Natural Resources Canada Headquarters
Booth Street Complex Environmental Remediation Project

CATEGORY: ENVIRONMENTAL REMEDIATION

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Natural Resources Canada's (NRCan) Booth Street Complex (BSC), located in Ottawa, Ontario, has been home to a multitude of occupants since the mid 1900's, including NRCan headquarters, research divisions and laboratories, land mapping, private and public rental space, commercial areas, and a daycare. Prior to NRCan's presence, the site had been contaminated by numerous industrial and commercial site uses, rail yards and backfilling of the property with fill of unknown origins dating back to before 1900. Added to this historical contamination were impacts from NRCan's laboratory activities on site, in an era when waste management practices were not understood or regulated in terms of their environmental impacts. Contamination included numerous heavy metals, petroleum hydrocarbons (PHCs), volatile organic compounds (VOCs), and various other compounds. The BSC property has an area of approximately 120,000m^2 over four quadrants and is located in central Ottawa. The Federal Government is considering redeveloping portions of the complex, and in order to do so, a major environmental remediation project was initiated in 2008. Since 1992, over 16 studies have been carried out by at least ten different environmental consultants to assess the extent of contamination, and to determine the best approach for remediation.

Between 2008 and 2010, Stantec Consulting Ltd. (Stantec) was commissioned by NRCan to summarize all existing reports, perform a gap analysis, update site data to current environmental standards, conduct additional assessment as necessary, complete a review of remedial options, complete an environmental impact assessment (CEAA EA) with public consultation, prepare a conceptual remedial action plan, prepare engineering specifications and drawings for selected quadrants of the site, and monitor the remediation work of multiple environmental consultants and contractors in collaboration with NRCan and Public Works and Government Services Canada (PWGSC).

The BSC Remediation Project was a complex collaborative effort between many organizations, each with an important role to play and with the common objective of completing the remediation in a safe, cost efficient and responsible manner. The following key organizations were involved in the project:

Natural Resources Canada – The Project Client, responsible for initiation, implementation and completion of the project.

Public Works and Government Services Canada – The contracting authority, responsible for management and contracting of the remediation contractors and remediation consultants.

Stantec Consulting Ltd. – NRCan's environmental consultant, responsible for environmental site assessment, conceptual remedial design, project specifications and drawings for the Northwest and Central Quadrants of the BSC, third party site monitoring of environmental contractors and consultants contracted by PWGSC.

Dessau Inc., Franz Environmental Inc., AMEC Earth and Environmental, Golder Associates – Environmental Consultants contracted through PWGSC, responsible for risk assessment, preparation of specifications and drawings for the Southeast Quadrant and on site consulting and monitoring (soil, groundwater, particulate matter in air, dust, and surface soil testing) before, after and during the various phases of the BSC remediation.

Quantum Murray LP, R.W.Tomlinson Limited, and Taggart Construction Limited – Environmental contractors, responsible for remediation of the various quadrants of the BSC.

SNC-Lavalin Operations & Maintenance Inc. – Building managers, responsible for assisting with building and occupant issues as the site was to remain operational throughout all phases of remediation.

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The BSC Remediation Project was a unique and complex undertaking on an important and valuable property owned by the Federal Government. Although the remediation project was completed by traditional methods that included excavating, testing, and off-site disposal of contaminated soils, as well as collecting, testing, and discharging groundwater from the remedial excavation, it had in its design and delivery a unique blend of complicating factors that required detailed engineering solutions from a variety of disciplines outlined below.

All remediation work had to be completed while keeping the facilities in full operation and protecting the health and safety of over 3000 building occupants. Operational areas included numerous NRCan laboratories with sensitive air quality and vibration control issues, offices, commercial areas, and a children's daycare. Potential risks to humans and the environment were assessed through the EA process and a comprehensive mitigation plan was developed and implemented to address these risks. Mitigation measures included extensive testing of air, soil, groundwater and dust throughout the remediation efforts. A team approach to rapid problem solving was coordinated by PWGSC to come up with the best solution in the least amount time, when unknown site conditions were encountered.

One of the unique challenges to this project was that much of the work was conducted under winter conditions. These conditions required detailed engineering solutions in consideration of the breaking and excavating of frozen ground and shallow bedrock adjacent to heritage buildings with seventy year old foundations, underground tunnels, and a myriad of utilities that required extreme care and vibration monitoring. The parking lot asphalt and concrete design also had to be modified to allow for installation in the dead of winter. The asphalt was designed with an additional sacrificial layer and a warm, not hot asphalt mix design with special provisions to keep the asphalt plant open during winter. The use of large, clear granular for backfilling was employed to reduce the risk of frost heaving and to allow for better compaction in the winter. On the environmental sustainability angle, the project was designed such that soils would not be handled multiple times by heavy construction equipment unless absolutely necessary. Direct excavation and loading in trucks and local landfill/quarries were prioritized to minimize vehicle emissions reducing the overall carbon footprint of the project.

For the purposes of assessment and remediation, the property was segmented into four distinct quadrants. Stantec summarized all past studies into quadrant assessments that superimposed past data (updated to current environmental standards) onto site plans that led to further assessment where there were data gaps. The result was an updated and detailed picture of current contamination issues needed for the preparation of the remedial design. Design that considered multiple disciplines such as environmental, geotechnical, civil, electrical, mechanical, structural, urban design, landscape architecture and others, was completed for each quadrant using the NMS format. Following the remedial design of each quadrant, work was tendered and overseen by PWGSC in a phased approach that allowed for remediation to be completed in parallel to design work on future quadrants. This allowed the physical remediation to be conducted almost continuously during the project period without waiting for design or contracting, and allowed the project to be completed within the very aggressive schedule required by the Economic Action Plan (EAP) under the Accelerated Federal Contaminated Site Action Plan (FCSAP) program. The concurrent activities phased approach also allowed for the multi-disciplinary design to be refined based on lessons learned from previous quadrants. This resulted in work efficiencies and cost reductions over standard remedial excavation practices. Approximately 121,284 metric tonnes of contaminated soil was excavated and used as needed cover at local landfills. The remediation and reinstatement cost of the project, including engineering and testing fees was approximately $115/tonne compared to initial estimates of $150/tonne. The property value also increased significantly and resulted in the removal of a $25 million environmental liability for Canada.

This project is a great example of federal leadership in the management of federal contaminated sites where the net benefit to the local population includes improving the environmental quality of the site, and the overall value of a prominent federal property in central Ottawa. It was carried out in an environmentally sustainable manner, while using advanced design, excavation and testing techniques to protect the local human receptors, historical infrastructure, and the general community.

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Introduction

The Booth Street Complex (BSC) is prominently located in Central Ottawa and is occupied by over 3000 people. It has been owned by Natural Resources Canada (NRCan) since the 1930s and serves as NRCan's National Headquarters. The Complex houses a variety of facilities including administrative offices, national air photo libraries, research facilities, commercial space, and a children's daycare. Figure 1 provides an air photo of the current site configuration of the BSC.

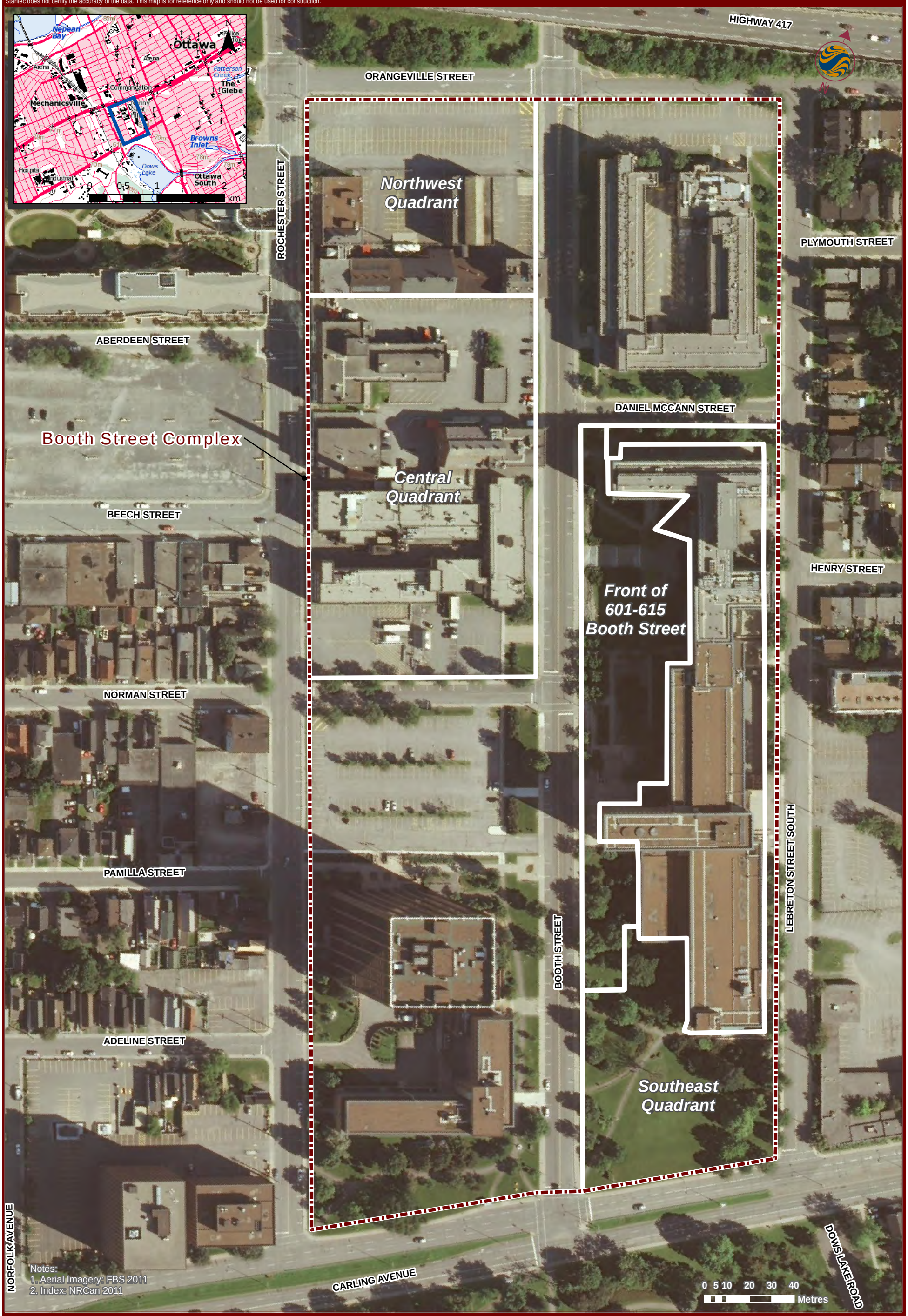
Prior to the current development of the complex in the 1930s, the site included various commercial and industrial activities that likely contributed to the present-day subsurface impacts to the site. Backfilling of the site during development, and chemical and material handling after development of the site is also believed to have resulted in residual contamination to soil and groundwater in the area.

Portions of the site have been subject to over sixteen environmental studies over the years to assess the extent of subsurface contamination; however, no comprehensive and up-to-date study had been completed. In 2008, NRCan identified several options for redeveloping the BSC for both federal and private use. For the site redevelopment to be viable in accordance with NRCan's environmental and sustainability policies and to avoid limiting the potential redevelopment options of the site, remediation of the extensive contamination was required.

In 2008, Stantec was hired by NRCan to compile all past environmental studies, identified information gaps, complete additional environmental site assessments and develop a conceptual remedial plan for the entire site with respect to the applicable Federal and Provincial environmental criteria. In accordance with the Canadian Environmental Assessment Act (CEAA), an environmental impact assessment and a public consultation were also provided by Stantec to address potential negative impacts associated with the remediation of the BSC and to identify how to mitigate these potential impacts.

Due to the variety of contaminants on site, the requirement to keep the complex in full operation and the short time available to complete remediation, an engineered excavation and landfilling of contaminants was selected as the preferred remedial approach. Many factors contributed to the complexity of this remediation project, requiring innovation and advanced applications of engineering principals. Much of the Complex's sub-grade infrastructure is aged and needed special protection, there were many underground utilities that could not be significantly disrupted but needed upgrading to current codes, the schedule of the project was driven by funding, requiring much of the work to be completed in winter conditions and the health and safety of the building occupants and the general public in the community was of utmost concern.

This map may contain data from a variety of sources. This map is not intended to replace a survey by a Licensed Surveyor.
Stantec does not certify the accuracy of the data. This map is for reference only and should not be used for construction.



Geographic Information Systems

Cartographic Design By: Marc Bouchard

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Booth Street Complex Remediation Quadrants

Natural Resouces Canada
Ottawa, Ontario

Figure 1: Current site configuration of the BSC

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Once the conceptual approach was determined, the BSC was divided into four quadrants based on the future land use (Federal, Provincial, Residential, Commercial…) and detailed specifications and drawings were developed by Stantec and other consultants in accordance with Federal tendering processes, overseen by Public Works and Government Services Canada (PWGSC). Stantec completed pre-remediation condition surveys as a baseline for future reinstatement. To expedite the work, remediation of each quadrant was tendered separately by PWGSC to allow design work on subsequent quadrants to take place simultaneous to remediation of the initial quadrants. This also allowed for lessons learned to be implemented throughout the four phases of the project.

A key to the project's success was the collaborative approach taken by all stakeholders, consultants and contractors in meeting NRCan's objectives. Contractors and consultants were hired by PWGSC to remediate the quadrants and monitor the work respectively. Stantec maintained a role throughout the project, working on behalf of NRCan as an Independent Engineer to assess the extent of remediation, conduct an Environmental Impact Assessment, provide public consultation, design the remediation for two of the four quadrants, monitor the work of other consultants and the contractors in accordance with the design intent, conduct independent testing of soil, groundwater, air and dust and to assist with multi-disciplinary solutions to problems encountered on site.

The result of the project was that the four quadrants were successfully remediated on time, in accordance with the project design and under initial budget estimates. By completing this project, not only did the Federal Government remove potentially hazardous contaminants from a central urban site and improve the local environment, they also increased the appraised property value by an estimated $10 million and removed a $25 million federal environmental liability.

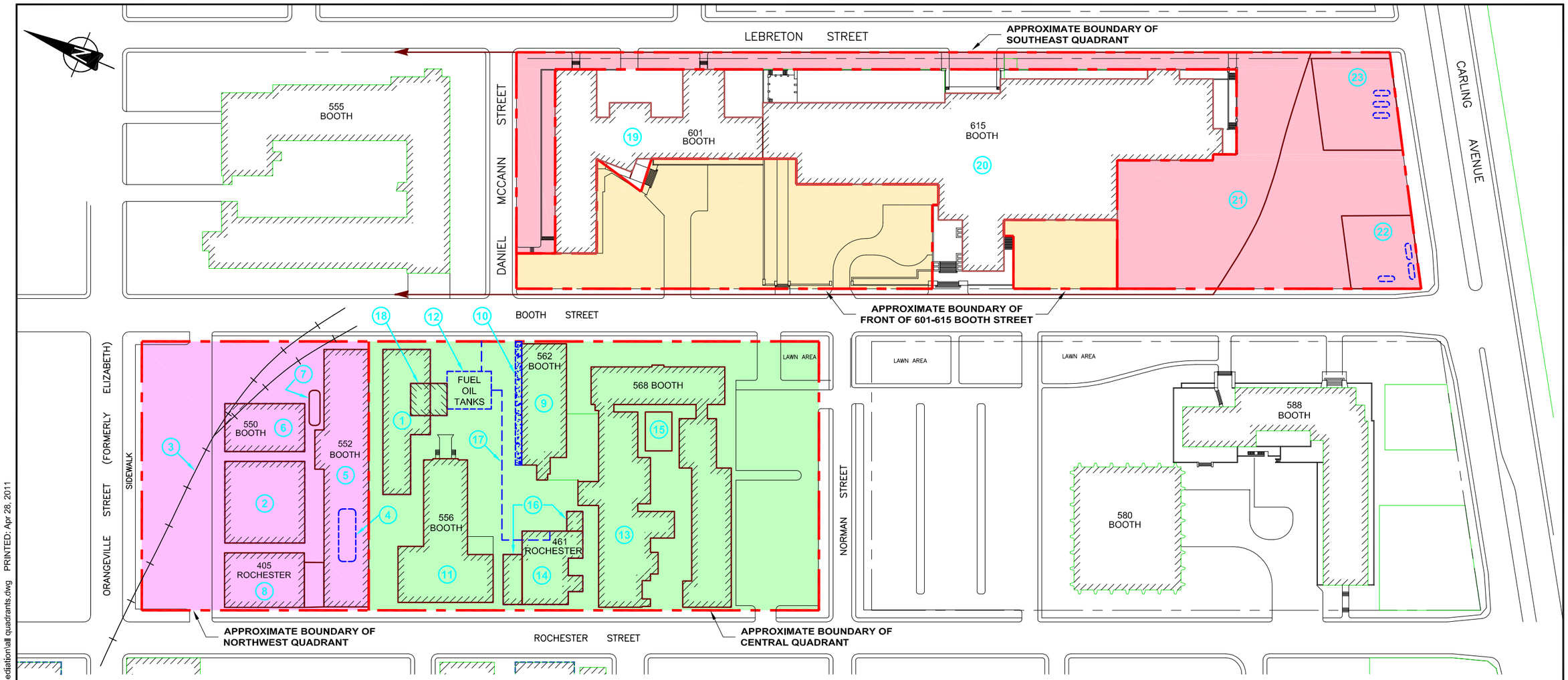
Site Description

The BSC is a federally-owned property located in Central Ottawa. The Complex is nestled between Highway 417, a major thoroughfare in Ottawa and a section of the Rideau Canal known as Dow's Lake. The entire BSC is approximately 12 ha and includes 11 buildings, several parking lots, a vehicle fuel area to fuel NRCan's fleet of vehicles, and green space. The buildings are occupied by over 3000 NRCan employees as well as over 250 staff from other federal departments, private companies, and a children's daycare.

Central and Northwest Quadrants before remediation

The site was developed around 1900 and over the years has included facilities such as a fuels testing station, machine shops, minerals and metals research facilities, rail and lumber yards, gas stations, etc. The activities typically conducted at these types of facilities are generally considered to be potential sources of contamination and likely contributed to the present-day subsurface impacts to the site. Backfilling of the site during development to its current use is also believed to have resulted in residual contamination to soil and groundwater. Chemical and material handling after development of the site followed standard practices at the time, yet also may have contributed to environmental impacts.

Figure 2 presents a summary of historical activities of environmental concern that have occurred at the BSC.



SOURCES OF POTENTIAL CONCERN

1. FORMER AUTO GARAGE/MACHINE SHOP.
   FORMER LABORATORY – RADIOACTIVITY AND ELECTRICAL.
   FORMER COKING OVEN/COAL STORAGE SHED.
   FORMER BURIED/PILED WASTES.
2. TWO FORMER QUONSET HUTS – LABORATORY– RADIOACTIVITY, MINING AND COMBUSTION/COAL/FUEL RESEARCH.
3. FORMER CNR.
4. FORMER UST.
5. LABORATORY– ORE DRESSING, FUELS/COAL, INDUSTRIAL MINERAL, CONCRETE TESTING.
   FORMER LUMBER YARD/ORE AND MINERAL WASTES DISPOSAL.
   FORMER HAZARDOUS WASTE BARREL STORAGE.
   REGISTERED HAZARDOUS WASTE GENERATOR.
6. FORMER CRN AND BAG HOUSE LABORATORY – ORE DRESSING, INDUSTRIAL MINERAL TESTING.
   FORMER PCB AND ORE STORAGE IN PARKING LOT.
   REGISTERED HAZARDOUS WASTE GENERATOR.
7. FORMER CORRODED DRUM STORAGE.
8. LABORATORY – ORE DRESSING, CONCRETE, INDUSTRIAL MINERAL TESTING.
   REGISTERED HAZARDOUS WASTE GENERATOR
   REGISTERED PCB STORAGE SITE.
9. LABORATORY – COAL/GAS, COKE BYPRODUCT, DUST (METALS), SEA WATER CORROSION, URANIUM, CHEMICAL TESTS.
   FORMER FOUNDRY AND HAZARDOUS WASTE BARREL STORAGE.
10. FORMER OIL STAINING.
11. PAINT SHOP.
    FORMER MACHINE SHOP, WORK YARDS.
    LABORATORY.
    FORMER PCB AND HAZARDOUS WASTE.
    BARREL STORAGE AND DISPOSAL ON–SITE.
    REGISTERED HAZARDOUS WASTE GENERATOR.
    REGISTERED PCB STORAGE SITE.
12. FORMER USTS – TWO OF THE THREE FORMER USTS (54,600 L) WERE LEAKING UPON REMOVAL.
    CURRENTLY CONCRETE BUNKER – TWO 125,000 L ASTS (NO. 2 OIL).
    FUEL SPILL FROM BUNKER IN 1987.
13. FOUNDRY AND LABORATORY – PHOTO PROCESSING AND METALS TESTING.
    X–RAY MACHINERY.
    HYDRAULIC OIL SPILL.
    FORMER UST.
    AST FOR HEATING OIL.
    DEGREASER PIT.
    WASTE STORAGE IN FOUNDRY.
14. CENTRAL HEATING PLANT – COAL, NO. 2 HEATING FUEL, AND NOW GAS POWERED.
    HYDRAULIC LOADING DOCKS.
    BULK FUEL STORAGE.
    SUMPS, FLOOR TRENCHES AND DRAINS.
    FUEL OIL DISCHARGES TO COMBINED SEWER FROM SUMP.
    NO OIL/WATER SEPARATOR AT SUMP OR DRAINS.
    CHEMICAL TREATMENT FACILITY.
    MACHINERY STORAGE.
    5,000 L WASTE OIL DISPOSED OF ON–SITE.
    REGISTERED HAZARDOUS WASTE GENERATOR.
    REGISTERED PCB STORAGE SITE.
15. DRUM STORAGE.
    LEAKING TRANSFORMER.
    CORRODED BAG HOUSE BARRELS.
16. FORMER COAL STORAGE.
17. UNDERGROUND FUEL TRENCH.
18. FORMER BUTLER BUILDING.
19. 601 BOOTH STREET
    – PRINT SHOP AND LABORATORIES
    GENERATOR OF HAZARDOUS WASTE
20. 615 BOOTH STREET
    – PRINT SHOP AND LABORATORIES
    – PCBS STORED ON–SITE
    – GENERATOR OF HAZARDOUS WASTE
21. FORMER RAIL YARD AND TRACKS
    FUEL LINES BETWEEN BOILERS ARE RUSTED/LEAK.
22. FORMER GARAGE/AUTO REPAIRS – 3 USTS
23. FORMER GASOLINE SERVICE STATION – 3 USTS

GRAPHIC SCALE
15 0 15 30 45 60 m
1 : 1500

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:	**Job No.:** 122510217 **Scale:** 1 : 1500 **Date:** 11/04/28 **Dwn. By:** GBB **App'd By:**	**Client:** NATURAL RESOURCES CANADA **Site Address** BOOTH STREET COMPLEX OTTAWA, ONTARIO	SOIL REMEDIATION	POTENTIAL SOURCES OF ENVIRONMENTAL CONCERN	**Dwg. No.:** 2

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The buildings on site were constructed between 1937 and 1974, with the majority built in the 1950s. All facilities on site are owned by NRCan, with the exception of the Central Heating Plant which is owned and operated by PWGSC. The Central Heating Plant provides heat to the entire BSC via underground steam tunnels located throughout the Complex.

The BSC Remediation project included approximately 5.5 ha of the Complex, which was subdivided into four areas to facilitate the remediation. A summary of the four areas is provided in Table 1 below.

Table 1: Remediated Areas of the BSC

Quadrant	Area (m^2)	# of Buildings	Estimated Volume of Impacted Soil Removed (tonnes)
Southeast Quadrant	29,350	2	68,840
Front of 601-615 Booth St.			10,440
Northwest Quadrant	8,960	3	15,700*
Central Quadrant	17,340	5	26,300

*Including approximately 36 tonnes of leachate hazardous soil.

Scope of Work

The general scope of work included the compilation of past studies, updated to current standards, identification of information gaps, additional environmental site assessment, development of a conceptual remedial action plan, preparation of an environmental impact assessment, public consultation, preparation of detailed engineering specifications and drawings for each of the four quadrants of the site, tendering of the work, remediation according to plans and specifications, monitoring of the remediation and reinstatement of the property to original conditions, upgraded where necessary to meet applicable codes and standards.

The above scope of work was a complex collaborative effort between many organizations, each with an important role to play, and with the common objective of completing the remediation in a safe, cost efficient and responsible manner. NRCan and PWGSC were instrumental in clearly defining the roles of all parties, coordination of efforts and communications throughout the project. The following key organizations were involved in the project:

Natural Resources Canada - The Project Owner and Client, responsible for initiation, implementation and completion of the project.

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Public Works and Government Services Canada - The contracting authority, responsible for management and contracting of the remediation contractors and remediation consultants on behalf of the Federal Government.

Stantec Consulting Ltd. - NRCan's environmental consultant, responsible for environmental site assessment, conceptual remedial design, environmental impact assessment, public consultation, building condition reviews, project specifications and drawings for the Northwest and Central Quadrants of the BSC, third party site monitoring and document review of environmental contractors and consultants contracted by PWGSC.

Dessau Inc. - Environmental consultant contracted through PWGSC, responsible for preparation of specifications and drawings for the Southeast Quadrant and the Front of 601-615 Booth St., as well as on site consulting and monitoring (soil and groundwater sampling, vibration monitoring) for the Southeast Quadrant, the Northwest Quadrant, and the Front of 601-615 Booth St.

Franz Environmental Inc. - Environmental consultant retained by PWGSC to complete a risk assessment related to the remediation and to provide real-time particulate matter monitoring during periods of active remediation, as well as discrete sampling and testing of settled dust and surface soil before and after each phase of the remediation.

AMEC Earth and Environmental - Environmental consultant retained by PWGSC to complete a screening level risk assessment related to the remediation and responsible for on -site consulting and monitoring (soil, groundwater sampling) for the remediation of the Central Quadrant.

Golder Associates - Environmental consultants retained by PWGSC, responsible for post-remediation groundwater monitoring of the remediated areas of the BSC.

Quantum Murray LP - Environmental contractor responsible for the remediation of the Southeast and Northwest Quadrants.

R.W.Tomlinson Limited - Environmental contractor responsible for the remediation of the Central Quadrant.

Taggart Construction Limited - Environmental contractor responsible for the remediation of the Front of 601-615 Booth St.

SNC-Lavalin Operations & Maintenance Inc. - Building managers, responsible for assisting with building and occupant issues as the site was to remain operational throughout all phases of remediation.

Environmental Site Assessment Activities

Since 1992, over 16 environmental investigations were conducted at the Booth Street Complex by at least ten different consulting firms. The investigations included the collection of soil and groundwater samples from various sections of the BSC and generally concluded that concentrations of various contaminants of concern in both the soil and groundwater were greater than federal and provincial environmental standards.

The Federal Contaminated Sites Action Plan (FCSAP) program was initiated and funded as part of the Economic Action Plan to help address contaminated federal sites such as the BSC. In 2008, Stantec was commissioned to complete an updated Phase I Environmental Site Assessment (ESA) of the BSC to identify activities and areas of potential environmental concern (APECs) and the associated potential contaminants of concern.

Stantec also completed a Data Gap Analysis which included the consolidation of the 1000+ soil and groundwater analytical results collected by others at the BSC and a comparison of the results to the applicable 2008 soil and groundwater quality standards. As the BSC is a federal property, the results were compared to the applicable federal guidelines for commercial and parkland land use. However, since NRCan is considering divesting portions of the BSC for redevelopment, the analytical results were also compared to provincial standards for residential, parkland, and commercial land use.

Based on the results of the Phase I ESA and the Data Gap Analysis, a detailed field program or a Phase II ESA was initiated in 2009 to obtain updated soil and groundwater data where needed to confirm the best approach to remediate the BSC. The field program included a total of 145 boreholes and the instrumentation of 30 holes as groundwater monitoring wells. The boreholes were advanced across the BSC using multiple drilling methods (e.g. portable, direct push, solid stem auger, diamond coring, etc) based on the accessibility of the borehole location and the subsurface conditions anticipated.

Drilling a borehole using a solid stem auger drill rig

In general, the overburden soil on site consisted of sandy fill material and debris overlying limestone bedrock. The depth to bedrock varies considerably across the BSC, outcropping in some sections near the northern end of the site and as deep as 7 metres below grade surface (m bgs) towards the south end of the site.

Approximately 200 soil samples were submitted for laboratory analyses of the contaminants of concern identified in the Phase I ESA: petroleum hydrocarbons (PHCs), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), metals and inorganics. Samples were selected for submission to an accredited laboratory based on field observations field vapour screening results. In general, one sample was submitted from boreholes in which bedrock was encountered within 2m of the surface, and two or more samples were submitted from boreholes deeper than 2m. The submission of multiple samples from deeper boreholes assisted in the vertical delineating of impacts to the soil.

The depth to groundwater was measured in all recently installed monitoring wells, as well as all accessible historical monitoring wells. The depth to groundwater ranged from between 2.0 and 9.8m bgs and was generally within the bedrock. Groundwater samples were collected from the recent and historical monitoring wells and submitted for analyses of the project contaminants of concern.

Soil and groundwater analytical results were compared to the applicable federal and provincial environmental standards. Since the ultimate goal of the BSC remediation is the potential divesture of portions of the site for redevelopment, the soil and groundwater analytical results were compared to several environmental standards based on both the current and proposed land use. Table 2 presents a summary of the land uses by quadrant.

Table 2: Current and Proposed Land Use by Quadrant

Quadrant	Current Land Use	Proposed Land Use
Southeast Quadrant	Commercial and Parkland	Private Residential
Front of 601-615 Booth St.	Commercial	Private Residential
Northwest Quadrant	Commercial	Private Commercial
Central Quadrant	Commercial	Commercial

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Based on the results of the Phase II ESAs, approximately 57 % of the Quadrants assessed, not including the building footprints, was underlain by soil containing concentrations of one or more of PHCs, PAHs, metals, and inorganics greater than the applicable federal guidelines. Approximately 63% of the assessed areas included soil with concentrations of one or more of the contaminants of concern greater than the applicable provincial standards. The impacts to the soil were generally present in both the shallow and deep soils in boreholes where multiple samples were analysed. In total, approximately 70,000 m^3 of impacted soil was estimated to be present in the areas assessed during the Phase II ESA.

The identified contaminants of concern were also measured in groundwater at the site in concentrations greater than the applicable provincial standards for non-potable groundwater conditions. Remediation of the groundwater was not recommended based on the results of the Phase II ESA as the drinking water to the area is provided by the City of Ottawa , removal of soil contaminants was assessed to reduce groundwater contaminants and the risk to current and future site occupants associated with the groundwater impacts was calculated to be minimal.

Groundwater sampling at the Booth Street Complex

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Remedial Design

The objective of this project was to cost effectively remediate on site soils to the applicable standards within the project schedule while adhering to the following restrictions:

- The activities in the buildings could not be disturbed or impacted by the project;
- Sufficient parking had to be maintained for occupants of the buildings during remediation;
- Following remediation, all services, structures, equipment, installations and site features had to be reinstated to their original condition unless code requirements called for upgrades;
- Continuous air monitoring was required to show that no airborne contaminants would create a risk to anyone, including children in a daycare located at the BSC;
- All work on site had to be complete between by March 31, 2011 at which point project funding would end. This required engineering design work to be complete by December 31, 2010 for the final quadrant;
- The 100 year old Central Heating Plant and associated underground steam tunnels, underground utilities, on-site and neighbouring site building foundations had to be protected from structural damage during construction;
- Major portions of the work had to be completed during the winter, including parking lot paving and concrete structures and landscaping;
- Adjacent roads and sidewalks in this central Ottawa location had to be protected and could not be closed to traffic at any time;
- The heritage building status of buildings located at 550, 555, 552, 562, 568, 601, and 615 Booth Street and 405 Rochester Street had to be maintained;
- No contaminated groundwater or surface water could be discharged from the site without prior treatment
- The existing fueling system on site had to be upgraded to current federal fuel storage and electrical standards and relocated to a better location;
- Any inaccessible contaminated soil remaining on site had to be separated with a liner and identified for future consideration.

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Several possible remedial approaches were considered and evaluated against the project criteria. An engineered excavation and removal of contaminated soils was selected as the preferred approach because it could effectively address the multiple groups of contaminants identified at the BSC at the same time while meeting all of the other project criteria listed above.

It was decided to remediate the site as four separate projects to meet the tight timelines, allowing multiple contractors to be working on different quadrants simultaneously. This also allowed for competitive pricing and less contractor risk for each quadrant. A list of "lessons learned" was coordinated by PWGSC and prepared by all parties working on the job to ensure continuous improvement as work progressed.

Northwest Quadrant during remediation

Project Challenges and Engineering Innovations

Schedule

The Federal Contaminated Sites Action Plan (FSCAP) program was initiated to help federal groups address contaminated properties such as the BSC. The Economic Action Plan (EAP) accelerated funding for FCSAP projects to help stimulate the economy. For a remediation program to qualify for FSCAP EAP funding, site work was required to be complete by March 31, 2011. This funding deadline presented a significant challenge to the BSC remediation team and required a very aggressive schedule for the preparation of design specifications, and ultimately the tendering, award, and completion of contract works.

A phased approach was employed to help achieve the final project deadline. The phased approach involved the division of the remedial work into four phases as summarized in Table 1. Design specifications and drawings for each phase were prepared in parallel and tendered separately (in both official languages) to allow time for the PWGSC's contracting review and award process, and ultimately the site works, to proceed on one phase while the tender documents for subsequent phases were being finalized and contracts awarded. This approach was essential to meeting the project schedule.

Additional advantages were realised through the phased approach to the project. The phased approach meant that only one phase of the BSC was under active remediation/ construction at a time. Therefore any disruption to the building occupants in each phase was condensed into a shorter time frame and any concerns raised were addressed immediately as the project team wasn't juggling multiple areas of the Complex at once. This also meant that disruptions to parking operations were limited to just the active remediation phase, an important benefit in an area of the City with limited parking. Another benefit was that the project team maintained a collective list of "lessons learned" on each phase to support the refinement of the team's approach to the design process, contract approval, and site operations on subsequent phases.

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Winter Conditions

To achieve the aggressive schedule, both the southeast and central quadrants required remediation during the winter months. Remedial excavation and site reinstatement in the winter in Ottawa presented several unique challenges to the project team and required innovative solutions to ensure that the unpredictable weather would not impact the final product or negatively impact the project schedule.

Excavating in frozen ground, particularly with a collection of older active and abandoned utilities and underground structures – both known and unknown, is difficult. Further complicating the issue at the BSC was the age of the buildings adjacent to many of the excavations and limited information regarding the building foundations and underlying materials. Test excavations were completed adjacent to buildings to confirm the type and condition of the building foundations, and hydrovac equipment was used where possible to confirm the location or condition of known utilities since excavating by hand as is typically done in warmer conditions, is difficult and time consuming in frozen ground. Exposed building foundations and underground services were protected from freezing to prevent damage.

Excavating through frozen ground in the Southeast Quadrant

Protection from freezing temperatures was also a design requirement for the concrete retaining walls, curbs, walkways, stairs, fuel containment structures, and pads in the Central Quadrant. A combination of insulated tarps, heaters, and glycol lines were used to maintain the design temperatures needed to ensure the integrity and strength of the concrete.

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A significant challenge associated with excavation work completed in the winter is how to backfill the excavation to achieve the required compaction. Both phases of the project completed in the winter were backfilled using a coarser-grained backfill material (i.e., blast rock or surge material) than would typically be used on similar projects completed in warmer weather. The primary benefit of using surge material is that the material can be placed and compacted regardless of its water content. Finer-grained material often requires the addition of water to properly compact the material and is also frost susceptible, both of which are unsuitable qualities for winter placement or in extremely wet conditions as encountered in the Southeast Quadrant. Coarse-grained material can also be placed in thicker lifts and if sourced locally can be less expensive than fine-grained materials, so the switch in the backfill material selected was not only a sound technical decision but also a benefit to the project schedule and budget.

Protection of exposed features and concrete from freezing during the remediation of the front of 601-615 Booth St in the Southeast Quadrant

The reinstatement of the parking lots in the Central Quadrant was a requirement of the BSC remediation and because of the aggressive schedule, a plan to pave the parking lots in winter conditions was developed. Although every effort was made to avoid the use of fine-grained material on site, fine-grained Granular A is a necessary component of a pavement structure. As part of the novel approach to reinstate the large parking lots in the Central Quadrant, the fine-grained material was placed immediately before the placement of the asphalt to limit the risk of ice lenses forming in the Granular A which could cause future settlement of the pavement as the ice melts. The thickness of the Granular A layer was increased from typical pavement structure designs to dissipate the effects should any ice lenses form before the asphalt could be placed.

Paving is typically only completed in warmer months because conventional Hot Mix Asphalt (HMA) cannot be compacted properly before cooling in the lower ambient temperatures. To allow for a proper compaction in colder temperature, an innovative asphalt design was developed by the project team that involved the use of Warm Mix Asphalt (WMA). WMA

is similar in composition to HMA, however it includes special additives that allow it to be placed and compacted at slightly cooler temperatures, thereby reducing the challenges of maintaining the high temperature of the asphalt during transport to the site and paving in the winter. The asphalt design also included a thicker than normal layer of the asphalt to allow for a sacrificial layer of material in the event that the conditions at the time of paving cooled the WMA in contact with the fine-grained Granular A material.

To ensure the availability of the WMA at a time of year when most asphalt plants are closed, provisions were made with contractor Tomlinson to open a nearby plant for this project. Using an asphalt product that could be produced at a local plant reduced the travel-time and assisted in maintaining the requisite temperatures for the placement and compaction of the WMA in the winter.

Maintaining Building Operations

The BSC is NRCan's national headquarters and has over 3000+ building occupants. Operational areas include NRCan office spaces, laboratories with sensitive equipment, commercial space, national libraries, and a children's daycare space. Building operations were maintained throughout the project through ongoing communication and coordination amongst the project team and with the building occupants. Excavations adjacent to buildings often required the temporary closure of loading docks and building exits, including emergency and reduced mobility exits. Work was scheduled outside of normal business hours to avoid disruptions to building occupants when possible. In instances when closing exits was unavoidable, changes such as revising emergency exit locations or the construction of temporary ramps into buildings were communicated to the building occupants to ensure their safety throughout the work.

Potential risks to humans and the environment associated with the remediation program were assessed through the Environmental Assessment process and a comprehensive mitigation plan was developed and implemented to address these risks while maintaining building operations. Mitigation measures included extensive testing of air, surficial soil, and surface dust throughout the remediation efforts.

Ambient air quality was monitored continuously during active phases of the remediation using multiple monitoring stations placed throughout the BSC. Trigger concentrations for each monitoring station were developed as part of a risk assessment completed by Franz and reviewed by Stantec and Health Canada, and mitigation measures were developed should any of the trigger concentrations be measured during remediation. Through the use of proactive dust suppression measures such as the installation of 8-foot tall jersey barrier and plywood hoarding around the site perimeter, none of the contingency measures were implemented over the course of the project. The air monitoring results were also reported daily to building occupants.

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Underground Steam Tunnels

Heat to the BSC is supplied via large underground steam tunnels. Steam originates at a Central Heating Plant in the Central Quadrant operated by PWGSC and is conveyed to the buildings in the BSC via pipes within the underground tunnels. Built in the 1940s, the concrete tunnels measure as big as 2m high by 2m wide and were believed to be founded either on or within bedrock depending on the section of the BSC. The top of the tunnels was less than a metre from surface and the condition of the tunnels prior to remediation was reported as poor in some sections. Damage to the tunnels and the steam lines would impact the delivery of heat to the entire BSC during the winter months. Therefore, the tunnels presented a unique challenge to the project as travel across the tunnels, as well as excavation, backfilling and surface reinstatement above and adjacent to the tunnels, was required to complete the remediation.

An updated structural assessment of the interior of the steam tunnels was completed and careful test excavations were conducted near sections of the tunnels identified as being in poor condition to ascertain the condition of the concrete before proceeding. The specifications for all equipment traversing or working in the vicinity of the tunnels, including equipment required to quickly place and compact the asphalt, were reviewed to ensure that static and operating loads of the equipment did not exceed those identified in the structural assessment. Backfill material and compaction methods were also adjusted in areas adjacent to and above the tunnels, using clear stone backfill, manual installation and static compaction to limit the risk of damaging the tunnels.

Site Reinstatement

The reinstatement of the BSC was an important and very challenging aspect of the project. Because the project was a remediation project first and foremost, the original plan was to leave as much surface and subsurface infrastructure (e.g., utilities, retaining walls, etc) in place as possible. Unfortunately, the age and poor condition of many of the site features necessitated their redesign and replacement. In the earlier phases, the need to replace items such as manhole and catchbasin structures, or light standards, wasn't known to the project team until the features were exposed during excavation. A team approach to problem solving was coordinated by PWGSC to come up with the best solution in the least amount time, when these unknown underground conditions were encountered.

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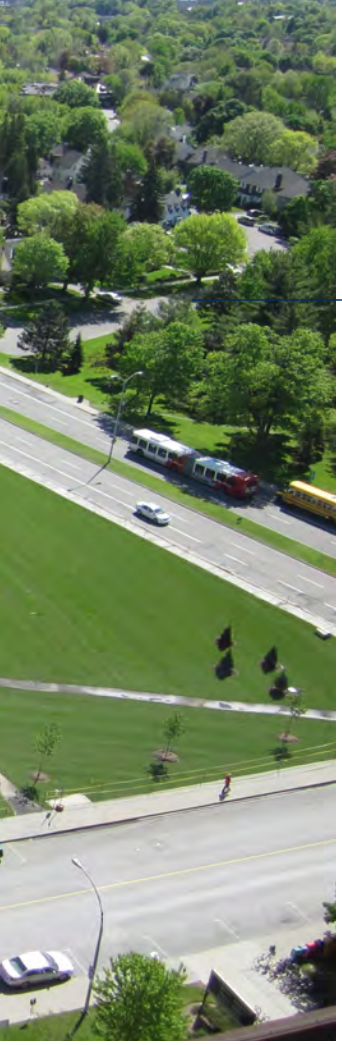
For later phases of the project, the designs were revised to include the replacement of sewers and associated structures based on the team's experience on the project. The surface features were also carefully examined by the design team to ensure that existing retaining walls, stair cases, fuel tanks, etc. were in good conditions and satisfied the applicable updated codes and standards. Features deemed to be in poor condition or out of date, were redesigned and replaced during site reinstatement.

The reinstatement of the vehicle pool area in the Central Quadrant presented a unique challenge to the team. The vehicle pool area was a small fenced area within the south parking lot in this quadrant and included biodiesel and ethanol fuel tanks used to fuel a fleet of NRCan vehicles. The pre-remediation layout of this area did not function very well for the occupants and a slight redesign was requested as part of the reinstatement. A coordinated multi-disciplinary team of engineers was involved in redesign of the area which included the following key elements.

- Enlarge the fenced area to facilitate refilling the fuel tanks.
- Replacement of an approximately 3:1 slope with a 29.5-m long concrete retaining wall to add additional parking spaces.
- Redesign the parking lot grading and relocating catchbasins to provide proper surface water drainage without altering the drainage to neighbouring City property.
- Designing a concrete structure comparable to a 10,000-L concrete bathtub positioned to work in conjunction with the revised site grading and serve as a secondary fuel containment area in the event of a fuel spill. The secondary containment area was needed to ensure the fuel tank area applies with applicable federal standards.

Reinstated vehicle fuel tanks in Central Quadrant

- Parking lot light standards and electrical outlets in the vicinity of the fuel tanks were replaced with explosion-proof fixtures as required by applicable codes.
- Relocation of fuel tank emergency shut-offs to enhance employee safety.
- Installation of extra subsurface electrical conduit to facilitate the anticipated future installation of electrical power outlets for vehicle charging stations and the addition of automated, secure gates to vehicle fuel area.



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Environmental Benefits

An estimated 120,000 tonnes of contaminated soil was extracted from the BSC and safely deposited at local landfills for use as cover material to contain other solid wastes disposed at the landfill. Approximately 37 tonnes of hazardous solid waste was also removed from site and brought to a licensed hazardous waste storage facility. Although contaminated soil on site was located below grade and generally well-covered by asphalt parking lots and landscaped areas, its presence posed a low level of risk to people through possible skin contact, inhalation, and ingestion. Furthermore, the presence of this contamination had a long term negative impact to groundwater, slowly leaching contaminants into the local aquifer. It is anticipated that removal of contaminated soil will allow for the groundwater impacts to naturally attenuate over time.

By removing these environmental hazards from the BSC, the risk of exposure to occupants, future construction workers, the general population and groundwater is greatly reduced. The engineered approach to the BSC Remediation project ensured that the process by which the contaminants were removed was safe and effective. Continuous air, water, dust and soil testing showed that the project did not result in any releases of contaminants from the project zone. Transportation manifests and landfill weigh bills were also closely monitored to ensure that transportation and disposal of contaminated materials were carried out in accordance with stringent environmental regulations.

Social and Economical Benefits

For the over 3000 people who worked at the BSC and the community in the vicinity of this prominent property, there was a negative stigma associated with the environmental contamination on site. The clean-up project of the complex has removed this stigma and resulted in a renewed energy about the future of the site.

There are also many financial benefits to this project. Accounting rules of the Federal Government require that the cost of future environmental remediation be counted as a financial liability on the Government balance sheet. By completing this remediation, this federal liability has been removed for the BSC, benefitting all Canadians.

With on-site contamination removed, future development plans can be designed for best use, without the restrictions that the environmental impacts would have created. This has also increased the property value significantly (estimated at over $10 million), resulted in the removal of a $25 million environmental liability for Canada, and will allow for all development options to be fully considered, maximizing future value.

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Results of the Project

By all accounts, the Booth Street Complex Environmental Remediation Project was a success. The project met all remedial objectives, was completed within the aggressive schedule and was completed under initial cost estimates. This project was an excellent example of collaboration between project proponents, engineering consultants and contractors. The project has improved the environment around the Complex, resulted in increased property values and allowed for future development plans to proceed unimpeded.

"The many technical and logistical challenges of the Booth Street Complex Remediation project required the integration of a multitude of engineering and project management skills, applied at a fast pace to meet the project objectives. The federal government relied on Stantec and the other consultants involved in this project to provide innovative and timely solutions throughout the project. I am very satisfied that this project brought good value to Canadians."

Miguel Larivière, PWGSC Project Manager

"NRCan had a need to remediate our headquarters site in a timely, safe and cost effective manner, with minimum disruption to our tenants. Stantec was involved from the start of this project and together with all the other contributors, provided excellent engineering advice and service to ensure success."

Trevor Bergh
NRCan Environmental
Manager and Project Client

Reinstated green space in the Southeast Quadrant