidescan sonar data were recovered from the ExaByte tapes recorded on the GeoAcoustics SE880 recorder and processed to remove geometric distortions present in sidescan sonar data. (These distortions are caused by the need to tow the sensor above the sea floor.) The geometrically corrected data were then integrated with navigation and processed to remove the effects of varying sensor gain with angle. The sidescan sonar data from adjacent survey lines were then integrated to produce a sidescan sonar mosaic of the harbour using software developed by the Geological Survey of Canada - Atlantic.

Bathymetry data (soundings and navigation) were processed by PWGSC and provided to the GSC. These data were used to construct a coloured, shaded-relief bathymetric map and three-dimensional, shaded relief views.

The 3.5 kHz and processed sidescan sonar data collected during the survey were used to prepare a geological interpretation of the dumpsites.

Summary of Activities

Wednesday 11 May 1994 - Mobilization
The vessel Miramichi Surveyor was delivered to the Geological Survey of Canada garage at the Bedford Institute of Oceanography in Dartmouth, NS. Geophysical equipment required for the survey, consisting of sidescan sonar, sub-bottom profiler and the digital data logger were loaded on the vessel and secured to benches. The vessel returned to Liverpool later that evening.

Friday 13 May 1994 - Field test of Gear
GSC personnel drove to Liverpool. Weather conditions were too rough to allow surveying at the offshore dumpsites. Electrical connections were completed for all gear, and a test line was run in harbour with sidescan, sub-bottom profiler and the digital recorder to confirm that all equipment was operational. GSC personnel returned to Halifax later that evening.

Saturday 14 May 1994 - Attempt to survey
After a call from R. Murphy of DPW, GSC personnel drove to Liverpool. After checking the site, DPW decided that the sea state was too severe for survey operations in the dumpsite area, and the survey was cancelled for the day. GSC personnel returned to Halifax.

Sunday 15 May 1994 - Survey Dumpsite A
After call from R. Murphy of DPW, GSC personnel drove to Liverpool. Weather conditions were more favourable. The equipment was checked at the dock and the Miramichi Surveyor proceeded to Dumpsite A. Three 300m range (600m swath) lines were run at offsets of 0, +500 and -500 metres from the baseline at the dumpsite to provide a regional view of the site. Detailed lines were then run at 100 m range (200 m swath) and an offset of 75 metres between lines. The entire site was surveyed, before survey operations stopped at 20:00. The vessel returned to Liverpool and the sampling gear was loaded onto the vessel at the dock.

Monday 16 May 1994 - Sample dumpsite A and survey dumpsite B
Mobilization of the sampling gear started at 06:00, and continued while en route to Dumpsite A. Ten grab samples were taken along the baseline and in the middle of a large sand deposit. Dumpsite B was surveyed at 300 m range (600 m swath) and an offset of 125 metres. The vessel returned to Liverpool and all gear was demobilized from the vessel. GSC personnel returned to Halifax.