Q. In the attached paper by Robert Meyers and Ralph Carpenter entitled "Victoria Dam Penstock - A Second Generation Wooden Penstock Replaced with 114-Inch Spiral-Welded Steel Pipe" the authors state that in 2001 the Upper Peninsula Power Company (Michigan, U.S.A.) replaced a 6050 linear foot (1.8 km) wooden penstock with a spiral welded steel penstock of 2.9 m in diameter for slightly more than $5,000,000 U.S. Please explain how if at all the design and installation methods used for the Michigan project differs from that contemplated by Newfoundland Power Inc. in the proposed penstock replacement (which is estimated to cost approximately $11.7 million) and please further detail the estimated cost of the penstock replacement on the assumption that the design and installation methods used in the Michigan project were employed in the project at hand?

A. **1.0 Introduction**

Newfoundland Power has read the paper referred to in this Request for Information.

To inform themselves sufficiently to respond to the Requests for Information CA-18.0 NP through CA-25.0 NP, Newfoundland Power engineering staff have discussed the Victoria Dam penstock installation with one of the co-authors of the paper, Mr. Robert Meyers, and with the design engineer for the penstock.

Newfoundland Power has not conducted a thorough examination of the engineering detail associated with the Victoria Dam penstock installation. However, given the results of Newfoundland Power's broad-brush review of the applicability of the Victoria Dam penstock design to the proposed Rattling Brook penstock, further detailed review appears unnecessary.

The application of the Victoria Dam penstock design does not appear to present any potential material advantage, cost or otherwise, for the proposed Rattling Brook penstock replacement.

2.0 Engineering Design

2.1 Principal Design Differences

A principal design difference between the Victoria Dam penstock and the proposed Rattling Brook penstock is the type of penstock support used.

The Victoria Dam penstock is supported on a floating bed of granular material. The proposed Rattling Brook penstock is supported on concrete piers.

Another material design difference relates to weld configurations. But this difference, in Newfoundland Power's view, flows from alternative penstock support designs.

The Victoria Dam penstock employs a lap-weld joint configuration. This is suitable for penstock installations such as that at Victoria Dam which have full lateral support. The proposed Rattling Brook penstock is an above ground design supported on concrete piers.

Accordingly, a butt-weld configuration is suitable to withstand the different forces associated with this type of design.

2.2 Types of Penstock Support

The ASCE Manual No. 79 describes the types of penstock support as follows:

> "A penstock can be supported in a variety of ways, depending on the initial design selected, existing geologic conditions, and penstock profile. The penstock can be totally buried, partially buried, or supported above ground".[1]

The Victoria Dam penstock design, which uses a floating bed of granular material as support, is a partially buried above ground design. Such a support design which is not referred to in ASCE Manual No. 79 is something of a hybrid in that it is partially buried and above ground. To Newfoundland Power's knowledge, no similar penstock designs have been employed at any hydro-electric generating facilities in Canada.

The Rattling Brook penstock design is conventional. According to the ASCE Manual No. 79:

> "An above ground support system is the most commonly encountered installation and allows a better handling of inspection and repair access and corrosion problems".[2]

2.3 Victoria Dam Penstock Design

The design chosen for the Victoria Dam penstock was highly influenced by local conditions and engineering judgments made in respect of those conditions.

The penstock which was being replaced was an above ground design that was supported by concrete saddles. Due to the local soil conditions, each saddle was supported by a minimum of two friction piles to provide the necessary bearing strength. Friction piles are used to transmit the load of a structure to the soil.

In considering design options, both the presence of the existing piles and the requirement for additional piles appeared to present obstacles to certain design alternatives.[3] To install a buried, or partially buried penstock would require removal of existing piles. This was assessed as costly and risked destabilizing the existing soil conditions. To install an above ground design would require driving new pile support which was also assessed as costly.

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1 *ASCE Manuals and Reports on Engineering Practice No. 79: Steel Penstocks* ("ASCE Manual No. 79"), American Society of Civil Engineers, 1993, p. 155.
2 ASCE Manual No. 79, p. 156.
3 See: *Victoria Dam Penstock – A Second Generation Wooden Penstock Replaced With 114-Inch Spiral Welded Steel Pipe*, Robert Meyers and Ralph Carpenter ("Meyers & Carpenter"), p. 4.

Given the local soil conditions, the owners of the Victoria Dam penstock, Upper Peninsula Power Company (“UPPC”), chose to propose installation of the Victoria Dam penstock on a floating bed of granular material.

The preliminary design for the Victoria Dam replacement penstock was required to be approved by the Federal Energy Regulatory Commission (the “FERC”).[4] The FERC questioned certain aspects of the proposed project. Ultimately, the preliminary design proposed by UPPC was approved by the FERC.[5]

To Newfoundland Power’s knowledge, UPPC is the only hydro-electric plant owner which has used a bed of floating granular material as support for a penstock.

2.4 Rattling Brook Penstock Design

At the time of its proposed replacement in 2007, the Rattling Brook penstock will have been in service for 49 years.

The proposed design for the Rattling Brook penstock replacement is a fairly common above ground design. The proposed design will permit efficient inspection and repair over the life of the installation because of the relative ease of access the design allows. This will, over the installation’s life, tend to minimize cost associated with the penstock.

The proposed Rattling Brook penstock support design will provide more secure support than the Victoria Dam penstock design. This reflects the difference between concrete pier support and floating granular bed support.[6] In addition, the proposed Rattling brook penstock weld configuration will be a stronger one than that used with the Victoria Dam penstock.

The proposed design for the Rattling Brook penstock is similar to Newfoundland and Labrador Hydro’s 2006 Snook’s Arm penstock replacement. It is also broadly similar to Corner Brook Pulp and Paper’s recent replacement of penstocks associated with its Deer Lake hydro-electric plant.

In addition, the proposed design for the Rattling Brook penstock is similar to Newfoundland Power’s recent replacement of penstocks at New Chelsea (2004), Lockston (2003), Seal Cove (2002), Cape Broyle (2001), Horsechops (2000) and Petty Harbour (1999).

[4] In the United States, the FERC exercises licensing and safety oversight for hydro-electric power plants.
[5] Meyers & Carpenter, p. 5.
[6] The soil conditions at Rattling Brook are sufficiently stable that the penstock does not require pile support for foundations.

3.0 Comparative Costs

3.1 General Observations on Cost Comparisons

The question posed implies that the 2001 installed cost of the Victoria Dam penstock of approximately US$5.3 million[7] is a reasonable comparator to the proposed 2007 budget for the Rattling Brook penstock. Newfoundland Power does not believe such a comparison is reasonable.

Installation costs of a penstock suitable to local conditions in Michigan will not necessarily be indicative of the installation costs of a penstock suitable to local conditions in Newfoundland and Labrador. For example, for the Rattling Brook penstock installation, it will be necessary to build an access road. This was not a requirement for the Victoria Dam penstock installation. Concrete requirements for anchor blocks are higher for the Rattling Brook penstock than the Victoria Dam penstock due to differing site conditions. The additional cost of these 2 items alone is in the order of $750,000.

Similarly, prevailing market conditions at a point in time in the midwestern United States can be expected to render different supply and demand dynamics than prevailing markets in Newfoundland and Labrador six years later. One obvious difference relates to the commodity cost of hot-rolled plate steel used to fabricate a steel penstock. In 2007, the cost of hot-rolled plate steel is expected to be approximately 3 times the 2001 cost[8].

Another factor affecting comparability is exchange rates between American and Canadian currencies. At the time of the installation of the Victoria Dam penstock in 2001, the average rate of exchange between the currencies was C$1.548 to US$1.00.[9]

3.2 Comparative Costs of Victoria Dam Penstock Design

Newfoundland Power is not in a position to definitively determine at this time whether the design and installation methods associated with the Victoria Dam penstock are technically feasible for the Rattling Brook penstock. However, to respond to the question posed in this Request for Information, Newfoundland Power has assumed such design and installation methods are technically feasible.

Newfoundland Power has made a broad brush comparative estimate of the cost of implementing the Victoria Dam penstock design at Rattling Brook versus the cost of implementing the proposed penstock design.

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[7] The installed cost of US$5.3 million was provided by Mr. Robert Meyers and excludes engineering costs of approximately $500,000.

[8] *North American Steel Prices – Hot Rolled Plate.*, MEPS (International) Ltd.

[9] Bank of Canada

Details of the comparative cost estimates can be found in Table 1 below.

Table 1
Estimated Comparative Cost
Rattling Brook Penstock Design
($000s)

	Rattling Brook Design	Victoria Dam Design	Difference
Penstock Supply	$ 5,842	$ 6,330	488 [10]
Penstock Installation	2,635	2,260	(375)[11]
Civil Works	2,882	2,475	(407)[12]
Newfoundland Power Costs	346	346	0
Total	**$ 11,705**	**$11,411**	**$ (294)**

Implementation of the Victoria Dam penstock design at Rattling Brook can be expected to reduce the cost associated with penstock support and welding. The cost reduction associated with penstock support essentially reflects lower required concrete requirements (due to the reduced requirement for saddles) associated with the granular bedding design. The cost reduction associated with welding essentially reflects the relative costs of lap-welds (the Victoria Dam penstock design) versus butt-welds (the proposed Ratting Brook penstock design).

Implementation of the Victoria Dam penstock design at Rattling Brook can also be expected to increase the cost associated with the supply of the penstock. Currently, no fabricated steel supplier in Canada provides spiral-welded steel pipe of 2.9m diameter that is 100% hydrostatically tested in accordance with AWWA C200[13]. To meet this design specification would require either (i) international supply of the penstock or (ii) a comprehensive weld testing program on the penstock fabrication. Either alternative will cause the cost of the supply of the penstock to be higher than currently proposed.

[10] The cost increase associated with penstock supply is Cdn $488,000. This additional cost would be required to (i) either purchase the penstock internationally or provide a comprehensive manufacturers' weld test program on the spiral-welded penstock fabrication and (ii) provide for more resilient coating required for buried penstock applications.

[11] The decrease in cost associated with the penstock installation is Cdn. $375,000. This cost reduction is associated with relative costs of lap-welds versus butt-welds. Lap-welds assemble quicker, are less susceptible to misalignment difficulties and require less expensive testing.

[12] The decrease in cost associated with the civil works is Cdn. $407,000. This cost reduction is associated with the lower concrete requirements due to the reduced requirement for concrete piers.

[13] *AWWA Standard C200 for Steel Water Pipe – 6 inch (150 mm) and Larger*, American Water Works Association, 1997.

When taken together, these estimated cost impacts of the difference indicate a reduction in the supply and installation costs of the Rattling Brook proposed penstock replacement of $294,000. This amounts to approximately $2.5% of the total estimated project cost which is within the accuracy limits of estimates at this level of assessment. However, use of the Victoria Dam design would certainly increase the engineering costs associated with the Rattling Brook replacement.[14] Accordingly, Newfoundland Power has concluded that no material cost advantage would result from implementing the Victoria Dam penstock design at Rattling Brook.

The Victoria Dam penstock design does not present material cost advantages for installation at the Rattling Brook site. This does not bear on the material cost advantages the design appears to have provided for UPPC at Victoria Dam. This likely reflects the fact that the soil condition related challenges presented with the Victoria Dam penstock replacement are not present with Newfoundland Power's proposed Rattling Brook penstock replacement.

4.0 Concluding

Newfoundland Power is proposing to replace the 48 year old Rattling Brook penstock with a proven penstock design. In addition, it is consistent with accepted engineering practice and local experience. Accordingly, Newfoundland Power is confident that once it is installed, it will remain in service for its expected design life of 50 plus years.

The Victoria Dam penstock installed in 2001 by UPPC is a relatively unique engineered design for a hydro-electric plant application. It was developed in response to specific local conditions and has been in service for approximately 5 years.

In considering the possible application of the Victoria Dam penstock design to the proposed Rattling Brook penstock replacement, Newfoundland Power has assessed potential cost savings and found them to be immaterial.

However, even if material potential cost savings would be expected from use of the Victoria Dam design, Newfoundland Power would still be required to fully consider the risks associated with adopting design and installation methods that neither have a long-term history nor achieved a broad degree of application.

[14] In fact, the engineering costs of UPPC on the Victoria Dam penstock replacement were in the order of US$500,000. Newfoundland Power's engineering costs for the Rattling Brook penstock replacement (which are also not part of the $11.7 million estimate) are expected to be in the order of Cdn.$200,000. Adopting the Victoria Dam penstock design for the Rattling Brook penstock would increase engineering costs associated with the project, however, Newfoundland Power clearly has not estimated these costs.