

# Pingston Hydro Project - New Production Challenges for Independent Developers of Small Hydro in British Columbia

*Paul G. Kemp, P. Eng. and Cory J. Williams, P. Eng.  
Canadian Projects Limited, Calgary, Alberta, Canada*

## **Abstract**

*Several independent small hydro projects have been developed in British Columbia (BC) during an initiative to meet new generation requirements from private sources by BC Hydro, the major provincial generation, transmission and distribution utility. At the same time, the project approval process and the associated government agencies continue to undergo major reorganization and refinement. In this setting, several project challenges have emerged through the stages of bringing new hydro production on-line in BC. Project managers and engineers draw on these experiences to strategize development for other new projects in British Columbia.*

*The 45 MW, 590 m head Pingston Hydro Project was a significant project undertaken in this period of approval and market uncertainty. The authors describe their numerous challenges, observations and the lessons learned over this ten year project.*

## **Introduction**

There are numerous challenges faced by independent developers of small hydro in British Columbia as they bring their projects on-line. These challenges can be categorized as follows:

- Market Challenges
- Approval Challenges
- Technical Challenges

The experiences during the development of the Pingston Hydro Project are described herein to provide the context and magnitude of these challenges.

The 45 MW, 590 m head Pingston Hydro Project is located 60 km south of Revelstoke in the interior of British Columbia. The project was technically aggressive, it included constructing 4 km of tunnel in a mountainous region that receives over 6 m of snow in its upper valleys and building and upgrading 52 km of 69 kV transmission line over public and private lands.

The project is jointly owned by independent power producers Canadian Hydro Developers of Calgary, Alberta and Brascan Power of Sault Saint Marie, Ontario. Canadian Projects Limited provided project management and engineering through development and construction.

The development process took ten years beginning in the fall of 1994. Detailed design and construction began in September 2000 and two generating units were commissioned in April 2003, with a third unit being commissioned in April 2004.

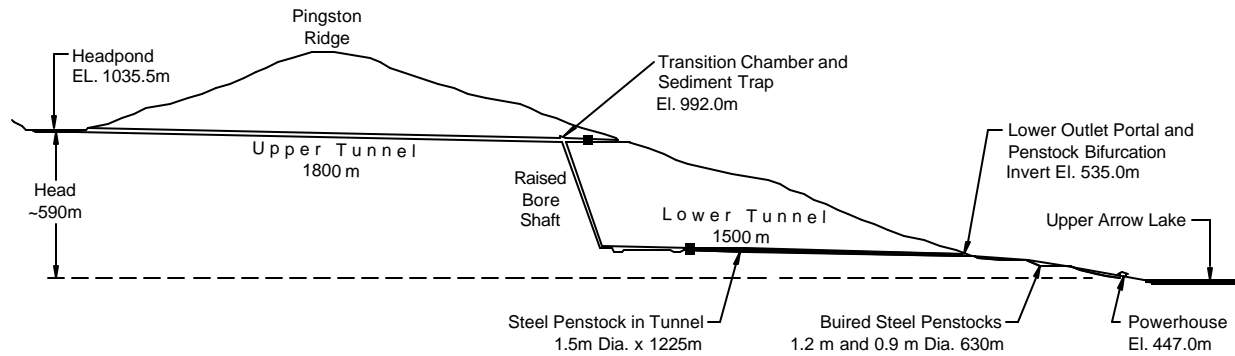


Figure 1: Pingston Hydro Project Profile

## Market Challenges

The Pingston project was conceived in 1994 by a local entrepreneur in Revelstoke, BC. In collaboration with the principals of Canadian Projects, the project concept was significantly refined and subsequently the project was sold to Canadian Hydro Developers, who later partnered with Brascan Power Limited to develop the project.

The project was submitted to BC Hydro in a 1995 Request for Proposals, but was not selected; losing out to several cogeneration projects, most of which have yet to be developed. A few years later, it was decided to take a rare step and pursue the project as a merchant plant. Thus, final design and construction began without an energy purchase agreement in place. The final project development and approvals process was initiated in 1997. During this process and continuing through detailed design, some opportunities arose to sell the power to various buyers. Meanwhile, negotiations continued with BC Hydro.

For several energy sales opportunities, energy delivered during peak load hours of the day was priced higher than off-peak hours. Although the plant would run at capacity and spill for 60-70% of the time, there was an opportunity to shape daily production during low-flow periods by constructing a small 'shaping' headpond at the intake. Although neither the energy purchaser nor the energy purchase agreement structure were known at the time, the headworks was designed and constructed to create this shaping headpond including a 12-metre high embankment dam and ogee-crested concrete spillway. The headpond can provide 8 to 12 hours of daily production shaping during low-flow periods.

In 2001, construction of this merchant plant was well underway, nearing 50% complete, when BC Hydro invited independent power producers to submit green power projects for energy purchase agreement (EPA) consideration. The Pingston Project was offered an EPA, which was executed just prior to plant commissioning. With significant risk, the "build it and they will come" market approach paid-off for Pingston. BC is currently Canada's most active renewable energy market.

## Approval Challenges

There are extensive approval challenges for small hydro in BC, some of the key ones are described here.

### *Regulatory Process*

Project approval uncertainty, variations and inconsistency are by far the most significant new production challenge for independent developers of small hydro in British Columbia. Although similar approval challenges exist in the rest of Canada, market or jurisdictional uncertainty appears to be the predominant limiter in these other regions today.

The Pingston Project approvals spanned over ten years from 1994 to 2004 extending through the design and construction. Over this time significant changes to the processes, agencies and requirements occurred. Today, the regulatory approvals process has increased from constituting less than 2% of the development cost to as much as 12% and from about 6 to 18 months in duration to 5 to 7 years or more.

Under the regulatory framework in 1995, the approval process for 25 MW and under projects was significantly less onerous than for higher capacity projects. This was one of several key factors in originally selecting the 25 MW application capacity for Pingston, other factors included the market risks discussed previously.

However, in 1998 it was decided to use the Environmental Assessment Office (EAO) process for Pingston approval since at the time it provided more clearly defined timelines for approvals albeit with more complex and onerous requirements than the alternative process intended for small to medium projects.

During detailed design, field information, conveyance system options and changed fish flow requirements lead the engineering team to realize the opportunity and moreover, the need to increase plant capacity. A nominal increase from 25 to 30 MW was sought within the existing project approval parameters, which was readily approved. It was determined that the ultimate capacity upgrade to 45 MW to substantially increase energy output was technically and economically feasible, however fisheries approval negotiations would have undoubtedly delayed the project so this prospect was not pursued immediately. This ultimate capacity increase, to be done as an 'expansion', was to offset increased tunnel, transmission and interconnection costs in order to improve the overall project economics by taking advantage of the 4 km minimum-sized tunnel's excess conveyance capacity and the project's valuable high head.

The project engineers spearheaded efforts to incorporate provisions for plant expansion where reasonable, which included; assuring adequate intake capacity, increasing the size of the penstock within the tunnel, a penstock bifurcation at the tunnel outlet, and rock excavation for the powerhouse expansion. The engineers proposed increasing the size of the 630 m long penstock from the tunnel to the powerhouse at a substantial overall project cost savings however, due to uncertainty with the expansion approvals and timing, the developers decided

against this incremental investment. The minimum-sized tunnel was already of sufficient size for the 45 MW plant and required no additional work. The expansion approvals and design proceeded during the later stages of construction and expansion work began a few months after the 30 MW plant began operation and is on schedule to be operational for the 2004 freshet.



*Figure 2: Pingston Creek headworks area and watershed during initial site investigations (2001) and during the 30 MW plant commissioning (2003).*

Interestingly, in 2001-2002, the small hydro approval process was transformed dramatically, mostly due to a provincial government change in position on renewable energy and streamlining of provincial resource development. In fact, a provincial crown corporation was created, Land and Water BC Inc., to streamline the waterpower approval process. This process amendment did not affect the project or its subsequent expansion as the project was originally approved and had approval amendments under the provincial Environmental Assessment Office (EAO) approval process.

#### *Existing Resource Infrastructure*

Other resource development infrastructure such as that provided by the forestry industry is complementary to small hydro development. Cooperation with the provincial Ministry of Forests, and timber licence operators involved project planning, road use, and use of works agreements. An existing network of over 50 km of forest access roads was instrumental in building the Pingston project.

#### *Fisheries Approval*

Pingston Creek was naturally void of fish, but as a result of rainbow trout stocking of Pingston Lake in the 1970s, upstream of the project intake, the Creek is now home to a limited population of rainbow trout. Consequently, the federal Department of Fisheries and Oceans (DFO) required mitigation and compensation for impacts to fish including lost habitat, fish entrainment, and reduced downstream flows.

There were areas of contention during DFO Project Authorization negotiations. DFO requested the headpond level be maintained relatively stable however, from an engineering and operations perspective this is contradictory to one of the key purposes for having the headpond. As well, the headpond's benefits to fish were not considered by DFO in the assessment of compensation. This seemed inconsistent since the rainbow trout were introduced to the lake upstream, which is now considered habitat.

The fish compensation developed by the environmental and engineering team consists of two habitat channels downstream of the embankment dam (shown in Figure 3) as well as habitat structures in the headpond and upstream in the main channel and two major tributaries. The two habitat channels, one an existing enhanced Pingston Creek tributary and one a new 'copy', provide spawning, rearing, and over wintering habitat. The habitat complexes provide fish refuge in otherwise fast moving water.



*Figure 3: Habitat channels for fish impact compensation (left) and embankment dam under construction upstream (right).*

The project was originally proposed at 25 MW capacity, as discussed earlier. During the approval process and early into final design, higher-than-expected winter minimum release flows were imposed by DFO resulting in lower winter generation. To offset this affect on the project economics and for other considerations, an application was made to increase the capacity to 30 MW and use more of the excess summer flow to make up the energy difference.

Upon DFO review, the 30 MW project was approved in February 2001 with the authorization stipulating minimum release flows at the intake. When applying to amend the Project Approval Certificate in 2002 for the project expansion to 45 MW, new criteria were applied by DFO resulting in the need for further hydrological and statistical analyses including; percentage of time at minimum flow, number of minimum flow occurrences, reduction in peak flow and number of days above 400% of mean annual discharge. These analyses were not required for the initial project approval, just two years prior. To some extent this additional analysis provided more insight, but some aspects were not useful. Minimum Release Flow was considered to be the key concern for the project expansion. In the end, the minimum downstream flows were increased, further impacting the project economics.

## *Recreation*

Despite the high falls at the mouth of Pingston Creek and narrow canyons, high-gradient rapids and drops, the approval by the Canadian Coast Guard under the Navigable waters protection Act was required for the project. There is currently significant concern with run-of-river hydro projects in BC from the kayaking community.

Pingston Creek has, on occasion, been used for whitewater kayaking downstream of the intake location, however poor access, short reaches and treacherous rock outcrops make it less than desirable. The project impact to kayak use was expected to be minimal owing to its infrequent use and that flows would be minimally impacted during spring and summer runoff conditions. The kayaking community was consulted up-front on the project to ensure the concerns of the stakeholders, if any, were addressed early so as not to cause project delays. For Pingston, a safety boom and signage were installed in the headpond and access to the creek was built.

## *Agency Stability*

Whether it's the long road from initial project approval application through to commissioning or the never-ending cycle of government agency change, it seems the only constant throughout the project development is the project team: the owner, the project manager and engineer and their commitment, persistence and patience to see the project through. Here are a few of the agency related changes that occurred during the Pingston project approval, design and construction process:

- The relationship, roles and responsibility for fish were significantly changed between the federal - Department of Fisheries and Oceans and the provincial agency - MELP. This new development resulted in new rules and new fisheries biologists with limited understandings of the project or the aspects of small hydro projects.
- The BC provincial Dam Safety Branch was created and the BC Dam Safety Regulation 44/00 was enacted in 2000.
- Ministry of Environment, Lands, and Parks (MELP) was split into Water, Land, and Air Protection (WLAP) and a provincial crown corporation, Land and Water BC Inc (LWBC), in 2002.
- LWBC became the lead agency for waterpower project approvals in the province for projects less than 50 MW capacity. Previously, projects above 25 MW were referred to the provincial Environmental Assessment Office (EAO).
- Federally, Navigable Waters (NavWaters) joined the Department of Fisheries and Oceans (DFO) which lead to having only a single 'responsible authority' (ra) as defined under the Canadian Environmental Assessment Act (CEAA) that the project was federally screened under. This was a concern given the rather limited mandate of DFO, focusing on the environmental aspects of fish, as opposed to the much broader coordination responsibility of the CEA agency, whose mandate includes a balanced federal consultation with authorities responsible for societal and economic factors as well.

- In late 2003 NavWaters left DFO to return to Transport Canada and the CEAA was amended to make the process more certain, predictable and timely. So again, it will be seen if these latest changes actually result in the intended improvements.

As the agencies change so do the staff resulting in a number of inexperienced individuals charged with, and sometimes struggling with, reviewing the project. Consequently, the project team spent considerable time and effort enlightening government decision-makers on the fundamental characteristics of renewable energy development, small hydro technical basics, as well as, discussing their particular role and responsibilities with respect to the Pingston project.

Although not easily discernable at the outset of the project, given the breadth of change in the regulatory environment, over 25 permits, authorizations and approvals were eventually acquired for the project. Some of these require ongoing interaction with agencies, which in some cases continues to be a challenge. For example, in accordance with the new Dam Safety Regulation legislated in February 2000, an Operation, Maintenance, and Surveillance Manual was prepared for the Pingston headworks dam and it took several weeks to determine who would receive and review the manual. In fairness, it is difficult for government agencies to assess their required amount of commitment in this evolving framework. Given the tremendous number of agencies, stakeholders and other factors involved in the current approval processes the timing and magnitude of these efforts are not easily predicted or staffed.

## **Technical Challenges**

There are multiple technical challenges encountered on small hydro developments in the interior of British Columbia given its rugged, remote terrain and dramatically varied weather. Here is a description of some of these technical challenges.

### *Construction Logistics*

As was experienced on the Pingston project, the development of new energy sources is leading to construction in increasingly remote locations. This poses challenges related to engineering techniques, workforce, contractor risks and construction methods. Engineering and construction challenges will inherently be present as more new hydropower sites are developed because, by nature, these are the 'more difficult' sites. Obviously, the straightforward and economic sites are the first ones developed.

Communications was the promise of technology and the cost of unrealistic expectations. Working in remote locations, the establishment of site communications can be difficult and costly, but good communications are a necessity particularly for today's overlapping design and construct approaches. Even in this day of advanced communications technology, several arrangements of radio and microwave communications were tried with limited success and portions of the communications system eventually had to be replaced with cable. Communication interruptions can be extremely frustrating to the project team and costly to the project.

Due to the long and expensive approval process, it is reasonable to expect developers want to build as soon as practical to start generating revenue and recover cost. Consequently, Pingston was no different and was constructed using a “design-and-build-as-you-go” approach. In this case, the intake construction was almost complete before the design of the powerhouse was even undertaken.

Construction was split into multiple sub-contracts to manage cost and control the process. This approach allows work to be done by local or regional contractors at optimum weather times thus capitalizing on local knowledge, minimizing mobilization and maximizing local economic benefits

However, there are always outside factors. The unfortunate events of September 11, 2001 caused unforeseen travel and shipping delays. There was difficulty in clearing US customs for some equipment and parts.

Noteworthy logistical issues addressed during the Pingston project include:

- Use of a newly developed concrete set retarder to allow concrete delivery from over 2.5 hours away. For some mass concrete pours the set time was retarded by more than 12 hours to allow pours to extend over two days to compensate for a shortage of local concrete delivery trucks.
- Ambulance and First Aid were stations required at two locations on site due to the 12 km steep road and sometimes poor access conditions between the intake and powerhouse.
- Tunnel drill and blasting operation from three headings 24 hours per day, 7 days a week, for 18 months. The two upper portals and their access roads experience over 6 metres of snow necessitating all-day snow removal for several weeks.
- Safety on a remote site of this in breadth and with relief exceeding 900 metres brings new challenges. These were met by appointing a full time safety manager to ensure all contractors and site personnel made the adaptations necessary for the varied site conditions they encountered throughout the day and the seasons. The number one safety hazard was driving on the forestry and access roads, requiring a strict radio communication protocol at all times, with particular attention during periods of logging activity.
- Development of the workforce in the interior of British Columbia to instil developer confidence in using local and regional skills was paramount. This not only resulted in minimized travel risks and reduced accommodation costs, but also established the commitment of the project to the community. The resulting good relationship continues to benefit the project during operations and expansion. The capabilities of the local contractors were considered in design, construction methods and contract strategies.
- The design of a specialized rail cart system for sequential installation of the 1.5 m diameter penstock into the 2.4 m x 2.7 m lower tunnel worked exceptionally well, with all 1200 m of pipe being installed in just 53 days.

## *Engineering Challenges*

Technical challenges for the independent developers in BC are predominantly dictated by their financial feasibility. However, renewable energy project managers and engineers are now applying innovative solutions, not from large hydro, but from other resource and industry sectors, to meet these challenges in today's economic climate.

When approval periods stretch from months to years, significant changes can occur on the project site. Between the early development stages in the mid-1990's and the start of detailed design in 2000, the watershed and headworks site were extensively logged to the point that it warranted a reassessment of the hydrology and modification of flood hydrograph shapes to account for "peakier runoff" and therefore higher design floods. The lesson learned is that the development and approval process can be significantly long to warrant periodic re-assessment of the existing physical site conditions.



*Figure 4: Pingston Powerhouse (left) and nearby Maintenance Building (right).*

Electrical advancements and the evolution of transmission system requirements for the independent power producer can impose significant, unexpected cost and rework to the project concept. In the case of Pingston, provincial transmission grid support and plant interaction influenced plant controls and conveyance system design. The plant was not intended to be designed for load response and demand on the grid, nor offer frequency and voltage control. However, in implementing the system guidelines and regulations it was apparent these do not readily accommodate the emerging IPP market, consequentially the Pingston plant was required to have a governor. The antiquity of the utility policy was also evident since putting the governor (speed control) function into the plants programmable logic controller was not acceptable, although it would have served the purpose in this case. The result was a physical governor module was required, at significantly more cost and set-up time.

In setting up the governor, it became apparent that the reactivity / voltage control that the plant could offer was quite limited by the conveyance system that was mostly constructed at the time. Nonetheless, the practically ineffective and expensive governor was still required. It is worthy to

note that the plant connects to the provincial grid near BC Hydro's 1800 MW Revelstoke Generating Station with 40 times the capacity of the Pingston project.

A total of 52 km of 69 kV transmission line was required to interconnect the project to the provincial grid near Revelstoke, with a tall order from BC Hydro, consisting of:

- Substation at Pingston plant - two transformers, circuit breaker, two air-break switches,
- 13 km of new line to Shelter Bay,
- 22 km of underhung line,
- 17 km of upgraded line, and
- Disconnect switch at BC Hydro's Walter Hardman Hydro Plant.

Due to jurisdictional issues with respect to modifications to the existing lines and limitations to the number of lines and voltages allowed in proximity to highways, it was necessary to have the utility complete a portion of the transmission system upgrades. Because both the developer and the utility constructed components of the transmission line, cost comparisons are inevitable. The cost premium of the utility constructed components was very evident, it resulted in a premium of 50%, which for this large project component was quite significant.

For Pingston, the premium cost of 'utility-built' facilities did not make IPP economic sense; however given that the utility is also the power purchaser and considering the associated jurisdictional issues, room for negotiation was limited. Nevertheless, IPP projects must be economical and in tune with the current market for goods, materials and energy pricing therefore further refinements of these interconnection responsibilities, jurisdictions and EPA relationships is required.

Finalizing the hydraulic conveyance system concept was a challenge with respect to determining the extent of tunnel versus penstock. After tunnelling horizontally through Pingston Ridge (1800 m) the two fundamental options to complete the conveyance system were:

1. *Penstock* – Construct a 2000 m long penstock down the slope to the powerhouse, developing the 590 metre head.
2. *Shaft and Tunnel* - Construct a vertical shaft 450 m deep down to a lower high-pressure tunnel to daylight closer to the powerhouse and complete with a 630 m long penstock.

A long penstock down the undulating slope would encounter steep difficult terrain that exhibited the indicative signs of substantial creep movement as well as, significant debris slide and large tree fall risks. The extra tunnelling option posed the risk of unknown rock and tunnelling conditions. After geotechnical investigations, assessment, and cost-risk analyses, the stepped tunnel and shaft approach was used.

In the end, the cost of this tunnelling option was higher than expected and higher than what the surface penstock could ever have been. Some parts of the tunnelling were straightforward and very productive (upper tunnel), while others, where problem ground and water conditions were encountered, resulted in delays, testing, and remedial action including liners and pressure

grouting, all resulting in significant cost increases. The actual drill and blast tunnel excavation aspects were not overly affected by the poor conditions but the subsequent permanent tunnel support and the associated logistics were costly and time consuming due to the sequential nature of the work. Although a comprehensive team of geotechnical and geological engineers was employed and thorough assessments made, tunnelling conditions cannot be predicted for certain.



*Figure 4: The 1.5 metre diameter penstock in place the lower tunnel (left) and the specialized rail-cart system designed for transporting the 40 m penstock sections into the tunnel with minimal clearance (right).*

It is apparent that the cost of tunnelling in poor conditions increases far more dramatically than the cost savings in good conditions, this dramatic imbalance must be taken into consideration in risk assessments at the project planning stage. Experience indicates this degree of cost risk imbalance is not nearly as much for penstock construction even on tricky ground. For Pingston, the safeguard was the over-capacity of the tunnel and the ample available summer flows that allowed a very cost effective 50% increase in project capacity at minimal additional capital cost. Having this up-sizing capability substantially lowered the tunnel risk assessments worse case scenario. However, for most IPP projects that do not have the up-size potential like Pingston and where capital cost increases are not recoverable from the market, substantial high-pressure tunnelling is likely beyond most developers risk tolerances.

## **Summary**

Over the past decade, the increased economic, social and environmental regulatory burden placed on independent hydropower development in BC is significant, to a point where new project viability is seriously in question. These projects, by their very nature, minimize impacts and are typically promoted by intrinsically environmentally friendly companies that are selling these qualities to the investment community and electricity markets.

To be successful, small hydro project managers and engineers must use their ingenuity to find inexpensive design and construction solutions. However, this success can be severely undermined by inappropriate, yet well-intentioned, policies and their implementers.

Project approval uncertainty, variations and inconsistency are by far the most significant new production challenge for independent developers of small hydro in British Columbia. The considerable project cost due to regulatory instability, market calls that create 'gold rush' type activity surges in this small but emerging industry sector and reduced basic scientific data, such as the severe decline of the hydrometric network, lead to the conclusion that there is doubt in our willingness to make a successful transition towards renewable energy developments.

For these new independent projects that are, by market design, economically strapped, there is a propensity to recover added approvals and development costs with shortcuts during development and construction, which can lead to their demise and consequently increase risk to the public and the environment.

The sporadic relationships and shifting of government agencies, the changing electricity market processes and the emergence of new or modified legislation and regulations, has created a project development process that is too long and costly for smaller, environmentally sound hydro projects to bare. It is increasingly more difficult to stay up-to-date on waterpower policy framework changes and efforts to hopefully streamline this process, in a lot of cases, seem to have had the opposite effect.

For Pingston, it is interesting to note that although significant time and money was spent satisfying changing regulatory requirements and agencies, minimal material change to the project concept was required and, in fact, further development of the resource was approved and has been undertaken over and above that originally proposed.

As has been illustrated, designing and building small hydro projects, even those as technically challenging as Pingston, is relatively straightforward, however finding out how to convince who to allow what, when and where is not easy or dependably predictable. The societal cost of this uncertainty will be borne in due course, as the development of renewable energy is inevitable. A deliberate and balanced course will provide the best opportunity to encourage long-term investment in our renewable energy development future.

## **Authors**

*Both authors are civil engineers specializing in hydropower development at Canadian Projects Limited, an engineering and project management consultant in Calgary, Alberta responsible for engineering and construction of the Pingston project.*

*Paul Kemp is a principal of the company, Project Engineer for the Pingston project and was involved with the project from its initial conceptualization. Cory Williams was assigned to the detailed development and design of Pingston in 1999.*