ONTARIO POWER GENERATION

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OPG-FORM-0076-R005*

Type 3 Business Case Summary

To be used for investments/projects meeting Type 3 criteria in OPG-STD-0076.

Executive Summary and Recommendations

Project Information			
Project #:	BK182777, BK182199	**Document #:**	NF20-PLAN-08707.021-0019
Project Title:	G5 Overhaul – Capital , Non-Std		
Class:	☒ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	**Investment Type:**	Sustaining
Phase:	Execution	**Release:**	Full
Facility:	SAB1 (NF20)	**Target In-Service or Completion Date:**	2020-07-29

Project Overview

We recommend the release of $32,175 k, including $5,008 k of contingency. The estimated total project is $ 36,993 k, including $ 5,488 k of contingency. The quality of estimate for this release is Class 2, and for the total project is Class 2.

This release will fund the unit refurbishment of the penstocks, turbine, generator and auxiliary mechanical and electrical systems to facilitate the business needs.

This project is included in the latest Life Cycle Plan (R-NF20-01556-0002) and will be managed within the Niagara Operations Capital Budget Envelope.

The business needs of this project are:

1. Ensure availability, reliability, and continued operation of SAB1 G5 for the next 25-30 years.
2. Enhance the capacity of the generating asset by 2 MW of clean power and maximize utilization of available water resources.

Summary of Preferred Alternative:

Alternative 2 Major Overhaul and Upgrade to a higher capacity as defined in the DPC is the preferred alternative as it more completely addresses the need for sustaining long-term reliable operation and enhancing the capacity of the generating asset.

Project procurement of long lead components identified in the PBCS release is in progress to help meet the scheduled execution phase planned for Q2 2019. The OEM will purchase long lead equipment not included in the PBCS.

The OEMs will be engaged to engineer, procure components, construct and provide Owner's Representation to address the condition of the unit. The OEM will be responsible for the BTU portion of the work, which is approximately 50% of the overall project SOW. The OEM will also have to execute the work in alignment with the schedule constraints imposed by the G1/G2 Project.

History of BCS releases and project cost estimates:

The total project cost is estimated at **$36,993 k**, including **$5,488 k** of contingency, compared to **$24,276 k**, including **$3,528 k** of contingency in the previous PBCS release. The variance is an incorrect assumption on the G10 OEM actuals and in part to a refinement of the estimate: the EBCS is based on proposal pricing from the OEM.

History of scope and schedule changes:

The outage plan is scheduled for May, 2019 to Jul, 2020. There is no change in scope or schedule from the PBCS which was approved August 30, 2018.

Key Assumptions and Risks:

The BK182198 G1/G2 Frequency Conversion Project schedule has been confirmed. Proceeding with the G5 Major Overhaul and Upgrade in advance of BK182198 is the preferred, supported alternative. It is discussed in the body of the EBCS under Part B – Description of the Preferred Alternative.

There is a risk of delays and higher costs due to increased coordination required for the 50/50 labour assignment (added complexity - see Part B). A cost allowance has been included in the project estimate. Daily coordination meetings will be held which will include participants from other projects (e.g. G1/G2).

*Associated with OPG-STD-0076, Developing and Documenting Business Cases

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Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release
Document #: NF20-PLAN-08707.021-0019

Project Cash Flows, NPV, and OAR Approval Amount									
k$	LTD	2018	2019	2020	2021	2022	2023	Future	Total
Currently Released		791	4,327						5,118
Requested Now:	-	-237	23,179	8,933					31,875
Future Required	-								
Total Project Cost		554	27,506	8,933					36,993
Ongoing Costs	-								
Grand Total		554	27,506	8,933					36,993

Estimate Class:	Class 2	**Estimate at Completion:**	36,993
NPV:	$136 M	**OAR Approval Amount:**	36,993
Additional Information on Project Cash Flows (optional):			

Approvals			
	Signature	**Comments**	**Date**
The recommended alternative, including the identified ongoing costs, if any, represents the best option to meet the validated business need.			
Recommended by (Project Sponsor): Jessica Polak, VP Operations, Niagara Operations			11/23/18
I concur with the business decision as documented in this BCS.			
Finance Approval: Norma Siroski Director Controllership, RG per OPG-STD-0076	Finance Controller Niagara	(DOA for Norma)	11/23/18
I confirm that this project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.			
Approved by: Mike Martelli President, RG per OAR 1.1			26 Nov 18

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Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Document #: NF20-PLAN-08707.021-0019

Business Case Summary

Part A: Business Need

The business needs of this project are:

1. Ensure availability, reliability, and continued operation of SAB1 G5 for the next 25-30 years.
2. Enhance the capacity of the generating asset. An opportunity exists to cost effectively increase production of G5 and maximize utilization of available water resources by replacing and upgrading the runner. The recommended alternative upgrades the current rating of the unit to the following capabilities:

	Turbine Rating	Generator Mechanical Limit
Pre-Overhaul Ratings	53.1 MW	73 MW
Post-Overhaul Ratings	**55.1 MW**	73 MW
Improvement	+2.0 MW	-

Background

Sir Adam Beck 1 (SAB1) G5 was placed in-service in 1923 as a 25 Hz unit rated for 45 MVA. It underwent frequency conversion to 60 Hz in 1985 as part of the runner upgrade program. SAB1 G5 has not had a major overhaul since 1985. Hydroelectric units of this type normally require overhauls on a 25-30 year cycle to maintain reliable operation. As a unit approaches end of life, it faces higher potential for production losses due to degraded reliability.

G5 has now passed the 25-30 year window (2010-2015) and since 2012 has had a restricted operating window in order to mitigate the effects of high generator rotor vibration. This approach has been used to manage the deterioration of the unit beyond its 30-year major overhaul schedule, due to a heavy overhaul program, which began in 2007. For the period from 2007-2018, a primary focus for Niagara Operations has been to overhaul and upgrade SAB1 units as they reached or exceeded the 25-30 year mark in their overhaul cycle. Over this period, G7 was converted to 60 Hz and upgraded (2009), while G9 (2010), G3 (2013) and G10 (2017) underwent major overhauls and runner replacements.

The 2015 SAB1 G5 Condition Assessment (R-NF20-01550—0011) included major water-to-wire electrical, mechanical and civil equipment/ structures related to G5, and assessment of an upgrade alternative. Feasibility was assessed for the following alternatives:

1. Do Nothing (Maintain Status Quo) – not feasible
2. Upgrade to a Higher Capacity provides 25-30 yr reliable operation with incremental capacity of 2 MW
3. Major Overhaul provides 25-30 yr reliable operation - no incremental capacity
4. Minor Overhaul provides 7-10 yr reliable operation with the need for a planned outage at the end of this period and no incremental capacity

There is a risk of failure of the generator due to high mechanical vibration on the rotor assembly, including the generator and turbine shafts. The OEM (Andritz) has asserted that a loose rim would contribute to vibration on the rotor. Their report recommends shrinking the rim to eliminate the vibration and minimize eccentricity. This project will implement the proposed remedy to move towards restoration of the unit's full, unrestricted operating window.

The recommended alternative proposed in the Definition Phase Charter (DPC NF20-PLAN-00121.2-0003) was Alternative 4, to perform a Minor Overhaul during the outage in 2019 and then perform the remainder of the overhaul scope during a planned outage after the BK182198 G1/G2 Frequency Conversion Project. At the time the recommendation was endorsed, there was uncertainty regarding whether the G5 Major Overhaul could be completed without affecting the BK182198 project. Given the risk of delaying the BK182198 project, a decision was made to proceed with the conservative schedule alternative which would only execute the Minor Overhaul scope as the leading alternative. Subsequently, the schedule details for BK182198 have been confirmed, logistics have been assessed, and further input from Production has concluded that proceeding with the Major Overhaul and upgrade in advance of BK182198 is the preferred, supported alternative.

The total required funding for this project is broken down in the following table.

k$	LTD	2018	2019	2020	2021	Future	Total
BK182199 Non-Std	0	0	2,202	0	0	0	2,202
BK182777 Cap	0	554	25,303	8,933	0	0	34,790
Total Project Cost	0	554	27,506	8,933	0	0	36,993

*Associated with OPG-STD-0076, Developing and Documenting Business Cases

Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Part A: Business Need

Part B: Preferred Alternative: Major Overhaul and Upgrade to a Higher Capacity (25-30 year reliable operation)

Description of Preferred Alternative

Alternative 2, Major Overhaul and Upgrade to a Higher Capacity, from the DPC is the preferred alternative as it most completely addresses the business needs for sustaining long-term reliable operation and enhances the capacity of the generating asset.

Advantages:

- Addresses generator vibration issues
- Reliable operation restored for the next 25 to 30 years
- Capacity is enhanced ~2 MW with positive Net Present Value (NPV) associated with upgrading the runner

Disadvantages:

- None

The project will execute a complete refurbishment of the unit. High level scope as follows:

- New upgraded turbine runner, wicket gates, draft tube extension, headcover, bottom ring, turbo-venting in the draft tube and surface air coolers
- Refurbish servomotors, turbine guide and thrust bearing
- Clean/re-wedge generator stator, refurbish generator windings (dry-ice blast cleaning), clean/shrink generator rotor, refurbish field poles
- New MOT, static exciter, bus work, and switches
- Perform further investigation and probable repair on the scrollcase, draft tube, moody cone and penstock (including completion of a load carrying capacity analysis)

The outage for the overhaul is planned for May, 2019 to Jul, 2020.

Procurement of long lead components identified in the PBCS release is in-progress to help meet the scheduled execution phase planned for Q2 2019. The items funded by the partial release include:

(1) A contract with American Hydro for purchase of new Francis Runner w cowl/skirt, new Nose Cone, Turbo-Vent Assembly, Turbine Shaft Refurb, Runner Shaft Assembly, Draft Tube Cone (Extension). The contract is being negotiated with American Hydro.

(2) An execution support contract from Andritz for Generator Rotor Rim Shrink oversight and special tooling. Negotiations are in progress.

(3) Protections and Controls (P&C) panel fabrications by OPG. The panels have been designed and material purchase is in progress.

Long lead equipment not purchased as part of the PBCS, will be purchased by the OEM from approved vendors. For the more detailed scope for the entire project see project Scope of Work (NF20-PLAN-00121.2-0008).

The project's labour determination was endorsed on April 24, 2018. The split of the work was approximately 50% PWU to 50% BTU. A 50/50 split in the labour determination means that OPG will need to assume the role of Owner-Constructor and will require more internal resources and coordination to manage the workgroups. In the recent past, overhauls having labour determinations with such a high proportion of PWU were overflowed to BTU. Niagara Ops Production and Plant Engineering Service (PES) have committed manpower to fulfill the resource requirements. Due to the high degree of coordination in this scenario, the Project Execution Plan (PEP) (NF20- PLAN-00121.1-0006) incorporates changes in Niagara Operations organizational structure, resource strategies and clear responsibilities for ensuring this coordination. Given the lessons learned from previous projects which have been entirely BTU, it is believed that this strategy will reduce risk associated with schedule as we leverage skills and knowledge better from both unions, OPG and the OEM. Strategies have been built into the plan to account for coordination effort requirements, such as detailed schedule monitoring, schedule flexibility options (e.g. double shifts, if required) and ensuring adequate OPG schedule contingency.

A Functional Specification has been developed for an EPC contract to an OEM to engineer, procure components, and construct the BTU portion of the work. The OEM will also provide Owner's Representative Services. Delivery of long lead material is scheduled to arrive after disassembly has begun but before the material is required for install in order to advance the outage start. Refer to the Contracting Strategy, report NF20-REP-00600-0003, for further details.

Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Part B: Preferred Alternative: Major Overhaul and Upgrade to a Higher Capacity (25-30 year reliable operation)

Description of Preferred Alternative

G5 Major Overhaul project normalized score was 240 which is a good score. The next steps required are defining schedule sequencing, resourcing, P&C panel completion, risk analysis, commissioning and training plan.

A Constructability, Operability, Maintainability, Environment and Safety (COMES) review was completed September 28, 2018. Major actions identified include:

1. Complete the Engineering floor loading assessment
2. Complete the detailed schedule
3. Tailrace isolation remedy required
4. Both ends of the powerhouse will have concurrent construction projects in execution which impacts safety routes. The contractors Site Specific Safety Plan and OPGs Safe work plan will include mitigation measures.
5. Install ethernet fibre trunk for the SAB1 station prior to G5 overhaul (a new base project)

A follow-up to the COMES review will be conducted in March 2019 to focus on COMES aspects of the detailed designs from the contractors.

A Class EA Amendment for G5 will not be required. Execution of the G5 Major Overhaul must precede the G1/G2 Frequency Conversion Project in order to be exempt from this requirement.

Deliverables:	Associated Milestones (if any):	Target Date:
Partial Release of Funds for procurement of long lead components and remaining definition phase deliverables.	PBCS Approved	Aug 30, 2018 Completed
Gate 3 Review for EBCS	RG PGR Committee meeting	Nov 23, 2018
Execution funds released	EBCS Approved	Dec 7, 2018
Select an OEM for EPC and be Owner's Rep.	Issue PO and LNTP	Dec 18, 2018
Outage start		May 6, 2019
Planned unit in service	REIS approved	Jul 29, 2020
Project Closure Report	PCR approved	Jul 29, 2021
Post Implementation Review Complete	PIR approved	Jul 29, 2022

Part C: Other Alternatives

For the detailed Scope of each alternative and evaluation information see Appendix A in the DPC.

Alternative 1: Base Case – Status Quo (No Project)

G5 would run in the short term without significant rehabilitation or overhaul work but would eventually run to fail. This alternative does not address the potential failure of the generator due to rotor vibration and turbine runner due to vibration-induced cavitation.

This alternative is not recommended because failure of the unit would result in an unplanned outage and reduce OPG's ability to reliably supply renewable power to the grid.

Alternative 3: Major Overhaul (25-30 yr reliable operation)

This alternative has the same scope of work as the preferred alternative except that the runner would be refurbished rather than replaced. Reliability is restored for 25-30 years but there is no increase in capacity.

This alternative has a lower project cost than the preferred alternative but is not recommended because the runner upgrade alternative has the highest NPV.

Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release
Document #: NF20-PLAN-08707.021-0019

Alternative 4: Minor Overhaul (5-10 yr reliable operation)

This alternative would perform the following scope only:

- The generator rotor floating rim is changed to shrunk design removing the vibration issue
- MOT and exciter are replaced.

This alternative is not recommended because the unit would likely require a subsequent unplanned outage within 5 to 10 years. This decreases the financial attractiveness of this alternative.

Part D: Project Cash Flows, NPV, and OAR Approval Amount

k$	LTD	2018	2019	2020	2021	2022	2023	Future	Total
Currently Released		791	4,327						5,118
Requested Now:	-	-237	23,179	8,933					31,875
Future Required	-								
Total Project Cost		554	27,506	8,933					36,993
Ongoing Costs	-								
Grand Total		554	27,506	8,933					36,993

Estimate Class:	Class 2	**Estimate at Completion:**	36,993
NPV:	$136 M	**OAR Approval Amount:**	36,993

Additional Information on Project Cash Flows (optional):

Part E: Financial Evaluation

M$	Alt2 – Major OH & Upgrade	Alt1 – Status Quo	Alt3 – Major OH Only	Alt4 - Minor OH
Project Cost	37.6	2.3	31.0	14.5
NPV	136	119	130	119

Summary of Financial Model Key Assumptions or Key Findings:

Assumptions

- Evaluated over a 25 year span
- All ongoing OM&A costs (i.e. standard operating expenses) are equivalent for each alternative
- Utilized Base System Economic Values (SEV)
- Capacity Credit not used
- Major Overhaul will be taken for each alternative in 25 years (2043)
- Alt 1 Status Quo: Vibration issue requires an outage for Major OH in 2023 (5 years). Operating restrictions are maintained. An unplanned outage would be required circa Oct 2023 to Oct 2024, which coincides with PNGS shutdown.
- Preferred Alternative – Alt 2 Major OH & Upgrade: 2 MW increase in capacity achieved with the runner upgrade. Planned outage May 2019 to Jul 2020
- Alt 3 Major OH only: Planned outage May 2019 to Jul 2020
- Alt 4 Minor OH: Planned outage May 2019 to Oct 2019 with another outage within 5 years
- The project will be completed in time to minimize the schedule impacts on BK182198 (G1/G2)

Part F: Qualitative Factors

- G5 is one of four units that provide station service power. Reliability of this unit is important to the stability of the station service system.
- Experience gained from G5 will be applied to the SAB2 overhaul program in alignment with the Strategic Imperative for Project Excellence.

Part F: Qualitative Factors

- P&C panel design and fabrication was removed from the scope for the main contractor and is being performed by OPG. There should be fewer delays due to vendor integration issues. Installation of the OPG design will be proven out on G5 and can then be applied to the G1, G2 project.

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	An increase to project costs would cause the overall expenditures to exceed the release amount for the project.	This release is based on bids received through the RFP process. Contingency (5% of the entire project) has been included for discovery work. Allowance for variability in material costs is 10% of total material cost. Allowance for variability in labour costs is 15% of total labour cost. The contract change management process will be used. The budget will be continuously monitored and controlled by the PL and CSA.	Low	Medium
Scope	There is a risk that the Moody Cone is not present.	Existence of the Moody cone was proved out Oct 26, 2018. This risk has been eliminated.	~~Low~~	~~Medium~~
Schedule	There is a risk that design completion and integration will take longer than anticipated delaying schedule.	OPG has assumed control of design and fabrication for PLC and Protection panels. PES will drive the control integration. They will provide work packages for PLC/ Software support for PWU. Electrical and Mechanical detailed engineering designs and work packages will be provided by the OEM. Integration of the whole system will require collaboration between the OEM and the OPG project team. Commissioning and integration will be led by OPG. OPG's contractor will be given advanced notice of this expectation (risk) and ensure a plan is in place by the contractor to mitigate. OPG will incorporate schedule variance of this type into OPG schedule float.	Low	Medium
Schedule	There is a risk that the increased coordination required for the 50/50 labour assignment will cause delays and or higher costs (Added complexity).	Leverage lessons learned from other projects – reviewed schedules for SAB1 G9 headcover, Des Joachims and Whitedog G3. OPG has included 2 months of schedule float to manage delays which includes the added coordination effort. Hold daily coordination meetings to manage logistical issues. These meetings will include participants from other projects (e.g. G1/G2). WOs will be added to AS7 for each of the scheduled tasks. OPG will mitigate delays due to schedule coordination by emphasis on schedule controls and OPG schedule float.	Low	Medium

Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Technical	There is a risk that the generator rotor rim shrink is not the root cause of the generator vibration. The risk of vibration is that when the unit starts up there will be a bearing wipe. The unit has been operating for 4 years avoiding starts/stops.	Vibration measurements in 2013/2014 and 2017 indicate that the condition is stable. Air gap readings over the full load range will be taken when the unit shuts down to confirm whether the vibration continues to be stable. The project will eliminate the most probable, largest contributor to vibration. If the vibration root cause has not been eliminated, Production will re-implement the restricted operating window. PES will continue root cause analysis to determine the source of vibration.	Low	High
Technical/ Schedule	There is a risk that the unit cannot be isolated due to inability to install tailrace stoplogs.	PES assessed the condition Oct 26, 2018. Divers removed obstructing concrete at the sill. The steel gains were in good condition. New stoplogs will be ordered under a separate project. Lead time requires expediting the new project approval. ETA Apr 2019.	Low	High
Technical	There is a risk of station outage if there is a single-line station service contingency due to G9 & G10 shutdown(s) for Hydro One E-bus upgrade.	A temporary diesel generator will be provided when necessary. PES is investigating an alternate station service supply from SAB2 or the feasibility of islanding.	Low	High
Technical	Lessons learned from recent projects have indicated the potential for configuration management issues impacting turnover of final as-built drawing and documentation package from the contractor(s).	The PEP documents the strategy for documentation expectations, exchange, delivery and tracking. The contracts for QA/QC support include scope requesting the contractor(s) provide pricing estimates for documentation control.	Low	Medium

Additional Risk Analysis:

Refer to the Risk Register in the PEP for further risk assessment information.

Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Part H: Post Implementation Review (PIR) Plan

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Simplified PIR	2020-07-29	2022-07-29

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
MCR (MW)	53.1	55.1	Unit Metering	SAB1 Production
Apparent Power (MVA)	55	63	Unit Metering	SAB1 Production
Runner Efficiency at best efficiency point.	Pre-overhaul Gibson Test (best) or G4's 1986 results.	[redacted]	Post-overhaul Gibson Test	Tech Support Eng. With RG P&T
Operating Restrictions	Rough zone >40% Must run >80% Shutdown on high gen runout alarm	Operating Window consistent with other SAB1 Units. Range 85% to 100% of maximum flow.	Visual Inspection	NiOps Operations and SAB1 Production

Part I: Definitions and Acronyms

AS7 – Asset Suite 7
BP – Business Plan
BTU – Building Trades Union
CAP – Capital
COMES – Constructability, Operability, Maintainability, Environment and Safety review
CSA – Cost and Schedule Analyst
DPC – Definition Phase Charter
EA – Environmental Assessment
EBCS – Execution Business Case Summary
ETA – Estimated Time of Arrival
Hz – Hertz
ITP – Inspection and Test Plan
LNTP – Limited Notice to Proceed
LTD – Life to Date
MCR – Maximum Continuous Rating
MOT – Main Output Transformer
MVA – Mega Volt Amp
MW – Mega Watt
NA, N/A – Not Applicable
Non-Std – Non Standard
NPV – Net Present Value
OAR – Organization Authority Register
OEM – Original Equipment Manufacturer
OH - Overhaul
OPG – Ontario Power Generation
OM&A – Operations, Maintenance and Administration
PBCS – Partial Business Case Summary
PCR – Project Closure Report
PDRI – Project Definition Rating Index
PEP – Project Execution Plan
PES – Plant Engineering Services (OPG Engineering)
PIR – Post Implementation Review
PO – Purchase Order
QA/QC – Quality Assurance/ Quality Control
REIS – Report of Equipment In-service
RFP – Request for Proposals
RG - Renewable Generation
SAB1 – Sir Adam Beck Generating Station 1
SAC – Surface Air Cooler
SEV – System Economic Values
SIA – System Impact Assessment
SoE – Summary of Estimate
TWh – Terra Watt hours
VP – Vice President
WOs – Work Orders

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Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

For Internal Project Cost Control

Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Document #: NF20-PLAN-08707.021-0019

Appendix A: Summary of Estimate (EBCS – Full Project – Non-Std + Capital)								
Project Number:	BK182199 + BK182777							
Project Title:	G5 Major Overhaul – Non-Std + Capital Scope							
k$	LTD	2018	2019	2020	2021	Future	Total	% of Project Total
OPG Project Management		99	216	151			466	1.3
OPG Engineering (including Design)		125	285	219			629	1.7
Procured Materials		96	143	10			249	0.7
OPG Other (PWU)		20	746	1,271			2,037	5.5
Design Contract(s)								
Construction Contract(s)		214	4,279	200			4,693	12.7
EPC Contract(s)			16,462	4,970			21,432	57.9
Consultants								
Other Contracts/Costs			65				65	0.2
Interest		1	317	815			1,132	3.1
Removal Costs			802				802	2.2
Subtotal		554	23,315	7,635			31,504	85.2
Contingency			4,191	1,297			5,488	14.8
Total Capital		554	27,506	8,933			36,993	100.0

Notes			
Project Start Date	Sep-18-2018	**Total Definition cost** (excludes unspent contingency for Nuclear)	343
Target In-Service (or AFS) Date	Jul-29-2020	**Contingency included in this BCS** (Nuclear only)	N/A
Target Completion Date	Jul-29-2021	**Total contingency released plus contingency in this BCS** (Nuclear only)	N/A
Escalation Rate	NA	**Total released plus this BCS without contingency** (Nuclear only)	N/A
Interest Rate	4.40%	**Total released plus this BCS with contingency** (Nuclear only)	N/A
Removal Costs	802	**Estimate at Completion** (includes only spent contingency for Nuclear)	36,993

Prepared by:	Approved by:
M. Sokol 26-NOV-2018	FOR KEN PRINCE NOV 26, 2018
Michele Sokol Project Leader Date	Ken Prince Section Manager - Projects Date

Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release
Document #: NF20-PLAN-08707.021-0019

Appendix A: Summary of Estimate (EBCS – Full Project Capital)								
Project Number:	BK182777							
Project Title:	G5 Major Overhaul – Capital Scope							
k$	**LTD**	**2018**	**2019**	**2020**	**2021**	**Future**	**Total**	**% of Project Total**
OPG Project Management		99	194	151			444	1.3
OPG Engineering (including Design)		125	234	219			578	1.7
Procured Materials		96	43	10			149	0.4
OPG Other (PWU)		20	664	1,271			1,955	5.6
Design Contract(s)								
Construction Contract(s)		214	4,179	200			4,593	13.2
EPC Contract(s)			14,914	4,970			19,884	57.2
Consultants								
Other Contracts/Costs			65				65	0.2
Interest		1	317	815			1,132	3.3
Removal Costs			802				802	2.3
Subtotal		554	21,412	7,635			29,602	85.1
Contingency			3,891	1,297			5,188	14.9
Total Capital		554	25,303	8,933			34,790	100.0

Notes			
Project Start Date	Sep-18-2018	**Total Definition cost** (excludes unspent contingency for Nuclear)	343
Target In-Service (or AFS) Date	Jul-29-2020	**Contingency included in this BCS** (Nuclear only)	N/A
Target Completion Date	Jul-29-2021	**Total contingency released plus contingency in this BCS** (Nuclear only)	N/A
Escalation Rate	NA	**Total released plus this BCS without contingency** (Nuclear only)	N/A
Interest Rate	4.40%	**Total released plus this BCS with contingency** (Nuclear only)	N/A
Removal Costs	802	**Estimate at Completion** (includes only spent contingency for Nuclear)	34,790

Prepared by:	Approved by:
M. Sokol 26-NOV-2018	FOR KEN PRINCE NOV 26, 2018
Michele Sokol Project Leader Date	Ken Prince Section Manager - Projects Date

Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release
Document #: NF20-PLAN-08707.021-0019

Appendix A: Summary of Estimate (EBCS – Full Project Non-Std)								
Project Number:	BK182199							
Project Title:	G5 Major Overhaul							
k$	**LTD**	**2018**	**2019**	**2020**	**2021**	**Future**	**Total**	**% of Project Total**
OPG Project Management			22				22	1.0
OPG Engineering (including Design)			51				51	2.3
Procured Materials			100				100	4.5
OPG Other			82				82	3.7
Design Contract(s)								
Construction Contract(s)			100				100	4.5
EPC Contract(s)			1,548				1548	70.3
Consultants								
Other Contracts/Costs								
Subtotal			1,902				1902	86.4
Contingency			300				300	13.6
Total Non-Std			2,202				2202	100.0

Notes			
Project Start Date	Sep-18-2018	**Total Definition cost** (excludes unspent contingency for Nuclear)	0
Target In-Service (or AFS) Date	Jul-29-2020	**Contingency included in this BCS** (Nuclear only)	N/A
Target Completion Date	Jul-29-2021	**Total contingency released plus contingency in this BCS** (Nuclear only)	N/A
Escalation Rate	NA	**Total released plus this BCS without contingency** (Nuclear only)	N/A
Interest Rate	4.40%	**Total released plus this BCS with contingency** (Nuclear only)	N/A
Removal Costs	NA	**Estimate at Completion** (includes only spent contingency for Nuclear)	2,202

Prepared by:	Approved by:
M. Sokol 26-NOV-2018 Michele Sokol Project Leader Date	FOR KEN PRINCE NOV 26, 2018 Ken Prince Section Manager - Projects Date

Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release
Document #: NF20-PLAN-08707.021-0019

Appendix B: Comparison of Total Project Estimates and Project Variance Analysis

Comparison of Total Project Estimates

Phase	Release	Approval Date	Total Project Estimate in k$ (by year including contingency)						Future	Total Project Estimate
			2018	2019	2020	2021	2022	2023		
DBCS	300	05-03-2018	510	4,755			125	10,945	3,160	21,550
PBCS	4,818	08-27-2018	791	16,637	6,848					24,276
EBCS	32,175	TBD	554	27,506	8,933					36,993

Project Variance Analysis

k$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management		370	466	96	Refined RQE estimate
OPG Engineering (including Design)		275	629	354	P&C Panel design
OPG Procured Materials		3,884	249	-3,635	PBCS: Am. Hydro, EBCS: P&C Panels
OPG Other (PWU)		3,565	2,037	-1,528	Refined RQE estimate
Design Contract(s)		190		-190	Andritz Rim Shrink design
Construction Contract(s)		11,407	4,693	-6,714	PBCS: covers OEM contract, EBCS: covers Am. Hydro and QAQC
EPC Contract(s)			21,432	21,432	EBCS: covers OEM contract - thought G10 OEM sum included Am. Hydro runner purchase
Consultants		748		-748	QA/QC moved to Constr. Contracts for EBCS
Other Contracts/Costs			65	65	ABB breaker support added in EBCS
Interest		308	1,132	824	Refined RQE estimate
Removal Costs		718	802		Refined RQE estimate
Subtotal		21,465	31,505	10,040	**OEM purchased mat'ls increase of 26%** **OEM Labour/Profit/Overhead increase of 29%** **Note: G5 does not include as much scope as G10**
Contingency		3,529	5,488	1,959	14.8% contingency request for: • discovery and • first time that NiOps will execute 50/50 PWU/BTU labour determination
Total		24,994	36,993	11,999	

Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Appendix C: Financial Evaluation Assumptions

Key assumptions used in the financial model of the Project are (complete relevant assumptions only):

Project Cost (Expenditures prior to 2043 = 25 year)**:**

1. 2.3 M$ in 2019, unplanned outage: 36.0 M$ in 2024
2. 37.6 M$ in 2020
3. 31.0 M$ in 2020
4. 14.5 M$ in 2019, planned outage 41.7 M$ in 2029 (10 years is optimistic)

Financial (NPV):

1. 119 M$
2. 136 M$
3. 130 M$
4. 119 M$

Project Life:

1. 5 years (or sooner) before an unplanned outage
2. 25 years reliable operation with upgraded turbine
3. 25 years reliable operation with refurbished turbine
4. 10 years reliable operation with planned outage in 2028 - 2029

Energy Production (2019 to 2043)**:**

1. 8.911 TWh
2. 9.353 TWh
3. 9.201 TWh
4. 8.813 TWh

Operating & Other Cost (2019 to 2043)**:**

1. 92.7 M$
2. 96.8 M$
3. 95.7 M$
4. 92.4 M$

****Financial Evaluation (NPV) available upon request.

Appendix D: References

R-NF20-01556-0002 SAB1 Life Cycle Plan
R-NF20-01550—0011 SAB1 G5 Condition Assessment
NF20-REP-00121.2-0001 SAB1 G5 Major Overhaul Alternatives – Feasibility
NF20-PLAN-00121.2-0003 BK182199_BK182777 G5 Major Overhaul Definition Phase Charter
NF20-PLAN-00121.2-0008 Project Scope of Work
NF20-REP-00600-0003 Contracting Strategy
NF20-PLAN-08707.021-0006 Partial Business Case Summary
NF20-PLAN-00121.1-0006 Project Execution Plan

ONTARIO POWER GENERATION

Records File Information:
Retention Permanent

OPG Confidential
OPG-FORM-0077-R002*

Project Over-Variance Approval

Project #	BK182777, BK182199	**Controlled Doc #**	NF20-PLAN-08707.021-0036
Project Title	G5 Major Overhaul – Capital, Non-Std		
Facility	SAB1 (NF20)	**Investment Classification**	Sustaining
Project Level (Scalability)	B	**Financial Classification**	☒ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others: [if applicable]
Release: Gate and Project Phase	☐ Over-variance G0☐: Initiation ☐ Over-variance G1☐: Choose an item.		☐ Over-variance G2☐: Definition ☒ Over-variance G3B☒: Execution
Estimate Class (overall project)	Class 2	**Target Project Completion Date**	8-Jul-2022

Recommendation

We recommend a release of $6,105 K, including $1,152 K of contingency. This will bring the total released-to-date to $43,098 K.
The total project cost is now estimated at $43,098 K, compared to $36,993 K in the previous release, including contingency.

This release will fund the completion of the reassembly and commissioning, and any additional scope and labour costs that may arise until completion of the project.

This POV is requesting an in-service date change to 8-Jul-2021.

The project BK182199 (non-standard portion of the project) is not included in the approved 2021-26 Business Plan. The project BK182777 (capital portion of the project) is included in the approved 2021-26 Business Plan. The 2021 funding will be managed within the South Central Capital and Non-Standard budgets.

Investment Cash Flows

$K	LTD	2021	2022	2023	2024	2025	2026	Future	Total
Previous releases (OMA)	2,202								2,202
Current request (OMA)		472							472
Total released to date	**2,202**	**472**	**-**	**-**	**-**	**-**	**-**	**-**	**2,674**
Future required	-								-
Total Project Cost (OMA)	**2,202**	**472**	**-**	**-**	**-**	**-**	**-**	**-**	**2,674**
Ongoing Costs	0								
					Gate:	**G3**	**OAR Approval:**		2,674

Investment Cash Flows

$K	LTD	2021	2022	2023	2024	2025	2026	Future	Total
Previous releases (CAP)	34,790								34,790
Current request (CAP)		5,633							5,633
Total released to date	**34,790**	**5,633**	**-**	**-**	**-**	**-**	**-**	**-**	**40,423**
Future required	-								-
Total Project Cost (CAP)	**34,790**	**5,633**	**-**	**-**	**-**	**-**	**-**	**-**	**40,423**
Ongoing Costs	0								
					Gate:	**G3**	**OAR Approval:**		40,423

Investment Cash Flows

$K	LTD	2021	2022	2023	2024	2025	2026	Future	Total
Previous releases	36,993								36,993
Current request		6,105							6,105
Total released to date	**36,993**	**6,105**	**-**	**-**	**-**	**-**	**-**	**-**	**43,098**
Future required	-								-
Total Project Cost	**36,993**	**6,105**	**-**	**-**	**-**	**-**	**-**	**-**	**43,098**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		$43,098 K

Project Overview

The G5 major overhaul project includes the unit refurbishment of the penstock, turbine, generator and auxiliary mechanical and electrical systems to facilitate the business needs.

The business needs of this project are:

1. Ensure availability, reliability, and continued operation of SAB1 G5 for the next 25-30 years.

Project Overview

2. Enhance the capacity of the generating asset by 2MW of clean power and maximize utilization of available water resources.

The original outage plan for G5 was scheduled for 6-May-2019 to 29-July-2020. In order to minimize the overlap between G1/G2 removals, the G5 outage was postponed and shortened to the period 27-Jan-2020 to 6-May-2021.

Due to COVID-19, the project on-site disassembly work was suspended on 26-Mar-2020 for a period of 7 weeks. There was additional time delay, as a result of decreased productivity due to new COVID controls on return to site. This POV is requesting an in-service date change to 8-Jul-2021 as well as requesting funding to cover additional scope for:

A) Civil Discovery Work and OPG Labour & Procurement costs, (Non-Standard)
B) OPG labour costs due to the prolonging of the project to complete, and (Capital)
C) Voith financial contract estimated T&M requirements, due to the prolonging of the project to complete. (Capital)

Key Risks on the Project remaining:

- Completion and approval for the CIA/SIA, COVER applications and reports, and IESO approval to have the unit return to the grid with the addition of 2MW. Low risk, as the project team have started the applications well in advance. High impact, as this would delay the unit returning to service.
- COVID-19 may further delay the project with increased cost and schedule delay.
- During Commissioning,
    - o if we have a component that forces the unit out of service. Low risk as the project team have been performing QA/QC diligently throughout execution of the project.
    - o if there are vibrations or issues caused by the rotor rim. Low risk as the project team have verified the check sheet measurements and they are showing that the rotor rim shrink performed are well within tolerances. High impact as this would delay the unit returning to service.
    - o if there is a bearing wiped. Low risk as the project team have taken additional precautions to test the oil and use a new oil filtration system to improve filtration quality. High impact as this would delay the unit returning to service.

Total Project Estimate Variance Explanation

Schedule Variance: During the COVID-19 Work Suspension period, Voith Hydro and American Hydro were able to continue off-site fabrication/manufacturing of the project long lead components. OPG and Contractor Engineering were able to continue design and drawing work. However, the team lost on-site disassembly time, and the in-service date was moved out as a result. The existing schedule float was lost due to the Crane Overhaul Project at SAB1, and sharing of the crane availability with the G1/G2 project.

Cost Variance:

A) Current Non-Standard Variance (BK182199) is due to the Civil Discovery Work Costs and additional OPG labour (excluding contingency ask). In review of the existing OEM Contract T&M actuals, we were able to reduce and move money to pay for over half of the discovery costs with remaining funds.

Breakdown of discovery work:

- Vibrating Strain Gauges $168,970
- Civil Scroll Case Discovery Work Repair $148,793
- Generator Shaft Discovery Work Repair $16,290
- Draft Tube Spalling Discovery Work Repair $19,677
- Penstock Discovery Work Repair $89,678

Labour and procurement of material for OPG to complete the project is $74,000 as the Non-Standard project added a number of additional resources not accounted for in the initial budget. This includes Civil Engineering adding additional effort for analysis of floor loading for the heavy component deliveries, concrete and rebar analysis so that bus and insulators could be installed in the locations intended, and Electrical Engineering adding additional support for added scope in the relay room for panel modifications.

Of the total Civil Discovery Work Costs of $443,408, this POVA is to cover the over variance of $202,974+$74,000 for a total of $276,973

B) Current Capital Variance (BK182777) for OPG Labour Costs

Labour costs have driven much of the cost variance in the project. In an effort to better capture project costs, OPG staff have been more diligent in charging their time to the appropriate cost category, therefore direct

Total Project Estimate Variance Explanation

labour charges for typically Fixed Distribution staff (Operations, Draftspersons, Project Controls, Supply Chain, Environmental, etc.) have been charged to the project correctly.
Labour costs have also increased as a result of additional work due to COVID cleaning costs as well as training costs related directly to the project.

Project Management Variance of $3,181,313

Additional Engineering support has been added to the original team for assistance, mainly towards electrical efforts. Quality Assurance and Quality Control Support and Documentation was included in the original budget however, costs have been higher due to the extension of the project schedule. Commissioning requires additional resources from MDCI and engineers to support IESO, CIA/SIA and COVER to return to the grid with an addition 2MW of power.

Engineering Variance of $315,060

QA/QC Support Extension of $307,766

OPG continues to purchase supplies and materials due to added electrical scope as the team reassembles and prepares for commissioning. The purchases included additional power cables, lighting, switches, breakers, instrumentation and fibre cable, as well as safety modifications that include additional guarding, and positioning of equipment for easier and safer maintenance. The variance is beyond the original budget because of various electrical standard changes and added scope introduced during execution.

Procurement $27,652

This POV is requesting to cover costs for $3,181,313 +$315,060+$307,766+$27,652 **Total $3,524,025**

C) Capital OEM Contractor additional funding requirements for T&M work to complete the project is $1.8 M. Funding of the Voith Financial Contract has stayed within budget to-date due to change controls moving money to various T&M releases based on actual costs versus estimated costs.

The Fixed portion of the SAB1 G5 project (Contract No. 50000823) was awarded at a value of $6,301,786 CAD.

The T&M portion of the SAB1 G5 project (Contract No. 50000823) was awarded at a value of $19,344.835 CAD.

The Contract has a constrained budget of $25,646,621 CAD.

During the course of the COVID Work Suspension, contractually agreed upon Division of Work scopes between OPG and Voith have changed as a result of adjusting the contract in alignment with the trades work assignment. The decisions are understood and approved by each party (OPG/VH).

Since a portion of the T&M budget is schedule duration dependent, Voith Site Management Overhead, Site Operating Costs and Main Office Support Costs continue to be spent as the schedule extends past the original contract completion date.

$25,646,621 CAD (Fixed and T & M Base Contract)
+ $4,824,948 CAD (Change Orders – PCD-001 to 009)
– $4,018,726 CAD (Shifts of labor/material from Voith to OPG)
+ $995,032 CAD (additional forecasted overhead costs from May 6, 2021 to July 8, 2021)
= $27,447,875 CAD (NEW Fixed and T&M Contract Value)

$27,447,875 CAD (NEW Fixed and T&M Contract Value) - $25,646,621 CAD (Fixed and T&M Base Contract)
= $1,801,254 CAD (Additional Funding Needed)

This POV is requesting to cover costs for **$1,801,254**

Summary:

(A) $202,973 + $74,000 = $276,973
(B) + (C) = $3,181,313 +$315,060+$27,652+$307,766+$1,801,254= $5,633,045

Contingency:

Additional scope, labour and material costs have used the entire project contingency.

- Requesting additional contingency of $151,853 for OMA and $1M for Capital.

Note: Removal Costs:

The original Voith proposal included an estimate removal cost of $1,843,370.00. On completion of disassembly, the actual costs for removal were $1,118,369. This POV is reducing the removal costs by $730,000.

Project #: BK182777, BK182199
Project Title: G5 Major Overhaul – Capital, Non-Std
Document #: NF20-PLAN-08707.021-0036

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Project Over-Variance Approval

Total Project Estimate Variance Explanation

Appendix A1: Summary of Estimate - Total Project Cost										
Project Number:	**BK182199**									
Project Title:	**G5 Major Overhaul - OMA Scope**									
$K	**LTD**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Future**	**Total**	**%**
Project Mgmt	96	44							140	5%
Inspection	-	-							-	0%
Engineering	72	25							97	4%
Procurement	22	5							27	1%
Construction	2,055	203							2,258	84%
Commissioning	-	-							-	0%
Closeout	-	-							-	0%
Subtotal	2,245	277	-	-	-	-	-	-	2,522	94%
Outside WBS	-	-							-	0%
Contingency	0	152							152	6%
Subtotal w/ Contingency	2,246	429	-	-	-	-	-	-	2,674	100%
Interest									-	0%
Other									-	0%
Total	**2,246**	**429**	**-**	**-**	**-**	**-**	**-**	**-**	**2,674**	**100%**
Removal Costs (incl. above)									-	0%

Appendix A1: Summary of Estimate - Total Project Cost										
Project Number:	**BK182177**									
Project Title:	**G5 Major Overhaul - Capital Scope**									
$K	**LTD**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Future**	**Total**	**%**
Project Mgmt	5,403	3,181							8,584	21%
Inspection	-	-							-	0%
Engineering	941	315							1,256	3%
Procurement	630	28							658	2%
Construction	22,179	2,826							25,004	62%
Commissioning	212	2,448							2,660	7%
Closeout	-	-							-	0%
Turnover(Doc & Training)	39	5							44	0%
Subtotal	29,405	8,802	-	-	-	-	-	-	38,207	95%
Outside WBS	-	-							-	0%
Contingency	-	1,000							1,000	2%
Subtotal w/ Contingency	29,405	9,802	-	-	-	-	-	-	39,207	97%
Interest	565	651							1,216	3%
Other	-	-							-	0%
Total	**29,970**	**10,453**	**-**	**-**	**-**	**-**	**-**	**-**	**40,423**	**100%**
Removal Costs (incl. above)	1,848	(730)							1,118	3%

Project #: BK182777, BK182199
Project Title: G5 Major Overhaul – Capital, Non-Std
Document #: NF20-PLAN-08707.021-0036

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OPG-FORM-0077-R002

Project Over-Variance Approval

Appendix A1: Summary of Estimate - Total Project Cost										
Project Number:	**BK182199 + BK182777**									
Project Title:	**G5 Major Overhaul - Non-Std + Capital Scope**									
$K	**LTD**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Future**	**Total**	**%**
Project Mgmt	5,499	3,226							8,724	20%
Inspection	-	-							-	0%
Engineering	1,008	345							1,354	3%
Procurement	653	33							685	2%
Construction	24,488	2,774							27,262	63%
Commissioning	212	2,448							2,660	6%
Closeout	-	-							-	0%
Turnover (Doc. & Training)	39	5							44	0%
Subtotal	31,898	8,831	-	-	-	-	-	-	40,729	95%
Outside WBS	-	-							-	0%
Contingency	0	1,152							1,152	3%
Subtotal w/ Contingency	31,899	9,983	-	-	-	-	-	-	41,881	97%
Interest	565	651							1,216	3%
Other									-	0%
Total	**32,464**	**10,634**	**-**	**-**	**-**	**-**	**-**	**-**	**43,098**	**100%**
Removal Costs (incl. above)	1,848	(730)							1,118	3%

Appendix A3: Summary of Estimate – In-Service Estimates				
$K	Only applicable to capital projects. In-Service amount shall include interest but exclude removal costs.			
Project #	**Date (YYYY-MM-DD)**	**Description**	**Amount**	**%**
BK182777	2021-07-08	G5 Major Overhaul - Capital Scope	41,541	100%
Total			41,541	100%

Prepared by:	**Reviewed and Endorsed by:**
Michele Sokol Project Leader, Maintenance Projects Date	Jack Saweczko Section Manager, Projects/Programming Date

Approvals	Signatures	Date
Recommended by: Project Sponsor John Hefford VP Regional Operations	*Electronic Approval attached*	*March 04, 2021*
Finance Approval: Bryan Shaddock Director Controllership	*Electronic Approval attached*	*March 18, 2021*
Line Approval per OAR 1.1: Nicolle Butcher SVP, RG & Power Marketing	*Electronic Approval attached*	*March 22, 2021*

ONTARIO POWER GENERATION

Records File Information:
Retention Permanent

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OPG-FORM-0076-R006*

Business Case Summary

Project #	BK182777, BK182199	**File #**	NF20-BCS-08707.021-0004
Project Title	G5 Major Overhaul – Capital, Non-Std		
Facility	SAB1 (NF20)	**Investment Classification**	Sustaining
Project Level (Scalability)	B	**Financial Classification**	☒ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others: [if applicable]
Release: Gate and Project Phase	☐ Choose an item. G0☐: Initiation ☐ Choose an item. G1☐: Choose an item.		☐ Choose an item. G2☐: Definition ☒ Superseding G3C☒: Execution
Estimate Class (overall project)	Class 2	**Target Project Completion Date**	2022-09-20

Recommendation

We recommend a release of $4,569 K, including $500 K of contingency. This will bring the total released-to-date to $47,666 K.

The total project cost is now estimated at $47,666K, compared to $43,098 K in the previous released, including contingency.

This release is to fund the schedule extension both for additional Contractor support and OPG labour costs and materials to complete the project commissioning phase.

This Superseding BCS is requesting an in-service date change to 20-Sep-2021.

The project BK182199 (non-standard portion of the project), is not included in the approved 2021-26 Business Plan.
The project BK182777 (capital portion of the project), is included in the approved 2021-26 Business Plan.
The 2021 funding will be managed within the South Central Operations Capital budget and Non-Standard budgets.

Investment Cash Flows - OMA BK182199

$K	LTD	2021	2022	2023	2024	2025	2026	Future	Total
Previous releases	2,494	180							2,674
Current request	-	(194)							(194)
Total released to date	**2,494**	**(14)**	-	-	-	-	-	-	**2,480**
Future required	-								-
Total Project Cost	**2,494**	**(14)**	-	-	-	-	-	-	**2,480**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		$2,480 K

Investment Cash Flows - CAP BK182777

$K	LTD	2021	2022	2023	2024	2025	2026	Future	Total
Previous releases	29,970	10,453							40,423
Current request	(5)	4,769							4,764
Total released to date	**29,965**	**15,222**	-	-	-	-	-	-	**45,186**
Future required	-								-
Total Project Cost	**29,965**	**15,222**	-	-	-	-	-	-	**45,186**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		$45,186 K

Investment Cash Flows - Total OMA/CAP

$K	LTD	2021	2022	2023	2024	2025	2026	Future	Total
Previous releases	32,464	10,633							43,097
Current request	(5)	4,574							4,569
Total released to date	**32,459**	**15,208**	-	-	-	-	-	-	**47,666**
Future required	-								-
Total Project Cost	**32,459**	**15,208**	-	-	-	-	-	-	**47,666**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		$47,666 K

Project #: BK182777, BK182199
Project Title: G5 Major Overhaul – Capital, Non-Std
Document #: NF20-BCS-08707.021-0004

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OPG-FORM-0076-R006

Business Case Summary

Approvals	Signatures	Date
The recommendation, including the identified ongoing costs, if any, represents the best option to meet the validated business need.		
Recommended by: Project Sponsor Paul Seguin VP Regional Operations, Niagara		17 Sep. 2021
I concur with the business decision as documented in this BCS.		
Finance Approval: Alec Cheng VP Treasurer		Sep 19 2021
I confirm that this investment/project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.		
Line Approval per OAR 1.1: Sean Granville Chief Operations Officer		17-Sep-21

EXECUTIVE SUMMARY – Project Overview

The original outage plan for G5 was scheduled for 6-May-2019 to 29-July-2020. In order to minimize the overlap between G1/G2 removals, the G5 outage was postponed and shortened to the period of 27-Jan-2020 to 6-May-2021.

The POVA requested and approved an outage change starting 29-Jan-2021 to 8-Jul-2021 and included additional funding for added scope to complete the project. We have since spent all funding from the POVA, and the scheduled in-service date has been pushed out due to an extended dry commissioning phase and equipment failure during wet commissioning.

The OMA project is coming in under budget by $166,405. The CAP project is requesting additional funding of $4,763,622. The total net additional funding request is $4,569,625.

This Superseding Business Case Summary (SBCS) is requesting additional funding to cover costs for:

1. OPG Labour costs for the extended commissioning schedule, late unknown scope, and hardware failure repairs of $1,934,149.77
2. Voith Hydro Inc – Total Ask $2,329,472.10 due to additional reassembly costs, site management, new scope and schedule changes.
3. Overall project Contingency of $500,000.00

Business Need

For Project Level B

The business needs of this project are:

1. Ensure availability, reliability, and continued operation of SAB1 G5 for the next 25-30 years.
2. Enhance the capacity of the generating asset by 2 MW of clean power and maximize utilization of available water resources.

	Turbine Rating	Generator Mechanical Limit
Pre-Overhaul Ratings	53.1 MW	73 MW
Post-Overhaul Ratings	**55.1 MW**	73 MW
Improvement	+2.0 MW	-

Background

Sir Adam Beck 1 (SAB1) G5 was placed in-service in 1923 as a 25 Hz unit rated for 45 MVA. It underwent frequency conversion to 60 Hz in 1985 as part of the runner upgrade program. SAB1 G5 has not had a major overhaul since 1985. Hydroelectric units of this type normally require overhauls on a 25-30 year cycle to maintain reliable operation. As a unit approaches end of life, it faces higher potential for production losses due to degraded reliability.

G5 has now passed the 25-30 year window (2010-2015) and since 2012 has had a restricted operating window in order to mitigate the effects of high generator rotor vibration. This approach has been used to manage the deterioration of the unit beyond its 30-year major overhaul schedule, due to a heavy overhaul program, which began in 2007. For the period from 2007-2018, a primary focus for Niagara Operations has been to overhaul and upgrade SAB1 units as they reached or exceeded the 25-30 year mark in their overhaul cycle. Over this period, G7 was converted to 60 Hz and upgraded (2009), while G9 (2010), G3 (2013) and G10 (2017) underwent major overhauls and runner replacements.

Project #: BK182777, BK182199
Project Title: G5 Major Overhaul – Capital, Non-Std
Document #: NF20-BCS-08707.021-0004

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Business Case Summary

Business Need — For Project Level B

The 2015 SAB1 G5 Condition Assessment (R-NF20-01550—0011) included major water-to-wire electrical, mechanical and civil equipment/ structures related to G5, and assessment of an upgrade alternative.

The total required funding for this project is broken down in the following table.

k$	LTD	2021	2022	2023	2024	Future	Total
BK182199 Non-Std	2,494	-14				0	2,480
BK182777 Cap	29,965	15,222				0	45,187
Total Project Cost	32,459	15,207				0	47,666

Deliverables:	**Associated Milestones (if any):**	**Actual Date** (DD-MMM-YYYY):
Previous releases: EBCS		
Gate 1 Review Change Request Authorization (CRA)	GR1	Jun 18, 2013
Project Manager Milestones	PMM	Jul 9, 2015
Gate 2 Business Case Summary Approved	GR2	May 4, 2018
Gate 2A Partial Business Case Summary Approved for procurement of long lead components and remaining definition phase deliverables.	GR2A	Aug 29, 2018
Gate 3 Execution Funds Approved signed by OAR		Nov 18, 2018
Gate 3 Review for Execution Business Case RG PGR Committee Meeting	GR3	Dec 12, 2018
EPC PO issued to Voith Hydro Inc.	EPC	May 29, 2019
Outage start / Start of Installation	SOI	Jan 27, 2020
Start of Work Suspension due to COVID-19	7 week on site work suspension; engineering continued off-site	Mar 26, 2020
Finish of Installation	FOI	Mar 19, 2021
Current release: POVA		
Gate 3B POVA Project Over Variance Authorization Approved	GR3B	Mar 22, 2021
Future release: SBCS		**Target Date** (DD-MMM-YYYY):
Gate 3C approval and BCS signed by OAR	GR3C	Aug 31, 2021
Available for Service	AFS	Sep 20, 2021
Report of Equipment In Service	REIS approved	Sep 30, 2021
Project Close Out Completed	PCO	Dec 31, 2021
Project Closure Report	PCR approved	Sep 30, 2022
Post Implementation Review Complete PIR approved	PIM	Sep 30, 2022

Key Risk Assessment — For Project Level A, B or C

Risk Class	Description of Risk	Response Type/ Actions/Final TCD	For Additional Review	Residual Ranking
Schedule	COVID-19 may further delay the project with increased cost and schedule delay.	Mitigate: • The work teams continue to off set shift start, breaks and finish times so that resources do not overlap in lunch/break rooms and entering and exiting the site at the same time.	No	Low

Key Risk Assessment			For Project Level A, B or C	
Risk Class	**Description of Risk**	**Response Type/ Actions/Final TCD**	**For Additional Review**	**Residual Ranking**
		• Full PPE warn and extra care taken at all times when congregated around display screens during commissioning. • OPG and the Contractor have identified additional support resources to step in to continue and complete the commissioning testing if required. **Final TCD: [17-Sep-2021]**		
Cost	During Commissioning, a component failure may force the unit out of service.	Mitigate: • The team have executed a number of wet commissioning tests already with no indication of further issues. **Final TCD: [17-Sep-2021]**	No	Low

Additional Risk Analysis — For Project Level A or B

COVID-19 Variant Concern: There are a large group of internal resources involved with the G5 Wet commissioning along with 3rd party resources. Voith have been limiting attendance to tailboard and commissioning face-to-face meetings sending 1 delegate at a time. OPG engineers are also being cautious and alternating on-site test witnessing.

The Commissioning Team are being cautious during the completion of the wet testing. Equipment failure has already occurred at the initial start of wet commissioning, and there is still a risk of equipment failure until the load rejection testing has completed and all data has been reviewed and analyzed.

Financial Evaluation — For Project Level A, B (with multiple feasible alternatives) or Value-Enhancing

$M	Alt2 – Major OH & Upgrade	Alt1 – Status Quo	Alt3 – Major OH Only	Alt4 – Minor OHH
Project Cost	47,666	2.3	31.0	14.5
NPV	136	119	130	119

Analysis of Financial Evaluation – Key Assumptions and Key Results:

- Evaluated over a 25 year span
- All on-going OM&A costs (i.e. standard operating expenses) are equivalent for each alternative
- Utilized Base System Economic Values (SEV)
- Capacity Credit not used
- Major Overhaul will be taken for each alternative in 25 years (2043)
- Alt1 Status Quo: Vibration issue requires an outage for Major OH in 2023 (5 years). Operating restrictions are maintained. An unplanned outage would be required circa Oct 2023 to Oct 2024, which coincides with PNGS shutdown.
- Preferred Alternative – Alt2 Major OH & Upgrade: 2MW increase in capacity achieved with the runner upgrade. Planned outage May 2019 to July 2020. Since revised to 29-Jan-2020 to 17-Sep-2021.
- Alt3 Major OH only: Planned outage May 2019 to Jul 2020
- Alt4 Minor OH: Planned outage May 2019 to Oct 2019 with another outage within 5 years
- The project will be completed in time to minimize the schedule impacts on BK182198 (G1/G2)

Refer to original EBCS

- The team is confident that the in-service date will be mid September
- The OPG Engineering Lead has confirmed through commissioning testing to-date, that the unit has achieved an additional 2MW output.

Qualitative Factors

- G5 is one of four units that provide station service power. Reliability of this unit is important to the stability of the station service system.
- Experience gained from G5 will be applied to the SAB2 overhaul program in alignment with the Strategic Imperative for Project Excellence.
- P&C panel design and fabrication was removed from the scope for the main contractor and is being performed by OPG. There should be fewer delays due to vendor integration issues. Installation of the OPG design will be proven out on G5 and can then be applied to the G1, G2 project.

Post Implementation Review (PIR) Plan (refer to OPG-PROC-0056)

Type of PIR Report	Simplified/Standard PIR	**PIR Completion Date**	2022-09-30

☐ Detailed PIR KPIs will be provided in future BCS(s) when Execution Phase BCS release is requested.

PIR KPIs	Current Baseline	Target Result	How to measure?	Who will measure?
MCR (MW)	53.1	55.1	Unit Metering	SAB1 Production
Apparent Power (MVA)	55	63	Unit Metering	SAB1 Production
Runner Efficiency at best efficiency point.	Pre-overhaul Gibson Test (best) or G4's 1986 results.	[redacted]	Post-overhaul Gibson Test	Tech Support Eng. With RG P&T
Operating Restrictions	Rough zone >40% Must run >80% Shutdown on high gen runout alarm	Operating Window consistent with other SAB1 Units. Range 85% to 100% of maximum flow.	Visual Inspection	NIA Operations and SAB1 Production

Definitions and Acronyms

AS7 – Asset Suite 7
BP – Business Plan
BTU – Building Trades Union
CAP – Capital
COMES – Constructability, Operability, Maintainability, Environment and Safety review
CSA – Cost and Schedule Analyst
DPC – Definition Phase Charter
EA – Environmental Assessment
EBCS – Execution Business Case Summary
ETA – Estimated Time of Arrival
Hz – Hertz
ITP – Inspection and Test Plan
LNTP – Limited Notice to Proceed
LTD – Life to Date
MCR – Maximum Continuous Rating
MOT – Main Output Transformer
MVA – Mega Volt Amp
MW – Mega Watt
NA, N/A – Not Applicable
Non-Std – Non Standard
NPV – Net Present Value
OAR – Organization Authority Register
OEM – Original Equipment Manufacturer
OH - Overhaul
OPG – Ontario Power Generation
OM&A – Operations, Maintenance and Administration
PBCS – Partial Business Case Summary
PCR – Project Closure Report
PDRI – Project Definition Rating Index
PEP – Project Execution Plan
PES – Plant Engineering Services (OPG Engineering)
PIR – Post Implementation Review
PO – Purchase Order
QA/QC – Quality Assurance/ Quality Control
REIS – Report of Equipment In-service
RFP – Request for Proposals
RG - Renewable Generation
SAB1 – Sir Adam Beck Generating Station 1
SAC – Surface Air Cooler
SEV – System Economic Values
SIA – System Impact Assessment
SoE – Summary of Estimate
TWh – Terra Watt hours
VP – Vice President
WOs – Work Orders

Project #: BK182777, BK182199
Project Title: G5 Major Overhaul – Capital, Non-Std
Document #: NF20-BCS-08707.021-0004

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Business Case Summary

APPENDICES

Appendix A1: Summary of Estimate - Released to date										
Project Number:	BK182777 / BK182199									
Project Title:	G5 Major Overhaul CAP / OMA									
$K	**LTD**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Future**	**Total**	**%**
Project Mgmt	5,499	4,019							9,518	20%
Inspection									-	0%
Engineering	1,008	719							1,727	4%
Procurement	653	209							861	2%
Construction	24,483	6,193							30,677	64%
Commissioning	212	2,670							2,883	6%
Closeout									-	0%
Turnover (Doc. & Training)	39	43							82	0%
Subtotal	31,893	13,854	-	-	-	-	-	-	45,747	96%
Outside WBS	-	-							-	0%
Contingency	0	500							500	1%
Subtotal w/ Contingency	31,893	14,354	-	-	-	-	-	-	46,247	97%
Interest	565	853							1,419	3%
Other									-	0%
Total	**32,459**	**15,208**	-	-	-	-	-	-	**47,666**	**100%**
Removal Costs (incl. above)	1,054	7							1,061	2%

Appendix A2: Summary of Estimate – Notes			
Escalation Rate	1.7%	**Interest Rate (going-forward)**	3.45%

Appendix A3: Summary of Estimate – In-Service Estimates				
$K	Only applicable to capital projects. In-Service amount shall include interest but exclude removal costs.			
Project #	**Date (YYYY-MM-DD)**	**Description**	**Amount**	**%**
BK182777	2021-09-17	G5 Major Overhaul	46,605	100%
				0%
Total			46,605	100%

Prepared by:	Reviewed and Endorsed by:
Michele Sokol 15-Sep-2021 Michele Sokol Project Leader, Maintenance Projects Date	Ray DeJonge 15 Sept 2021 Ray DeJonge Work Centre Manager, Maintenance Projects Date

Project #: BK182777, BK182199
Project Title: G5 Major Overhaul – Capital, Non-Std
Document #: NF20-BCS-08707.021-0004

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OPG-FORM-0076-R006

Business Case Summary

$K	LTD	2018	2019	2020	2021	2022	2023	Future	Total
G3A -EBCS	-	554	27,506	8,933					36,993
G3B -POVA				32,464	10,633				43,097
G3C -SBCS				32,459	15,208				47,666

Total Project Estimate Variance Explanation (delete if not required)

This Superseding Business Case Summary (SBCS) is requesting additional funding to cover costs for:

1. OPG Labour costs for the extended commissioning schedule, late unknown scope, and hardware failure repairs of $1,934,149.77
    - An increased number of OPG Engineers supporting IESO/COVER/SIA for electrical design changes, programming and testing, with additional field OPG labour estimated $120,000.00
    - Labour for hardware failure: engineering support, disassembly, removal, replacement, reassembly estimated $320,000
    - Higher than forecast labour commissioning schedule estimated $1,094,149.77 (May 6 - Sep 13)
    - Interest to cover schedule extension estimated $280,000
    - Allowance for schedule extensions of $60,000/week; assuming a 2 week schedule extension Sept. 13-27, 2021 $120,000
2. Voith Hydro Inc – Total $2,329,472.10 for prior outstanding costs not known at the time of the POVA. These costs cover site management, schedule changes, new scope and contingency.
    a) Reassembly costs from March, April, May 2021 (General T&M) of $1,382,714.23
        - Site & Office Management hours and expenses
        - New Scope based on original completion forecast of December 2020 in the field with the following vendors: The State Group, Tower Scaffolding Services, Acklands, Altra Construction Rentals, Bickles and Newman Bros.
    b) Project Change Directives for Site Management, Site Running Costs and Project Office Management caused by Schedule changes of $710,522.86
        - PCD-013 Original Fixed Commissioning Cost from the Voith proposal is based on 2 month scheduled duration. Due to circumstances outside of Voith's control, the Commissioning Schedule was extended to a 3 month duration. Total cost impact: $392,728.57
            - Original May 6, 2021 moved to July 8,2021
            - Actual (at the time of PCD-013): May 3, 2021 to August 14, 2021
        - PCD-014 Generator Shroud Seal failure occurred on June 29, 2021 and was resolved on August 3, 2021. This incident forced Voith Hydro to focus support personnel on the recovery effort and postponed the commissioning activities by one (1) additional month. As of August 12, 2021, the in-service date is pushed to September 13, 2021.Total cost impact: $317,794.29
    c) Project Change Directives (PCD-013 & 014) for new scope and replacement materials total cost estimates of $152,827.90
        - Additional Demobilization Cost $36,592.89
        - GeoArc/GKM training $2,864.40
        - Governor Spare Parts $16,889.43
        - Penstock Stress Analysis $36,538.00
        - Air Gap Sensor Extension Cable $4,046.40
        - Spare High Pressure Lift Pump/motor Assembly & Gear $3,231.63
        - Spare Strainers $12,715.14
        - Replacement Air Gap Sensors $32,430.10
        - Replacement GP03 material (estimate) $933.36
        - Replacement Shroud Rubber Seal $6,371.40
        - Replacement Shroud Rivets, washer, etc. (estimate) $215.15
    d) Allowance for schedule extension estimate $60,000/per week. 2 weeks schedule extension Sept. 13-27, 2021 $120,000.00
3. Overall project Contingency of $500,000.00

ONTARIO POWER GENERATION

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Business Case Summary

Project #	AGU83610	**Controlled Doc #**	P27-EBCS-29800-0001 R0
Project Title	Surge Tank Replacement		
Facility	Aguasabon GS (P27)	**Investment Classification**	Sustaining
Project Level (Scalability)	C	**Financial Classification**	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others: [if applicable]
Release: Gate and Project Phase	☐ Choose an item. G0☐: Initiation ☐ Choose an item. G2☐: Definition ☐ Choose an item. G1☐: Choose an item. ☒ Partial G3☐: Execution		
Estimate Class (overall project)	Class 3	**Target Project Completion Date**	December, 2020

Recommendation

We recommend a partial execution release of $5,000K, including $500K of contingency. This will bring the total released-to-date to $6,319K.

The estimated total project cost is $26,253K, including $2,287K of contingency.

This partial release is to fund the tank and pedestal final engineering, partial mobilization, site upgrades, road upgrades, tank material procurement and shop fabrication. While theses activities are ongoing, a full EBCS will be prepared and presented to the RG gate progression committee. A partial release is required to maintain schedule and the 2020 in-service date.

A future release will fund the complete mobilization, demolition, material supply, fabrication, labour, equipment, installation, commissioning, de-mobilization and a final turnover package.

Investment Cash Flows

$K	LTD	2019	2020	2021	2022	2023	2024	Future	Total
Previous releases		1,319							1,319
Current request	-	5,000	-						5,000
Total released to date	**-**	**6,319**	**-**	**-**	**-**	**-**	**-**	**-**	**6,319**
Future required	-		19,934						19,934
Total Project Cost	**-**	**6,319**	**19,934**	**-**	**-**	**-**	**-**	**-**	**26,253**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		~~$26,253 K~~ $6,319 K

Approvals	Signatures	Date
The recommendation, including the identified ongoing costs, if any, represents the best option to meet the validated business need.		
Recommended by: Project Sponsor Brian Dietrich Sr. Production Support Manager		Nov. 19, 2019
I concur with the business decision as documented in this BCS.		
Finance Approval: Brad Bacvar Finance Controller		November 19, 2019
I confirm that this investment/project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.		
Line Approval per OAR 1.1: Paul Giardetti Regional VP - NWO		November 19, 2019

EXECUTIVE SUMMARY – Project Overview

The surge tank is approximately 70 years old and is approaching the end of its service life. The surge tank is vital to the current water conveyance system that serves as a regulator of water flow and pressure for the two (2) hydroelectric units.

Business Case Summary

EXECUTIVE SUMMARY – Project Overview

Upon discovery of significant leakage on the lower bowl of the surge tank, an engineering condition assessment of the surge tank was completed. The assessment concluded the surge tank was in poor condition and should be replaced. See report P27-REP-29800-0001 – Surge Tank Condition Assessment dated June 21, 2018.

Based on the recommendation from the condition assessment and to ensure reliability of the station, the path forward is to replace the surge tank. This requires detailed engineering design, demolition of the existing tank, material procurement, shop fabrication, installation, and commissioning.

The project is entering into the execution phase. This partial release is to fund the tank and pedestal final engineering, partial mobilization, site upgrades, road upgrades, material procurement and shop fabrication.

A future release will fund the complete mobilization, demolition, material supply, fabrication, labour, equipment and de-mobilization to install a new surge tank.

Preferred Alternative:	**New Surge Tank**

Description of Preferred Alternative

This alternative address's replacing the existing 70-year-old structure with a new modern design, incorporating new materials, equipment and maintenance strategies with a minimum service life of 50 years.

OPG conducted a condition assessment of the existing tank which provides a detailed summary of the current condition of the tank. All of the tank steel components inspected required some variation of repairs ranging from moderate corrosion loss to tank wall thicknesses loss (up to 67%) due to corrosion. The existing tank is in poor condition.

OPG completed a Risk-Benefit Analysis on the replacement vs. rehabilitation option, see report P27-REP-295800-0001 R000 Aguasabon Surge Tank Risk Benefit Analysis of Asset Investment Alternatives dated July 07, 2018. The analysis considered the relative cost advantage (cost saving) gained from choosing one alternative vs. the other. The evaluation criteria used were safety risk, schedule risk, modification risk, and reliability risk.

Report Findings: The analysis revealed the below findings:

1. The risk associated with the tank replacement is considerably less than that of the tank rehabilitation.
2. The tank rehabilitation alternative is not a viable option in terms of its benefit to risk balance.
3. The tank replacement option has a favorable benefit to risk ratio.

Report Recommendations: It is recommended to proceed with the tank replacement option since it delivers the best risk benefit value for the money.

	Option #1 Tank Replacement	**Option #2 Tank Refurbishment**
	Pros	Cons
Asbestos and lead paint removal	limited exposure only during demolition (two week window)	added exposure and level of effort required
Working at heights	less exposure as pedestal and tank are built on the ground and tank is jacked into place.	added exposer as the tank will would remain standing during refurbishment
Safety management	Option #1 can be viewed as a predictive safety management approach since the scope is well defined. Replacement over rehabilitation aligns with OPG's Safety Basics, where elimination of the hazard is more effective than protection against it or minimizing it as the scope is well defined.	Option #2 can be viewed as a reactive safety management approach as tasks are not well defined.

Business Case Summary

Preferred Alternative:	**New Surge Tank**

Description of Preferred Alternative

Durability / Maintenance / Reliability	Simple and proven design focusing on safety and durability. Quality and reliability will increase with new material and safer working area.	Rehabilitation technologies presented by potential vendors are not proven for this scale of project. Reduced safety could impact quality of product.
Scope	clear definition and scope.	a large part of the tank could not be examined due to the fact all insulation and cladding was not removed during inspection. This will most likely lead to scope creep or could lead to a replacement.
Schedule	clear understanding of tasks required to complete the work as this is new construction. Vendor has installed numerous tanks of this size and type in the past.	high uncertainty exists in the estimated time needed to perform the repairs.
Cost	clear definition and scope reduces risk of cost overrun.	unknown effort required to complete work increased the potential for cost overruns.

Consultations with stakeholders and environmental permits for a tank replacement will likely be easier to obtain as those for tank rehabilitation as the environmental impacts (asbestos and lead paint removal) will be much less extensive.

Deliverables:	**Associated Milestones (if any):**	**Target Date:**
Previous releases:		
$1,319K (Definition BCS)	Detailed estimate, scope development, RFP review, preparation of long lead external contracts	October, 2019
Current release:		
$5,000K (Partial Execution BCS)	partial mobilization, site upgrades, road upgrades	December, 2019
	tank and pedestal final engineering,	January, 2020
	tank material procurement	January 2020
	shop fabrication	March 2020
Future release:		
$19,934K (Full Execution BCS)	mobilization	April, 2020
	demolition	May, 2020
	material supply, fabrication	May, 2020
	installation	September, 2020
	commissioning	October, 2020
	de-mobilization	November, 2020
	Turn over package	December, 2020

Business Case Summary

Key Risk Assessment			For Project Level A, B or C	
Risk Class	**Description of Risk**	**Response Type/ Actions/Final TCD**	**For Additional Review**	**Residual Ranking**
Cost	There is a risk that project costs could be impacted by the risk classes listed below.	Mitigate: Contractors RFP estimate was used to determine the release amount. Contingency is also included to mitigate impact.	No	Low
Scope	There is a risk of scope increase due to discovery work (i.e. ground conditions, condition of riser)	Mitigate: Scope is well defined and based on recent inspections. Contingency is included to mitigate impact. Using EPC agreement. Replacement of tank in its entirety reduces change for scope creep.	No	Low
Schedule	There is a risk of schedule delays due to vendor delivery delays, discovery work, equipment breakdowns and weather delays	Mitigate: Vendor has installed numerous tanks of this size and type in the past. Comprehensive schedule agreed to by relevant stakeholders prior to outage. Good communication through-out project and appropriate level of oversight by OPG is required. Tight outage window, looking at adjustments to assist contractor. Looking at scope change options to reduce stress on schedule.	No	Medium
Quality	There is a risk that installed or rehabilitated equipment will not meet expected performance or reliability standards.	Mitigate: Sufficient knowledge and experience in engineering, execution and associated contractors. Contractor and Owners Engineer have experience with similar tanks and lessons learned mitigate the risk significantly. Full time on-site OPG rep to monitor and report on quality and specification compliance.	No	Low

Post Implementation Review (PIR) Plan (refer to OPG-PROC-0056)			
Type of PIR Report	Project Closure Report (PCR)	**PIR Completion Date**	Q1-2021
☒ Detailed PIR KPIs will be provided in future BCS(s) when Execution Phase BCS release is requested.			

PIR KPIs	**Current Baseline**	**Target Result**	**How to measure?**	**Who will measure?**

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #: P27-EBCS-29800-0001 R0

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Business Case Summary

APPENDICES

Project Number:	**AGU83610**									
Project Title:	**Surge Tank Replacement**									
$K	**LTD**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Future**	**Total**	**%**
Project Mgmt	12	46	185						242	1%
Inspection			796						796	3%
Engineering	37	417	269						723	3%
Procurement									-	0%
Construction		400	21,287						21,687	83%
Commissioning									-	0%
Closeout									-	0%
Subtotal	49	863	22,537	-	-	-	-	-	23,448	89%
Outside WBS									-	0%
Contingency			2,288						2,288	9%
Subtotal w/ Contingency	49	863	24,824	-	-	-	-	-	25,736	98%
Interest	0	12	504						517	2%
Other									-	0%
Total	**49**	**875**	**25,329**	**-**	**-**	**-**	**-**	**-**	**26,253**	**100%**
Removal Costs (incl. above)			1,453						1,453	6%

Appendix A3: Summary of Estimate – In-Service Estimates

$K nly applicable to capital projects. In-Service amount shall include interest but exclude removal costs.

Project #	Date (DD-MM-YYYY)	Description	Amount	%
AGU83610	12/21/2020	Final installation, commissioning and a final turnover package. [Total Cost (26,253K) minus Removal Cost (1,453K)) = 24,800K	24,800	100%
Total			24,800	100%

Prepared by:		**Reviewed and Endorsed by:**	
Kris Chartrand Project Leader - NWO	November 12, 2019	Darryl Flank Section Manager - NWO	Nov 18, 2019 November 12, 2019

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Business Case Summary

Project #	AGU83610	**Controlled Doc #**	P27-BCS-08707-0815775 R0
Project Title	Surge Tank Replacement		
Facility	Aguasabon GS (P27)	**Investment Classification**	Sustaining
Project Level (Scalability)	B	**Financial Classification**	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others: [if applicable]
Release: Gate and Project Phase	☐ Choose an item. G0☐: Initiation ☐ Choose an item. G1☐: Choose an item.		☐ Choose an item. G2☐: Definition ☒ Full G3☒: Execution
Estimate Class (overall project)	Class 2	**Target Project Completion Date**	June 2021

Recommendation

To date we have a partial planning/execution release of $6,319K.

We recommend an additional execution release of $18,904K.

This will bring the full release to $25,223K.

The estimated total project cost is $25,223K, including $1,921K of contingency.

This execution BCS will fund the full replacement of the Aguasabon Surge Tank. The scope will include: final engineering, mobilization, site upgrades (tree removal, pad construction, road upgrades), material supply, shop fabrication, shipping, demolition, supervision, safety, labour, equipment, installation, commissioning, training, de-mobilization and a final turnover package. All work is to comply with the RFP specifications.

There is approximately $15M increase in the project forecast compared to the business plan. During business planning and during the project planning phase, Hatch developed a project estimate derived from past previous similar project information. This estimate was submitted in the latest business plan. Upon OPG conducting an open competition RFP process for this project, costs submitted with proposals came in significantly higher than anticipated. Of the 3 proposals received, OPG selected the proposal with the lowest cost.

Investment Cash Flows

$K	LTD	2020	2021	2022	2023	2024	Future	Total
Previous releases	781	5,538						6,319
Current request	-	18,868	36					18,904
Total released to date	**781**	**24,406**	**36**	**-**	**-**	**-**	**-**	**25,223**
Future required	-							-
Total Project Cost	**781**	**24,406**	**36**	**-**	**-**	**-**	**-**	**25,223**
Ongoing Costs	-							
				Gate:	**G3**	**OAR Approval:**		$25,223 K

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #: P27-BCS-08707-0815775 R0

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Business Case Summary

Approvals	Signatures	Date
The recommendation, including the identified ongoing costs, if any, represents the best option to meet the validated business need.		
Recommended by: Project Sponsor Paul Giardetti Regional Vice President - Northwest Operations	Routed in Smart Form for approval (ID#00495198)	
I concur with the business decision as documented in this BCS.		
Finance Approval: Martin Rupnik Acting Director RG Controllership	Routed in Smart Form for approval (ID#00495198)	
I confirm that this investment/project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.		
Line Approval per OAR 1.1: John Hefford COO (acting) - RG	Routed in Smart Form for approval (ID#00495198)	

EXECUTIVE SUMMARY – Project Overview

The surge tank is 72 years old and is approaching the end of its rated asset life of 75 years. The surge tank is vital to the water conveyance system that serves as a regulator of water flow and pressure to protect the two (2) hydroelectric units and associated water conveyance system. Upon discovery of significant leakage on the lower bowl of the surge tank in 2015, an engineering condition assessment of the surge tank was completed. The assessment concluded the surge tank was in poor condition and should be replaced. See report P27-REP-29800-0001 – Surge Tank Condition Assessment dated June 21, 2018.

Based on the recommendation from the condition assessment and to ensure reliability of the station and public safety, the path forward is to replace the surge tank. This requires detailed engineering design, demolition, material procurement, shop fabrication, installation, and commissioning.

The previous partial execution release was to fund the tank and pedestal final engineering, partial mobilization, site upgrades, road upgrades, material procurement and shop fabrication.

This release will fund the mobilization, demolition, material supply, fabrication, labour, equipment, de-mobilization, commissioning and turnover package for the new surge tank.

OPG Plant Engineering Services and Northwest Production Support group consulted with Nova Scotia Power, which operates 12 similar surge tanks. Nova Scotia Power is also pursuing tank replacement over tank refurbishment for similar age structures.

Business Need

The surge tank is in poor condition and a replacement surge tank is vital for safe and reliable plant operation. The tank was observed to be leaking again in 2019, after significant repairs in 2015. Tank replacement mitigates significant risks to generating assets, public safety, employee safety and the environment.

Preferred Alternative:	New Surge Tank

Description of Preferred Alternative

This alternative address's replacing the existing 72-year-old structure with a new modern design, incorporating new materials, equipment and maintenance strategies with a service life of 75 years.

OPG conducted a condition assessment of the existing tank which provided a detailed summary of the current condition of the tank. All of the tank steel components inspected required some variation of repairs ranging from moderate to significant tank wall thicknesses loss (up to 67%) due to corrosion. The existing tank is in poor condition.

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #: P27-BCS-08707-0815775 R0

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Business Case Summary

Preferred Alternative:	New Surge Tank

Description of Preferred Alternative

OPG completed a Risk-Benefit Analysis on the replacement vs. rehabilitation option, see report P27-REP-29800-0002 R000 Aguasabon Surge Tank Risk Benefit Analysis of Asset Investment Alternatives dated July 07, 2018. The analysis considered the relative cost advantage (cost saving) gained from choosing one alternative vs. the other. The evaluation criteria used were safety risk, schedule risk, modification risk, and reliability risk.

The analysis revealed the below findings:

1. The risk associated with the tank replacement is considerably less than that of the tank rehabilitation.
2. The tank rehabilitation alternative is not a viable option in terms of its benefit to risk balance.
3. The tank replacement option has a favorable benefit to risk ratio.

The report concludes the tank replacement option is the best value for OPG and the rate payer.

The advantages of this option are:

- A well defined project scope will allow the contractors to understand the tasks required to complete the work efficiently.
- Cost overruns will be minimized as clear definition and scope reduces this risk.
- Development of an accurate schedule can be accomplished as the project management plan, scope of work, specifications, material supply, fabrication and construction strategy will be well defined. The contractors past experiences installing tanks of similar size and complexity also play a key factor into producing an accurate schedule.
- The outage duration will be minimized as an accurate schedule, project management plan and construction strategy can be developed with a new tank.
- The new surge tank will provide safe and reliable operation for another 75 years.
- Current plant and public safety risks will be significantly decreased or eliminated.
- Damage to public assets, Hydro One and OPG infrastructure downstream of tank, in case of a failure, will be eliminated.
- Asbestos and lead paint work will be limited, only during demolition (two week window). All hazardous substances associated with this structure will be removed from site.
- Working at heights will be minimized as the pedestal and tank are built on the ground and tank is jacked into place.
- Maintenance costs will be reduced and reliability of the station will be restored.

The disadvantages of this option are:

- Highest initial capital cost

Deliverables:	Associated Milestones (if any):	Target Start Date:
Previous releases:		
$1,319K (Definition BCS)	Detailed estimate, scope development, RFP review, preparation of long lead external contracts	Complete
$5,000K (Partial Execution BCS)	Limited Notice to Proceed (LNTP) Issued	Complete
	Tank material procurement	Complete
	Partial mobilization, site upgrades, road upgrades	Complete
	Tank and pedestal final engineering	January, 2020
Current release:		
$18,904K (Full Execution BCS)	Final PO issued	February, 2020
	Shop fabrication	March, 2020
	Mobilization	April, 2020
	Site execution	July, 2020
	Commissioning	October, 2020
	In service	October, 2020
	De-mobilization	November, 2020

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #: P27-BCS-08707-0815775 R0

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Business Case Summary

Deliverables:	Associated Milestones (if any):	Target Start Date:
	Turn Documentation	December, 2020
	Project close out	November 2021

Alternative 2:	Base Case – No Project

This alternative does not address the poor condition of the tank. Issues identified in the Tank Condition Assessment report would be discounted. Under this option, there is an eventual risk of a major tank failure. This is not a preferred alternative.

The Aguasabon generating station requires the surge tank to operate. Not replacing or refurbishing the surge tank increases the risk of failure. A tank failure could result in damage to OPG, Hydro One and public assets and will have a significant impact on OPG's ability to produce electricity from this station.

The advantages of this option are:

- Only continued routine maintenance is required.
- Asbestos and lead paint are not disturbed.
- Lowest initial cost.

The disadvantages of this option are:

- Surge tank continues to deteriorate.
- Maintenance cost overruns are plausible as future repairs are not defined. In 2015 OPG spent $1,791K to repair leaks in the tank and the tank is now leaking again only 4 years later.
- Plant reliability will be diminished as repairs will not be scheduled.
- The tank service life of 75 years will soon be surpassed.
- Public safety risks will continue to increase as tank ages.
- Failure could occur at any time, causing damage to public assets, Hydro One and OPG infrastructure downstream of the tank.

Alternative 3:	Tank Refurbishment

This alternative addresses rehabilitating the tank in-situ. Rehabilitation of the 72 year old tank would involve: erecting scaffold around the riser and tank, asbestos removal, lead paint removal, sandblasting the inside and outside of the tank, complete 100% visual and NDE testing, engineering design repairs as they are identified, tank rehabilitation, and closeout. This is not a preferred alternative.

It is unclear at this time what the increased life expectancy of the tank would be after the refurbishment. Initial estimate is it would extend the life 10-20 years.

The potential for safety incidents, scope creep, schedule extensions, and quality of repair are high risk due to the height, age, condition of the tank and poor working conditions.

OPG's internal Risk-Benefit Analysis on the replacement and rehabilitation options recommends not to pursue this option.

The advantages of this option are:

- Lower initial cost compared to tank replacement.

The disadvantages of this option are:

- No clear scope of repair. Unknown scope due to discovery work will lead to inefficient repair work.
- Cost overruns will be unavoidable due to discovery work. The contract will most likely be a time and material contract due to lack of scope.
- The schedule and outage time will be unknown due to lack of scope, unreliable schedule and undefined construction strategy.
- The service life of a refurbished surge tank is uncertain. Initial assumption is 10-20 years, at which time a new surge tank will have to be installed.

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #: P27-BCS-08707-0815775 R0

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Business Case Summary

Alternative 3:	Tank Refurbishment

- Reliability and future maintenance costs will be unknown.
- Plant and public safety risks may still be an issue due to the nature of the repairs.
- Asbestos and lead paint exposure will be increased due to the intense abatement requirements.
- Working at heights will be maximized, as the refurbishment will be in-situ. This is a safety concern.

Alternative 4:	Tank Elimination

Hatch Engineering assessed this option in a hydraulic transient analysis and it is not technically feasible to eliminate the tank. The maximum penstock pressure peak when eliminating the surge tank reached approximately 277 psi, well above allowable pressure peak of 170 psi. As such, the elimination of the surge tank was deemed not technically possible. This alternative was discarded, and no further investigation was required.

Key Risk Assessment — For Project Level A, B or C

Risk Class	Description of Risk	Response Type/ Actions/Final TCD	For Additional Review	Residual Ranking
Cost	There is a risk that project costs could be impacted by the risk classes listed below.	Accept: Contractor's final price submission was used to determine the release amount. Contingency is also included to mitigate impact. Scope and schedule well defined.	No	Low
Scope	There is a risk of scope increase due to discovery work (i.e. ground conditions, condition of riser)	Accept: Scope is well defined and based on RFP specifications. Contingency is included to mitigate impact. Replacement of tank in its entirety reduces potential scope creep.	No	Low
Schedule	There is a risk of schedule delays due to vendor delivery delays, discovery work, equipment breakdowns and weather delays	Accept: Vendor has installed numerous tanks of this size and type in the past. Comprehensive schedule agreed to by relevant stakeholders prior to outage. Good communication through-out project and appropriate level of oversight by OPG is required.	No	Medium
Quality	There is a risk that installed or rehabilitated equipment will not meet expected performance or reliability standards.	Accept: Sufficient knowledge and experience in engineering, execution and associated contractors. Contractor and Owners Engineer have experience with similar tanks and lessons learned mitigate the risk significantly. Full time on-site Owners Engineer to monitor and report on quality and specification compliance.	No	Low

Financial Evaluation

$M	Tank Replacement	Base Case (No Project)	Delay work	Tank Refurbishment	Tank Elimination
Project Cost	25.223	-	-	14.160	-
NPV	-21.143	-	-	-25.347	-
Other: (e.g., IRR)	-	-	-	-	-

Analysis of Financial Evaluation – Key Assumptions and Key Results: Refer to Appendix A4

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #: P27-BCS-08707-0815775 R0

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Business Case Summary

Financial Evaluation

- Assumed refurbishment option would take 3 months longer to execute than a tank replacement due to inability to fully define scope ahead of time. This results in 3 months of incremental revenue losses.
- Refurbishment estimate based/scaled from minor repair project executed in 2015 which cost $1.8M. Repairs were ineffective as the tank has shown signs of leakage again in 2019.
- Tank refurbishment would extend life of tank by 10-20 years, with a full tank replacement required in 2035.
- Refurbishment option would result in a $10K increase in maintenance costs annually, to maintain remote heating system at top of tank.

Qualitative Factors

For Project Level A or B

- Tank replacement eliminates health and safety risks for both construction and maintenance.
- Tank replacement increases station reliability due to reduced chance of leaks or tank failure.
- Tank replacement reduces public and staff safety risks and improves OPG's social license compared to a tank refurbishment.
- Defined scope and schedule for tank replacement.
- Defined tank performance and reliability for another 75 years.
- Less exposure to hazardous substances with tank replacement.

Post Implementation Review (PIR) Plan (refer to OPG-PROC-0056)

Type of PIR Report	Simplified/Standard PIR	PIR Completion Date	Q4-2021

☐ Detailed PIR KPIs will be provided in future BCS(s) when Execution Phase BCS release is requested.

PIR KPIs	Current Baseline	Target Result	How to measure?	Who will measure?
Leaks	Leaky tank	No leaks	Visual	Contractor and OPG
Unit and Water Conveyance Protection	Adequate	Operates as per specification	Unit load rejections	OPG
De-icing system	Functions as intended. Difficult to maintain.	Operates as per specification and ease of maintenance.	Visual and monitor temperature	Contractor and OPG

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #: P27-BCS-08707-0815775 R0

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OPG-FORM-0076-R006

Business Case Summary

APPENDICES

Appendix A1: Summary of Estimate - Total Project Cost										
Project Number:	**AGU83610**									
Project Title:	**Surge Tank Replacement**									
$K	**LTD**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Future**	**Total**	**%**
Project Mgmt	23	192	13						228	1%
Inspection		790	10						800	3%
Engineering	507	179	12						698	3%
Procurement	42	5							47	0%
Construction	200	20,691							20,891	83%
Commissioning (PWU)		77							77	0%
Closeout									-	0%
Subtotal	772	21,934	36	-	-	-	-	-	22,742	90%
Outside WBS									-	0%
Contingency		1,921							1,921	8%
Subtotal w/ Contingency	772	23,855	36	-	-	-	-	-	24,662	98%
Interest	9	552							561	2%
Other									-	0%
Total	**781**	**24,407**	**36**	**-**	**-**	**-**	**-**	**-**	**25,223**	**100%**
Removal Costs (incl. above)		1,453							1,453	6%

Appendix A3: Summary of Estimate – In-Service Estimates				
$K	Only applicable to capital projects. In-Service amount shall include interest but exclude removal costs.			
Project #	**Date (YYYY-MM-DD)**	**Description**	**Amount**	**%**
AGU83610	12/21/2020	Surge tank in service estimate [total cost (25,223k) minus removal cost (1,453k)] = 23,770k	23,770	100%
Total			23,770	100%

Prepared by:	**Reviewed and Endorsed by:**
	Routed in Smart Form for approval (ID#00495198)
Sean Lacey FOR Kris Chartrand	Darryl Flank
Project Leader – NWO Date: February 5, 2020	Section Manager – NWO Date: February 5, 2020

References For Project Level A or B

1. Report P27-REP-29800-0001 R000 - Surge Tank Condition Assessment dated June 21, 2018.
2. Report P27-REP-29800-0002 R000 - Aguasabon Surge Tank Risk Benefit Analysis of Asset Investment Alternatives dated July 07, 2018.
3. Financial evaluation

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #: P27-BCS-08707-0815775 R0

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Business Case Summary

Appendix A4: Financial Evaluation

Surge Tank Replacement Estimate

AGU83610-SURGE TANK REPLACEMENT

Project Class	Choose Classification
Project Number	AGU83610
Project Name	SURGE TANK REPLACEMENT
Project Leader	K. CHARTRAND
CAPL or NSTD	CAPL
Start Year	2018

Estimate Class	2:-15% to +20%
Forecast Update Date:	2/5/2020
Earned Value Date:	2/5/2020

FINANCIAL SUMMARY	Prev	2019	2020	2021	2022	2023	2024	FUTURE	TOTAL
Regular Labour Total	$ 16,712	$ 114,901	$ 334,764	$ 20,795	$ -	$ -	$ -	$ -	$ 487,172
Overtime Labour Total	$ 3,480	$ 18,963	$ 41,244	$ -	$ -	$ -	$ -	$ -	$ 63,687
SAVH	$ 3,844	$ 26,427	$ 76,996	$ 4,783	$ -	$ -	$ -	$ -	$ 112,050
Material Total	$ -	$ 11,020	$ -	$ -	$ -	$ -	$ -	$ -	$ 11,020
Services Total	$ 25,000	$ 549,917	$ 21,465,601	$ 10,000	$ -	$ -	$ -	$ -	$ 22,050,518
Other	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Contingency	$ -	$ -	$ 1,920,814	$ -	$ -	$ -	$ -	$ -	$ 1,920,814
Interest	$ 112	$ 10,360	$ 567,263	$ -	$ -	$ -	$ -	$ -	$ 577,736
Sub-Total	$ 49,148	$ 731,588	$ 24,406,682	$ 35,578	$ -	$ -	$ -	$ -	$ 25,222,997
Removals	$ -	$ -	$ (1,453,300)	$ -	$ -	$ -	$ -	$ -	$ (1,453,300)
Total	**$ 49,148**	**$ 731,588**	$ 22,953,382	$ 35,578	$ -	$ -	$ -	$ -	$ 23,769,697
Total calculated	$ 49,148	$ 731,588	$ 22,953,382	$ 35,578	$ -	$ -	$ -	$ -	$ 23,769,697

Surge Tank Refurbishment Estimate

AGU83610-Surge Tank Refurbishment

Project Class	B
Project Number	AGU83610
Project Name	Surge Tank Refurbishment
Project Leader	KC
CAPL or NSTD	CAPL
Start Year	2020

Estimate Class	5:-50% to +100%
Forecast Update Date:	1/28/2020
Earned Value Date:	

FINANCIAL SUMMARY	Prev	2020	2021	2022	2023	2024	2025	2026	FUTURE	TOTAL
Regular Labour Total	$ -	$ 151,035	$ 47,190	$ -	$ -	$ -	$ -	$ -	$ -	$ 198,226
Overtime Labour Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SAVH	$ -	$ 34,738	$ 10,854	$ -	$ -	$ -	$ -	$ -	$ -	$ 45,592
Material Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Services Total	$ -	$ 6,085,000	$ 3,115,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 9,200,000
Other	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Contingency	$ -	$ 3,000,000	$ 1,500,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,500,000
Interest	$ -	$ 121,762	$ 94,316	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 216,077
Sub-Total	$ -	$ 9,392,535	$ 4,767,360	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 14,159,895
Removals	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total	**$ -**	$ 9,392,535	$ 4,767,360	$ 0	$ 0	$ 0	$ 0	$ 0	**$ 0**	$ 14,159,895
Total calculated	$ -	$ 9,392,535	$ 4,767,360	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 14,159,895

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #: P27-BCS-08707-0815775 R0

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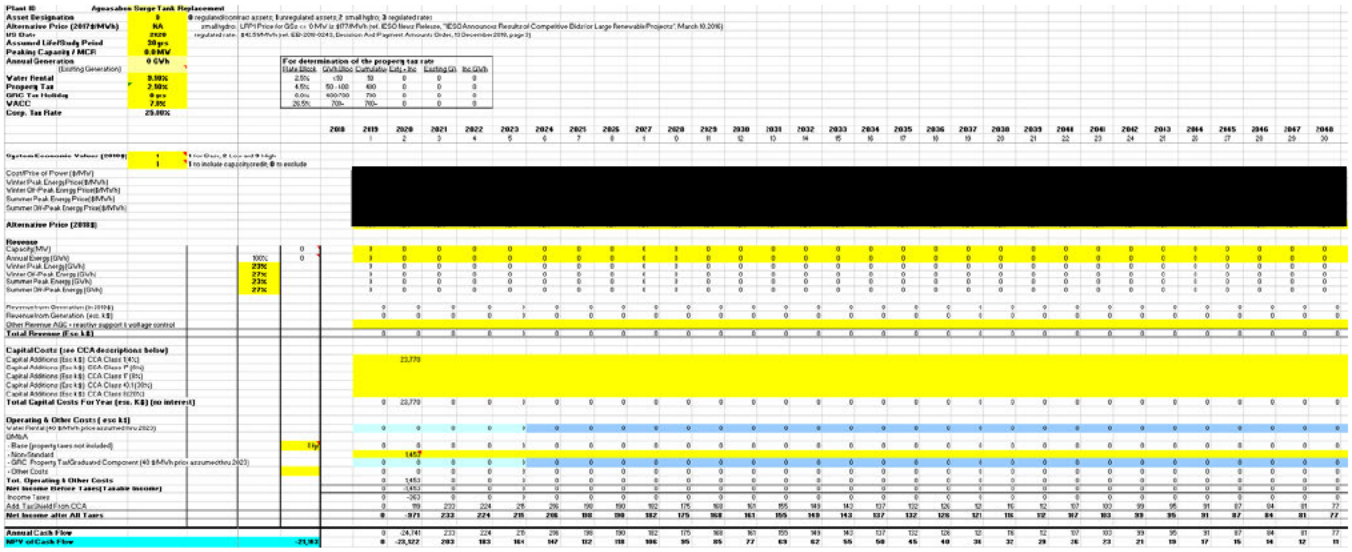
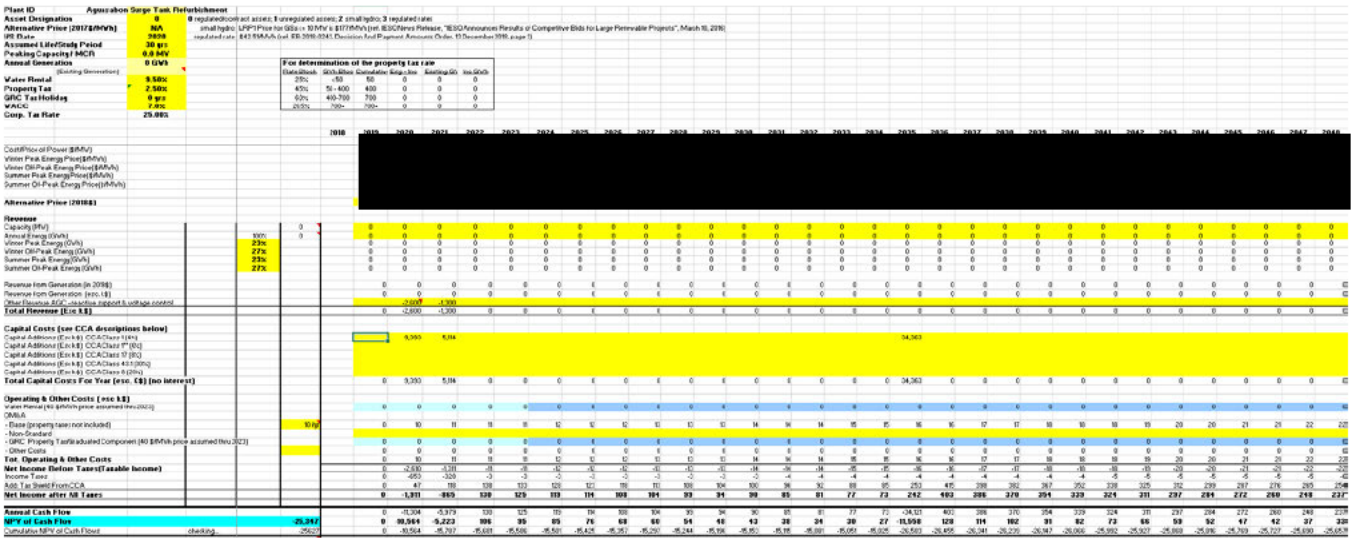
Business Case Summary

Net Present Value Calculation – Replacement



Net Present Value Calculation – Refurbishment



ONTARIO POWER GENERATION

Records File Information:
Retention Permanent

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Project Over-Variance Approval

Project #	AGU83610	**Controlled Doc #**	
Project Title	Surge Tank Replacement		
Facility	Aguasabon GS	**Investment Classification**	Sustaining
Project Level (Scalability)	C	**Financial Classification**	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others: [if applicable]
Release: Gate and Project Phase	☐ Over-variance G0☐: Initiation ☐ Over-variance G1☐: Choose an item.		☐ Over-variance G2☐: Definition ☒ Over-variance G3☒: Execution
Estimate Class (overall project)	Class 2	**Target Project Completion Date**	JUN-2022

Recommendation

We recommend a release of $1,383 K.

This will bring the total released-to-date to $26,606 K.

The total project cost is now estimated at $26,606 K, compared to $25,223 K in the previous release, including contingency.

This release is for additional funding for schedule delays due to COVID-19, discovery work not anticipated and contract change orders to address additional scope items not included in the base contract.

Investment Cash Flows

$K	LTD	2021	2022	2023	2024	2025	2026	Future	Total
Previous releases	25,187	36							25,223
Current request	-	771	612						1,383
Total released to date	**25,187**	**807**	**612**	**-**	**-**	**-**	**-**	**-**	**26,606**
Future required	-								-
Total Project Cost	**25,187**	**807**	**612**	**-**	**-**	**-**	**-**	**-**	**26,606**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		$26,606 K

Project Overview

The surge tank is 72 years old and is approaching the end of its rated asset life of 75 years. The surge tank is vital to the water conveyance system that serves as a regulator of water flow and pressure to protect the two (2) hydroelectric units and associated water conveyance system. Upon discovery of significant leakage on the lower bowl of the surge tank in 2015, an engineering condition assessment of the surge tank was completed. The assessment concluded the surge tank was in poor condition and should be replaced. See report P27-REP-29800-0001.

Based on the recommendation from the condition assessment and to ensure reliability of the station and public safety, the path forward is to replace the surge tank. This requires detailed engineering design, demolition, material procurement, shop fabrication, installation and commissioning.

The current status of the project is nearing completion of construction and will be available for service before the end of 2021. The project is expected to finish approximately 10-12% higher than the original gate 3 BCS budget. The project outage was delayed one year from the spring of 2020 to the spring of 2021 due to the COVID pandemic. Please see below for project variance.

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #:

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Project Over-Variance Approval

Total Project Estimate Variance Explanation

Project Management:
Original BCS: $228 K
Revised Estimate including closeout: $426 K
Variance: $198 K

Extended Construction schedule due to COVID-19 delays and construction impacts resulting in increased costs. Additional resources required for establishing & monitoring baseline schedule.

Engineering / Consultants:
Original BCS: $1,498 K
Revised Estimate including closeout: $1,625 K
Variance: $127 K

Extended Construction schedule due to COVID-19 delays and construction impacts resulting in increased costs.

Procurement:
Original BCS: $47 K
Revised Estimate: $12 K
Variance: -$35 K

Fewer materials & procurement resources required during project than original estimate.

Commissioning:
Original BCS: $77 K
Revised Estimate: $77 K
Variance: $0 K

No change.

Interest:
Original BCS: $561 K
Revised Estimate: $609 K
Variance: $48 K

Extended schedule due to COVID-19.

Construction:
Original BCS including contingency: $22,812 K
Revised Estimate: $23,857 K
Variance: $1,045 K

The following discovery work and changes have occurred with respect to the original BCS:

Contractor Change Orders
PCCO 001 Roof Modifications
PCCO 002 Stair Tower Modifications
PCCO 003 Roof Vent Modifications
PCCO 004 Hydrotest Credit
PCCO 005 Lean to Modifications
PCCO 006 Project Delay 2021 Work (COVID)
PCCO 007 Building Permit
PCCO 008 Communication Line

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #:

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Project Over-Variance Approval

Total Project Estimate Variance Explanation
PCCO 010 Second Set of Rescue Equipment PCCO 011 Existing Riser Interior Coating Repairs PCCO 012 Communication Line Pole #12 to Pole #15 PCCO 013 Electrical Upgrades PCCO 014 Quadplex Cable Replacement & Trail Boulders PCCO 015 Lean to Ice Shield PCCO TBD Grounding Potential electrical modifications along with site improvements not included in the original specification. Additional Construction Changes: Fibre Line Replacement Seal Plug Acuren Inspection Turnkey Fibre Line Splice

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #:

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OPG-FORM-0077-R002

Project Over-Variance Approval

Appendix A1: Summary of Estimate - Total Project Cost										
Project Number:	**AGU83610**									
Project Title:	**Surge Tank Replacement**									
$K	**LTD**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Future**	**Total**	**%**
Project Mgmt	176	200	50						426	2%
Inspection									-	0%
Engineering	990	560	75						1,625	6%
Procurement	11	1							12	0%
Construction	10,350	13,107	400						23,857	90%
Commissioning			77						77	0%
Closeout									-	0%
Subtotal	11,527	13,868	602	-	-	-	-	-	25,997	98%
Contingency									-	0%
Subtotal w/ Contingency	11,527	13,868	602	-	-	-	-	-	25,997	98%
Interest	167	432	10						609	2%
Total	**11,694**	**14,300**	**612**	**-**	**-**	**-**	**-**	**-**	**26,606**	**100%**
Removal Costs (incl. above)		1,827							1,827	7%

Appendix A3: Summary of Estimate – In-Service Estimates				
$K	Only applicable to capital projects. In-Service amount shall include interest but exclude removal costs.			
Project #	**Date (YYYY-MM-DD)**	**Description**	**Amount**	**%**
AGU83610	10/26/2021	90% In-Service	22,027	89%
AGU83610	11/30/2021	98% In-Service	1,800	7%
AGU83610	1/30/2022	100% In-Service	852	3%
AGU83610	6/30/2022	PCR	100	0%
Total			24,779	100%

Prepared by:	**Reviewed and Endorsed by:**
Kris Chartrand Project Leader NWO Production Support Date	Darryl Flank Section Manager NWO Production Support Date

Approvals	**Signatures**	**Date**
Recommended by: Project Sponsor Brian Dietrich Director Asset Management & Production, Western Region		
Finance Approval: Bryan Shaddock Director Controllership, RG	Routed in Smart Form for approval (ID # 00723940)	
Line Approval per OAR 1.1: Nicole Butcher SVP, RG & Power Marketing		