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East In-Pit Overflow Structure

Client: Syncrude

Submitted by:

WorleyParsons resources & energy

amec foster wheeler

INTRODUCTION

The East In Pit Overflow Structure is *one of the largest culvert systems in Western Canada* and is located within Syncrude Canada's *dam under Highway 63*. It consists of a 60m wide inlet channel, seven arch culverts and a 33 m wide outlet channel.

PROJECT BACKGROUND

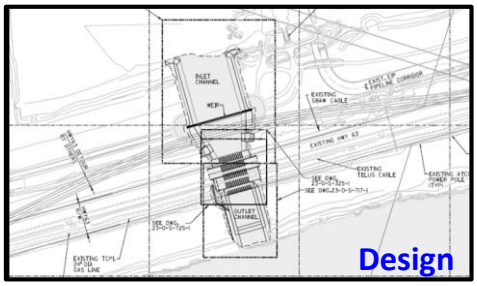
As part of the ongoing reclamation activities, Syncrude Canada Ltd. is in the process of filling the East In Pit (EIP) Pond with sand to create the final closure topography required to reclaim the area.

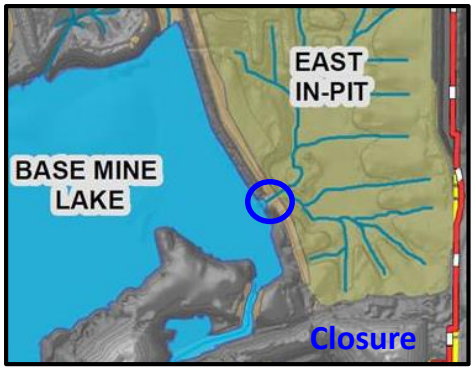
As placement of sand progresses, the storage volume provided between the operational fluid level and the top of licensed freeboard of this dam structure will decrease. A study concluded that the closure topography would not provide adequate freeboard storage and would require an overflow structure to keep the pond level below the licensed freeboard of this dam during possible extreme storm events. The overflow structure would need to convey the *extreme flood* into Base Mine Lake (BML, the downstream impoundment) while ensuring the water level in EIP is below the licensed freeboard. EIP eventually would be converted from a tailings pond into a closure landform (dry landscape) and the surrounding dams would be de-licensed.

EXECUTION

The client required a higher level of assurance for this project. Therefore, this project required *unique, unconventional and technically challenging features* in the design and construction stages to complete the project within the *tight schedule and without sacrificing the integrity of the dam.*

Where It Begins……..





Return it back to Mother Nature

PROJECT TEAM

Client / Prime Contractor: Syncrude Canada Ltd.
Geotechnical Consultant: Amec Foster Wheeler
Civil & Hydraulic Consultant: WorleyParsons
Sub-Consultant (Fillcrete): Tetra Tech EBA
Contractor: North American Construction Group
Culvert Supplier: Canada Culvert

DETAILS OF THE CULVERTS

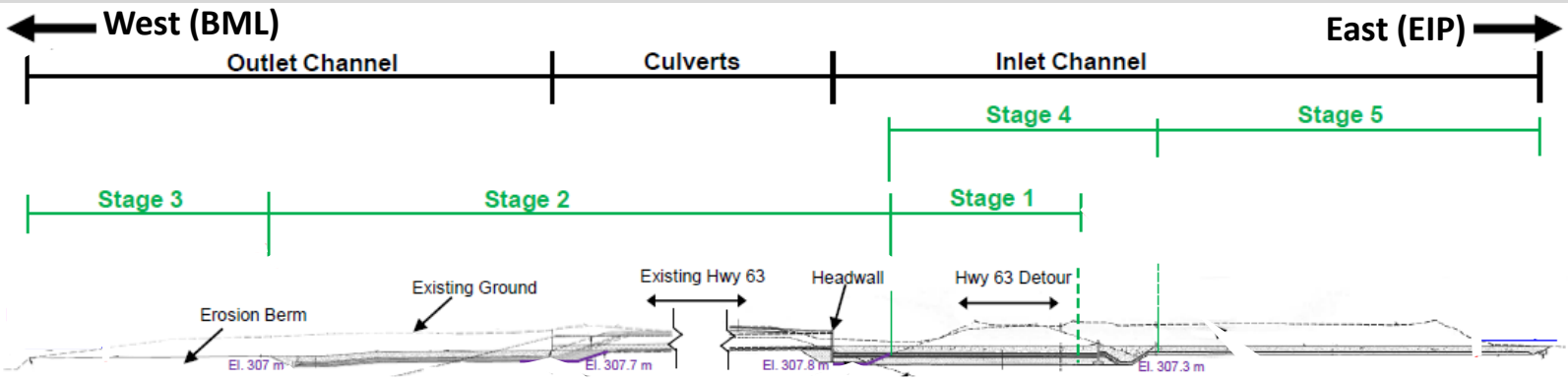
The overflow structure consists of seven multi-plate arch culverts *through the dam below Highway 63*. Each culvert had a span of 2.6 m, rise of 1.9 m and placed at a spacing of 2 m (measured at the haunches) between culverts.

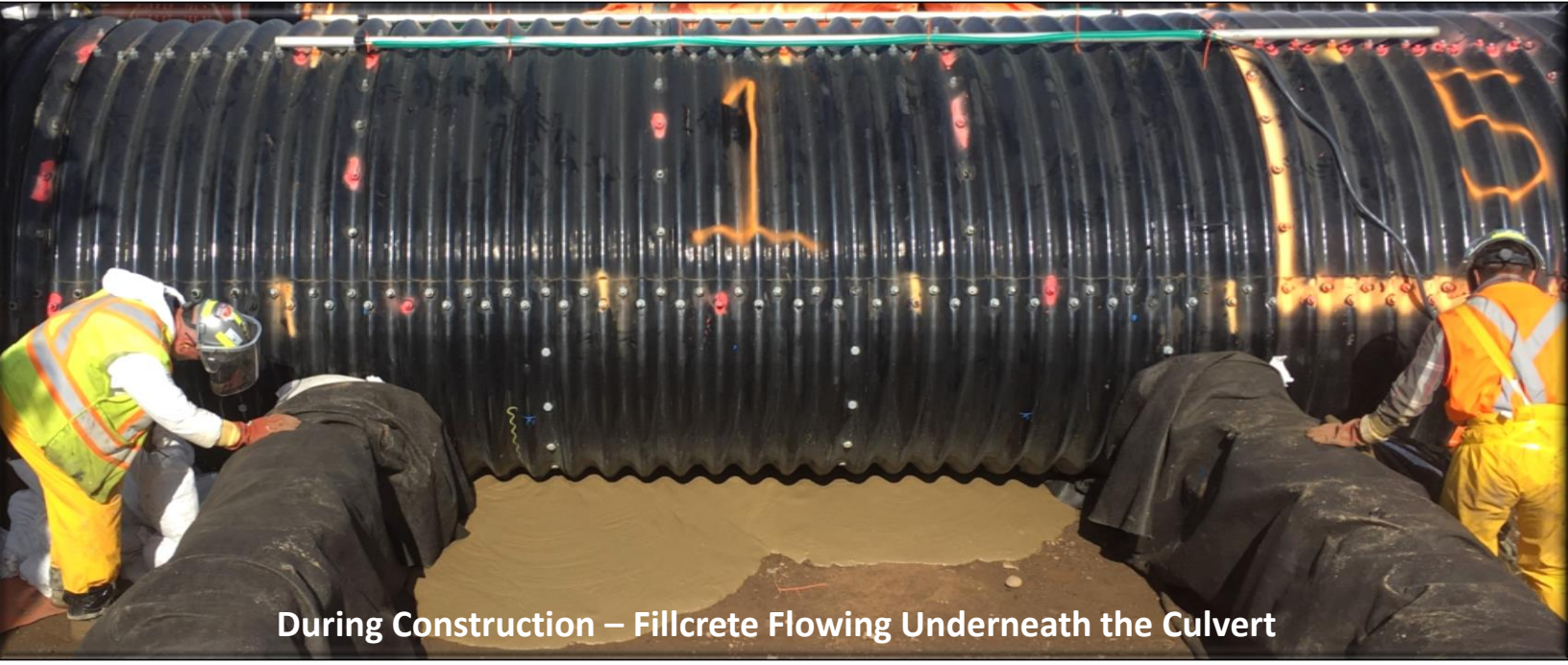
CONSTRUCTION STAGES

This was a *fast-paced, time-sensitive project* for the client to meet the long-range/closure plan. However, this construction was on a dam with active ponds on both side of the dam and across a major highway in Alberta (Highway 63 Southbound Lanes). In order to minimize the risks and to meet dam safety requirements, the construction of the East In-Pit Overflow structure was carried out in stages.

- **Stage 1**: Highway 63 Detour Construction and Relocating Gas, Fibre and Power Lines with Horizontal Directional Drilling (HDD)
- **Stage 2**: Culvert and Headwall, Portion of the Outlet Channel and Minimum 5 m Inlet Channel Construction
- **Stage 3**: Remainder of the Outlet Channel Construction Towards Base Mine Lake (BML)
- **Stage 4**: Demolition of the Detour and Portion of the Inlet Channel Construction
- **Stage 5**: Remainder of the Inlet Channel Construction Towards East In-Pit Pond (EIP)

A full-time geotechnical field engineer monitored the entire construction of the overflow structure. After the completion of construction stages, the project site was inspected and approved by the project stakeholders which included Alberta Transportation and Alberta Energy Regulators.





During Construction – Fillcrete Flowing Underneath the Culvert

PROJECT HIGHLIGHTS – INNOVATION AND TECHNICAL EXCELLENCE

The conventional practice in culvert design considers granular backfill around the culverts to maintain the culvert integrity. Placing and compacting the granular backfill below the haunches of the culvert is difficult due to the shape of the arch culvert which does not meet the compaction requirements for the dam and the higher level of assurance required for this project. The presence of a gap could create preferential seepage paths that *could compromise the safety of the dam. These concerns necessitated an unconventional backfill design for this large culvert system*.

To meet the dam license requirements, a proprietary fillcrete mix was developed for the culvert backfill application. Development of this *unique fillcrete mix* required extensive laboratory and field trials to meet the flow criteria (flow through the 6″ x 2″ corrugations underneath the culvert) and strength/ ductility criteria to meet the project requirements. A *full-scale field trial* starting from batching plant to placement at the construction site was carried out to streamline the construction process.

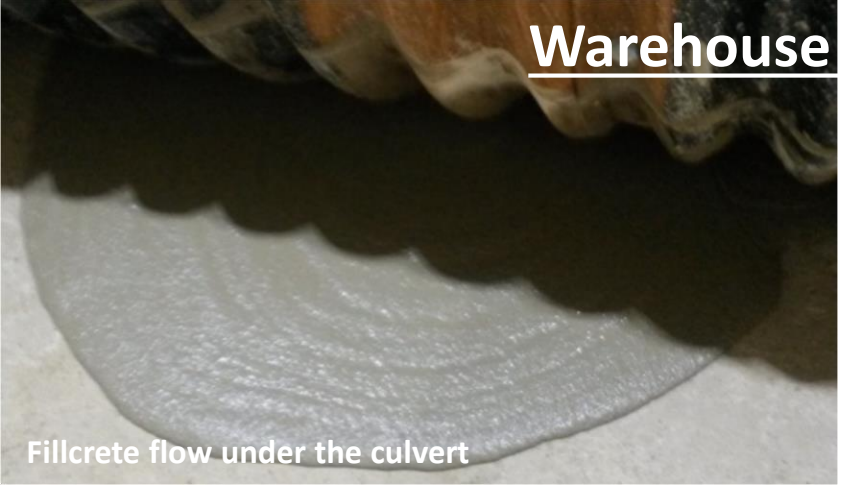
The other unique aspect of this project was the construction of the full-speed detour with tailings sand subgrade. The client preferred to utilize the readily available tailings sand material to raise the grade to the super-elevation subgrade of the full-speed detour rather than other materials due to the schedule and to minimize the cost. An engineered subgrade design using the tailings sand was developed and constructed successfully with detailed QA/QC procedures to meet the Alberta Transportation requirements.

The large multi-plate arched culverts were made at the Canada Culvert's one of a kind *fully automated facility* in London, Ontario. Live video feeds of the fabrication were sent to the client in Fort McMurray, Alberta during the production.

Live Video Feeds from the Facility

Fully Automated Facility

Warehouse Trial



Fillcrete flow under the culvert

After Removing the Culvert Confirmed Flow through the Culvert Corrugations

DETAILS OF THE PROPRIETARY FILLCRETE MIX

A *proprietary fillcrete mix* was developed for this project application. The following criteria and tests were specified for the fillcrete mix to meet the geotechnical design requirements.

- **Shrinkage:** less than 0.2% *(Shrinkage Test - ASTM C157/C157M-04)*
- **Flowability:** *should flow through 6" x 2" corrugations underneath the culvert (Flow Cone Test – ASTM C939)*
- **Strength:** a 28 days compressive strength of 1 to 2 MPa *(Confined Compression Test – ASTM D2850)*
- **Ductility:** minimum 2% strain at peak & post-peak stress-strain behavior (*Confined Compression Test – ASTM D2850)*
- **Permeability:** less than 1 x 10^{-6} cm/s (*Flexible Wall Permeameter Test – ASTM D5084)*
- **Erosion Resistance:** non-erodible *(Pinhole Test – ASTM D4647)*

Developing a fillcrete mix that met the above design requirements especially the flowability was a *challenge in the design* and required a *proprietary fillcrete mix* developed for this project application based on *full-scale plant, warehouse and field trials*, laboratory testing and input from the material specialist. To avoid delays in the construction (which was not acceptable for the project schedule), the developed fillcrete mix was tested in the field (*full-scale field trial*) with the associated laboratory testing prior to using this mix in the construction.

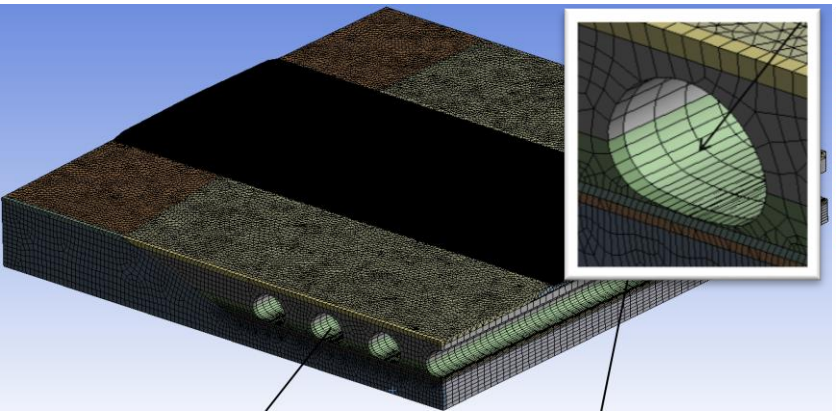
Quality control measures such as checking the mix preparation at the plant, fillcrete trucks reaching the site at a specified time intervals (time between batching to placement was critical for flowability), performing field flow cone testing and collecting additional test samples from each truckload were implemented during the construction. The testing (results summarized below) confirmed the suitability of the selected fillcrete mix for the project application.

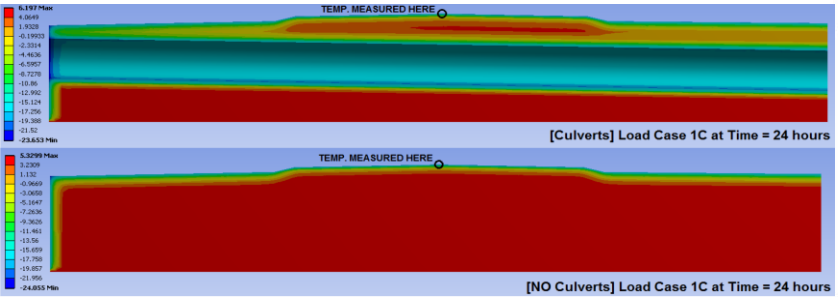
Description	Test Results
Shrinkage	0.06% or less
Flowability	Flowed less than 10 seconds
Strength & Ductility	1 to 2 MPa with greater than 2% strain at peak
Permeability	1.17 x 10^{-6} cm/s or less
Erosion resistance	Non-erodible

Full Scale Field Trial

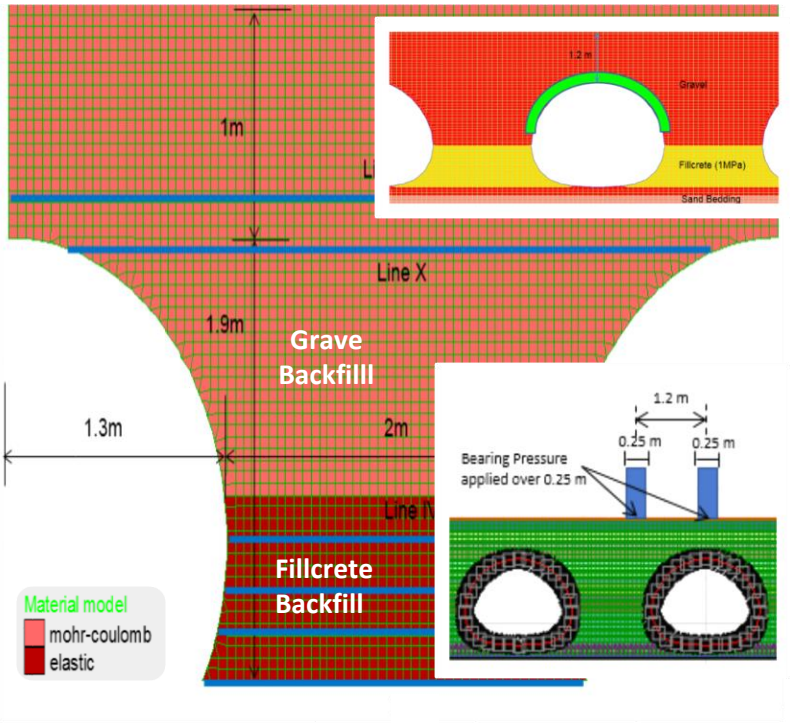
Fillcrete pour

Flow through the culvert corrugations was confirmed after removing the culvert section





ANSYS Thermal Analysis



FLAC Deformation Analysis

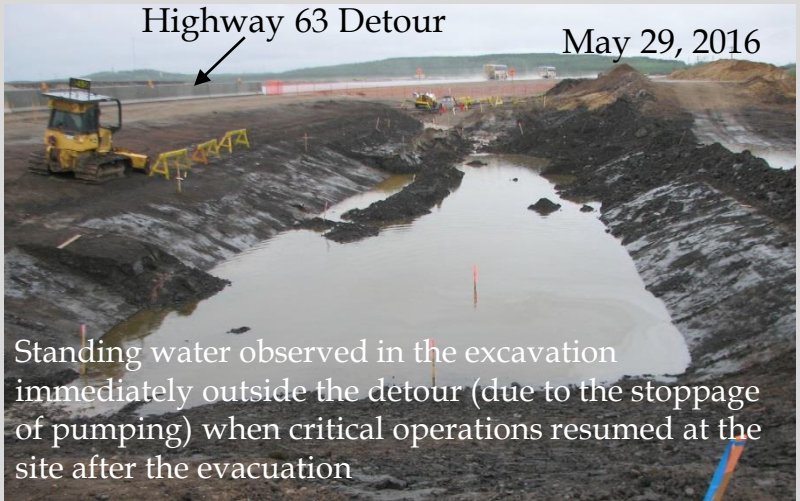
PROJECT HIGHLIGHTS - COMPLEXITY

Several utilities including powerlines, gas lines and regional communication cables were located within the excavation limits of this project. *To minimize service disruptions, horizontal directional drilling (HDD) was adopted* to relocate the underground utilities in this area.

A *hybrid backfill* using fillcrete and gravel is not commonly used in conventional culvert design. A sophisticated numerical modelling (using FLAC software) was carried out to prove the strain compatibility of various materials (steel, fillcrete and gravel) and the culvert integrity under highway loading to meet the Alberta Transportation and Dam Safety requirements.

Alberta Transportation expressed concerns regarding *preferential black ice formation* in this location due to the presence of this large culvert system. Advanced numerical modelling (using ANSYS software) was carried out as part of this project to investigate the thermal performance of the highway with the culvert system to meet the Alberta transportation requirements.

The excavation was carried out within the saturated tailings sand. Stilling wells, perimeter ditches, french drain and sumps were in operation to manage the seepage water at the site and to maintain the stability of the highway detour. *The site was under construction in 2016 during the Fort McMurray wildfire*, and the pumping activities were halted during the evacuation and resumed immediately after limited people were allowed to resume critical activities in Fort McMurray. The client identified this project as a critical project and the detour side slopes were inspected to ensure the safety of the slopes due to the stoppage of pumping.



Standing water observed in the excavation immediately outside the detour (due to the stoppage of pumping) when critical operations resumed at the site after the evacuation

Photo Source – Syncrude Canada Limited Website

PROJECT HIGHLIGHTS – ENVIRONMENTAL BENEFITS

The main objective of the client is to reclaim the East In-Pit pond and *return it back to mother nature similar to the pre-mining state in this area*. This overflow structure project is one key step towards this reclamation process.

Once this area is fully reclaimed the closure landscape within the East In-Pit would consist of hills, valleys, creeks, vegetation and ecosystem, that is *comparable to a natural landform*. The closure landscape would be self-sustainable and consistent with the natural landscape in the surrounding areas.

Channels and vegetated waterways would be designed to facilitate hydrologic characteristics similar to natural landscape to have a *sustainable ecosystem* in this area. Revegetation in this area would be developed to establish the boreal forest which is a common feature in the surrounding area. Variety of *boreal forest plants would be planted to be consistent with the surrounding ecosystems*.

The client has successfully reclaimed and revegetated the Gateway Hill and is in the process of reclaiming the East In-Pit. The EIP Overflow Structure project is a stepping-stone for the greater environmental benefits that would be achieved when this area is fully reclaimed.

PROJECT HIGHLIGHTS – SOCIAL AND ECONOMIC BENEFITS

The EIP Pond is located south of the Syncrude main plant site and is situated between the northbound lanes of Highway 63 bordering Suncor Energy Inc. and the southbound lanes of Highway 63 bordering Syncrude's Base Mine Lake. As such, the *safe and continued reliable operation of the EIP Pond is important to ensure transportation routes servicing the areas north of Syncrude are maintained.*

The construction of the EIP Overflow Structure is one key component in the reclamation plan in the area. Ensuring compliance with the reclamation plan provide ongoing assurance to the public the need to ensure safe and sustainable development in the area. Successful and safe execution of the long-term reclamation plan will ensure continued regional interest and support.

Successful reclamation in this area would provide opportunities for *recreation activities in the future* within the end-pit demonstration lake located on the downstream side of the overflow structure.

Artistic Rendition of Recreational Activities in a End-Pit Lake

Image Source – Google Images

PROJECT HIGHLIGHTS – MEETING CLIENT'S NEEDS

This was a *time-sensitive project to meet the client's reclamation schedule* for the East In-Pit area. Completion of this project on schedule was a key driver. This project also involved various stakeholders as well as the need for a robust design to get the approval from the appropriate government agencies in a timely manner to complete this project successfully. Safety was a paramount factor for the client and it was expected that the project is completed without compromising the safety of the workers and the public. The other key objective of the client was to have a minimal disturbance to the public using the highway.

The design team worked closely with the client to meet their requirements. A *robust design was developed that was not only technically sound but completed within ten months from conceptual to detail design*. The design was approved by the stakeholders within the expected timeframe. A detailed Inspection and Testing Protocol (ITP) was developed with QA/QC information for each construction stage to ensure the design intent was met during construction. A *full-speed detour was constructed and a traffic accommodation plan was developed to minimize the disturbance to the traffic.* A higher standard of safety was followed by periodically reviewing the safety plan and conducting daily safety meetings during the construction. *The project was completed successfully within the schedule and without any safety incidents to the public.*

Overall, the project team ensured that the design and the construction assured safety, minimized risk, complied with dam license requirements and continued safe operation of Highway 63 during the construction period.

AT COMPLETION IN 2017

Key Facts – Culverts

- ✓ *One of the largest culvert systems in Western Canada*
- ✓ *Culvert system consists of 51 m long 7 multi-plate arch culverts assembled with 32,000 bolts*
- ✓ *Each culvert has a span of 2.6 m and rise of 1.9 m and installed at a 2 m spacing between the haunches (lower portion) of the culvert*

Key Facts – Material Volumes

- ✓ *Lean Oilsand Fill – 10,000 m^3*
- ✓ *Riprap - 6,500 m^3*
- ✓ *Gravel – 3,300 m^3*
- ✓ *Fillcrete – 1,400 m^3*

Key Facts – Material Testing

- ✓ *Field Density Tests – 2,150*
- ✓ *Fillcrete Flow Cone Tests – 270*
- ✓ *Grainsize Tests – 130*
- ✓ *Compressive Strength Test – 90*

Key Facts – Project Milestones

- ✓ *Conceptual Design – December 2013*
- ✓ *FEED – Apr 2014*
- ✓ *Detailed Design – Aug 2014*
- ✓ *Stage 1 (Detour Construction) – Aug 2014*
- ✓ *Gas, Fibre and Power lines Relocation – May 2015*
- ✓ *Stages 2 and 3 Construction Start – May 2016*
- ✓ *Stages 4 and 5 Construction Start – May 2017*
- ✓ *Completion of the Construction – Sept 2017*

A total of 620 construction days from groundbreaking to completion of the construction. At times up to 50 people per day worked on this project and the project was completed within the schedule and the budget.