2021 Canadian Consulting Engineering Awards

BOAT HARBOUR (A'SE'K)

SLUDGE THICKNESS DETERMINATION

Environmental Remediation

wsp

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA

Custom Built Barge

ABOUT THE PROJECT

This is a tragic story stretching back 50 years, involving a once marine tidal water bay within Northumberland Strait called Boat Harbour, or in the Mi'kmaq language A'se'k, which is owned by the Pictou Landing First Nation. 1965 saw the construction of a kraft pulp mill, set back a few kilometres from the shoreline. The harbour was dammed soon after to create a closed wastewater effluent stabilisation basin. The damming of the harbour, and the resulting rise in water, deprived the First Nations people of many acres of spiritually significant land used for hunting and gathering. The pollution of the waters with contaminated sludge, accumulating at a rate of 4 mm annually ever since, also put an end to all fishing and recreational use of the harbour.

The injustice came to a head in 2014 when a pipeline ruptured, releasing millions of litres of effluent. It prompted the passing of the Boat Harbour Act in 2015 which aims to remediate the entire 546-hectare site and ultimately return the harbour to its original state as a tidal estuary. In 2017, Nova Scotia Lands commissioned an environmental assessment and the development of a Remedial Action Plan for the removal of the contaminated sediment that had built up over five decades.

The remediation and restoration of the Harbour present significant engineering, environmental, and stakeholder challenges. The specific objective of this phase of work was to accurately measure the in place volume and distribution of contaminated sludge which has accumulated within the Harbour over the last 50+ years. Accurately understanding the volume and distribution of the contaminated sludge within the Harbour was essential for the design of the remedial dredging and sediment management program to restore Boat Harbour to its natural state.

WSP's approach was to employ corroborating techniques to identify the top and bottom elevations of the contaminated sludge. Both traditional Single Beam Echo Sounder and Multi Beam Echo Sounder surveys were completed to define the top of the sludge surface. A unique approach employing in-situ Laser Induced Fluorescence and Electric Conductivity profiling was employed to accurately identify the distribution and thickness of contaminated sludge across the Harbour. The real-time high resolution data collected in-situ was coupled with more traditional physical sampling techniques (gravity and percussion coring) to provide further confidence in the in-situ methods Two mobile barges collected a total of 504 discrete Laser Induced Fluorescence and Electric Conductivity profiles across the Harbour. The data collection occurred over a two-month period in October and November 2019 where weather conditions and the full-scale deployment of a novel characterization technique presented numerous challenges to the expedient collection of high quality, spatially accurate data.

INNOVATION

Laser Induced Fluorescence and Electric Conductivity instrument installed and operated from a barge.

Removing the contaminated sediment will be a huge undertaking, but just establishing how much sludge needed to be removed took some creative thinking.

The team (which included SCG Industries and local Pictou Landing First Nation members) spent many weeks in late 2019 floating on specially constructed barges measuring the sludge thickness at 500 individual points across the Harbour, using Laser Induced Fluorescence. Using field tablets, with a secure cloud-based platform, allowed team members, project managers and client representatives to access the data for review and quality assurance and to observe progress and view collected data in real time. Laser Induced Fluorescence was an innovative use of a technology that is more commonly deployed for quantifying hydrocarbon impacted soils, allowing them to detect the interface between the sludge and the marine sediments beneath, and provide a more efficient and precise means of measurement, compared to traditional methods such as gravity coring.

With sludge depths ranging between 10 cm and 1.7 m across the harbour, the Team refined the estimate of sludge volume in the final stabilization basin and determined how it contributed to the 1 million cubic metres of sludge to be removed from all impacted areas.

That's a lot of mud.

And what's more, the team estimated that close to 6 million cubic metres of water will need to be treated also during the remediation process.

FUTURE APPLICATIONS

Using Laser Induced Fluorescence and Electric Conductivity on future applications beyond Boat Harbour would bring a novel approach to other sludge characterization and quantifying projects, waste water treatment systems, and other ports and marine facilities.

The team working inside the barge

COMPLEXITY

While the outcome of this project provided many benefits to the Nova Scotia Lands, Pictou Landing First Nation, and other stakeholders, it was not without its challenges. The table below demonstrates the challenges we faced and how we mitigated those challenges.

Challenge	Mitigation Techniques
Uncertainty in the sludge volume and distribution: This represented the greatest risk to the client's remedial designs for sludge removal (dredging) and disposal (containment).	– Utilize in-situ methods for sludge measurement using Laser Induced Fluorescence; – Survey controls on all measurements to ensure models are precisely georeferenced; – Digital field data collection and cloud-based data management to facilitate rapid interpretation and data quality reviews.
Safety: Working over water, fatigue management, weather conditions, and repetitive physical tasks.	– We had a dock installed for easy access to the boat and hired dedicated boat operators to allow our team to focus on the task at hand. – All team members wore cold weather suits and constantly monitored weather patterns. – Made sure there were scheduled breaks for fatigue management. – Had a robust health & safety plan in place.
Schedule: Limited time for field work (prior to freeze up), short days, weather delays.	– Increased data collection capacity by building two custom barges equipped with Laser Induced Fluorescence and survey equipment; – Use of single beam bathymetry equipment for initial surveys and in shallow waters; followed by multi-beam bathymetry where water depths and ice coverage would allow.
Field Implementation: Scaling pilot trial Laser Induced Fluorescence and Electric Conductivity data collection to full-field implementation.	– Application of Laser Induced Fluorescence for sludge thickness measurements developed at test scale and pilot scale prior to a full-scale implementation; – Real time measurements, digital field data collection and cloud-based data management allowed for the effective integration of new data into the interpretation model and to identify new sludge and sediment characteristics.

WSP staff on site at Boat Harbour

SOCIAL AND/OR ECONOMIC BENEFITS

The social and/or economic benefits not only relates to its role in the ecosystem, but also to the value people place on it. This could include scientific, social, cultural, economic, historical, archaeological or aesthetic importance.

The loss of A'se'k over 50 years ago was devastating to the community.

Through the proposed Boat Harbour Remediation Project, it is Pictou Landing First Nation's hope that A'se'k be restored to allow the community to re-establish its relationship with the water and land of A'se'k. In this regard, the Project's effects on health, socio-economic conditions, and physical and cultural heritage as a result of changes caused through remediation activities are net positive in relation to Pictou Landing First Nation.

In a few years, when A'se'k is restored and returned to a tidal estuary, the long-term changes to fish and fish habitat, marine plants, and migratory birds will be positive. This will allow the land to be re-established as an area used for traditional recreation, fishing, hunting and gathering, as well as for physical, mental, spiritual and emotional purposes by the Mi'kmaq.

ENVIRONMENTAL BENEFITS

Many people and organizations are working together to make sure that Boat Harbour returns to a healthy tidal estuary. The Pictou Landing First Nation has been planning all of the positive things that a renewed estuary can bring to the local environment and communities such as fishing, swimming, nature trails, or other tourist-related activities.

On all of our projects, WSP strives to deliver sustainable projects with outcomes that include:

Sustainable Initiatives	Boat Harbour Project
Economical and Efficient:	– Using the Laser Induced Fluorescence and Electric Conductivity instrument, along with gravity core, and Single Beam and Multi Beam Echo Sounder data set, provided additional insight that dramatically reduced the risk in the client's remedial design. – Increased the data coverage using two custom built barges and in-situ measurements that provided greater spatial coverage and increased measurement precision.
Durable: design to last; design to serve long-term needs.	– The updated sludge estimates provided greater confidence in the client's remedial design and sludge containment design. This allowed the design to meet the needs of the project and limits the risk of design changes during remediation.
Adaptable: multipurpose; meet changing social trends and needs.	– When Boat Harbour becomes a healthy tidal estuary, plant and animal life will return along with the positive benefits such as fishing, hunting, tourism.
Restorative: deal with historic mistakes; "give something back"; focus on quality of environment we live in.	– Through meaningful dialogue, shared aspirations, and collective accountability, Boat Harbour is becoming a healthy environment.

MEETING THE NEEDS OF NOVA SCOTIA LANDS

Sludge Observations: Compact Sludge

The goal of the Boat Harbour Remediation Project is to return Boat Harbour to its original state - that of a tidal estuary. Using the Laser Induced Fluorescence and Electric Conductivity instrument for the pilot program confirmed the ability to use Laser Induced Fluorescence and Electric Conductivity profiling as a characterization tool at the larger scale. Beyond achieving the principal objective in understanding the contaminated sludge volume and distribution through the Harbour, combining the three research instruments - Laser Induced Fluorescence and Electric Conductivity, gravity core, and Single Beam Echo Sounder and Multi Beam Echo Sounder data set - provided additional insight and value to the client.

WSP's solution to this great challenge provided the client with critical information in order to design the remedial dredging and disposal programs. The knowledge gained through this project has reduced the risk in the remedial design and is transferable to other areas of Boat Harbour which have not been assessed.

CLIENT TESTIMONIAL

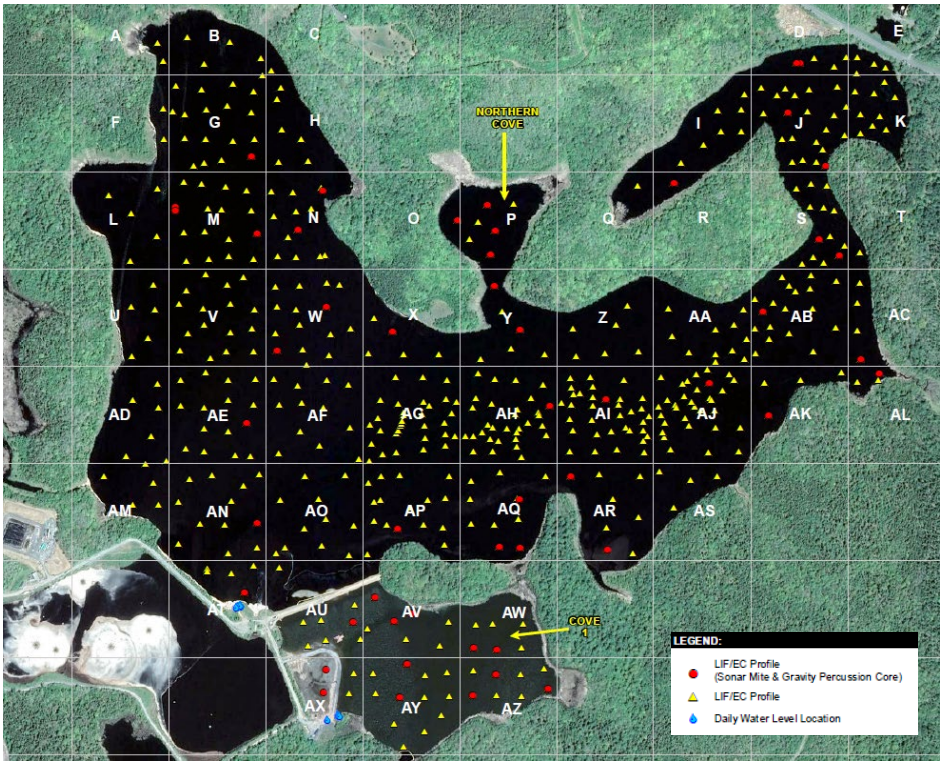
"I would like to impress upon you that we were very happy with your work on the project. We appreciate how you listened to our needs, quickly proposed solutions to any issues on site, pushed on through some challenging fall conditions, and overall, did a great job." Angela Swaine – Senior Project Manager, Boat Harbour Remediation Project. Nova Scotia Lands Inc.

PROJECT SUCCESS

The performance of the Laser Induced Fluorescence and Electric Conductivity system was consistent with results from previous research and pilot scale work, further confirming the ability for this technique to provide rapid and spatially accurate mapping of the sediment distribution in-situ. Based on the successful research, the volume of contaminated sludge was calculated, which is critical to the design of the remedial dredging and disposal programs. The knowledge gained through this study is transferable to a broader context of sludge and sediment characterizations as part of other reclamation efforts involving organic sludge characterization, removal, and disposal.

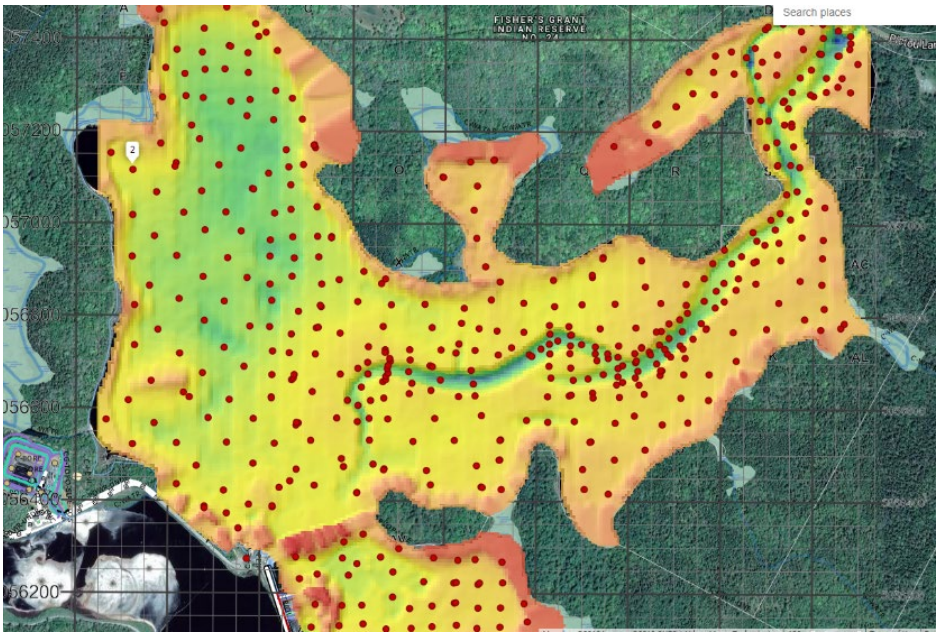
Not surprisingly the team is feeling pretty satisfied with the outcome.
"Back in the 1960s the Pictou Landing First Nation was misled about the impacts that dumping waste from the mill in the harbour would have on their traditional fishing and hunting grounds. What's worse is the fact that the practice persisted for five decades and took a major spill before finally forcing the issue. So, knowing that we are collectively helping to right a wrong has been really positive for the WSP team; it's definitely a feel-good story," Sean Cassidy – Director of Atlantic Canada, Environment, WSP

DATA COLLECTION



The project area was subdivided in 200 x 200 m grids (A-AZ)

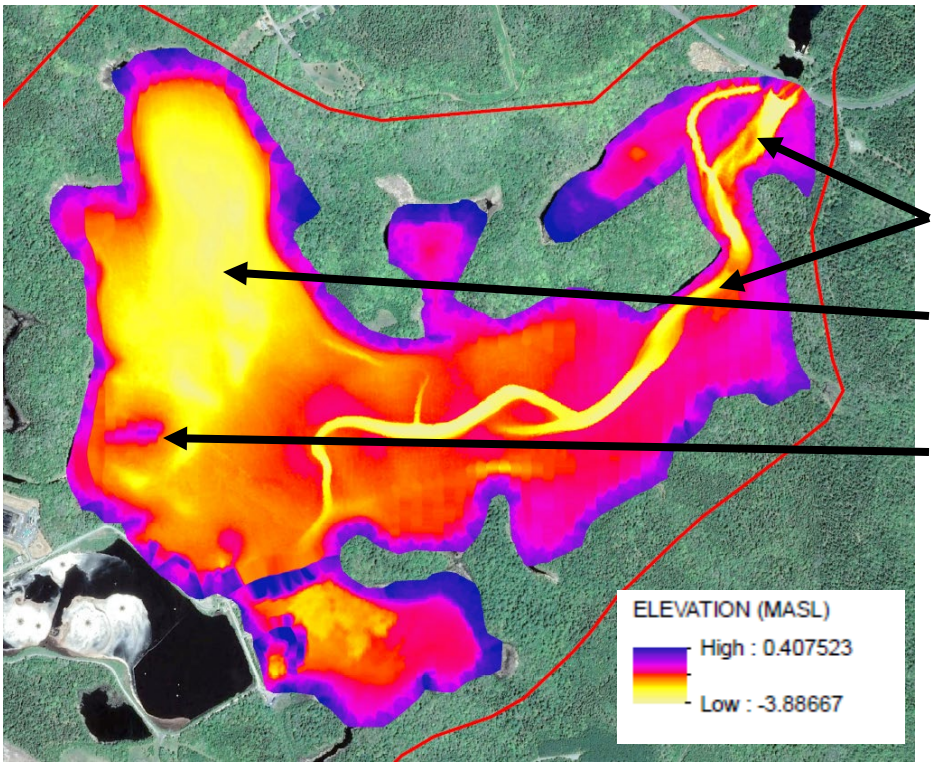
500 points were added to the grid to refine the data.



Data collection was synced and uploaded automatically into the Fulcrum web-based app. This provided real time review accessible to WSP and Nova Scotia Lands representative.

The app was accessed on barges through the use of iPads. The mapping, as shown to the left, was used to locate the points where the anchor poles would be dropped to collect Laser Induced Fluorescence and Electric Conductivity system data.

BATHYMETRIC SURFACE

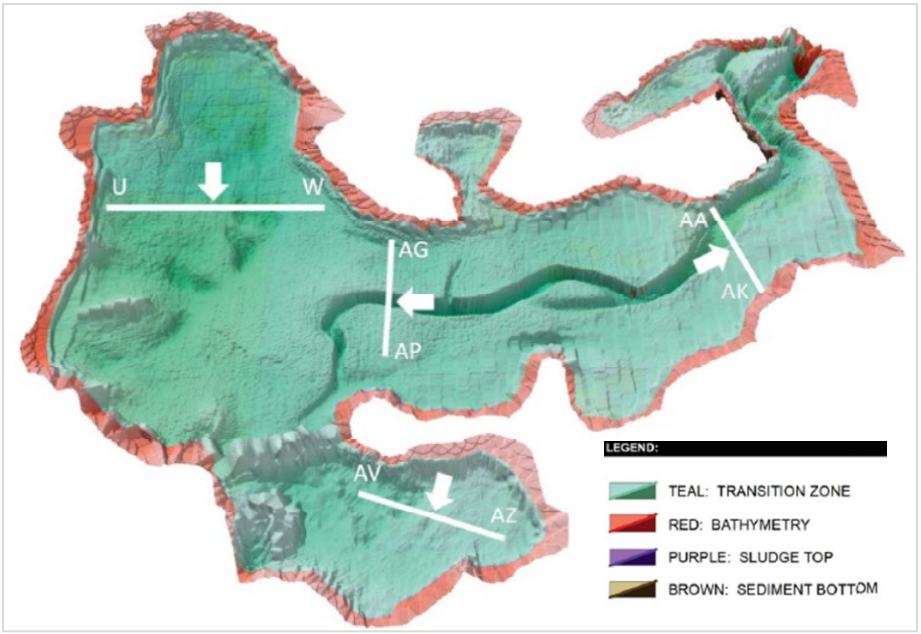


Historic tidal channels

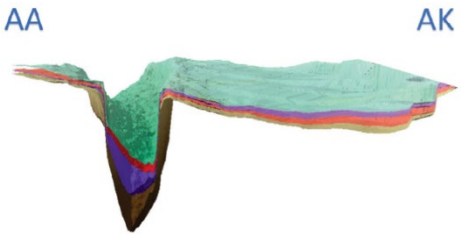
Deeper in the western bay

Historic Island

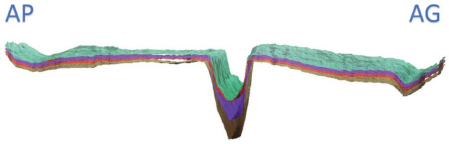
CROSS SECTION OF DATA



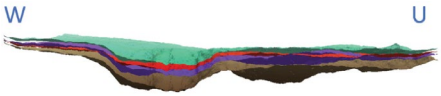
Channel view section AA-AK



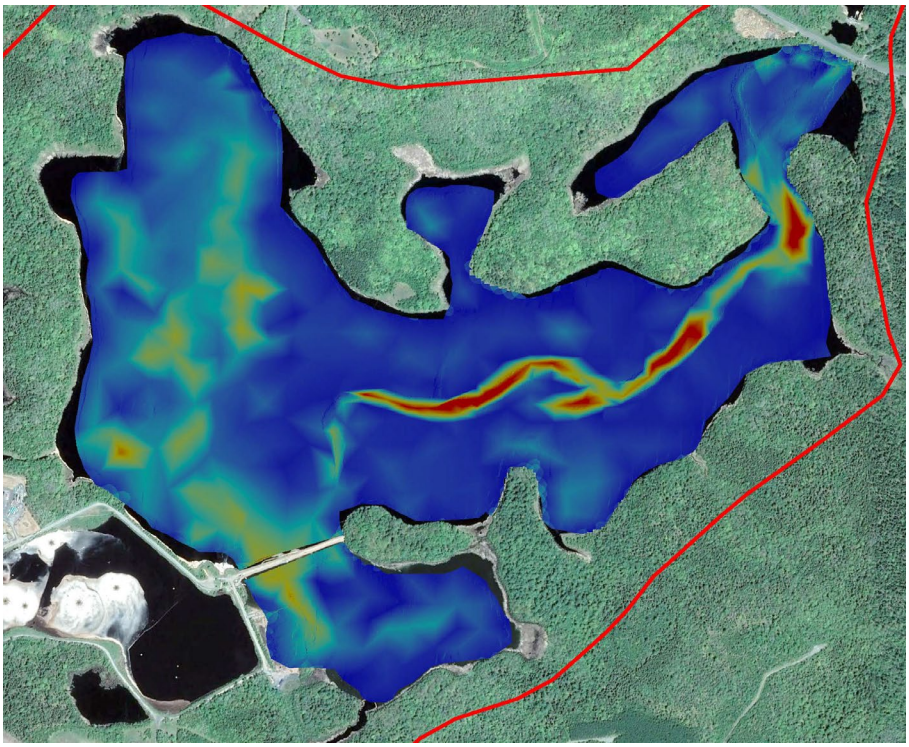
Channel view section AP-AG



Western Basin view section W-U



Cove 1 (part of test pilot) section AZ-AV



SLUDGE DISTRIBUTION AND VOLUME

Sludge is thickest in the channel and western basin.

Sludge volume estimates:

- Competent sludge: 271,000 m3
- Competent sludge plus transition zone: 400,500 m3

EXAMPLE LIF/EC LOG