



Clair Murdock at
one of the new locks
Panama Canal Third
Lane Expansion

Photo courtesy of Autoridad del Canal de Panamá



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BIOSKETCH

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SOME RELEVANT CONSULTING ASSIGNMENTS


	Value
1. Site C Hydroelectric Project, northern British Columbia	Some part of \$ 8 Billion
2. McLymont Creek Hydroelectric Project, northern British Columbia	\$ 400 million
3. Reventazon Hydroelectric Project, Limon Province, Costa Rica	\$2.0 Billion
4. Pando & Monte Lirio Hydroelectric Projects, Chiriqui Province, Panama	\$300 million
5. Rusumo Falls Hydroelectric Project, Kagera River, Rwanda & Tanzania, Africa	\$200 million
6. Bonyic Hydroelectric Project, Bonyic River, Bocas del Toro Province, Panama	\$95 million
7. Inga 3 Hydroelectric Project, Congo River, Democratic Republic of the Congo, Africa	\$4.5 billion
8. Gull Island Hydroelectric Project, Lower Churchill River, NL, Canada	\$200 million
9. Eastmain 1-A Powerhouse Excavation, James Bay, QC, Canada	\$50 million
10. Rupert River Dam, Dikes & Control Structure, James Bay, QC, Canada	\$56 million
11. Rupert River Diversion Tunnel, James Bay, QC, Canada	\$57 million
12. Little Jackfish Hydroelectric Project, ON, Canada	\$500 million
13. Revelstoke Unit 5 Hydroelectric Project, Columbia River, BC, Canada	\$230 million
14. Concepcion & Alto Lino Hydroelectric Projects, Chiriqui Province, Panama	\$30 million
15. Peribonka Dam, Dikes A & B, Phase II Spillway Excavation, QC, Canada	\$91.7 million
16. Panama Canal Third Lane Locks, Panama	\$5.25 billion
17. Grand-Mere Powerhouse Concreting, Grand-Mere, QC, Canada	\$122 million
18. Touloustouc Powerhouse Excavation, Touloustouc River, QC, Canada	\$50 million
19. Touloustouc Intake Tunnel, Touloustouc River, QC, Canada	\$80 million
20. Touloustouc River Dam & Dike, Touloustouc River, QC, Canada	\$75 million
21. Eastmain River Diversion Tunnel, James Bay, QC, Canada	\$30 million
22. Eastmain Intake & Powerhouse Excavation, James Bay, QC, Canada	\$50 million
23. Eastmain River Main Dam, James Bay, QC, Canada	\$100 million
24. Eastmain Intake & Powerhouse Concreting, James Bay, QC, Canada	\$110 million
25. Fortuna Dam, Chiriqui Province, Panama (1979 – My first Panama Project)	\$250 million

SUMMARY OF EXPERIENCE

I am a Canadian Professional Quantity Surveyor (PQS) and heavy civil construction consultant, with 58 years of heavy civil experience on four continents.



Following 20 years out on projects, the last 46 years of my career have been as a bidding consultant, helping contractors with their bids for dams, powerhouses, spillways and, particularly, for tunnels of all types, as required for: potable water, storm and waste water; hydroelectric-diversion, intake, penstock, tailrace; rapid transit, vehicular, nuclear waste storage and for defense purposes. During this period, I have also provided specialist support to owners, engineering firms and bonding companies on the cost, constructability, schedule, risk-sharing and contractual aspects of heavy civil projects- tunnels, dams, dikes, locks, bridges and hydroelectric powerhouses, intakes and spillways.



Owner clients during this period include: ACP - the Panama Canal Authority, BC Hydro, Hydro-Québec, INMET Mining, Nalcor Energy (Newfoundland & Labrador Hydro), Newmont Mining, OPG (Ontario Hydro), SEBJ (James Bay Energy Corp.), the Lesotho Highlands Development Authority (LHDA), City of Edmonton, Metro Vancouver (GVRD) and the BC Ministry of Transportation & Highways. Some engineering clients during this period: AECOM, AMEC, Bechtel, Canadian International Project Managers (CIPM), Delcan, EBA, Halcrow, Hatch Energy (Acres), Klohn Crippen Berger, MWH (Harza), Parsons-Brinkerhoff, SNC-Lavalin, Worley-Parsons, along with several large civil works contractors, for projects both within and outside Canada. Prior to leaving the SEBJ staff in 1976, I had worked over 20 years with contractors and owners, including: Peter Kiewit Sons, Perini, Merritt-Chapman & Scott, Ontario Hydro (now OPG), Hydro-Québec and SEBJ.






My estimating software, used for over 15 years, is  **HeavyBid** HCSS HeavyBid Comprehensive, widely used by Canadian, American and international contractors and engineers for their cost estimating and bidding. My experience as a tunnel estimator and project manager includes: drill & blast, TBM, EPBM, RH, NATM, and immersed tubes. I have served on several panels of experts, including: the Lesotho Highlands Water Project in southern Africa, comprised of 85km of 5.5m TBM-bored tunnels in basalt, and Katse Dam, a 185m high double-curvature arch dam, which required 2,320,000m³ of concrete; The Sir Adam Beck III twin intake tunnels at Niagara Falls- 2 tunnels of 10.4km each, with a 13.5m TBM (layout was changed to one slightly larger tunnel); Vancouver's Seymour-Capilano Water Tunnels- 2 tunnels, each 7.1km, driven with two 3.9m dia. TBMs, with 3 deep shafts.






I am a member of: The Canadian Institute of Quantity Surveyors- CIQS; the Association for the Advancement of Cost Engineering- AACE International; Tunnelling Association of Canada- TAC; the Canadian Dam Association- CDA (ICOLD-affil.) and SME- Society for Mining, Metallurgy and Exploration, Inc.- Underground Construction Association. I have presented tunnelling papers to two World Tunnel Congresses, in Prague, May 2007 and in Vancouver, May 2010; RETC in Toronto, June 2007; NAT in Portland, June 2010 and the Tunnelling Association of Canada, Niagara Falls, September, 2008.

SOME RELEVANT CONSULTING ASSIGNMENTS

- 1. Site C Hydroelectric Project, northern British Columbia** **Some part of \$ 8 Billion**
Owner: BC Hydro My client: BC Hydro/KCB
Project: 1,100 MW hydroelectric plant, with 2 diversion tunnels, 6 generating units, 8 bay spillway and an auxiliary spillway. 22,000,000 m³ of embankment, 32,000,000 m³ of excavation- near Fort St. John, BC.
My assignments:
a) Review the 2010 cost estimates, including the two diversion tunnels, then at 9.8 m finished diameter.
b) Develop methods, costs and schedules for the 2 tunnels, using alternate excavation & support methods.
c) Develop methods, costs and schedules for 2 larger tunnels, of ~11.2 m finished diameter.
- 2. McLymont Creek Hydroelectric Project, northern British Columbia** **\$ 400 million**
Owner: AltaGas My client: AltaGas/AECOM/RSW
Project: A private power project, with a diversion weir, an intake, a 3 km long power tunnel, a 3-unit, 77 MW powerhouse, substation and 10 km of transmission line. This project is near the Forest-Kerr powerhouse. Isolated northern site, with demanding access logistics and extremely challenging site conditions.
My assignment: To review, on behalf of AltaGas, the project layout, the construction cost and the schedule.
- 3. Reventazon Hydroelectric Project, Limon Province, Costa Rica** **\$2.0 Billion**
Owner: Instituto Costarricense de Electricidad (ICE) My client: IDB/AECOM
Project: A run-of-river hydroelectric plant, 305 MW installed capacity.
Review the project costs, planning, methods and equipment, as part of the Inter-American Development Bank's due diligence review, preparatory to IDB making a \$ 200 million loan.
My assignment: To participate in San Jose and onsite meetings, reviewing and commenting on the project costs.
- 4. Pando & Monte Lirio Hydroelectric Projects, Chiriqui Province, Panama** **\$300 million**
Owner: Electron Investments, S.A. My client: SNC-Lavalin Inc.
Project: Two run-of-river hydroelectric projects, in cascade- 33 MW (Pando) & 52 MW (Monte Lirio)
13,000m (combined) for 2 intake tunnels, bored by EPBM; 67,000m³ of RCC; 53,000m³ of conventional concrete
My assignment: Review constructability, cost estimates and schedules; comment on job risks & contingencies.
- 5. Rusumo Falls Hydroelectric Project, Kagera River, Rwanda & Tanzania, Africa** **\$200 million**
Owner: The governments of: Burundi, Rwanda, and Tanzania My client: SNC-Lavalin Inc.
NELSAP- Nile Equatorial Lakes Subsidiary Action Program
61.5 MW hydroelectric project- dam, spillway, intake, power tunnel, 3 unit powerhouse, tailrace channel.
My assignment: Prepare the construction cost estimate for: SNC-Lavalin, the World Bank, NELSAP, and other funding agencies. 
- 5. Bonyic Hydroelectric Project, Bonyic River, Bocas del Toro Province, Panama** **\$95 million**
Owner: Hidroecologica del Teribe, S.A. (Columbia) My client: Constructora Urbana
Project: 30 MW hydroelectric project, including: 80,000m³ RCC dam, 4km intake tunnel, 3 unit powerhouse.
My assignment: Prepare the contractor's bid. 

- 7. Inga 3 Hydroelectric Project, Congo River, Democratic Republic of the Congo, Africa** **\$4.5 billion**
Owner: The Democratic Republic of the Congo My client: SNC-Lavalin
Project: 4,000 MW hydroelectric project on the Congo River, at the early planning stages. 16 unit powerhouse; 8 intake tunnels of 15m diameter, to be excavated with two TBMs, each tunnel 6,360m long= 50.9 km in total; 8,765,000m³ of underground excavation, by TBM and drill & blast; 25,000,000 m³ of open cut rock excavation.
My assignment: Prepare the capital cost estimate for all civil works. 
- 8. Gull Island Hydroelectric Project, Lower Churchill River, NL, Canada** **\$200 million**
Owner: Nalcor-Newfoundland & Labrador Hydro My client: Nalcor
Project: 2,400 MW hydroelectric project- 4 unit surface powerhouse; underground penstocks; diversion tunnels; 11,000,000m³ zoned rock fill embankment.
My assignment: Review the diversion tunnel construction methods, equipment fleet, manpower and schedule.
- 9. Eastmain 1-A Powerhouse Excavation, James Bay, QC, Canada** **\$50 million**
Owner: Société d'énergie de la Baie James (SEBJ/Hydro-Québec) My client: Simard-Beaudry Construction
Project: Rock excavation for the 3 unit powerhouse, with rock cuts up to 80m deep, done in 9 benches. 1,602,500m³ of rock excavation, using 55 tonne trucks and 988 loaders.
My assignment: Prepare the contractor's estimate and participate in the JV bidding exercise. 
- 10. Rupert River Dam, Dikes & Control Structure, James Bay, QC, Canada** **\$56 million**
Owner: Société d'énergie de la Baie James (SEBJ/Hydro-Québec) My client: Simard-Beaudry Construction
Project: Construct the Lemaire Dam & 15 dikes, all zoned S+G till core embankments, totaling 900,000m³ of fill; 400,000m³ of rock excavation, 500,000m³ of common excavation; construct 2 concrete flow control structures.
My assignment: Prepare the contractor's estimate and participate in JV bidding; job was awarded to my client.
- 11. Rupert River Diversion Tunnel, James Bay, QC, Canada** **\$57 million**
Owner: Société d'énergie de la Baie James (SEBJ/Hydro-Québec) My client: Simard-Beaudry Construction
Project: Excavate a diversion tunnel to redirect a substantial portion of the flow of the Rupert River into the Eastmain River watershed, for hydroelectric purposes. The diversion tunnel is 2,908m long, 12.7m wide and 18.6m high, all done by drill & blast, by the heading & bench method. Underground excavation- 651,300m³. Of this total, 282,000m³ is top heading, 369,300m³ as benching. The US & DS portals required a further 467,000m³ of rock excavation.
My assignment: Prepare the contractor's estimate and bid. Assist Simard-Beaudry Construction with equipment purchases and sub-contractor negotiations, leading to the Q2 2007 mobilization to the site. Three Sandvik (Tamrock) Axera T-11 three-boom drill jumbos (two with full data control) and one Sandvik T-8 two-boom jumbo were purchased for the project. 55 tonne trucks and 988 loaders were used to muck the tunnel. Job completed.
- 12. Little Jackfish Hydroelectric Project, ON, Canada** **\$500 million**
Owner: Ontario Power Generation My client: Hatch Energy (Acres)
Project: Plan and engineer a hydroelectric project at a remote site, north of Lake Superior and Lake Nipigon, considering both two-stage and single-stage generation developments. Involved are: access roads, construction camp(s), sub-aqueous excavations, embankments, intake structures, spillways, powerhouse(s) and 4,000m of tunnel and shaft work.
My assignment: Review the schedules, planning and budgets. Comment on constructability, suggest alternatives.

- 13. Revelstoke Unit 5 Hydroelectric Project, Columbia River, BC, Canada** **\$230 million**
Owner: BC Hydro My client: BC Hydro
Project: Add a fifth generating unit (520 MW) to the circa 1983 powerhouse, which has a current installed capacity of 1,980 MW, bringing the total to 2,500 MW.
My assignment: Perform a peer review of the capital cost estimate, including analysis of the construction methods, schedule, design and project management elements, risk assessment and escalation provisions.
- 14. Concepcion & Alto Lino Hydroelectric Projects, Chiriqui Province, Panama** **\$30 million**
Owner: Two private developers, planning on selling into the national grid. My client: Constructora Urbana
Project: Two small run-of-river hydroelectric plants, both on extremely difficult foundations.
My assignment: Review constructability, including cut-off walls, develop alternate construction methods, bid.
- 15. Peribonka Dam, Dikes A & B, Phase II Spillway Excavation, QC, Canada** **\$91.7 million**
Owner: Hydro-Québec My client: Simard-Beaudry Construction
Project: Zoned rockfill dam & two dikes, with slurry wall cut-offs- 4,037,000m³ of embankment; spillway rock excavation of 1,056,000m³, with the excavated rock placed into the three embankments.
My assignment: Prepare the contractor's estimate and bid. 
- 16. Panama Canal Third Lane Locks, Panama** **\$5.25 billion**
(4,500,000 m³ of concrete and 95,000,000 m³ of excavation)
Owner: Autoridad del Canal de Panama- ACP My client- ACP/Parsons Brinkerhoff
Project: The Third Lane Locks, adding 6 new locks and water-saving basins, 3 at the Atlantic end, 3 on the Pacific. The 6 locks required 4,500,000m³ of concrete and RCC, 95,000,000m³ of wet and dry excavation.
My assignment: Provide estimating leadership to ACP's Estimating Team, by detailed conceptualization of the construction methods, equipment, crews and productivities required to develop and complete a realistic Owner's Estimate, based on conceptual-level pre-bid documents; in addition, review and critique the drawings, to identify those areas requiring further engineering consideration in advancing the design towards bidding.
My contribution was cited by ACP in their inaugural press release and was favourably commented-on by the ACP Panel of Experts- see the ACP website- www.pancanal.com. At my suggestion, ACP acquired a multi-user  and had 6 ACP engineers trained by an  coach.
- 17. Grand-Mere Powerhouse Concreting, Grand-Mere, QC, Canada** **\$122 million**
Owner: Hydro-Québec My client: Simard-Beaudry Construction
Project: 250 MW Grand-Mere Powerhouse, 2 units, 10 bay spillway, 125,000m³ of concrete.
My assignment: Prepare the contractor's estimate and bid. 
- 18. Toulnostouc Powerhouse Excavation, Toulnostouc River, QC, Canada** **\$50 million**
Owner: Hydro-Québec My client: Simard-Beaudry Construction
Project: Excavation of the powerhouse, the surge shaft, the powerhouse access tunnel, the penstocks and the downstream 2,500m of the 11m x 13m intake tunnel, all totaling to 400,000m³ of rock, all done by drill & blast.
My assignment: Prepare the contractor's estimate and bid. 

- 19. Toulnostouc Intake Tunnel, Toulnostouc River, QC, Canada** **\$80 million**
Owner: Hydro-Québec My client: Simard-Beaudry Construction
Project: 550 MW Toulnostouc hydroelectric project- Excavation of the intake structure, the upstream 7,600m of the intake tunnel (11m x 13m cross-section) and the 500m long access adit- 11m x 8m cross-section. 1,100,000m³ of underground rock excavation, by drill and blast.
My assignment: Prepare the contractor's estimate and bid. 
- 20. Toulnostouc River Dam & Dike, Toulnostouc River, QC, Canada** **\$75 million**
Owner: Hydro-Québec My client: Simard-Beaudry Construction
Project: Construct the main dam and south dike, both concrete-faced rockfill embankments; excavate the diversion tunnel and the spillway; remove the existing Lac Ste-Anne Dam; low level outlet structure.
My assignment: Prepare the contractor's estimate and bid. 
- 21. Eastmain River Diversion Tunnel, James Bay, QC, Canada** **\$30 million**
Owner: Société d'énergie de la Baie James (SEBJ/Hydro-Québec) My client: SEBJ
Project: 500 MW EM-1 hydroelectric project- Diversion tunnel excavation- 343m long x 14m wide x 18.4m high, 80,000m³ of underground rock, heading and bench; 506,000m³ of open cut rock in the approach channel.
My assignment: Prepare the Owner's tender check estimate and perform the pre-award analysis of 11 bids.

- 22. Eastmain Intake & Powerhouse Excavation, James Bay, QC, Canada** **\$50 million**
Owner: Société d'énergie de la Baie James (SEBJ/Hydro-Québec) My client: SEBJ
Project: 500 MW EM-1 hydroelectric project- Powerhouse excavation- 1,177,000m³ of common excavation, 1,088,000m³ of open cut rock; 46,000m³ of underground rock for the penstock access tunnel and 3 penstocks.
My assignment: Prepare the Owner's tender check estimate and perform the pre-award analysis of 8 bids.

- 23. Eastmain River Main Dam, James Bay, QC, Canada** **\$100 million**
Owner: Société d'énergie de la Baie James (SEBJ/Hydro-Québec) My client: A surety company
Project: Construction of the Eastmain River Dam and nearby dikes- 5,000,000m³ of zoned fill.
My assignment: Review a contractor's bid for their bonding company.
- 24. Eastmain Intake & Powerhouse Concreting, James Bay, QC, Canada** **\$110 million**
Owner: Société d'énergie de la Baie James (SEBJ/Hydro-Québec) My client: Simard-Beaudry Construction
Project: 500 MW EM-1 Powerhouse and Intake Concreting- 61,400m³ of concrete, 3,900 tonnes of rebar.
My assignment: Prepare the contractor's estimate and bid. 
- 25. Fortuna Dam- Chiriqui Province, Panama** **\$250 million**
Owner- IRHE (state electricity board) Instituto Recursos Hydro Electricos **(in 1979 rates)**
Project: 300 MW installed capacity- largest hydro plant in Panama.
Finance by- The World Bank, Washington, D.C. Engineer- Charles T. Main Consultants, Boston, Massachusetts
My assignment: Prepared a contractor's bid for the JV of CUSA and SNC, Montreal

SUBAQUEOUS TUNNEL EXPERIENCE

1. Montréal Urban Community (MUC/CUM)

Cow Island Outfall Tunnel (Emissaire Ile-Aux-Vaches)

- 5km, under the St. Lawrence River
- 7m dia. Robbins TBM, probe drilling

My client: Di Orio / De Silva JV - contractor

2. Hydro Québec Grondines Cable Tunnel

- 4km, under the St. Lawrence River
- 15% downslope, 15% upslope at the two ends
- 4m dia. Robbins TBM, conveyour muck removal.

My client: Torno Construction, Milan, Italy

My assignment: Bid the work, find the TBM and people

3. DEVCO – Cape Breton Development Corporation, (a Canadian government agency)

Donkin–Morien Mine Access Tunnels

- Two parallel tunnels, on a 20% downgrade, out under the Atlantic Ocean, to give access to several million tonnes of high-grade coal.
- One drive by a 7m dia., Lovat TBM, the other by drill & blast, 5m x 7m heading – Gassy Mine

My assignment: I bid the project for my contractor client, Beaver Construction, Montréal.

Note: I proposed to DEVCO a unique contract formula – “target price and incentives”. DEVCO liked it and signed a contract with Beaver. I also served for several months as Site Project Manager for Beaver.

Both drives were completed on-time and under budget.

4. SEBJ – Société d’énergie de la Baie James (a Hydro Québec subsidiary, created to build an eight (8) powerhouse project that can generate 16,527 megawatts).

Rupert Diversion Tunnel

- This large tunnel – 2,907m long, 18.6m high x 12.7m wide – is, for several hundred metres, 50 to 100m directly below Lake Sillimanite, Québec.
- Probe-drilling 20m beyond the face was required. No water problems were encountered.

The project was completed 1 year early, on budget.

My assignment: Prepare a “stealth bid”, (don’t let the competition know what you’re up to); conceptualized the execution; identified potential site staff; participated in negotiations for four (4) Tamrock jumbos – 11 booms; followed-up jumbo fabrication in Tampere, Finland, etc.

SUBAQUEOUS TUNNEL EXPERIENCE (con't)

5. Translink – Vancouver’s transit authority

Canada Line – downtown Vancouver to Vancouver International Airport, (the section between Olympic Village station and Vancouver City Centre station, crossing under tidal False Creek).

I had two separate involvements:

#1 – for Golder Associates - Enumerate, quantify, discuss (and “solve”?) questions related to encountering -

- Abandoned tie-backs, detensioned
- Abandoned tie-backs, under tension
- Boulder and cobble nests
- Boulder & cobbles requiring intervention at the face
- Sand pockets with water connection
- Liquid soils

#2 – for SNC-Lavalin - after they were awarded the overall contract by Translink

SNC-Lavalin had previously declined my offer to do a cost estimate risk & definition. My intent was to give SNC-Lavalin a document from which the prospective tunnel sub-contractors’ proposals might be evaluated.

- Tunnel length – 2,467m x 2 tunnels.
- Tunnel bore diameter – 6.2m.
- Seli’s contract value C\$138 million.

Note: SNC-Lavalin asked me to do a an analysis of Seli’s proposal. After several weeks of work, I found a systematic error in Seli’s proposal that gave SNC-Lavalin an opportunity to negotiate a price reduction of C\$6 million in the overall cost. (My consulting fees totalled less than C\$60,000).

Seli went on to complete the job, on-time and without (as far as I know) any claims.

TRANSIT TUNNEL EXPERIENCE

CANADA

- Montreal Metro – Various sections, including the recent Laval extension
- Ottawa LRT – Downtown tunnels
City of Ottawa, Delcan
- Toronto TTC - Sheppard Avenue
Delcan
- Calgary LRT - Cemetery Hill
Beaver Construction
- Edmonton - Various lines
AECOM
- Vancouver LRT - Canada Line
1. Golder
2. SNC – Lavalin

USA

- San Juan, Puerto Rico - Tren Urbano
Dr. Gary Brierly ([Doctor.Mole](#))

PANELS OF EXPERTS / BOARDS OF CONSULTANTS

1. Lesotho Highlands Development Authority (LHDA)

At the suggestion of ACRES, I was recruited to a 4-man panel, chaired by Pierre Londe, France, (a former ICOLD president); Alfred “Skip” Hendron – Professor, University of Illinois, Champagne-Urbana campus; Prof. Jeff Johnson, University of Grenoble.

LHDA convened the panel to review and comment – leading to some very substantial revisions in the design to:

Katse Dam – 185m high durable-curvature arch dam, requiring 2,320,000m³ of concrete.

Transfer & delivery tunnels, by 5.5m diameter TBMs.

The panel met frequently in Maseru, Lesotho over the following years and made a very substantial contribution to the success of this first phase of the project.

2. Lesotho Highlands Development Authority (LHDA)

Again, at ACRES’ suggestion, I was appointed to a panel, this time covering the siting of Mohale Dam and spillway. Each of the 5 potential sites has unique advantages and disadvantages, having to do with:

Foundation conditions; excavation and fill quantities; proximity to burrow volumes, etc. Each of the 5 potential sites was suitable for a CFRD. The panel was able to agree on a site.

3. Metro Vancouver (GVRD) - Seymour-Capilano Twin Wáter Tunnels

Along with tunnel luminaries such as Dr. Evert Hoek and John McDonald, I was engaged by GVRD to review and critique the planned twin tunnels – 2 x 7.1km with two 3.9m dia. TBMs. We found lots to critique, resulting in a 6-month delay due to the required engineering. All of our changes were incorporated in the final design.

4. Peace Bridge Authority - Peace Bridge Twinning – Buffalo, New York to Fort Erie, Ontario

Member of an advisory panel on the proposed twinning. Over the past 15 years, nothing has been done to advance this vital project, proving once again – *“Talking is cheaper than building”*.

(And several other panels and boards).



Fast-track drill+blast in Canada

Apr 2010

Impressive drill+blast excavation had a large-scale water transfer tunnel in Canada completed in record time. Clair Murdock and Ron Glowe, independent bidding and explosives consultants to the contractor, describe the undertaking.

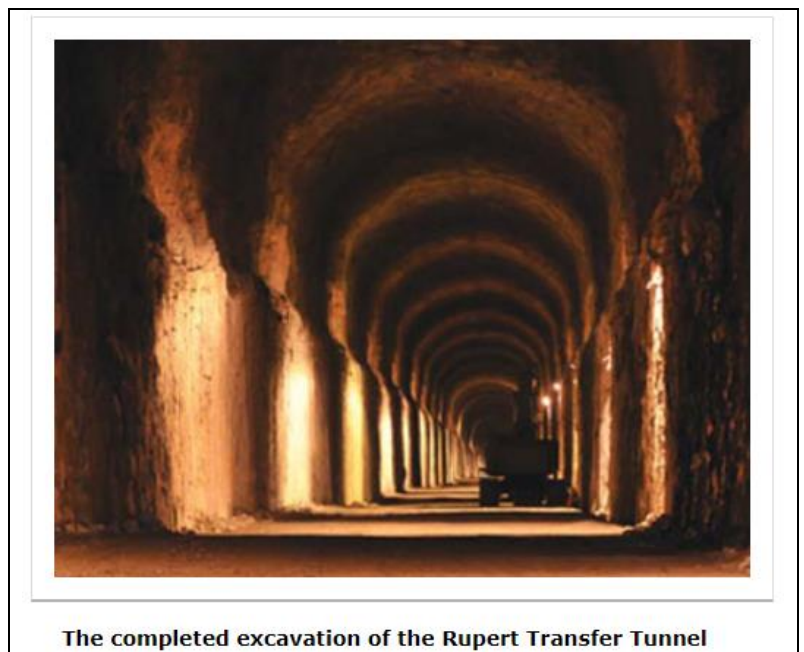
The Rupert Transfer Tunnel in Québec, Canada is 2.9km long and is designed to transfer 800m³/sec of water from the Rupert River watershed into the Eastmain River watershed to double the generating capacity of five hydro plants on the Eastmain River - two new generating stations now under construction - the 768MW Eastmain-1-A powerhouse and the 150MW Sarcelle powerhouse - and three existing schemes.

The 2.9km long x 18.6m high x 12.7m wide pay-line tunnel was excavated on a drill+blast topheading and bench sequence using modern computer-controlled jumbos to progress the heading from both ends, working alternating rounds, and employing crawler hydraulic drills for vertical charge holes to advance the 10m high bench from one end only. Large side-dump loaders and 50 tonne trucks mucked out both the heading and bench. Working on a schedule of two 10hr shifts/day, five and a half days/week, the 651,300m³ of Canadian Shield granite rock was excavated in 13 months.

To put this into a TBM context, the excavated volume equals 23km of 6m diameter TBM tunnel. To excavate the same rock volume in the same amount of time, that hypothetical 6m TBM would have to advance at an average of 1,772m/month.

The total 229m² tunnel was excavated in 2007 and 2008 working through a tough sub-Arctic winter with temperatures reaching -40° Celsius and avoiding the need to endure a second.

In addition to the 2,908m long tunnel, the Can\$5 billion investment by Hydro-Québec, the largest hydropower generator in the world, includes four dams, a spillway on the Rupert River, the two new powerhouses and two forebay lakes.



The completed excavation of the Rupert Transfer Tunnel

Two 3-boom Sandvik (Tamrock) T11A data jumbos, with man-baskets worked in the 8.6m high x 13.7m wide (102m² excavated) topheading to remove 282,000m³ of rock. The 5.8m deep x 57mm diameter charge holes in the topheading round pulled on average 5.4m to break about 524 bulk m³ of rock, or about 1,400 tonnes of muck per round. For 15m at each end, the pilot-and-slash technique was used, with the pilot rounds limited to a 2.5m pull, leaving at least 2m of rock to the pay-line for the subsequent slash round. For the 300m drive under Lake Sillimanite, probe drilling was required for a minimum 10m beyond the topheading face.

Five hydraulic crawler drills were used to excavate the 369,300m³ of the 10m high x 12.7m wide (127m²) bench. Each 10-12m bench round broke out about 1,524 bulk m³, or about 4,100 tonnes of rock. Cat 988 side-dump loaders, into a fleet of up to six Cat 773 trucks of 50 tonne capacity mucked out each topheading and bench round. Power scaling was done with Cat 365 hoes. Each round was bolted and meshed to the face before drilling of the next round was started.



Loading a topheading round with a Sandvik T11A jumbo in the foreground

The job was bid in January 2007 and awarded for \$57 million to the low bidder, Simard-Beaudry Construction, in late March 2007. Four new drill jumbos were ordered conditionally from Sandvik (Tamrock) in February to gain time on the schedule. The fleet of jumbos comprised two data T11's, one non-data T11, and a 2 boom T8 for rockbolting. Mobilization, clearing of the portals and construction of temporary power lines and access roads started in April, 2007.

After site mobilisation, pilot-and-slash work at the downstream portal started in September 2007. Due to unforeseen rock excavation difficulties, the upstream portal work was finished later than planned, concluding in October 2007. Tunnelling on a sustained basis from both ends started in mid-October 2007.

After a two-week shutdown for the Christmas/New Year holiday, topheading work finished in early June 2008, completing the topheading in a total eight months. Benching was completed by early November for a benching duration total of five months and an overall tunnel excavation of 13 months and substantial demobilization of the site by December 2008, avoiding a second winter

The tunnel was finished 12 months ahead of the owner's diversion schedule requirement with filling of the Rupert River forebay started in November 2009, a year after all tunnelling was completed.

As the largest hydroelectric generator in the world, Hydro-Québec currently operates 59 hydroelectric powerhouses equipped with 336 turbines and producing 33,680MW. The generator also owns and operates the largest underground powerhouse complex in the world, with the 22 units installed at the Robert Bourassa (LG-2) and LG-2A site having a total capacity of 7,722MW. The added water delivery of the Rupert Transfer Tunnel will add substantially to the energy benefits of the powerstations in the Eastmain River chain of installations.

Further details of the project will be described in a paper by Clair Murdock and Ron Glowe, to be presented at the ITA World Tunnel Congress in Vancouver in May 2010.

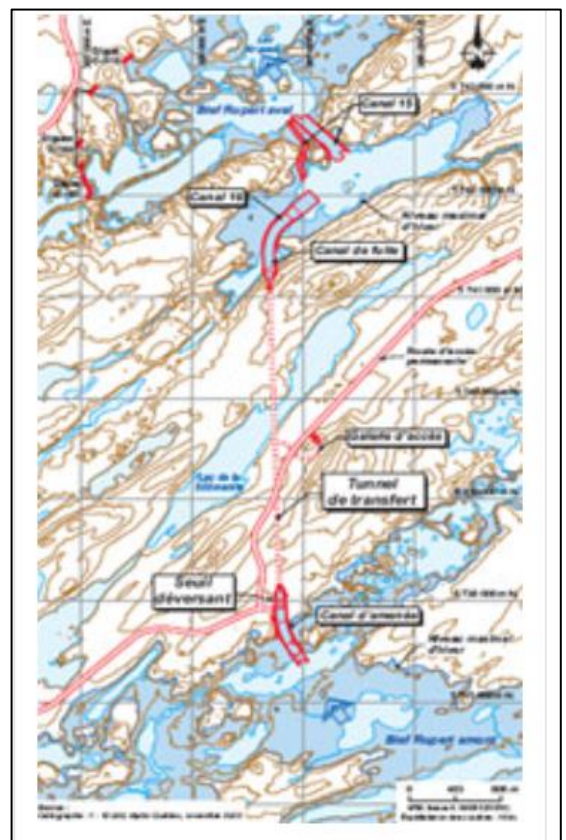


Fig 1. Plan of the Rupert Transfer Tunnel

Article and graphics can be viewed online here

<http://www.tunneltalk.com/Canada-Apr10-Fast-track-drill-blast-excavation.php>