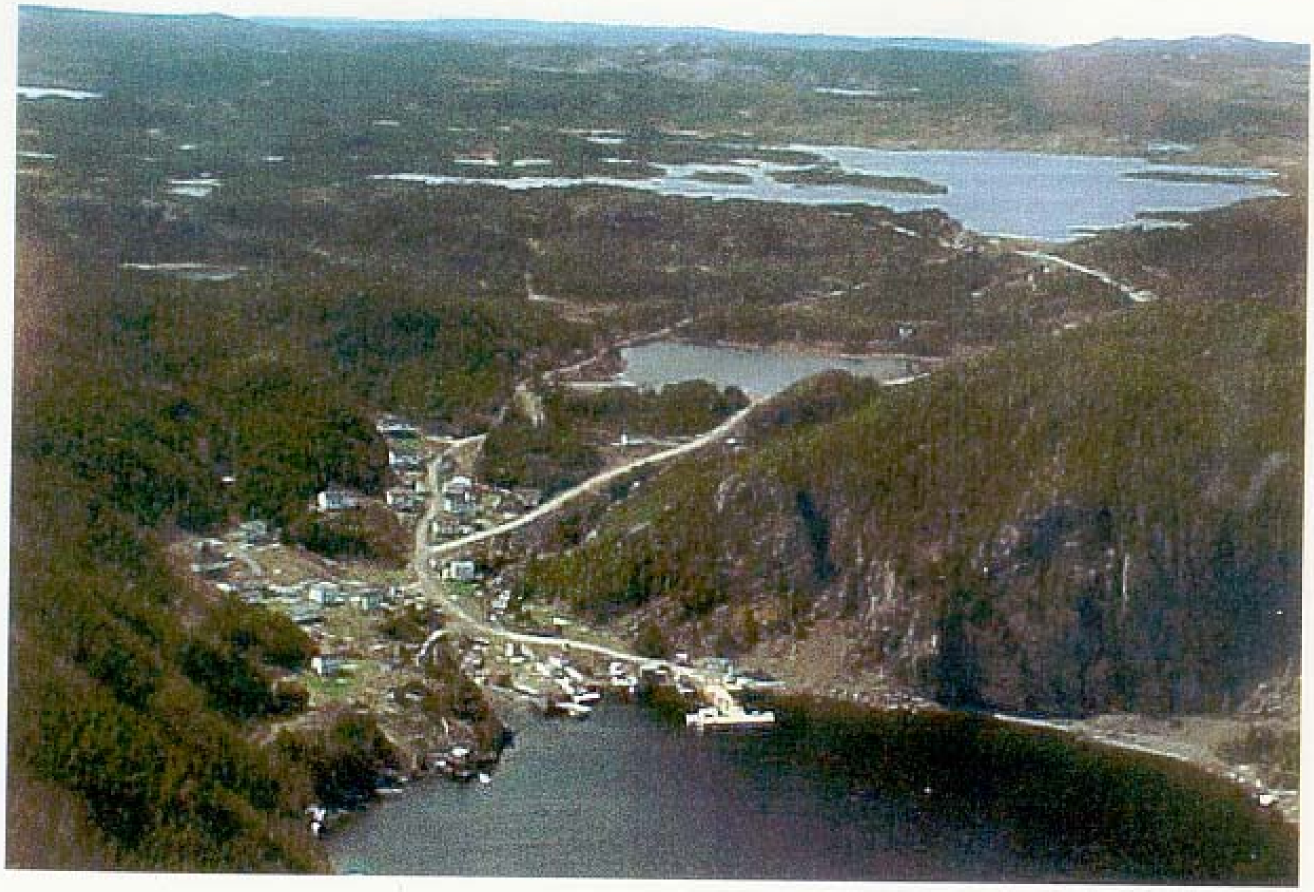
SECTION G
Tab 1

NEWFOUNDLAND & LABRADOR HYDRO

Snook's Arm Wood Stave Penstock

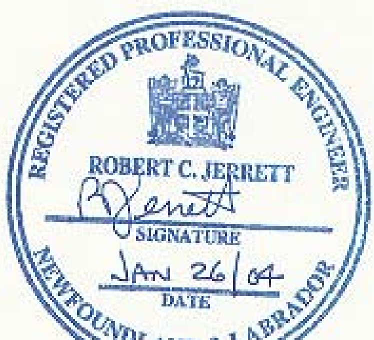
Evaluation, Recommendation and Estimated Cost for Replacement



Prepared By:

Newfoundland and Labrador Hydro
Generation Engineering

January 26, 2004



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1.0 Introduction

.1 Project Location

The Snook's Arm hydroelectric development is located on the Baie Verte Peninsula, approximately 80 km from the Trans Canada Highway. A map showing the location of the penstock in relation to the community of Snook's Arm is provided in Appendix A.

.2 Project Description

.1 General

The hydroelectric development was constructed in 1956 for the Maritime Mining Corporation and was purchased by Newfoundland & Labrador Hydro in 1968. The development has a watershed of approximately 11.8 mi^2 and includes Armchair Pond, Red Cliff Pond, West Pond and East Pond. The main dam and intake is located on the south side of East Pond. The unit has a rated output of approximately 590 kW and produces an average of 3,500,000 kWh/year.

.2 Penstock

The penstock was built in 1956 by the Pacific Coast Pipe Co. The penstock has an inside diameter of 30" and a length of 3050 ft.

The wood staves were machined from nominal 2" x 4" Douglas Fir with tongue and groove radial side joints, double tenon end joints, and creosote pressure treated to 8 lbs/ft^3 net retention or rejection. As a result of damage during shipment, many stave ends (double tenon end joints) were cut square and field jointed with metal splines.

The bands are ½" dia x 9-2" long, 1 piece with button head one end and rolled thread on the other, and ½" x 36" pipe shoes. There are approximately 12,000 steel bands with spacing varying from 10" on centre at the intake to 3" on centre at the powerhouse. The penstock is supported on chock block cradles (6" x 6" chock on 4" x 6" sill) on 8-foot centers.

There is a 4" air release valve and a 4" drain valve on the line.

.3 Summary of Reports

Several reports have been prepared over the years, describing the condition of the penstock and associated components. These reports have been used to determine the problems that have been identified over the years and the condition of the penstock. The reports include:

Inspection Report of Venam's Bight and Snook's Arm Wood Stave Penstocks, Prepared by Canbar Inc., Sept. 3-4, 1998.

Inspection Report of Venam's Bight and Snook's Arm Wood Stave Penstocks, Prepared by Canbar Inc., Aug. 15-16, 2000.

Snook's / Venam's Penstock, Prepared by L. Kearley, Civil Technologist - Newfoundland & Labrador Hydro (Interoffice Memo), April 12, 2001.

Snook's Arm Penstock Enclosure, Prepared by G. Poole, P. Eng. - Newfoundland & Labrador Hydro (Interoffice Memo), June 28, 2001.

Snook's / Venam's Penstock Assessments, Prepared by L. Kearley, Civil Technologist - Newfoundland & Labrador Hydro (Interoffice Memo), Dec. 21, 2001.

.4 Maintenance History

Detailed records of maintenance history were not kept or are unavailable, however, since the early 1990's significant efforts have been undertaken to maintain the penstock. This includes:

- Patching of leaks;
- Replacement and addition of steel bands;
- Repair and replacement of penstock cradles;
- Removal of vegetation and growth;
- Improvement of drainage around penstock.

2.0 Identified Problem Areas

Described below are areas of the penstock that have been identified as problem areas.

.1 Penstock Design and Profile

The wooden penstock is 3050 ft long and has a head of 300 ft and there is no surge tank available. The lack of a surge tank causes limitations on the operation of the Plant and also stresses the penstock. In the event of a unit trip, a sudden water hammer surge would occur, which causes pressure on the joints between the wooden staves. Typically after such a water hammer event, additional leaks appear in the penstock.

The penstock profile has several flat sections and one reverse section in the mid to upper half of the penstock, see photos #1 & #2. The reverse grade increases the probability of the penstock collapse during operation, when the Plant is fully loaded. The only protection from collapse is a vacuum breaker valve located at the mid-point of the line. This valve is designed to break any vacuum that may cause a collapse. It is critical that this valve is kept in good working condition to ensure that it will operate as required. Recent problems experienced include a fire in the valve enclosure and a malfunction of the valve.

.2 Penstock Material

The penstock is constructed from 2" x 4" Douglas fir timbers machined to create the diameter of the penstock. Steel bands spaced on 3" – 10" centers, hold the wood stave material together and maintain the shape of the penstock.

.1 Wood Staves

Various inspections of the penstock have indicated that there is joint leakage between the staves, brooming at stave ends and between steel bands and crushing of the staves along the spring line or top of the penstock. The brooming and crushing is worse at the lower end of the penstock, which is subject to higher pressures. The crushing and brooming indicates delamination between the wood fibers and deterioration of wood, see photos #3 & #4. The rate and areas of deterioration continues to grow with the age of the structures.

Also along the length of the penstock, areas of moss and other vegetation are growing directly on the penstock; see photos #5 & #6. Vegetation growth typically retains moisture and cause stave deterioration. In some cases the vegetation can be parasitic to the wood stave. Vegetation thrives because of continuous water supply leaking from the penstock. The cost of removing the vegetation continues to increase.

.2 Steel Bands

There are approximately 12,000 steel bands used to maintain the shape and integrity of the penstock. All of the bands show various signs of rusting, corrosion and deterioration. Also, in recent years some bands have been observed with significant corrosion below the threads on the band, see photos #7 & #8. These bands are required to be replaced or new ones installed adjacent to the old ones (where possible). In addition, there is bright, visible corrosion on the majority of the steel bands that do not receive direct sunlight. These areas include the penstock enclosure, buried section of the penstock and at the road crossings. In these same areas it is difficult if not impossible to replace the steel bands because of the limited access. Also, in several locations it is impossible to replace the bands unless the penstock is dewatered, because of the decreased band spacing and the higher pressure on the lower half of the penstock. However, frequent dewatering of the penstock is not recommended because of its aged and deteriorated condition.

.3 <u>Leaking Water from Penstock</u>

Leaking of the penstock joints have been observed since at least 1968, see photos #9, #10 & #11. The leaks were sometimes repaired by driving nails into the leaking area, this method however tends to promote deterioration of the wooden staves, see photo #12. The more common method of sealing the leaks involved the installation of small steel plates under the existing steel bands or by adding new bands between the existing ones in the area of the leak, see photo #13. The penstock has been dewatered approximately 4-5 times since 1989 to repair the leaks. During one event, the penstock was dewatered for approximately 5-6 days, which allowed the wood staves to dry out and shrink in size. When the penstock was watered up there were a significant number of additional leaks of various sizes, which required lengthy time and effort spent to correct and seal the new leaks. Based on this experience, the penstock has been dewatered and watered up during the same day to repair any leaks in the penstock. However, each time the penstock is dewatered, additional leaks appear when the penstock is watered up again. Overall, the dewatering of the penstock is a significant activity that creates just as many or more leaks than those that are repaired.

The leakage of water from the penstock has caused an accelerated rate for:

- Wood penstock to deteriorate;
- Metal bands to corrode and rust;
- Increase growth of vegetation;
- Deterioration of wood supports and enclosures; and
- Increase maintenance cost for control, sealing and patching of leaks.

.4 Ice Buildup

All leaks from the penstock result in significant ice formation during the winter. The ice formations are becoming an increasing problem for Hydro because of its danger/risk to local residents.

The formation of ice was investigated during the winter of 2001 and several observations were made. The ice formations were fed from the penstock by the constant flow of running (leaking) water. The ice formations extended down over the sides of the penstock to the ground. One ice formation observed was 8 ft high and 3 ft long at its base, the average ice formation was 5 – 6 ft in height, see photo #14. The danger caused by the ice formations is that the ice loads or large ice chunks could severely damage or rupture the weakened penstock. Another key area of ice formation was under the penstock enclosure. The leaking water causes large ice formations under the enclosure around the area of the access road, see photo #15. Besides adding a substantial load to the penstock and its support structure, it also interrupts local traffic (this sometimes leads to unsupervised demolition of the ice).

.5 Steel Section of Penstock

The first section of the penstock, from the intake to approximately 80 ft downstream, is fabricated from riveted steel plate; refer to location #1 on map SA-1 and photos #16 & #17. Because of the age of this steel section of penstock plus the fact that it has been partially or totally submerged for years, it continues to deteriorate. In addition, the concrete saddles for this section are also damaged. This section of penstock will likely be required to be replaced at the same time as the adjacent wooden penstock.

.6 Enclosure Over Access Road

There is a section of the penstock, located just above the community, which crosses over a small access road, refer to location #2 on map SA-2. There are two critical areas with this location; the support structure and enclosure, see photos #18 & #19.

.1 Support Structure

The support structure for the penstock is supported by 8" x 8" timbers at roughly 8.5 ft centers. At the upstream end, the enclosure is practically on the ground and it rises off the ground until it reaches the road where it is supported 10 ft off the ground by 8"x 8" and 6" x 6" timbers. The penstock is supported horizontally by two poles spanning the road. Some of the timbers appear to be creosote treated while others do not show any signs of protective coating. This structure is original and is showing its age. This structure supports the penstock, the enclosure, snow loads and substantial ice loads, while providing daily access to local residents.

.2 Penstock Enclosure

The penstock is enclosed for a length of 75 ft in the vicinity of the access road; the enclosure was built to reduce ice formation during the winter. The penstock invert was heat traced to reduce ice buildup inside of the structure; however, ice buildup inside and outside of the enclosure is still an ongoing problem. There are several concerns associated with this structure including the old and deteriorated condition of the enclosure, reliability of the heat tracing, and the limited access for inspection and maintenance of the penstock inside the enclosure. In general, the structure is becoming more of a safety concern as it ages.

.7 <u>Buried Section of Penstock</u>

The penstock passes through the middle of the community and at times, is within a few feet of the adjacent houses; see photos #20 & #21. Also a considerable length of the penstock, approx. 200 ft is buried, refer to location #3 on map SA-2 and see photo #22. In 1998, a section of the buried penstock was excavated and it was observed that the penstock is supported on cradles, similar to the rest of the penstock. Buried penstocks are designed to be fully supported along their length, the discovery of cradles supporting the penstock in the buried section, suggests that the penstock was not designed to be buried. The burial of the penstock subjects it to additional loads from the overburden soil and live loads from vehicles, skidoos, woodpiles, etc. In addition, there is very poor drainage around the penstock causing the penstock to be submerged in water. The risk associated with this section of penstock is high because of additional loading, moist conditions and lack of maintenance; there is a high probability of failure of this section of the penstock.

.8 <u>Road Bridge</u>

A section of the penstock (approximately 30 ft) crosses under the main access road through the community, refer to location #4 on map SA-2. There are two key items at this location, the support structure and penstock condition.

.1 Bridge Structure

Some of the existing bridge components were constructed in 1971 and they are showing obvious signs of deterioration. The bottom section (approx. lower ¾) of the bridge abutments are constructed from local untreated timbers and they are deteriorating, see photo #23. It appears that the only thing keeping the abutments from collapsing is a framework of pressure treated timber braced between the existing abutments, which were installed several years ago, see photo #24. The department of Works, Services and Transportation have indicated that they have no plans to replace this structure in the near future.

.2 Penstock

It is extremely difficult to inspect the condition of the existing penstock due to the limited access under the bridge and around the penstock. However, from the limited inspections it has been observed that several steel bands are severely deteriorated and there are several leaks. There has been very little or no maintenance to this section of the penstock because of the limited access.

.9 Road Crossings

There are a total of four locations where the penstock crosses various access roads. Two of the four have been identified above (penstock enclosure and road bridge), at the remaining two locations the penstock passes under the roads. The first location is near the intake and is the access road for the Nugget Pond gold mine and was constructed in the early 1990's. The penstock is enclosed in a culvert for a length of 65 ft. The second location is near the powerhouse and crosses the main access road to the community. The penstock is buried for a length of 130 ft. At this location, the penstock is buried and is heavily covered in vegetation. The type of structure used to protect the penstock from additional loads caused by the road crossing is unknown, however, it is assumed to be a culvert. In both of these locations it is impossible to inspect or perform any maintenance on the wooden penstock or steel bands.

.10 Penstock Coating

The original wooden penstock components were coated with creosote to provide protection from deterioration and sunlight. Typically a wood penstock would be recoated with creosote every 5-10 years to maintain the protective coating. This penstock has not been coated for at least 15 years (due to environmental restrictions on the use of creosote) and as a result the majority of the wooden penstock has no protection coating, especially along the top, see photo #25. The lack of protective coating has accelerated the deterioration of the wooden staves.

.11 Use by Residents of Community

As indicated earlier, the penstock passes through the community and in several locations the penstock is within a few feet from homes and roadways. The proximity of the penstock to the homes has encouraged many residents to tap into the penstock for a source of water, see photos #26 & #27. These taps were constructed without any permission from Hydro and in several locations have been abandoned and leaking water, see photo #28. In addition, all terrain vehicles and skidoos travel over and under the penstock, which imposes additional loads and stresses on the penstock. In the upper half of the penstock, there is firewood stacked adjacent to the penstock, see photo #29, and in several places there are cuts in the penstock from chainsaws. The use (or abuse) of the penstock by local residents has lead to increased deterioration of the penstock.

.12 Summary

A significant number of these identified problems are located in the high-pressure section of the penstock that runs through the community. In addition, there is more than 300 feet of covered or buried penstock, located within this section, which had very minimum maintenance over the years due to the limited access. This section has a potential for high liability in case of a failure.

3.0 Significant Historical Events

During the operating history of the Plant, several events have occurred which have caused damage or had potential to damage the penstock.

.1 Flood Damage – 1992

The lower section of the penstock passes under the main access road to the community and then proceeds along the side of a brook towards the powerhouse, refer to location #5 on map SA-2. In 1992 high water levels in the brook caused a section of the embankment under the penstock to erode. Untreated timber cribbing was installed along side of the brook to support the penstock, see photos #30 & #31. The timber support is 15 years old and is still subject to brook damage. The penstock has also developed a noticeable dip in elevation at this location resulting in more leaks.

.2 Flood Damage – 1996

In 1996 water overtopped Snook's Arm main dam and caused flooding downstream. The flooding caused a 200 ft section of the access road to the Nugget Pond gold mine to be washed away. The flooding caused a significant amount of rock and debris to move downstream and adjacent to the penstock. Though, the majority of the rock debris was removed, however some of the rocks remain next to the penstock, see photos #32 & #33. This rock debris probably has and will continue to impose stresses on the penstock and, which over time, may displace the penstock transversely. Another similar event would likely have a major impact on this section of the aged and weakened penstock.

.3 Fire Damage

In 2002 a fire occurred in the valve enclosure around the vacuum breaker valve, see photos #34 & #35. The fire was caused by a malfunction of the heat tracing and caused the destruction of the valve enclosure and damage to the valve. Luckily, there was no apparent damage to the penstock. However, the vacuum breaker valve did require repair. And, as stated earlier, if this valve fails to operate when required, the penstock may collapse.

4.0 Reliability

.1 General

Wooden stave penstocks typically have a design life of 40 years. The Snook's Arm penstock has been in operation since 1956. Numerous assessments of the penstock condition have been conducted and are summarized in Table 1.

Report	Author	Date	Comments
Inspection Report of Venam's Bight & Snook's Arm Penstocks	Canbar Inc.	Sept. 1998	"This pipe is 42 years old but is still expected to provide several more years of service, provided proper maintenance practices are still observed."
Inspection Report of Snook's Arm & Venam's Bight Penstocks	Canbar Inc.	Aug. 2000	"Should icing up become unmanageable or potential liability become significant, due consideration should be given to the replacement of all or part of this pipe prior to the end of the pipe's otherwise practical and safe service life."

Table 1: Summary of Penstock Inspection Reports and Recommendations

.2 Summary

The normal design life of most wooden penstocks is 40 years. This penstock is 47 years old and when replaced, in 2006, will be 50 years old.

This penstock is significantly beyond its original design life, has many identified problem areas, continues to deteriorate and maintenance costs are increasing. The probability of failure and its impact on generation, as well as, loss of life and property will continue to increase. It is recommended to replace the penstock as soon as possible.

5.0 Safety

.1 General

The penstock is 3050 ft long and approximately half of its length travels through the community. In several places it is only a few feet away from adjacent homes. The penstock is 47 years old and considering its age, condition and known problems, the probability of failure is increasing with time.

.2 Failure Analysis

A computer simulated failure of Snook's Arm main dam was completed in 2001 and revealed that there would be potential damage to structures and injury to those individuals in the immediate area. The majority of the flooding may be confined to the river valley that runs along the east side of the community and the area around the harbour.

A major break in the upper portion of the penstock is expected to cause flooding in a similar area to that of a dam failure. Damage would also be expected to occur to the balance of the penstock and to nearby property.

However, if a major break occurred in the lower half of the penstock, it is expected that the water would flow through the middle of the community. Due to the proximity of the homes adjacent to the penstock, it is expected that significant property damage and personal injury would occur.

It is important to note that the extent of flooding would depend on numerous factors, including:

- Time of year;
- Time of day;
- Weather conditions;
- Location of break or leak;
- Time between break occurring and break detected;
- Amount of time between break and stopping flow of water.

.3 Summary

As the age of the penstock increases so does the probability of a major break. It is recommended to replace the penstock as soon as possible.

6.0 Alternatives

.1 General

The penstock is currently 47 years old and beyond its normal design life. It has deteriorated and must be replaced. The following alternatives were studied:

i.) Do Nothing;
ii.) Retire Plant;
iii.) Replace Penstock;
iv.) Phased Replacement of Penstock.

.2 Do Nothing

This alternative is available in any project. However, in this case, a break in the penstock is most likely to occur in the lower section of the penstock, which is subject to the highest pressure. Due to the proximity of the community to the lower half penstock, significant damage would occur to private property, community infrastructure and the potential exists for personal injury. Based on this risk to Hydro, this alternative is not recommended.

.3 Replace Entire Penstock

This alternative would involve replacing the existing penstock with a new penstock from the intake to the Plant. The detailed design for the new penstock would consider the least cost consistent with reliable service. The material used may be steel, fiberglass or high-density plastic products. The estimated cost for the replacement penstock with steel in 2006 is $1,930,000 (in 2003 dollars).

.4 Phased Replacement of Penstock

Under this alternative the penstock will be replaced in two phases. The lower, high-pressure section of the penstock which runs through the community (from mid point of the penstock to the powerhouse approximately 1500 ft long) will be replaced in 2006. This would reduce the higher potential liability to Hydro, caused by a failure in the high-pressure section. The design of the phased replacement of the penstock would consider a method(s) to reduce the impact to the community in the event of break in the upper portion of the penstock. In addition, the work will include maintenance to the upper section of the existing wood stave penstock. In the second phase, under this alternative, the upper remaining section of the penstock will be replaced in 2016.

.5 Retire Plant

Under this alternative the existing Plant and associated facilities would be retired. However, there would be a cost associated with the retirement of the Plant, including:

- Removal of powerhouse and equipment;
- Removal of penstock;
- Removal of dam structures (in a controlled manner);
- Remediation of the environment.

It is estimated that it would cost approximately $500,000 to remove the existing structures and remediate the sites. Also, an Environmental Impact Statement would have to be prepared and submitted to the Provincial Government for review and approval.

It is recommended that this alternative be considered for further evaluation.

.6 Environmental Considerations

Snook's Arm generation displaces thermal generation at Holyrood and represents a direct reduction in fossil fuel emissions. With the heightened profile of the Kyoto protocol and other environmental initiatives there will likely be interest in the emissions reductions associated with this and similar projects. The following table presents an estimate of annual CO_2, N_2O and SO_2 reductions attributable to Snook's Arm.

Alternative	Estimated Emission Reductions (Tonnes per year)		
	CO_2	N_2O (CO_2e)	SO_2
Snook's Arm	2,796	0.06 (18)	32

While it is difficult to estimate the exact nature of future emissions control programs and the resulting value of any emissions credits, the following representative values have been used for sensitivity analysis:

- $10/tonne for CO_2 based on Government of Canada estimates; and

- $200/tonne for SO_2 based on recent emissions trading experience in the US.

7.0 Cost Evaluation

.1 General

Four alternatives are identified in the previous section.

Three alternatives, except "do nothing", are further evaluated. Listed below are the cost estimates, assumptions and analysis of the data:

.2 Cost Estimates

Direct capital cost estimates for each alternative is listed in Table 2.

Alternative		Est. Cost (2003 $'s)
1.)	Replace Entire Penstock	$1,930,000
2.)	Phased Replacement of Penstock	$2,140,000
3.)	Retire Plant	$500,000

Table 2: Summary of Cost Estimates for Penstock Alternatives

.3 Assumptions

Several assumptions were made in order to complete the cost analysis for each alternative. These include:

- Average escalation rate of 2%;
- Average interest (discount) rate of 8.5%;
- Project contingency rate of 10%;
- Corporate overheads at a rate of 6%;
- Unit Output: 590 kW;
- Average annual production of 3.5 GWh
- Annual Operator Cost: $15,000;
- Annual O & M Costs: $25,000;
- Runner Maintenance: $7,500 every ten years.

Additional assumptions were required for each alternative investigated, these include:

Alternative #1 (Replace Entire Penstock)

- Engineering Costs of $115,000 in 2005;
- Construction Costs of $1,815,000 in 2006.

Alternative #2 (Phased Replacement of Penstock)

- Engineering Costs of $90,000 in 2005;
- Construction Costs of $1,100,000 in 2006;
- Engineering Costs of $50,000 in 2015;
- Construction Costs of $900,000 in 2016;
- Annual penstock maintenance for upper section until replaced in 2016: $20,000.

Alternative #3 (Retire Plant)

- Retire Plant and Remediate Site(s) at a cost of $500,000 in 2006;
- Replace energy from Holyrood.

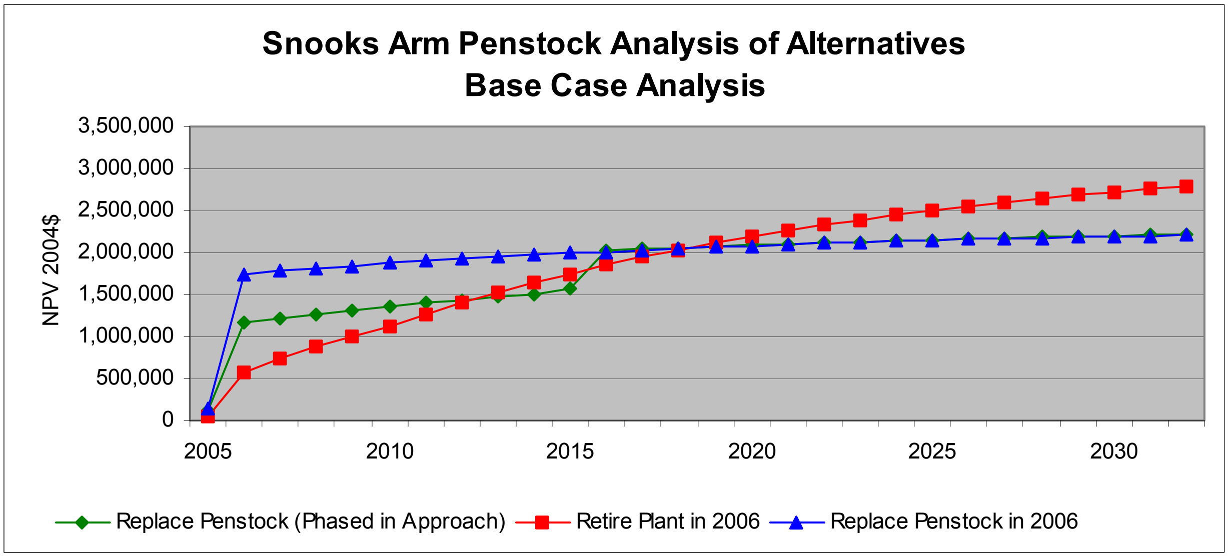
.4 Economic Analysis

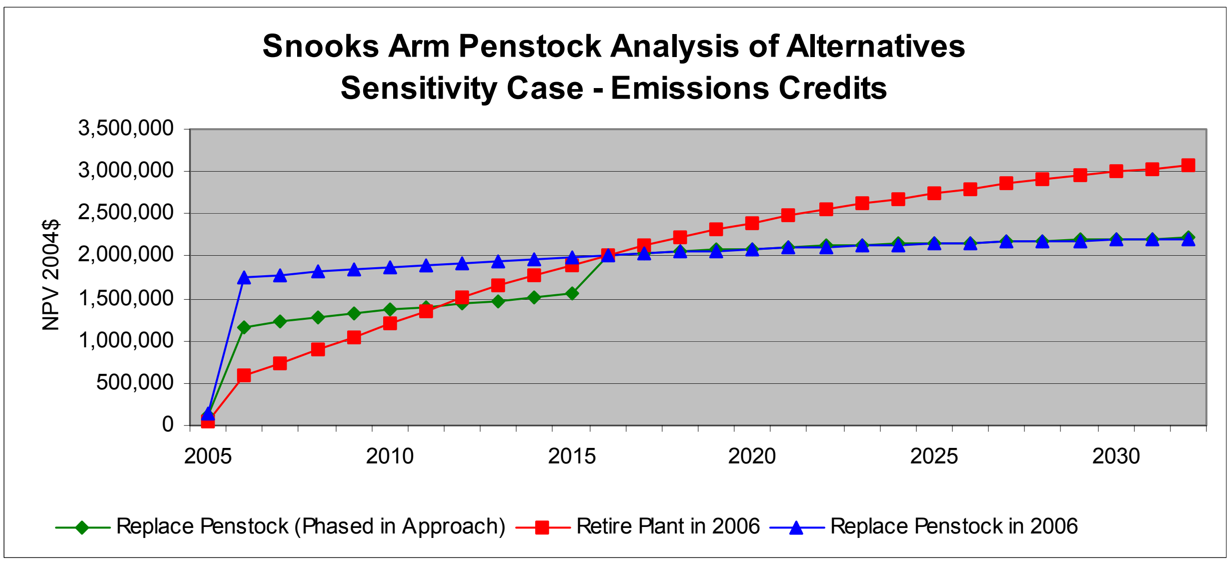
The economic analysis compared the cumulative present worth cost (capital and operating) of each of the penstock replacement alternatives against each other and against the plant retirement alternative. In addition to the base case analysis, a sensitivity case addressing the inclusion of emissions related costs was also prepared.

A summary of the detailed economic analysis found in Appendix C is presented in the following table and the graphs that follow:

Table 7-1

Snook's Arm Penstock Replacement Comparison of Alternatives		
	CPW Preference Against Plant Retirement Alternative	
	CPW (2004$)	Payback Period
Base Case:		
Full Replacement in 2006	$585,923	13 Years
Phased in Replacement (2006 & 2016)	$577,488	Phase 1 - 7 Years Phase 1+2 – 13 Years
Sensitivity Case – Emissions Costs:		
Full Replacement in 2006	$862,672	10 Years
Phased in Replacement (2006 & 2016)	$854,237	Phase 1 - 6 Years Phase 1+2 – 11 Years





Based on this analysis, it is evident that the replacement of the penstock is preferred over the plant retirement alternative. While the phased in replacement of the penstock shows an initial payback of 7 years on the first replacement phase, the payback on the complete project in both replacement alternatives is 13 years. Further, there is a negligible difference in the cumulative present worth costs of either of the replacement alternatives after 13 years.

Sensitivity analysis indicates that the inclusion of emissions related costs improves the preference for the penstock replacement alternative over the plant retirement alternative and also shortens the payback period for the full replacement alternative by 3 years.

8.0 Results

The results of the economic analysis indicated that the phased replacement of the penstock could provide the greatest net positive result. However, there are several disadvantages associated with this alternative, these include:

1. The upper section of the penstock would be 60 years old if replaced in 2016; this will be approximately 20 years beyond the design life of the penstock. Therefore, the upper portion of the penstock will remain a potential liability to Hydro.

2. The phased replacement of the penstock would require the entire penstock to be dewatered. Some method would have to be implemented to ensure the wood staves in the upper portion of the penstock do not dry out. The methods could include installing a bulkhead at the end the section of penstock, to be reused, and then keeping the penstock watered up or installing a sprinkler system (or similar system) to provide a continuous flow of water over the wooden staves. All of the methods would require the existing penstock to be dewatered for some period of time, which will cause some leakage when the penstock is put back into operation.

3. This alternative would also include the construction of a dam or similar structure near the joint between the new and existing penstocks to allow any water from the failure or rupture of the penstock to be diverted away from the community.

4. There would be additional costs associated with the upgrade of the existing penstock in 2006 to ensure an additional ten years of service life. In addition there will be annual operating maintenance costs associated with the existing penstock until it is replaced.

Based on the disadvantages associated with the phased replacement of the penstock, it is recommended that this alternative not be considered.

The next alternative with the greatest net positive result is the entire replacement of the penstock. The advantages of this alternative include:

1. Substantial reduction of potential liability to Hydro from potential failure or rupture of wood stave penstock.

2. Increased reliability of penstock.

3. Decreased energy losses, such as water loss from wood stave penstock and head loss (friction) in new penstock material.

4. Use of a renewable resource;

5. A design life in excess of 30 years for the new penstock;.

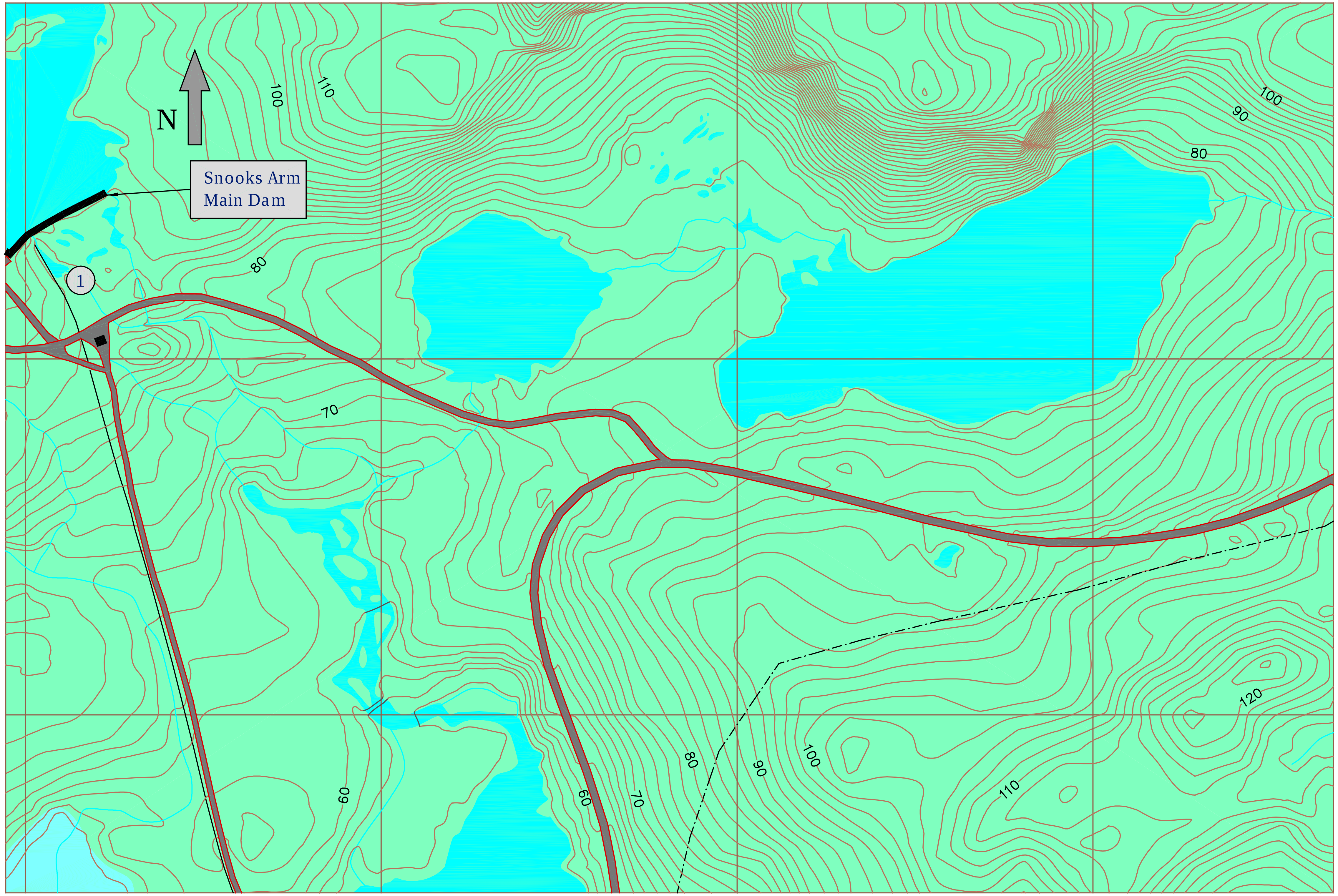
The entire replacement of the penstock will provide the lowest overall cost to Hydro while providing an acceptable level of reliability for the production of electricity.

9.0 Recommendations

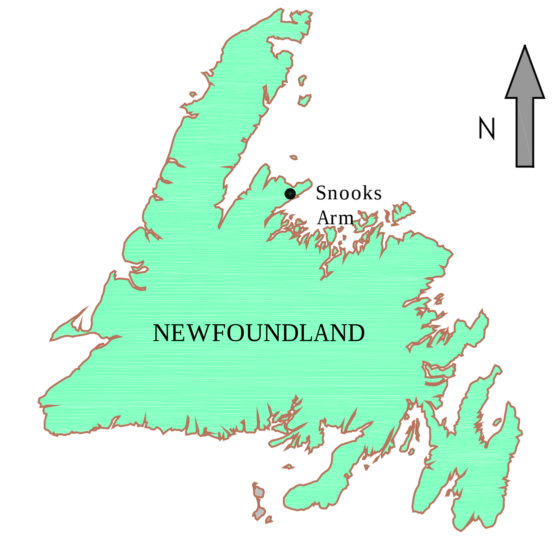
Based on the review of the available alternatives and the economic analysis, it is recommended to replace the entire Snook's Arm penstock. The design should be completed in 2005 and the replacement completed in 2006. A proposed project schedule for the penstock replacement is included in Appendix D.

APPENDIX A

MAP OF SNOOK'S ARM PENSTOCK



MATCH TO SHEET "SV1-2"



LEGEND :

- ROAD
- STREAMS / ORIGINAL WATER LEVEL
- HOUSES / CABINS / BUILDINGS
- 50 ELEVATION (m)
- WHARFS / PIERS / SLIPWAYS
- PENSTOCK
- 1 REFERENCE LOCATION

NOTES:

1. MAP ORIGIN, AIR PHOTO AND MAP LIBRARY, GOVERNMENT SERVICES AND LANDS. SCALE 1: 2500 CONTOUR INTERVAL 2 m.

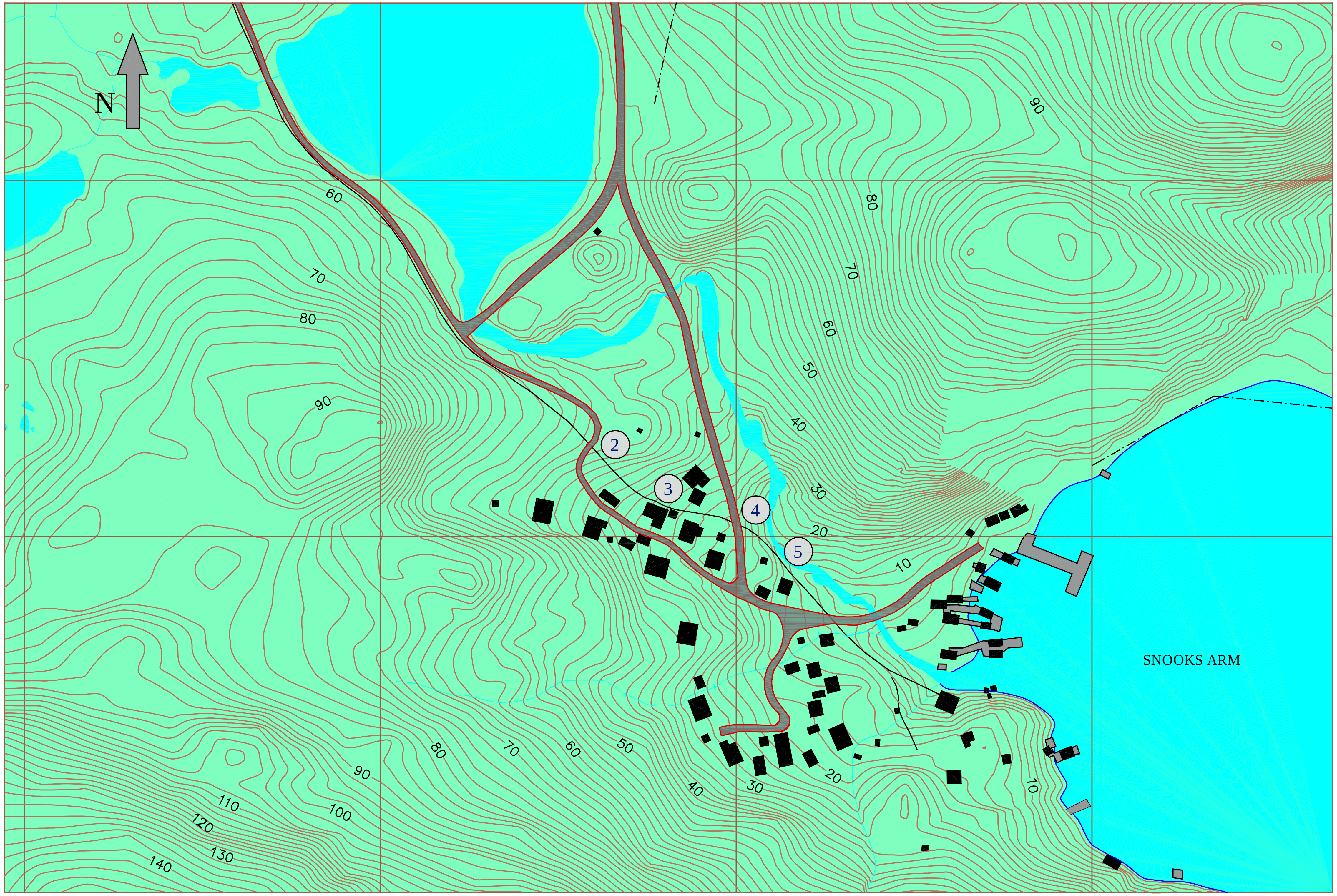
SCALE
0 100 200 m.
0 500 ft.

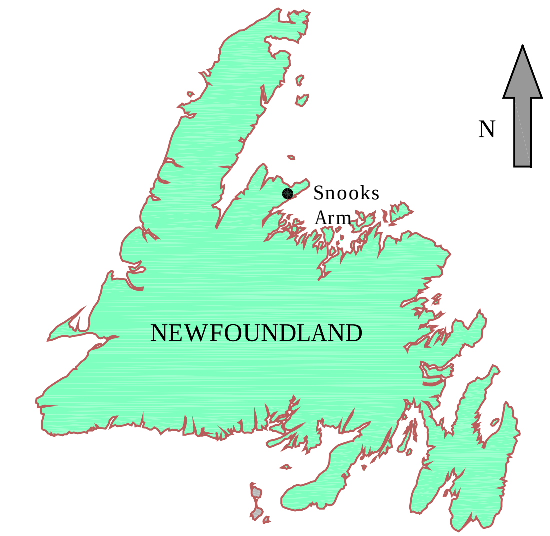
NEWFOUNDLAND AND LABRADOR HYDRO

SNOOKS ARM PENSTOCK
TOPO MAP
km 0.0 to km 0.5

Date : Mar. 2001	Design: J. Phillips	Map No. SA-2
Dwn.: D. Oliver	App.:	Sheet 1 of 2

MATCH TO SHEET "SV1-1"





LEGEND :

- ROAD
- STREAMS / ORIGINAL WATER LEVEL
- HOUSES / CABINS / BUILDINGS
- 50 — ELEVATION (m)
- WHARFS / PIERS / SLIPWAYS
- PENSTOCK
- (1) REFERENCE LOCATION

NOTES:

1. MAP ORIGIN, AIR PHOTO AND MAP LIBRARY, GOVERNMENT SERVICES AND LANDS. SCALE 1: 2500
   CONTOUR INTERVAL 2 m.

SCALE

0 — 100 — 200 m.

0 — 500 ft.

NEWFOUNDLAND AND LABRADOR HYDRO

SNOOKS ARM PENSTOCK
TOPO MAP
km 0.5 to km 1.2

Date : Mar. 2001	Design: J. Phillips	Map No. SA-1
Dwn.: D. Oliver	App.:	Sheet 2 of 2

APPENDIX B

PHOTOS

Photo #1: View of penstock, August 2000.

Photo #2: View of flat and reverse section of penstock, August 2000.

Photo #3: View of brooming between metal bands, August 2000.

Photo #4: View of crushing and brooming of wooden staves, August 2000.

Photo #5: Vegetation growth around and on penstock, June 2001.

Photo #6: Moss and other vegetation growing directly on penstock, June 2001.

Photo #7: View of corrosion below threads, August 2000.

Photo #8: View of corrosion on metal bands, August 2000.

Photo #9: Water leaking from penstock, August 2000.

Photo #10: Water leaking from penstock, August 2000.

Photo 11: View of water leaking from penstock, August 2000.

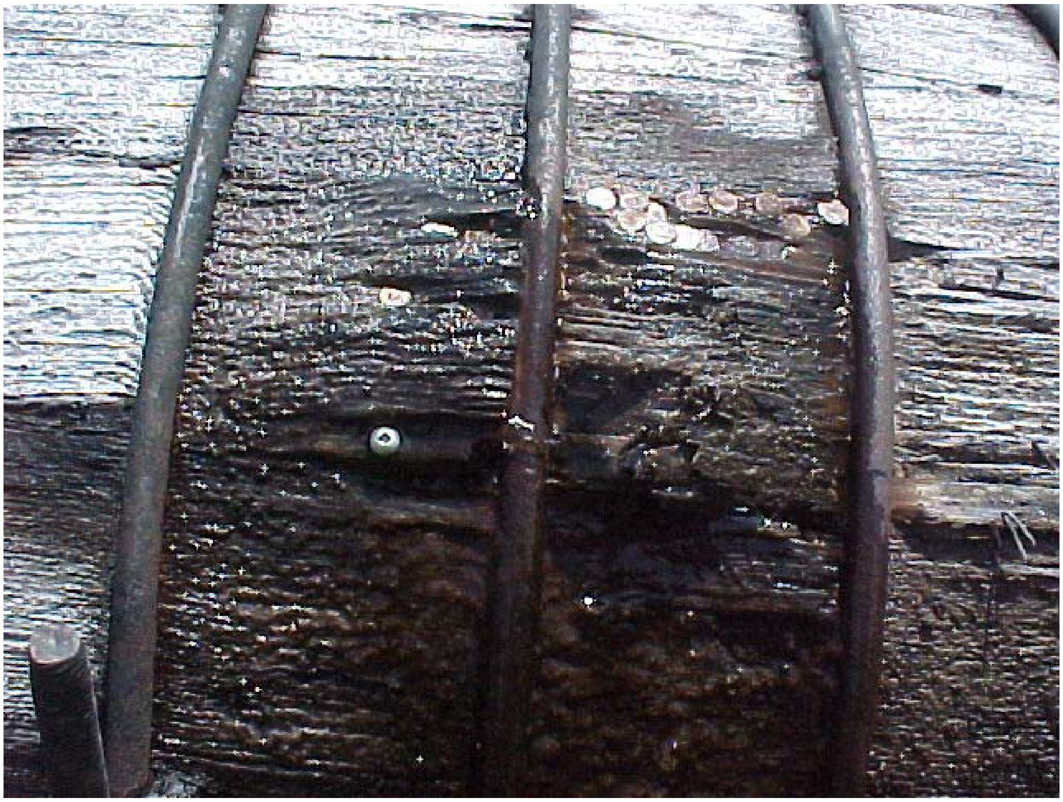


Photo #12: Nails driven into penstock to stop leaks, June 2001.

Photo #13: Metal patches placed under new bands to stop leaks, October 2003.

Photo 14: Ice formation above penstock, April 2001.

Photo 15: Ice formations under penstock enclosure, April 2001. For location of ice formation refer to Photo #18.

Photo #16: Accumulation of water behind concrete cut-off dam, June 2001.

Photo #17: Steel section of penstock, partially submerged in water, June 2001.

Photo 18: Penstock enclosure over access road, July 2002. Highlighted area indicates location of ice formation shown in Photo #15.

Photo 19: Support structure for penstock enclosure, July 2002.

Photos #20 & #21: View of penstock passing through community, October 1992.

Photo #22 Buried section of penstock in community, June 2001.

Photo 23: View of bottom portion of bridge abutment, June 2001.

Photo 24: Road bridge over penstock, note timber reinforcement between abutments, July 2002.

Photo #25: Loss of protective coating on penstock and bleaching of the wood, August 2000.

Photos #26 & #27: Water take-offs to adjacent homes (left) and Nugget Pond gold mine security building (right), August 2000.

Photo #28: Location of abandoned water tap in penstock, June 2001.

Photo #29: View of access road and firewood adjacent to penstock, August 2000.


Photos #30 & #31: Timber support added under penstock after erosion of embankment, October 1992.

Photo #32: View of rocks and gravel washed up against penstock, April 1996.

Photo #33: View of rocks and gravel under penstock, August 2000.

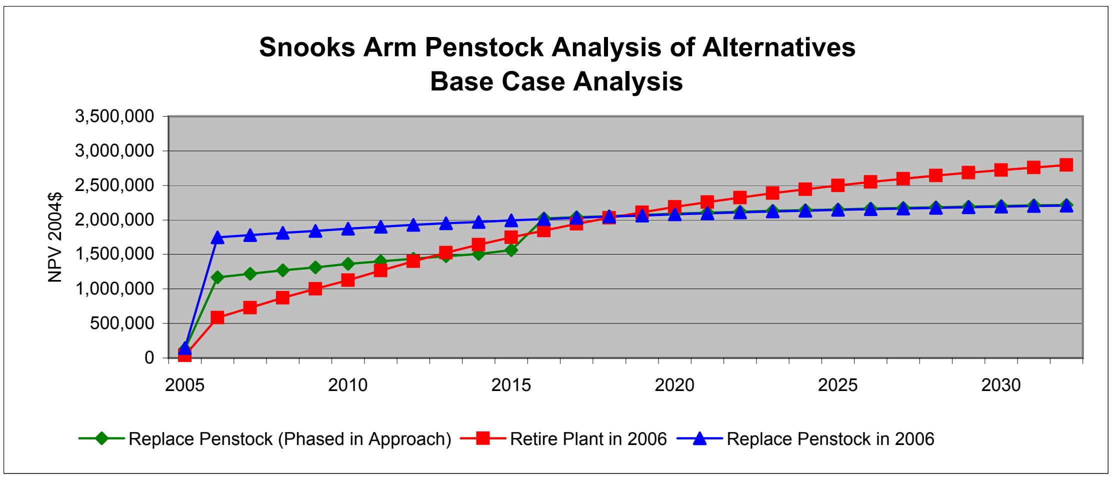
Photo 34: Fire damage to vacuum breaker valve enclosure, July 2002.

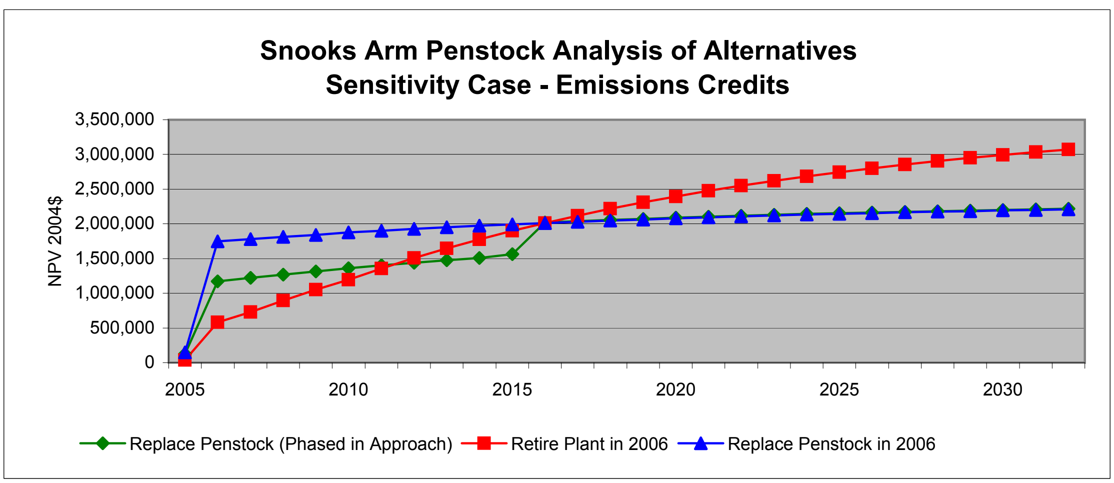
Photo 35: Vacuum breaker valve after fire, July 2002.

APPENDIX C

DETAILED ECONOMIC ANALYSIS

Snook's Arm Penstock Replacement Comparison of Alternatives		
Base Case	**CPW Preference against Plant Retirement Alternative** **CPW (2004$)**	**Payback Period**
Full Replacement in 2006	$585,923	13 years
Phased in Replacement (2006 and 2016)	$577,488	7 & 13 years
Sensitivy Case - Emissions Credits		
Full Replacement in 2006	$862,672	10 years
Phased in Replacement (2006 and 2016)	$854,237	6 & 11 years



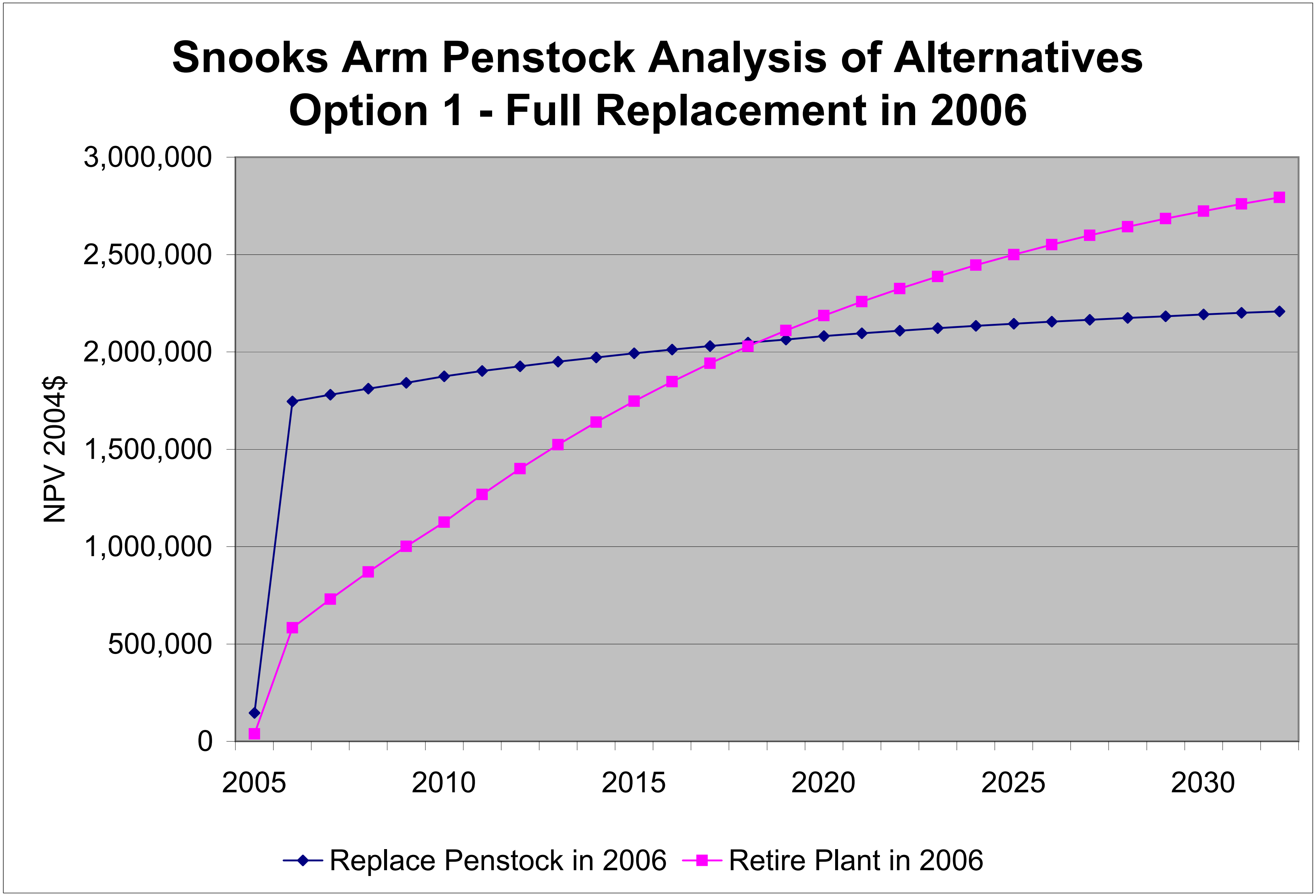


Snooks Arm Penstock Replacement

Option 1 - Full Replacement in 2005/6

Assumptions				
Annual Escalation:	2.0%		Engineering (2005):	112,000
Discount Rate:	8.5%		Construction (2006):	1,735,000
Installed Capacity:	590	kW		
Annual Energy:	3,500,000	kWh		
Holyrood Conversion:	624	kWH/BBL	Operator + O&M (2003$):	40,000
Holyrood Var O&M:	4.5	mills/kWh 2004$	Runner Maintenance (2003$):	7,500
Fuel Forecast:	Fall 2002	mills/kWh	Upper Penstock Maintenance (2003$)	20,000
Capacity Value (CT equiv.):	100	$/kW/yr 2004$	Retire Plant in 2006:	500,000

	Replace Penstock in 2006					Retire Plant in 2006							Difference	
Year	Capital Cost	Plant O&M	Runner & Penstock Maint.	Sub-total Current$	Sub-total CPW 2004$	Capital Cost	Operator	Capacity	Holyrood Var O&M	Fuel	Sub-total Current$	Sub-total CPW 2004$	TOTAL Current$	TOTAL CPW 2004$
2004														
2005	116,525	41,616		158,141	145,752		41,616				41,616	38,356	116,525	107,396
2006	1,841,196	42,448		1,883,644	1,745,823	530,604	21,224		8,193	81,190	641,211	583,036	1,242,433	1,162,787
2007		43,297		43,297	1,779,721				16,714	170,513	187,227	729,617	-143,930	1,050,104
2008		44,163		44,163	1,811,588				17,048	176,402	193,451	869,206	-149,287	942,382
2009		45,046		45,046	1,841,546				17,389	181,731	199,120	1,001,630	-154,074	839,916
2010		45,947	8,615	54,563	1,874,990				17,737	184,535	202,272	1,125,612	-147,710	749,378
2011		46,866		46,866	1,901,466			45,895	18,092	187,340	251,327	1,267,593	-204,460	633,873
2012		47,804		47,804	1,926,356			45,895	18,454	190,144	254,493	1,400,100	-206,689	526,256
2013		48,760		48,760	1,949,755			45,895	18,823	192,949	257,666	1,523,749	-208,907	426,006
2014		49,735		49,735	1,971,752			45,895	19,199	195,753	260,847	1,639,118	-211,112	332,634
2015		50,730		50,730	1,992,431			45,895	19,583	198,558	264,036	1,746,748	-213,306	245,683
2016		51,744		51,744	2,011,872			45,895	19,975	201,643	267,512	1,847,253	-215,768	164,619
2017		52,779		52,779	2,030,147			45,895	20,374	204,728	270,997	1,941,091	-218,218	89,057
2018		53,835		53,835	2,047,328			45,895	20,782	207,813	274,489	2,028,692	-220,655	18,637
2019		54,911		54,911	2,063,480			45,895	21,197	210,897	277,990	2,110,460	-223,078	-46,980
2020		56,010	10,502	66,511	2,081,511			45,895	21,621	213,982	281,499	2,186,773	-214,987	-105,262
2021		57,130		57,130	2,095,785			45,895	22,054	217,348	285,297	2,258,057	-228,167	-162,271
2022		58,272		58,272	2,109,205			45,895	22,495	220,994	289,383	2,324,697	-231,111	-215,493
2023		59,438		59,438	2,121,820			45,895	22,945	224,639	293,479	2,386,986	-234,041	-265,167
2024		60,627		60,627	2,133,679			45,895	23,404	228,566	297,864	2,445,254	-237,238	-311,574
2025		61,839		61,839	2,144,829			45,895	23,872	232,212	301,978	2,499,698	-240,139	-354,869
2026		63,076		63,076	2,155,310			45,895	24,349	236,138	306,382	2,550,608	-243,306	-395,299
2027		64,337		64,337	2,165,163			45,895	24,836	240,064	310,795	2,598,207	-246,458	-433,044
2028		65,624		65,624	2,174,426			45,895	25,333	243,990	315,218	2,642,700	-249,594	-468,274
2029		66,937		66,937	2,183,134			45,895	25,840	248,197	319,932	2,684,321	-252,995	-501,187
2030		68,275	12,802	81,077	2,192,855			45,895	26,356	252,404	324,655	2,723,248	-243,578	-530,393
2031		69,641		69,641	2,200,551			45,895	26,883	256,611	329,389	2,759,649	-259,748	-559,097
2032		71,034		71,034	2,207,786			45,895	27,421	261,098	334,414	2,793,709	-263,380	-585,923

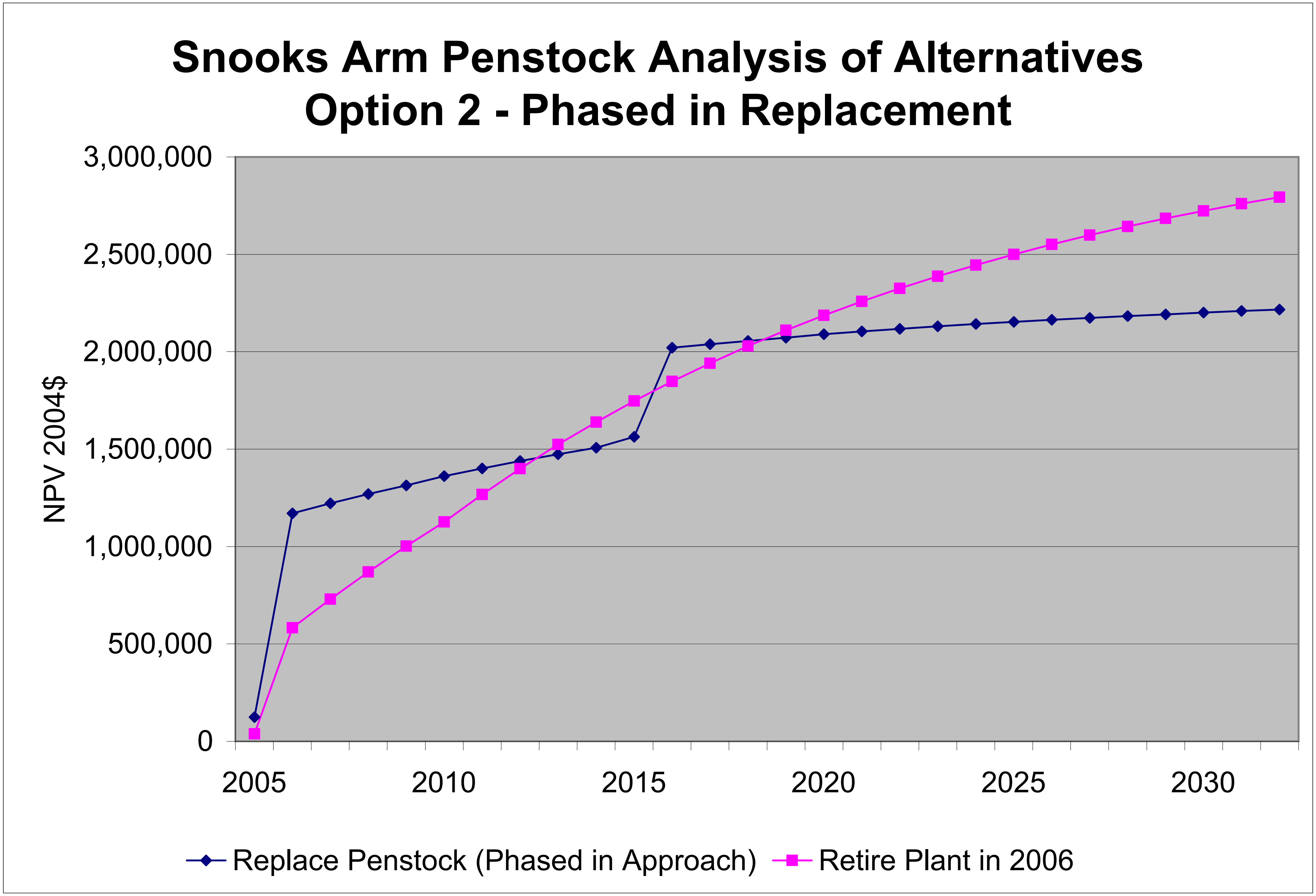


Snooks Arm Penstock Analysis of Alternatives
Option 1 - Full Replacement in 2006
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
NPV 2004$
2005
2010
2015
2020
2025
2030
Replace Penstock in 2006
Retire Plant in 2006

Snooks Arm Penstock Replacement
Option 2 - Phased in Replacement

Assumptions				
Annual Escalation:	2.0%		Engineering - High Pressure Section (2005):	90,000
Discount Rate:	8.5%		Construction - High Pressure Section (2006):	1,100,000
Installed Capacity:	590	kW	Engineering - Low Pressure Section (2015):	50,000
Annual Energy:	3,500,000	kWh	Construction - Low Pressure Section (2016):	900,000
Holyrood Conversion:	624	kWH/BBL	Operator + O&M (2003$):	40,000
Holyrood Var O&M:	4.5	mills/kWh 2004$	Runner Maintenance (2003$):	7,500
Fuel Forecast:	Fall 2002	mills/kWh	Upper Penstock Maintenance (2003$)	20,000
Capacity Value (CT equiv.):	100	$/kW/yr 2004$	Retire Plant in 2006:	500,000

	Replace Penstock (Phased in Approach)					Retire Plant in 2006							Difference	
			Runner &											
	Capital	Plant	Penstock	Sub-total		Capital			Holyrood		Sub-total		TOTAL	
Year	Cost	O&M	Maint.	Current$	CPW 2004$	Cost	Operator	Capacity	Var O&M	Fuel	Current$	CPW 2004$	Current$	CPW 2004$
2004														
2005	93,636	41,616		135,252	124,656		41,616				41,616	38,356	93,636	86,300
2006	1,167,329	42,448	21,224	1,231,001	1,170,337	530,604	21,224		8,193	81,190	641,211	583,036	589,790	587,301
2007		43,297	21,649	64,946	1,221,183				16,714	170,513	187,227	729,617	-122,281	491,566
2008		44,163	22,082	66,245	1,268,984				17,048	176,402	193,451	869,206	-127,206	399,778
2009		45,046	22,523	67,570	1,313,921				17,389	181,731	199,120	1,001,630	-131,550	312,291
2010		45,947	31,589	77,536	1,361,446				17,737	184,535	202,272	1,125,612	-124,736	235,834
2011		46,866	23,433	70,300	1,401,161			45,895	18,092	187,340	251,327	1,267,593	-181,027	133,568
2012		47,804	23,902	71,706	1,438,495			45,895	18,454	190,144	254,493	1,400,100	-182,787	38,396
2013		48,760	24,380	73,140	1,473,594			45,895	18,823	192,949	257,666	1,523,749	-184,527	-50,155
2014		49,735	24,867	74,602	1,506,589			45,895	19,199	195,753	260,847	1,639,118	-186,245	-132,528
2015	63,412	50,730	25,365	139,507	1,563,457			45,895	19,583	198,558	264,036	1,746,748	-124,529	-183,291
2016	1,164,246	51,744		1,215,990	2,020,307			45,895	19,975	201,643	267,512	1,847,253	948,478	173,054
2017		52,779		52,779	2,038,583			45,895	20,374	204,728	270,997	1,941,091	-218,218	97,492
2018		53,835		53,835	2,055,763			45,895	20,782	207,813	274,489	2,028,692	-220,655	27,072
2019		54,911		54,911	2,071,915			45,895	21,197	210,897	277,990	2,110,460	-223,078	-38,545
2020		56,010	10,502	66,511	2,089,946			45,895	21,621	213,982	281,499	2,186,773	-214,987	-96,827
2021		57,130		57,130	2,104,221			45,895	22,054	217,348	285,297	2,258,057	-228,167	-153,836
2022		58,272		58,272	2,117,640			45,895	22,495	220,994	289,383	2,324,697	-231,111	-207,058
2023		59,438		59,438	2,130,255			45,895	22,945	224,639	293,479	2,386,986	-234,041	-256,731
2024		60,627		60,627	2,142,115			45,895	23,404	228,566	297,864	2,445,254	-237,238	-303,139
2025		61,839		61,839	2,153,264			45,895	23,872	232,212	301,978	2,499,698	-240,139	-346,434
2026		63,076		63,076	2,163,745			45,895	24,349	236,138	306,382	2,550,608	-243,306	-386,864
2027		64,337		64,337	2,173,598			45,895	24,836	240,064	310,795	2,598,207	-246,458	-424,608
2028		65,624		65,624	2,182,861			45,895	25,333	243,990	315,218	2,642,700	-249,594	-459,839
2029		66,937		66,937	2,191,569			45,895	25,840	248,197	319,932	2,684,321	-252,995	-492,752
2030		68,275	12,802	81,077	2,201,291			45,895	26,356	252,404	324,655	2,723,248	-243,578	-521,958
2031		69,641		69,641	2,208,986			45,895	26,883	256,611	329,389	2,759,649	-259,748	-550,662
2032		71,034		71,034	2,216,221			45,895	27,421	261,098	334,414	2,793,709	-263,380	-577,488


Snooks Arm Penstock Analysis of Alternatives
Option 2 - Phased in Replacement
NPV 2004$
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
2005
2010
2015
2020
2025
2030
Replace Penstock (Phased in Approach)
Retire Plant in 2006

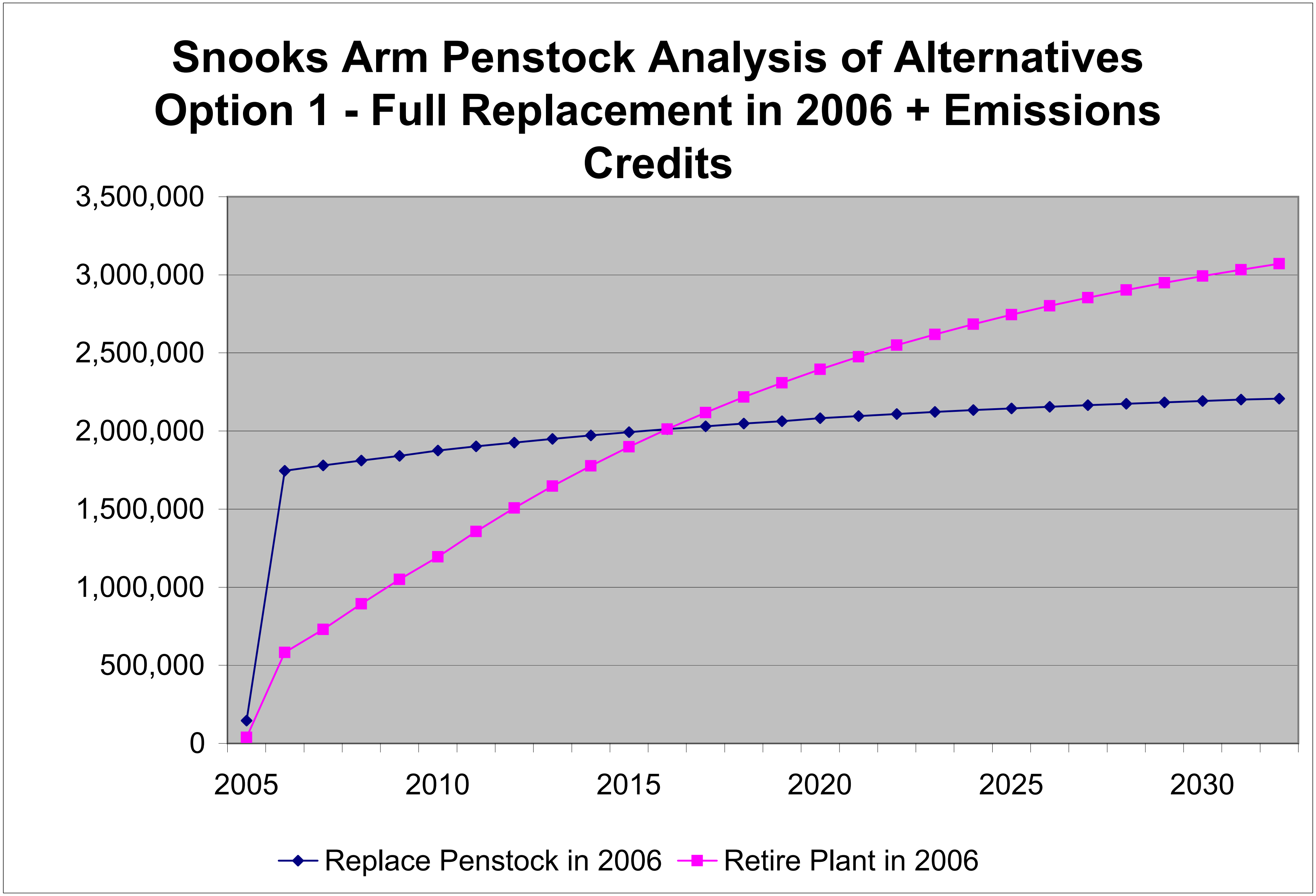
Snooks Arm Penstock Replacement

Option 1 - Full Replacement in 2005/6 + Emissions Credits

Assumptions				
Annual Escalation:	2.0%		Engineering (2005):	112,000
Discount Rate:	8.5%		Construction (2006):	1,735,000
Installed Capacity:	590	kW		
Annual Energy:	3,500,000	kWh		
Holyrood Conversion:	624	kWH/BBL	Operator + O&M (2003$):	40,000
Holyrood Var O&M:	4.5	mills/kWh 2004$	Runner Maintenance (2003$):	7,500
Fuel Forecast:	Fall 2002	mills/kWh	Upper Penstock Maintenance (2003$)	20,000
Capacity Value (CT equiv.):	100	$/kW/yr 2004$	Retire Plant in 2006:	500,000

	Replace Penstock in 2006					Retire Plant in 2006								Difference	
			Runner &												
	Capital	Plant	Penstock	Sub-total		Capital			CO_2 & SO_2	Holyrood		Sub-total		TOTAL	
Year	Cost	O&M	Maint.	Current$	CPW 2004$	Cost	Operator	Capacity	Emissions**	Var O&M	Fuel	Current$	CPW 2004$	Current$	CPW 2004$
2004															
2005	116,525	41,616		158,141	145,752		41,616					41,616	38,356	116,525	107,396
2006	1,841,196	42,448		1,883,644	1,745,823	530,604	21,224			8,193	81,190	641,211	583,036	1,242,433	1,162,787
2007		43,297		43,297	1,779,721					16,714	170,513	187,227	729,617	-143,930	1,050,104
2008		44,163		44,163	1,811,588				34,540	17,048	176,402	227,991	894,130	-183,827	917,459
2009		45,046		45,046	1,841,546				34,540	17,389	181,731	233,660	1,049,524	-188,614	792,022
2010		45,947	8,615	54,563	1,874,990				34,540	17,737	184,535	236,812	1,194,677	-182,250	680,313
2011		46,866		46,866	1,901,466			45,895	34,540	18,092	187,340	285,867	1,356,171	-239,000	545,296
2012		47,804		47,804	1,926,356			45,895	34,540	18,454	190,144	289,033	1,506,661	-241,229	419,695
2013		48,760		48,760	1,949,755			45,895	34,540	18,823	192,949	292,206	1,646,885	-243,447	302,870
2014		49,735		49,735	1,971,752			45,895	34,540	19,199	195,753	295,387	1,777,531	-245,652	194,221
2015		50,730		50,730	1,992,431			45,895	34,540	19,583	198,558	298,576	1,899,241	-247,846	93,190
2016		51,744		51,744	2,011,872			45,895	34,540	19,975	201,643	302,052	2,012,723	-250,308	-851
2017		52,779		52,779	2,030,147			45,895	34,540	20,374	204,728	305,537	2,118,520	-252,758	-88,373
2018		53,835		53,835	2,047,328			45,895	34,540	20,782	207,813	309,029	2,217,145	-255,195	-169,816
2019		54,911		54,911	2,063,480			45,895	34,540	21,197	210,897	312,530	2,309,072	-257,618	-245,592
2020		56,010	10,502	66,511	2,081,511			45,895	34,540	21,621	213,982	316,039	2,394,749	-249,527	-313,238
2021		57,130		57,130	2,095,785			45,895	34,540	22,054	217,348	319,837	2,474,663	-262,707	-378,878
2022		58,272		58,272	2,109,205			45,895	34,540	22,495	220,994	323,923	2,549,258	-265,651	-440,053
2023		59,438		59,438	2,121,820			45,895	34,540	22,945	224,639	328,019	2,618,878	-268,581	-497,058
2024		60,627		60,627	2,133,679			45,895	34,540	23,404	228,566	332,404	2,683,901	-271,778	-550,222
2025		61,839		61,839	2,144,829			45,895	34,540	23,872	232,212	336,518	2,744,573	-274,679	-599,744
2026		63,076		63,076	2,155,310			45,895	34,540	24,349	236,138	340,922	2,801,223	-277,846	-645,913
2027		64,337		64,337	2,165,163			45,895	34,540	24,836	240,064	345,335	2,854,111	-280,998	-688,948
2028		65,624		65,624	2,174,426			45,895	34,540	25,333	243,990	349,758	2,903,480	-284,134	-729,054
2029		66,937		66,937	2,183,134			45,895	34,540	25,840	248,197	354,472	2,949,594	-287,535	-766,460
2030		68,275	12,802	81,077	2,192,855			45,895	34,540	26,356	252,404	359,195	2,992,663	-278,118	-799,807
2031		69,641		69,641	2,200,551			45,895	34,540	26,883	256,611	363,929	3,032,880	-294,288	-832,329
2032		71,034		71,034	2,207,786			45,895	34,540	27,421	261,098	368,954	3,070,459	-297,920	-862,672

** Assumes value associated with reduction of 2814 tonnes CO_2 @ $10/tonne and 32 tonnes SO_2 @ $200/tonne annually


Snooks Arm Penstock Analysis of Alternatives
Option 1 - Full Replacement in 2006 + Emissions Credits
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
2005
2010
2015
2020
2025
2030
Replace Penstock in 2006
Retire Plant in 2006

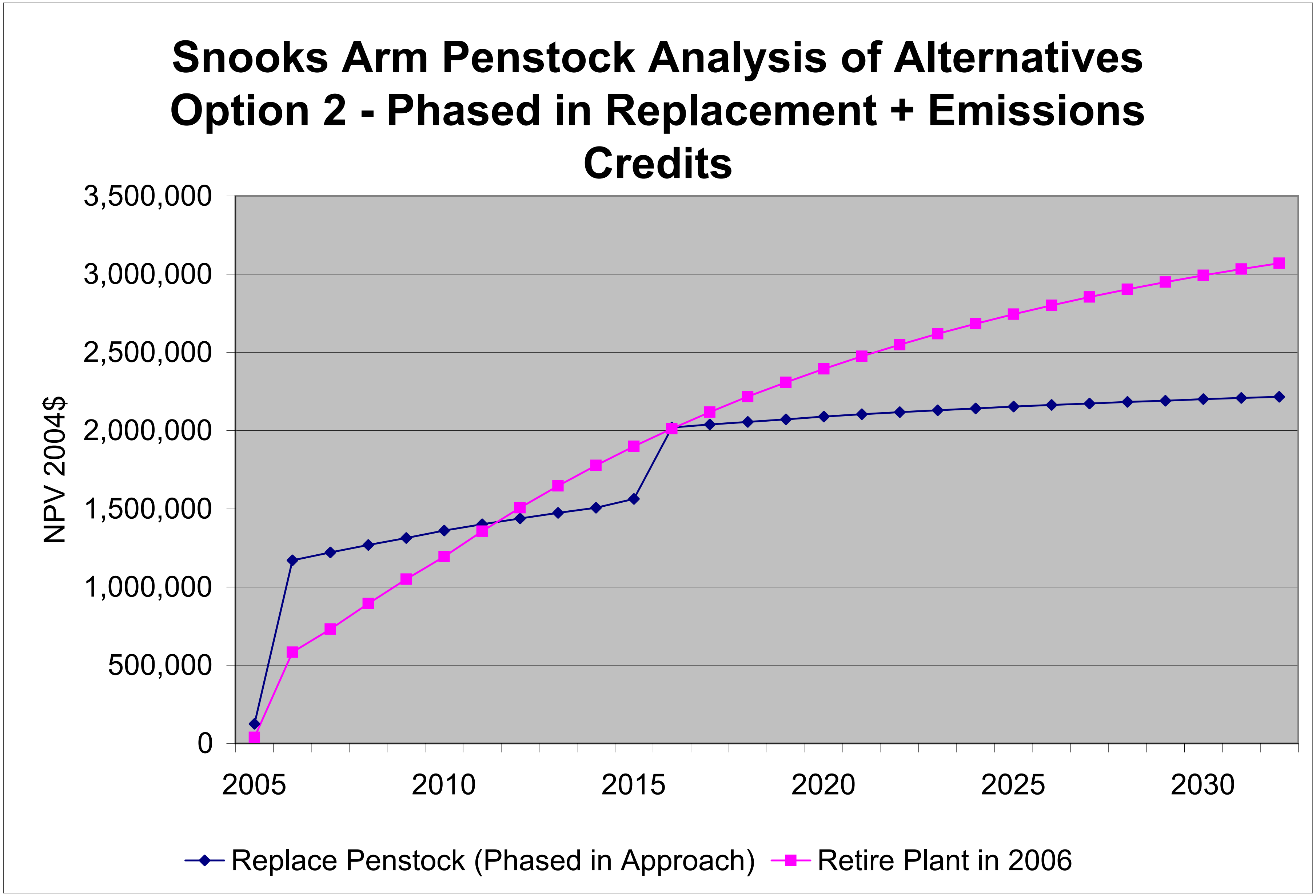
Snooks Arm Penstock Replacement

Option 2 - Phased in Replacement + Emissions Credits

Assumptions				
Annual Escalation:	2.0%		Engineering - High Pressure Section (2005):	90,000
Discount Rate:	8.5%		Construction - High Pressure Section (2006):	1,100,000
Installed Capacity:	590	kW	Engineering - Low Pressure Section (2015):	50,000
Annual Energy:	3,500,000	kWh	Construction - Low Pressure Section (2016):	900,000
Holyrood Conversion:	624	kWH/BBL	Operator + O&M (2003$):	40,000
Holyrood Var O&M:	4.5	mills/kWh 2004$	Runner Maintenance (2003$):	7,500
Fuel Forecast:	Fall 2002	mills/kWh	Upper Penstock Maintenance (2003$)	20,000
Capacity Value (CT equiv.):	100	$/kW/yr 2004$	Retire Plant in 2006:	500,000

	Replace Penstock (Phased in Approach)					Retire Plant in 2006								Difference	
			Runner &												
	Capital	Plant	Penstock	Sub-total		Capital			CO_2 & SO_2	Holyrood		Sub-total		TOTAL	
Year	Cost	O&M	Maint.	Current$	CPW 2004$	Cost	Operator	Capacity	Emissions**	Var O&M	Fuel	Current$	CPW 2004$	Current$	CPW 2004$
2004															
2005	93,636	41,616		135,252	124,656		41,616					41,616	38,356	93,636	86,300
2006	1,167,329	42,448	21,224	1,231,001	1,170,337	530,604	21,224			8,193	81,190	641,211	583,036	589,790	587,301
2007		43,297	21,649	64,946	1,221,183					16,714	170,513	187,227	729,617	-122,281	491,566
2008		44,163	22,082	66,245	1,268,984				34,540	17,048	176,402	227,991	894,130	-161,746	374,854
2009		45,046	22,523	67,570	1,313,921				34,540	17,389	181,731	233,660	1,049,524	-166,090	264,397
2010		45,947	31,589	77,536	1,361,446				34,540	17,737	184,535	236,812	1,194,677	-159,276	166,769
2011		46,866	23,433	70,300	1,401,161			45,895	34,540	18,092	187,340	285,867	1,356,171	-215,567	44,990
2012		47,804	23,902	71,706	1,438,495			45,895	34,540	18,454	190,144	289,033	1,506,661	-217,327	-68,166
2013		48,760	24,380	73,140	1,473,594			45,895	34,540	18,823	192,949	292,206	1,646,885	-219,067	-173,291
2014		49,735	24,867	74,602	1,506,589			45,895	34,540	19,199	195,753	295,387	1,777,531	-220,785	-270,941
2015	63,412	50,730	25,365	139,507	1,563,457			45,895	34,540	19,583	198,558	298,576	1,899,241	-159,069	-335,784
2016	1,164,246	51,744		1,215,990	2,020,307			45,895	34,540	19,975	201,643	302,052	2,012,723	913,938	7,584
2017		52,779		52,779	2,038,583			45,895	34,540	20,374	204,728	305,537	2,118,520	-252,758	-79,938
2018		53,835		53,835	2,055,763			45,895	34,540	20,782	207,813	309,029	2,217,145	-255,195	-161,381
2019		54,911		54,911	2,071,915			45,895	34,540	21,197	210,897	312,530	2,309,072	-257,618	-237,157
2020		56,010	10,502	66,511	2,089,946			45,895	34,540	21,621	213,982	316,039	2,394,749	-249,527	-304,803
2021		57,130		57,130	2,104,221			45,895	34,540	22,054	217,348	319,837	2,474,663	-262,707	-370,442
2022		58,272		58,272	2,117,640			45,895	34,540	22,495	220,994	323,923	2,549,258	-265,651	-431,618
2023		59,438		59,438	2,130,255			45,895	34,540	22,945	224,639	328,019	2,618,878	-268,581	-488,622
2024		60,627		60,627	2,142,115			45,895	34,540	23,404	228,566	332,404	2,683,901	-271,778	-541,787
2025		61,839		61,839	2,153,264			45,895	34,540	23,872	232,212	336,518	2,744,573	-274,679	-591,309
2026		63,076		63,076	2,163,745			45,895	34,540	24,349	236,138	340,922	2,801,223	-277,846	-637,478
2027		64,337		64,337	2,173,598			45,895	34,540	24,836	240,064	345,335	2,854,111	-280,998	-680,513
2028		65,624		65,624	2,182,861			45,895	34,540	25,333	243,990	349,758	2,903,480	-284,134	-720,619
2029		66,937		66,937	2,191,569			45,895	34,540	25,840	248,197	354,472	2,949,594	-287,535	-758,025
2030		68,275	12,802	81,077	2,201,291			45,895	34,540	26,356	252,404	359,195	2,992,663	-278,118	-791,372
2031		69,641		69,641	2,208,986			45,895	34,540	26,883	256,611	363,929	3,032,880	-294,288	-823,894
2032		71,034		71,034	2,216,221			45,895	34,540	27,421	261,098	368,954	3,070,459	-297,920	-854,237

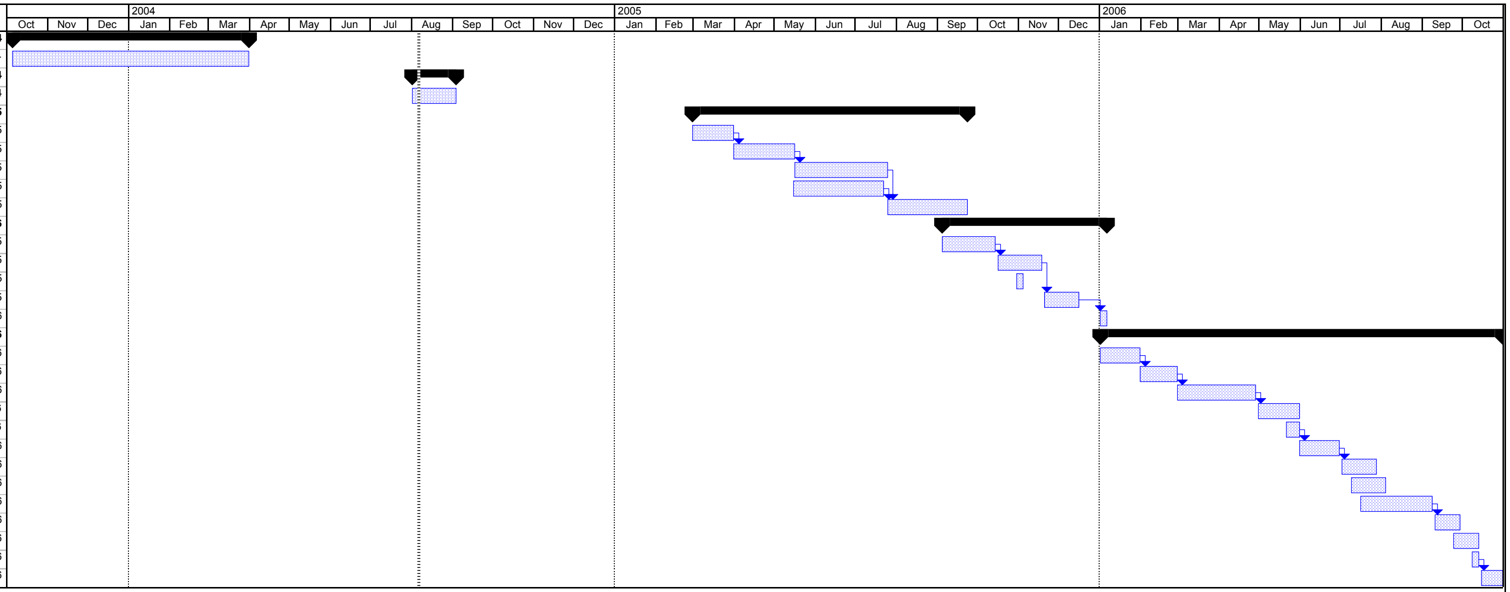
** Assumes value associated with reduction of 2814 tonnes CO_2 @ $10/tonne and 32 tonnes SO_2 @ $200/tonne annually


Snooks Arm Penstock Analysis of Alternatives
Option 2 - Phased in Replacement + Emissions Credits
NPV 2004$
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
2005
2010
2015
2020
2025
2030
Replace Penstock (Phased in Approach)
Retire Plant in 2006

APPENDIX D

PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Project Review**	**128 days**	**Mon 10/6/03**	**Wed 3/31/04**
2	CBP Review	128 days	Mon 10/6/03	Wed 3/31/04
3	**PUB**	**25 days**	**Mon 8/2/04**	**Fri 9/3/04**
4	PUB Approval	25 days	Mon 8/2/04	Fri 9/3/04
5	**Pre-Construction**	**149 days**	**Tue 3/1/05**	**Fri 9/23/05**
6	RFP Engineering Services	23 days	Tue 3/1/05	Thu 3/31/05
7	Field Data	32 days	Fri 4/1/05	Mon 5/16/05
8	Options & Recommend.	50 days	Tue 5/17/05	Mon 7/25/05
9	Project Logic	50 days	Mon 5/16/05	Fri 7/22/05
10	Design & Spec	44 days	Tue 7/26/05	Fri 9/23/05
11	**Tender**	**90 days**	**Mon 9/5/05**	**Fri 1/6/06**
12	Prepare Tender	30 days	Mon 9/5/05	Fri 10/14/05
13	Issue Tender	25 days	Mon 10/17/05	Fri 11/18/05
14	Site Visit	5 days	Mon 10/31/05	Fri 11/4/05
15	Evaluation	20 days	Mon 11/21/05	Fri 12/16/05
16	Contract Award	5 days	Mon 1/2/06	Fri 1/6/06
17	**Construction**	**217 days**	**Mon 1/2/06**	**Tue 10/31/06**
18	Documentation	22 days	Mon 1/2/06	Tue 1/31/06
19	Shop Drawings	20 days	Wed 2/1/06	Tue 2/28/06
20	Fabrication	43 days	Wed 3/1/06	Fri 4/28/06
21	Delivery	23 days	Mon 5/1/06	Wed 5/31/06
22	Mobilization	8 days	Mon 5/22/06	Wed 5/31/06
23	Removals	22 days	Thu 6/1/06	Fri 6/30/06
24	Site Preparation	20 days	Mon 7/3/06	Fri 7/28/06
25	Road / Brook Crossings	20 days	Mon 7/10/06	Fri 8/4/06
26	Installation	40 days	Mon 7/17/06	Fri 9/8/06
27	Commissioning	15 days	Mon 9/11/06	Fri 9/29/06
28	Clean-up	15 days	Mon 9/25/06	Fri 10/13/06
29	Demobilization	5 days	Mon 10/9/06	Fri 10/13/06
30	Contract Completion	12 days	Mon 10/16/06	Tue 10/31/06



Project: SA Penstock Schedule
Date: Fri 8/6/04

Task		Progress		Summary		Rolled Up Split		Rolled Up Progress		Project Summary		Deadline	
Split		Milestone		Rolled Up Task		Rolled Up Milestone		External Tasks		External Milestone			