IEEE – 7-September-2011

ONTARIO POWER GENERATION

Niagara Tunnel Project Overview

- Hydroelectric diversion tunnel, 10.2 km long and 12.7 m in diameter, within the urban and tourist area of Niagara Falls, Ontario, Canada
- Increase water diversion capacity at the Sir Adam Beck complex by 500 m^3/s (+27%)
- Increase average annual energy output at the Sir Adam Beck complex by 1.6 billion kWh (+14%)
- Design Build Contract awarded to Strabag AG (Austria) in August 2005
- Owner’s Representative is Hatch Mott MacDonald with Hatch Acres
- Project budget is $1.6 billion
- In-Service by December 2013

<u>Progress at 10-May-2011</u>

- TBM excavation completed
- Invert concrete @ 7.8 km
- Profile restoration @ 5.1 km
- Arch concrete @ 3.8 km

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In April 1999, Ontario Hydro became…

Ontario Power Generation (OPG) generates approximately 70% of the electricity the market needs in Ontario through its fossil, nuclear, and hydroelectric plants.

Hydro One runs most of the high voltage transmission and some of the lower voltage distribution systems for power in Ontario.

Independent Market Operator (IMO) - later renamed Independent Electricity System Operator (IESO) - administers the electricity grid and ensures there is adequate supply of electricity on a day-to-day basis.

Electrical Safety Authority enforces electrical safety across Ontario.

Ontario Electricity Financial Corporation - responsible for servicing the debt and liabilities of the former Ontario Hydro that were not assigned to the successor companies.

Ontario Power Generation Inc (OPG)

- OPG is an Ontario-based electricity generating company whose principal business is the generation and sale of electricity in Ontario.
- OPG's focus is on efficient production while operating the generation assets, in a safe, open and environmentally responsible manner.
- OPG's sole shareholder is the Government of Ontario.
- OPG has about 11,500 employees located throughout Ontario.
- OPG's electricity generating asset portfolio includes:

	Number of Generating Stations	Station Capacity MW	Station Capacity %	2010 Energy TWh	2010 Energy %
Nuclear	3	6,606	30.6	46.8	50.6
Fossil-Fuelled	5	8,057	37.3	9.5	10.3
Hydroelectric	65	6,941	32.1	36.2	39.1
Other (Wind, etc)	-	2	-	-	-
OPG Totals	72	21,606	100.0	92.5	100.0

- OPG's Sir Adam Beck – Niagara generating stations provide 30% of this hydroelectric capacity and 35% of the clean, renewable hydroelectric energy.

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Niagara’s Hydroelectric Resource

- The Niagara River, 56 km (35 mi) in length, flows from Lake Erie to Lake Ontario and has a total drop of about 99 m (325 ft).
- About 55% of the drop occurs at the Horseshoe Falls and another 40% occurs through rapids upstream and downstream over a distance of about 8 km (5 mi).
- Lake Erie outflow varies from about 4,000 m^3/s (140,000 cfs) to about 10,000 m^3/s (350,000 cfs), averaging about 6,000 m^3/s (212,000 cfs).
- Commitments in the 1950 Treaty for scenic flow over Niagara Falls, domestic and navigation purposes require about one-third of the average Niagara River flow and the remainder is shared between Canada and the United States for clean, renewable hydroelectric power generation.

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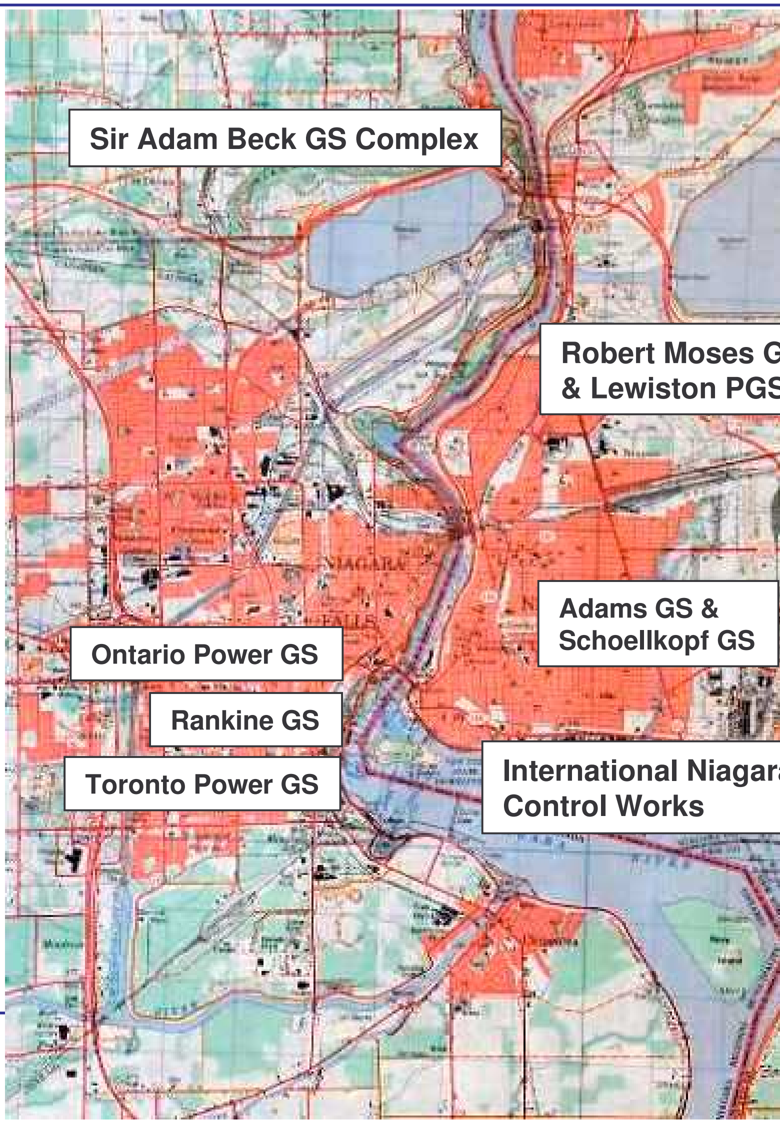
Niagara’s Hydroelectric Facilities



- The Cascade plants, Adams GS No.1 & 2, Schoellkopf GS, Toronto Power GS, Ontario Power GS and Rankine GS used only the head available in the vicinity of the Falls and now have all been removed from service.
- Sir Adam Beck GS No.1 (SAB1), built in the early-1920’s, was the first of the Niagara River hydroelectric facilities to capture the hydraulic head available through the rapids upstream and downstream of the Falls, about 96% of the drop between Lake Erie and Lake Ontario.
- Sir Adam Beck GS No.2, built in the 1950’s, and NYPA’s Robert Moses GS, built in the 1960’s, followed the lead of SAB1 in optimizing capture of the available head.
- Remedial and Joint Works, such as the International Niagara Control Works, plus OPG’s Sir Adam Beck PGS and NYPA’s Lewiston PGS are instrumental in meeting the 1950 Treaty requirements and optimizing the hydroelectric generation.

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Water Availability - 1950 Niagara Diversion Treaty

- **Effective October 1, 1950 the Niagara Diversion Treaty established priority for scenic, navigation and domestic purposes and allows remaining flow to be used for power generation.**

- **The required minimum scenic flow over Niagara Falls is:**
  - **100,000 cfs (2,832 m^3/s) during Tourist Season Daytime (April through October), and**
  - **50,000 cfs (1,416 m^3/s) during Tourist Season Nighttime and Non-Tourist Season (November through March).**

- **About two-thirds of the average Niagara River flow is available for power generation and is shared equally by Canada and the United States.**

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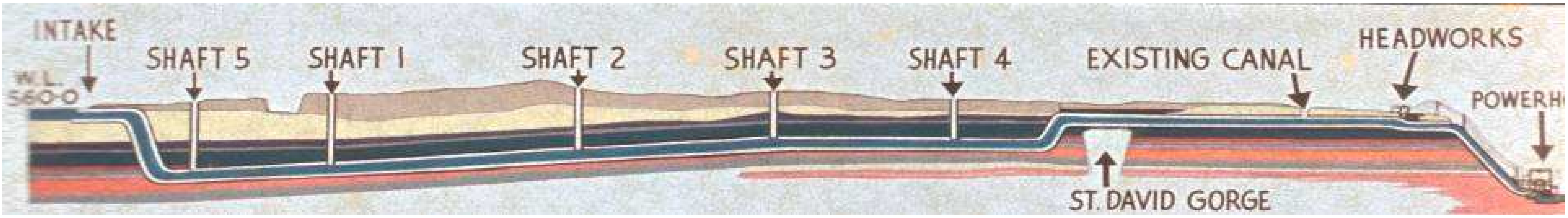
Preliminary Engineering & Environmental Assessment Work

- Feasibility study to enhance Ontario's Niagara hydroelectric facilities from 1982 to 1988.
- Definition engineering and environment assessment (EA) from1988 to 1994 included extensive geotechnical investigations and engagement of domestic and international experts.
- EA submitted in 1991 for the preferred alternative with 2 new diversion tunnels each with nominal capacity of 500 m^3/s, an underground generating station with up to three 300 MW units and transmission improvements between Niagara Falls and Hamilton.
- EA Approval was received in 1998 for the full development with provisions for staging construction.

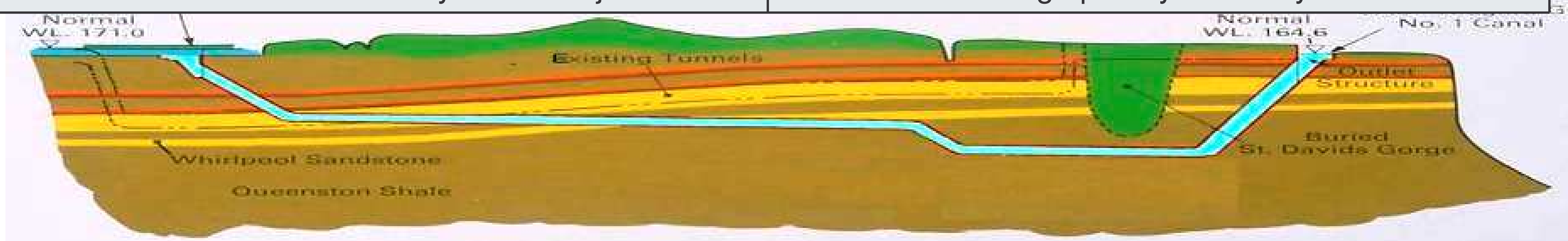
<u>Key Commitments made during the EA process included:</u>

- Avoid community disruption experienced during the 1950's tunnel construction and minimize impacts on residents and tourists.
- Tunnel excavation from the outlet near the Sir Adam Beck PGS to the intake at the International Niagara Control Works.
- Use a Tunnel Boring Machine (TBM) to excavate the tunnel.
- Tunnel under the buried St. Davids Gorge and follow the corridor established for the existing tunnels under the City of Niagara Falls.
- Re-use of excavated materials (particularly Queenston shale).

Comparing Niagara Tunnel with Sir Adam Beck No.2 Tunnels



Sir Adam Beck No.2 Tunnels (above)	Niagara Tunnel (below)
Excavated by drill & blast in 1950's	Excavated by tunnel boring machine (TBM)
Two tunnels each 8.5 km long & 15.5 m diameter – Open cut canal to cross St. Davids Gorge	One tunnel 10.2 km long & 14.4 m diameter
Five major construction shafts	Construction through outlet portal
Major impacts (traffic, noise, vibration, dust, etc)	Little impact on residents & tourism
At least 8 fatalities & many serious injuries	High priority on safety



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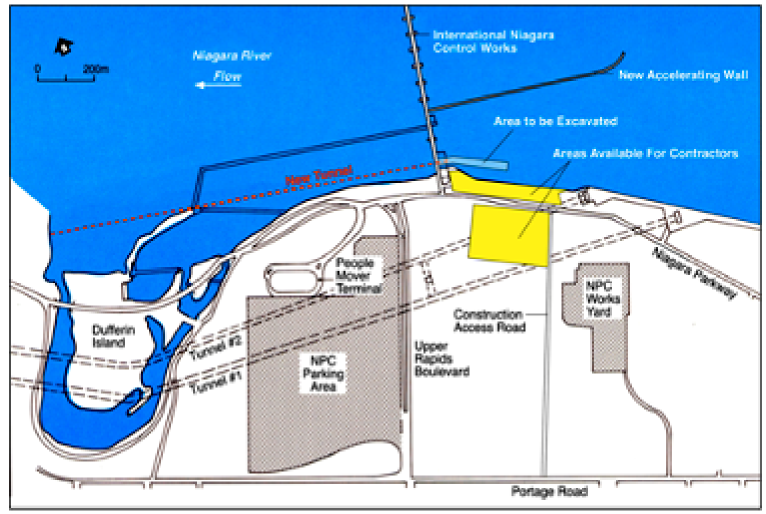
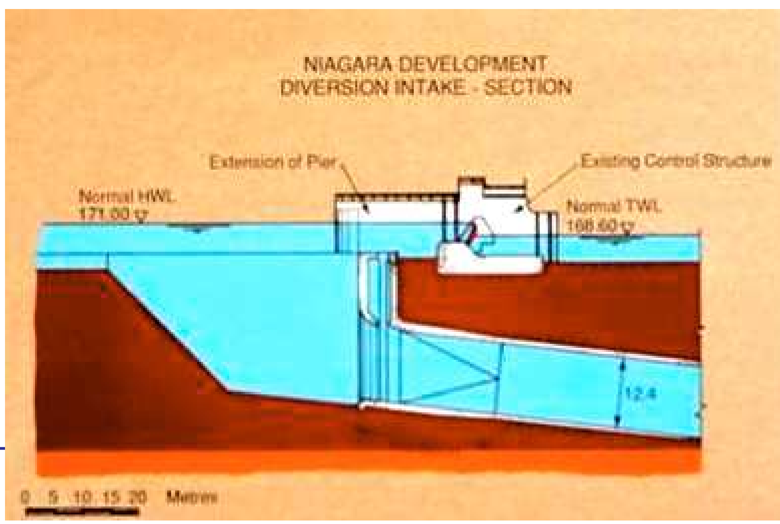
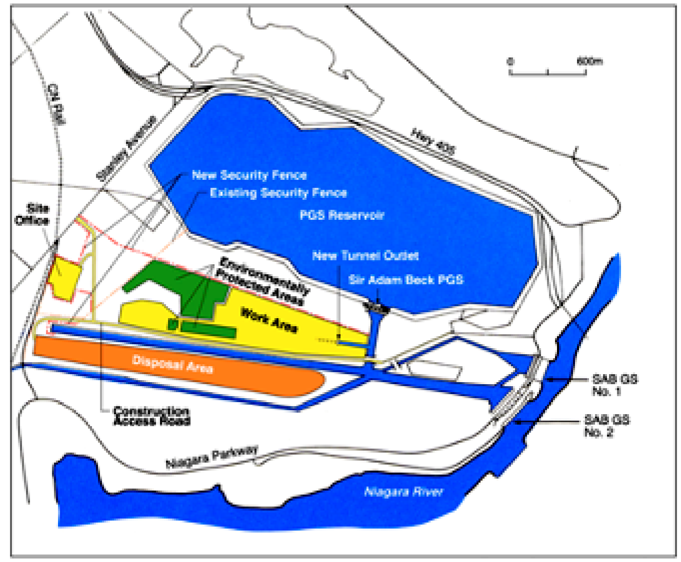
Concept Scope of Work - Intake

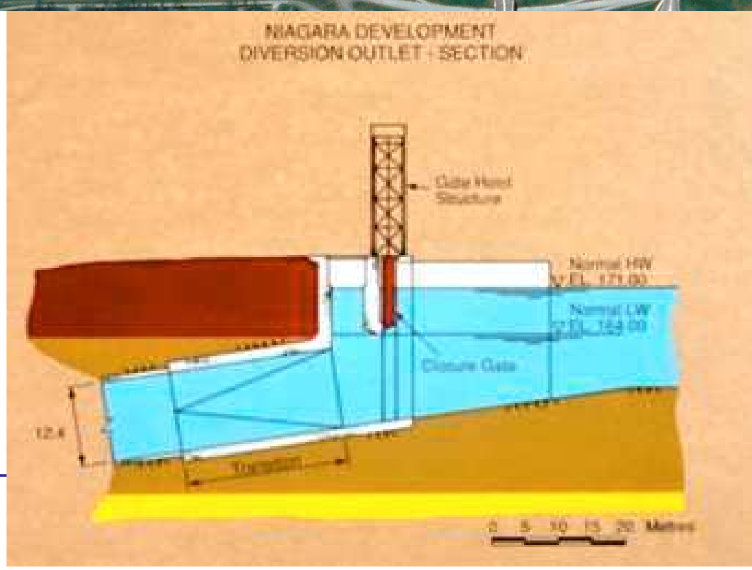




- **Intake area conceptual design developed through physical and numerical models.**
- **The tunnel intake will be located below Bay 1 of the existing International Niagara Control Works (INCW).**
- **A new Accelerating Wall will extend upstream from INCW Pier 5.**
- **A new road from Portage Road provides construction access.**

Concept Scope of Work - Outlet





- A new road from Stanley Ave provides access to the main construction area and outlet structure near the PGS reservoir.
- The storage area for the excavated rock is between the existing canals.
- The emergency gate will be incorporated into the tunnel outlet structure.

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Outlet Area & Tunnel Construction

- Blasting and rock excavation (300 m long, 23 m wide and 30-40 m deep) was completed in Apr-2006.
- A series of four conveyors transport the excavated rock from the TBM to the storage area between the existing canals
  - Queenston shale is segregated for re-use by Ontario's brick manufacturer's
  - Rock containing BTEX is initially stored on an impermeable pad.
- An enclosure was installed at the end of the overland conveyor to mitigate fugitive dust impacts in the area.
- Settling ponds and the on-site treatment plant clarify water pumped from the tunnel before discharge into the power canal.
- On-site batch plant produces shotcrete and concrete for the tunnel lining.

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Intake Construction Progress

- Mobilization of marine equipment (barges, tugs, cranes, etc) started in Apr-2006.
- Accelerating Wall replacement, Approach Wall installation and cellular cofferdam installation were completed in 2006.
- Cofferdam foundation grouting and dewatering were completed in Jul-2007.

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Intake Construction Progress

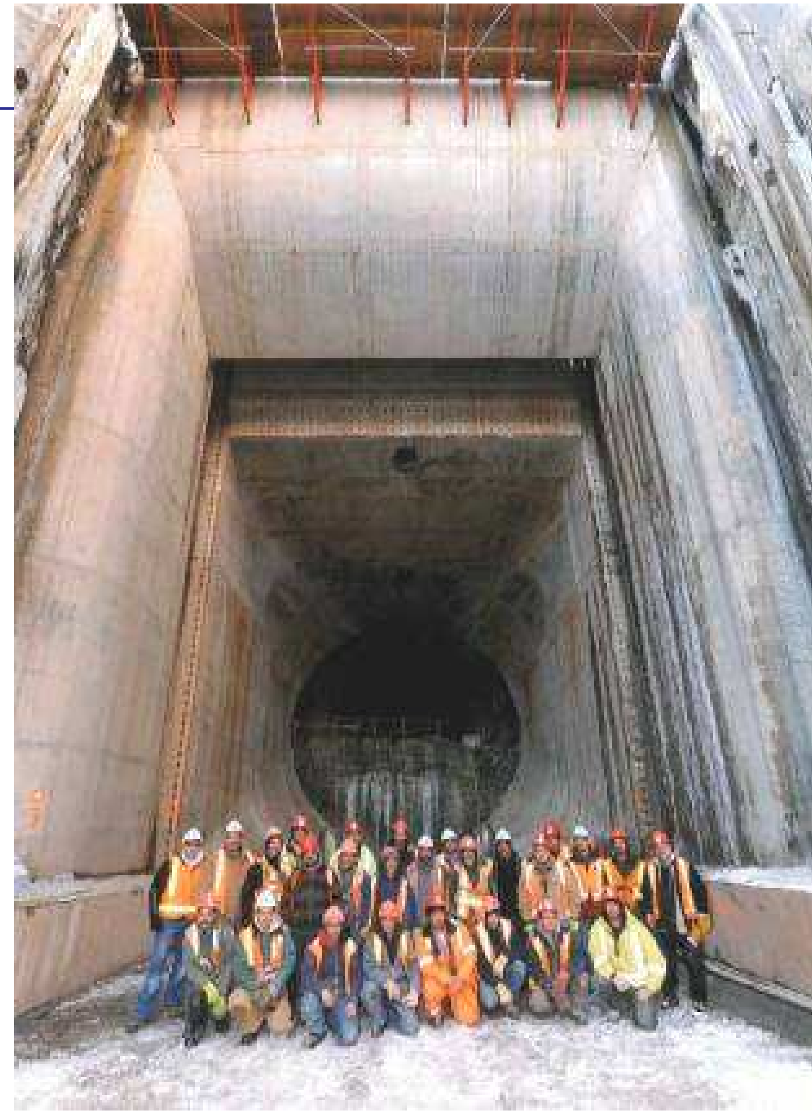
- **Intake channel excavation was completed in Jun-2008.**
- **Excavation of the 300m long grouting tunnel started in Jul-2008 and was completed in May-2009.**
- **Intake concrete followed excavation of the 300 m long grout tunnel under the Niagara River bed.**

Intake Construction Progress

Reinforced concrete Intake structure incorporates the rectangular to circular transition and sectional gates for tunnel dewatering

ONTARIO POWER GENERATION

Intake Construction Progress



Construction of the Intake Structure started in Sep-2009 and primary concrete was completed in Jan-2011

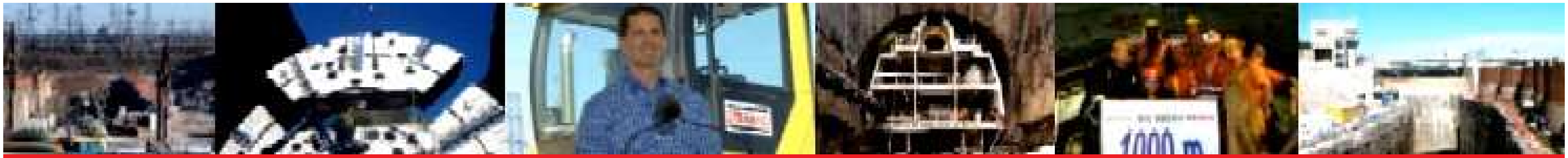
Outlet Construction Progress

Rebar and concrete placement for the Outlet structure foundation was completed during the Summer of 2008.

Outlet Construction Progress

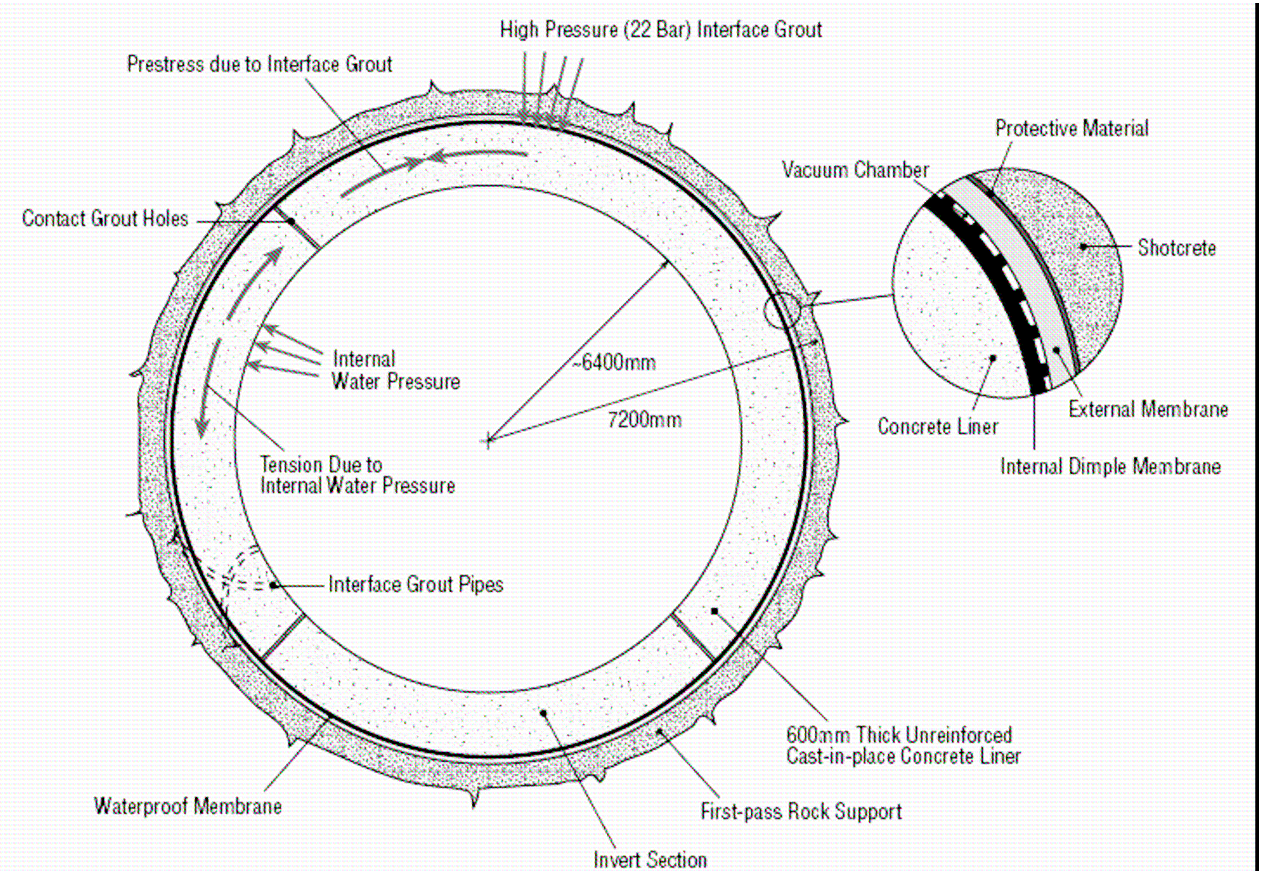
The reinforced concrete Outlet structure incorporates the circular to rectangular transition, a surge shaft and the tunnel emergency closure gate.

Primary concrete for the Outlet structure started in Jan-2011, must accommodate tunnel traffic during construction and is expected to be completed by Spring 2012.



Key Elements of the Tunnel Design

- Higher alignment with shallower slopes for decline and incline sections.
- Variable initial rock support dependent on host rock conditions includes rockbolts, wire mesh, steel ribs and shotcrete.
- Relatively simple open, hard rock TBM with sidewall grippers.
- Impermeable polyolefin membrane to prevent swelling of host shales.
- Unreinforced, cast-in-place, pre-stressed, permanent concrete liner, 600 mm thick.



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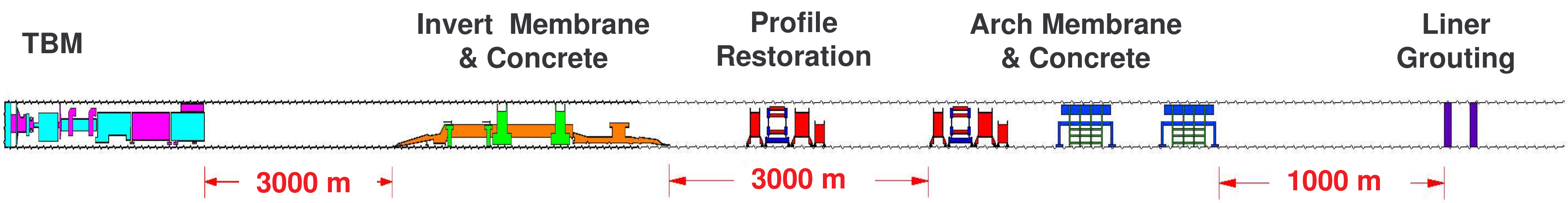
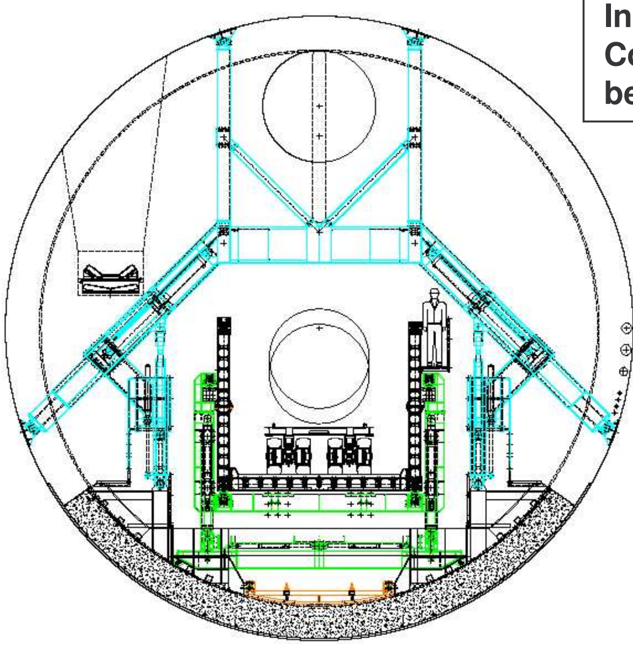
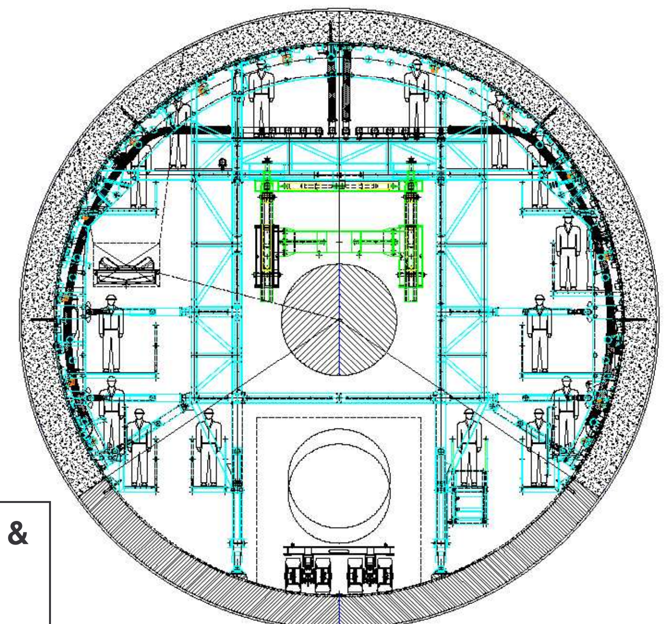
Tunnel Construction Sequence





Install Invert Membrane & Concrete Liner 3000 m behind the TBM



Install Arch Membrane & Concrete Liner 3000 m behind the Invert Liner

Launching the TBM “Big Becky” on 08-Aug-2006

- The largest open-gripper hard-rock tunnel boring machine in the world.
- Assembled for the first time on site in the outlet canal rock cut from May-Aug, 2006.
- “Big Becky” is 14.44 m high, 150 m long, weighs about 4,000 tonnes and has 85 x 500 mm cutters.
- Crew of 20 operates Big Becky 24 hours per day, 7 days per week to excavate the tunnel.

TBM Excavation Progress

TBM excavation started on 01-Sep-2006 and was substantially completed in Mar-2011.

Utilities advanced with the TBM drive included the fresh air duct, conveyor, power & communication cables, lighting, clean & dirty water piping.

Turning / parking platforms are advanced along with the various tunneling activities.

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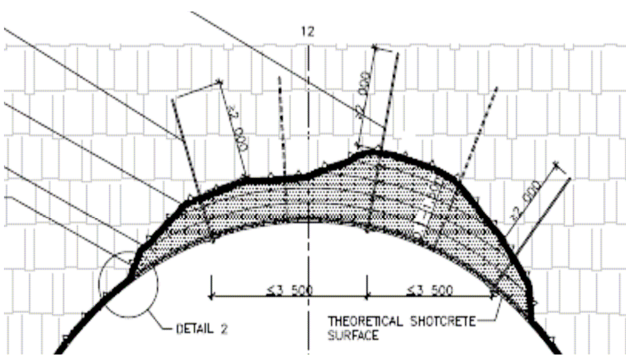
Excess Overbreak During Tunnel Excavation

Expected

Actual in Queenston Shale (Typical)

Infill Overbreak Areas



<u>Impacts of Significant Overbreak</u>

- Slow progress of TBM
- Modify TBM to safely install initial support
- Change tunnel alignment
- Additional operation to infill overbreak area
- Logistics due to concurrent TBM, infill & arch concrete
- Higher cost including more interest

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TBM Breakthrough at Intake on 13-May-2011

Invert Membrane & Concrete started in December 2008

Invert Concrete is the bottom one-third of the permanent cast-in-place tunnel lining.

The Invert Concrete operation was launched in Dec-2008 and has now progressed about 70% of the way along the tunnel route.

Invert Membrane & Concrete

Installing the polyolefin membrane

Finishing the invert concrete

Invert Membrane & Concrete

Crown Profile Restoration started in September 2009

Work platforms required to infill zones with excess crown overbreak and restore the circular cross-section of the tunnel facilitate drilling, grouting, installation of rock bolts, forms, shotcrete & concrete.

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Crown Profile Restoration in Progress

Applying shotcrete from Carrier 2

Installing steel forms from Carrier 1

Crown Profile Restoration in Progress

Shotcrete is applied to complete arch the formwork before infill with shotcrete or self-consolidating concrete

Sacrificial steel forms are suspended in position from rock anchors

Arch Membrane & Concrete Carriers

- **The arch carrier assembly is about 450m long and includes platforms for handling the ventilation duct and conveyor, for installing the membrane and for concrete placement.**

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Installing & Testing the Arch Membrane

HV testing to verify membrane integrity

Electrically testable polyolefin panels are attached by Velcro and seams are heat welded

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Arch Membrane & Concrete

Arch Membrane and Concrete near the Outlet

Concrete, delivered by 15 m^3 agitator trucks, is pumped into the arch forms

Arch Membrane & Concrete

Completed Arch Concrete at the Outlet portal

Impermeable membrane installed before the Arch Concrete at the dewatering shafts

Grouting Carrier Assembly

Assembly of Grouting Carriers at the tunnel outlet.

Contact Grouting started in Apr-2011 & Pre-stress Grouting started in Aug-2011.

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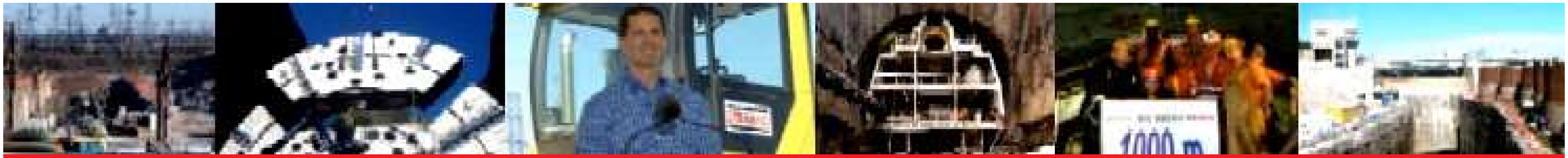

Arch Concrete completed near the Outlet Portal

Safety & Environmental Performance

- **Health & Safety Performance**
  - Health & Safety is a key focus of Strabag.
  - Strabag and its subcontractors have worked 4,776,000 hours since Sep-2005.
  - Lost Time Injury Frequency is 0.67 per 200,000 hours worked, less than half of the 1.47 average for Heavy Civil Construction in Ontario (Rate Group 732).
  - AIR is 4.6 (Rate Group 732 average is 11.4).
  - ASR is 16.5 (Rate Group 732 average is about 800).

- **Environmental Performance**
  - Challenges with design and operation of one of the most sophisticated water treatment plants employed on a construction site have been addressed.
  - Environmental non-compliances have been substantially reduced, with only 4 infractions on Certificates of Approval and only 8 minor spills to date in 2011.

Tag In / Tag Out for Tunnel Access

Water Treatment Plant

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Current Status

On Schedule & Within Budget

for updates visit
www.opg.com/niagaratunnel

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