ONTARIO POWER GENERATION

Records File Information:
See Guidance Section

OPG-FORM-0076-R003*

Type 3 Business Case Summary

Final Security Classification of the BCS: **OPG Confidential**

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

Executive Summary and Recommendations				
Project #:	16-31535	**Title:**	DNGS Water Treatment Plant Replacement Project	
Phase:	Definition		**Release:**	Full
Facility:	DNGS		**Records File:**	D-BCS-74000-10004
Class:	Capital		**Investment Type:**	Sustaining

Project Overview

We recommend the release of $5.233 M ([redacted] base costs plus [redacted] contingency).
This release will be used to complete the preliminary and detailed engineering of a new DNGS Water Treatment Plant (WTP) and associated engineering to de-energise and "lay-up" the existing WTP.

The total capital project is currently estimated to cost $57.8M (including [redacted] contingency). The "Available for Service" (AFS) date of the new Water Treatment Plant (WTP) is currently planned for 11/25/2016.

OM&A expenditures for Project #16-38939 were $226k (against a release of $307k). The OM&A Project #16-38939 was used to determine a preferred alternative and long term solution to the existing WTP. The OM&A portion has been completed. All subsequent expenditures will be capitalized under this project since a preferred alternative has been selected.

The objective of this project is to ensure a continuous, high quality, cost effective supply of demineralised water to DNGS until station End of Life (EOF).

The existing DNGS WTP has been in service since 1987. It uses conventional Ion-Exchange (IX) technology and was designed with 3 separate de-mineralization trains with a total design output of 142 lps. Currently, the plant has provided the desired quality of de-mineralized water with a reliable industrial and environmental safety record. There have been no adverse effects on the Steam Generators and the plant has been contributing successfully to the WANO CPI (Chemistry Performance Indicator). However, OPEX from other CANDU nuclear stations suggests that the average life span for IX based water treatment plants is 28 years [Ref 1] which is short of their nominal 30 year design life. As a result, the estimated design EOL of the current WTP is 2015. Despite past reliable operation, the WTP will be challenged to maintain satisfactory system health status and reliability as it reaches or exceeds the end of its design life. The current condition of the WTP will not support the long term needs of DNGS to the end of station life (est. 2050).

Failure of the WTP plant would result a four unit sequential shut-down of DNGS after 24-48 hours (the time required to deplete the stored de-mineralized water inventory) since there is no backup supply of water available. Equipment aging, degradation and obsolescence combined with higher maintenance requirements will increase the likelihood of extended WTP outages which could result in forced DNGS unit outages. In addition, the risk of environmental spills of acids and caustic liquids used in the current WTP process could increase as the condition of the equipment degrades and maintenance activities increase.

An economic and engineering evaluation was completed by an external engineering vendor in June 2012 [Ref 2] under Project #16-38939 to review the available alternatives for the WTP and recommend a preferred alternative for a long term solution.

The recommendations of the report were reviewed by Senior DNGS Management resulting in the approval to replace the existing WTP with a new Vendor Engineer / Procure / Construct (EPC) facility outside the protected area.

The decision on who will operate the new WTP (Vendor or OPG) will be made at a later stage of the project.

The report also concluded that maintaining the existing WTP (Status Quo) to DNGS EOF is not feasible since many of the existing WTP components and systems are obsolete and/or ending their useful life.

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

Type 3 Business Case Summary

The project will comprise of the following four phases:

- Phase 1: Full Definition Phase (i.e. Preliminary and Detailed Design)
- Phase 2: Site Preparation and Long Lead Materials
- Phase 3: Installation/Commissioning of a new WTP
- Phase 4: De-Energization of the Existing WTP

The current Business Case Summary (BCS) will support the completion of Phase 1. A subsequent BCS(s) will be prepared for the execution of the remaining 3 phases of the project.

All engineering shall follow the OPG Engineering Change Control (ECC) process. This will ensure that the engineering documentation is prepared to a sufficient standard to allow OPG to operate and maintain the facility should OPG choose to do so upon completion of the project, or sometime thereafter.

Project Cash Flows

k$	LTD	2012	2013	2014	2015	2016	2017	Future	Total
Currently Released	0	0	0	0	0	0	0		0
Requested Now	-	143	1478	3237	375	0	0		5233
Future Required	-	0	40	3500	19430	26312	3301		52583
Total Project Cost		143	1518	6737	19805	26312	3301		57816
Ongoing Costs	-								
Grand Total	0	143	1518	6737	19805	26312	3301		57816

Estimate Class:	Class 4	**Estimate at Completion:**	[redacted]
NPV:	$2600 k	**OAR Approval Amount:**	$ 5,233k

Additional Information on Project Cash Flows (optional):

1. Grand Total does not include ongoing operating costs (Darlington Station OM&A).
2. Cash Flows include contingency.
3. The Estimate Class is Class III for the current release and Class IV for the future release. Since the costs for the future release are estimated to be much greater, then a Class IV estimate class was used.

ONTARIO POWER GENERATION

Records File Information:
See Guidance Section

OPG-FORM-0076-R003*

Type 3 Business Case Summary

Approvals			
	Signature	**Comments**	**Date**
This BCS represents the best option to meet the validated business need in a cost effective manner.			
Recommended by: Sandy Stock Project Sponsor	S.D. Stock		17 OCT 2012
I concur with the business decision as documented in this BCS.			
Finance Approval: Carla Carmichael VP Nuclear Finance Position per OPG-STD-0076			17/OCT/12
I confirm this project will address the business need, is of sufficient priority to proceed, and provides value for money.			
Approved by: Brian Duncan, SVP, DNGS Position per OAR, per OAR 1.1	Brian Duncan		Oct 18/2012

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

ONTARIO POWER GENERATION

Records File Information:
See Guidance Section

OPG-FORM-0076-R003*

Type 3 Business Case Summary

Final Security Classification of the BCS: **OPG Confidential**

Business Case Summary

Part A: Business Need

Business Need:

The objective of this project is to ensure a continuous, high quality, cost effective supply of demineralised water to DNGS until station End of Life (EOF).

The current WTP is approaching the end of it design life and will be challenged to maintain satisfactory system health status and reliability. Failure of the current WTP would result is a shortage of demineralised water to the station and the start of a 4 unit shutdown if the WTP cannot be returned to service within 24hours. The current condition of the existing WTP will not support the long term needs of DNGS to end of station life (est. 2050).

Part B: Preferred Alternative

Description of Preferred Alternative: Vendor EPC new WTP Outside the "Protected Area"

An economic and engineering evaluation was completed by an external engineering vendor in June 2012 [Ref 2] under Project #16-38939 to review the available alternatives for the WTP and recommend a preferred alternative.

The report reviewed the following alternatives:

- Status Quo (continued major maintenance of the current WTP (using the existing IX technology)),
- Major refurbishment of the existing WTP using conventional IX technology (systematic replacement of all the major components and control systems with new equipment for example);
- Upgrade the existing WTP with new WTP technology (Reverse Osmosis (RO) for example);
- Vendor Engineer, Procure and Construct (EPC), OPG own and operate a new WTP inside the security fence;
- Vendor Engineer, Procure, Construct, Maintain (EPC-M) and operate a new WTP outside the security fence. OPG would then purchase the water from the vendor similar to what is done at PNGS;
- Vendor EPC, OPG own and operate a new WTP outside the security fence;
- Vendor EPC-M and operate a skid / trailer mounted water treatment process outside the protected area;
- Vendor EPC, OPG operate a skid / trailer mounted water treatment process outside the protected area

The various alternatives were first assessed against a set of mandatory parameters to ensure the alternative satisfies the basic project objectives. The mandatory parameters were the following:

Parameter	Sub-Parameter
Performance	Demin Water Quality
	Capacity of WTP
Reliability	Design Life
	Guaranteed availability
Safety	Compliance with industrial Safety Standards
Vendor's Capability	Capability to Support, Service and Provide Training

If the alternative satisfied the mandatory parameter criteria, then the alternative was further scored against a set of "non-mandatory parameters" as shown below:

ONTARIO POWER GENERATION

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See Guidance Section

OPG-FORM-0076-R003*

Type 3 Business Case Summary

Parameter	Parameter Weighting Factor
Economic	30%
Impact on Environment	18%
Maintainability	12%
Site Location	15%
Operability	9%
Regulatory Risk	6%
Constructability	6%
Miscellaneous	4%

The following alternatives scored the highest:

Alternative	Rank
New Build – Vendor EPC outside the Protected Area	1
Upgrade the Existing WTP	2

The scoring of the top alternatives was close. As a result, a series of senior management presentations were prepared to communicate the conclusions of the report which resulted in the approval for the following alternative:

> Replace the existing WTP with a new Vendor Engineer / Procure / Construct (EPC) facility outside the protected area

The decision on who will operate the new WTP will be made at a later stage of the project.

Refer to [Ref 2] for a comprehensive analysis of all the alternatives reviewed.

Deliverables:	Associated Milestones (if any):	Target Date:
Preliminary Design Complete (under this BCS)	Prelim Eng. Milestone Complete	21 Feb 2014
Partial Execution Release BCS (under this BCS)	Partial Exec Release Approved	25July 2014
Detailed Design Complete (under this BCS)	Detailed Eng. Milestone Complete	19 Feb 2015
	(Note: No design contract issued at this time therefore Directed Change may be required to move engineering milestones based on vendor's proposed schedule)	

Part C: Other Alternatives

Base Case: Status Quo – No Project

[Ref 2] concluded that maintaining the existing WTP (Status Quo) to DNGS EOF is not feasible since many of the existing WTP components and systems are obsolete and/or ending their useful life. Reliability will not meet the project requirements. The existing WTP will also not be able to meet the present Pickering water quality specification and expected future higher water quality standards, especially Total Organic Carbon (TOC). As a result, the Status Quo option will not satisfy the project objectives.

ONTARIO POWER GENERATION

Records File Information:
See Guidance Section

OPG-FORM-0076-R003*

Type 3 Business Case Summary

Alternative 2: Delay Work – Postpone Replacement of WTP

A previous review of the options for the existing WTP was conducted in 2005 and concluded that a replacement of the existing WTP was not justifiable at that time. However, the WTP has aged significantly since that time. OPEX from other CANDU nuclear stations suggests that the average life span for IX based water treatment plants is 28 years [Ref 1] which is short of their nominal 30 year design life. As a result, the estimated design End of Life (EOL) of the current WTP is 2015. Despite past reliable operation, the WTP will be challenged to maintain satisfactory system health status and reliability as it reaches or exceeds the end of its design life if this project were to be postponed.

Alternative 3: Upgrade the Existing WTP with new RO Technology

[Ref 2] concluded that upgrading the existing WTP with new equipment and technology is possible however the project risks are greater. Working inside the protected within a pre-defined space allocation while maintaining the existing WTP in service throughout the upgrade will combine to make the engineering and construction very complex. As a result, this alternative is not recommended.

Alternative 4: Vendor EPC (OPG Own and Operate) a new WTP Inside the Protected Area

[Ref 2] concluded that constructing a new WTP inside the Protected Area is feasible; however the project and ongoing costs will be greater. In addition, there is limited available land within the protected area. As a result, this alternative is not recommended.

Part D: Project Cash Flows

k$	LTD	2012	2013	2014	2015	2016	2017	Future	Total
Currently Released	0	0	0	0	0	0	0		0
Requested Now	-	143	1478	3237	375	0	0		5233
Future Required	-	0	40	3500	19430	26312	3301		52583
Total Project Cost		143	1518	6737	19805	26312	3301		57816
Ongoing Costs	-								
Grand Total	0	143	1518	6737	19805	26312	3301		57816

Estimate Class:	Class 4	**Estimate at Completion:**	[redacted]	**OAR Approval Amount:**	$5,233k

Additional Information on Project Cash Flows (optional):

1. Grand Total does not include ongoing operating costs (Darlington Station OM&A).
2. Cash Flows include contingency.
3. The Estimate Class is Class III for the current release and Class IV for the future release. Since the costs for the future release are estimated to be much greater, then a Class IV estimate class was used.

Part E: Financial Evaluation

k$	Preferred Alternative	Base Case	Delay Work	Alternative 3	Alternative 4
Project Cost		N/A	N/A		
NPV (after tax)	2600	0	N/A	0	-12300
Other (e.g., LUEC)					

Summary of Financial Model Key Assumptions (see Guidance on this Type 3 BCS Form):

Type 3 Business Case Summary

[Ref 2] did not provide a status quo cost as it did not meet future requirements on water quality. For the purposes of providing indicative NPV's in the above table the base case was assumed as a major upgrade the existing facility.

[Ref 2] does provide the present value (PV) of the total life cycle cost of many alternatives which includes ongoing OM&A, capital investment, tax implication, and the time value of money.

The NPV of the alternatives are evaluated as NPV = PV_{alt} -PV_{base}, where the base case is defined as a major upgrade to the existing facility. Positive NPV indicates total life cycle cost less than the base case, where negative NPV indicates total life cycle costs greater than the base case.

For the preferred alternative the NPV (2.6 $M) indicates there is an economic advantage to a new water treatment plant outside the protected area compared to a major upgrade to the existing facility.

For alternative 4 it also indicates there is a significant economic penalty to building a new facility within the protected area as compared to a major upgrade to the existing facility.

More detailed economic assessments will be completed under this release as further information is made available from preliminary and detailed engineering.

Part F: Qualitative Factors

DNGS could benefit from the following potential opportunities of this project:

Improved Health and Safety: A new WTP using the latest technology will decrease or eliminate the handling of hazardous liquids (acids and caustics) used in the regeneration of the existing IX WTP columns.

Improved Environmental Performance: A new WTP using the latest technology is likely to decrease or eliminate the potential for hazardous spills since the amount of hazardous chemicals used is reduced or eliminated.

Reduced Operating and Maintenance Costs: A new WTP using the latest technology outside the Protected Area could benefit from the use of commercial grade equipment (instead of Nuclear Class 6) for spares, easier deliveries, and reduced operator and maintenance burdens. In addition, the operator and maintenance burdens can also be further reduced by outsourcing should this be determined to be in the best interest of OPG.

Increased Asset Protection: A new WTP using the latest technology will provide an opportunity to improve the quality of demineralised water. The improved water quality will help ensure DNGS remains fully aligned with current and future industry standards and trends. This investment will help DNGS maintain an excellent WANO Chemistry Performance Indicator and assist in Steam Generator asset preservation until Darlington End of Life (EOL).

Type 3 Business Case Summary

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	Modification Design Requirements (MDR) currently not defined for the new WTP. Cost of a new WTP could be impacted once the MDR is finalized	Mitigate: MDR to be completed early in the project (first step) using availble OPEX (PNGS, Bruce NGS etc). Rationale for each performance requirement of the new WTP to be documented and accepted. Overspecifying to be avoided. Costs used in this esitimate were based on OPEX and conceptual report [Ref 1] and associated reference material noted in [Ref 1].	Low	High
Scope	Site for new WTP not currently finalized. Site preparation scope (i.e. demolition/relocation of structures and buried services) for chosen site may increase	Mitigate: Project has engaged Campus Plan and Station Management for site selection approval. Site Preparation cost estimate assumes some re-location of structures required.	Medium	Low
Schedule	Delays to project schedule due to regulatory/Environmental approvals not achieved in a timely manner	Mitigate: Regulatory/Environmental Assessments and Impacts to be identified early. Allow sufficent time in the schedule for regulatory approvals. Initiate communications with the regualtory agencies in advance of formal submissions and seek and agreement in principal where the issue In not conventional.	Low	Medium
Resources	Station Support Resources may be limited	Mitigate: Establish dedicated and complete project team outlining requirement for stakeholders to inform Projects of upcoming issues which could impact deliverables.	Low	Medium
Quality/ Performance	Design Inputs (Modifcation Design Requirements) and Design Deliverables do not meet required quality	Mitigate: Subject Matter Experts will be used to prepare, review and approve Modification Design Requirements. OPEX will be used (e.g. PNGS, Bruce etc.)	Low	High
Technical	Proposed WTP technology to be used for the replacement WTP is custom, unique or unproven	Mitigate: Only proven technology to be used. Modularization shall be encouraged. Customization shall be discouraged.	Low	Low

Type 3 Business Case Summary

Additional Risk Analysis:

Refer to the Risk Management Plan in the Project execution Plan (PEP) NK38-PEP-74000-0439308.

Part H: Post Implementation Review (PIR) Plan

Type of PIR	Target Project In Service Date	Target PIR Completion Date
Comprehensive	2016-11-25	2017-11-25

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Comprehensive PIR parameters to be developed for subsequent BCSs				

PIR measures will be developed under this release and will be included in the next release. It is expected that the following topics will be included, but not limited to:

1. Capacity (Ips)
2. Reliability/Availability
3. Water Quality
4. Operating Cost

Part I: Definitions and Acronyms

AFS	Available for Service
BCS	Business Case Summary
CPI	Chemistry Performance Indicator
DNGS	Darlington Nuclear Generating Station
EPC	Engineer/Procure/Construct
EOF	End of Life
IX	Ion Exchange
MDR	Modification Design Requirements
OM&A	Operating, Maintenance and Administration
OPEX	Operating Experience
PNGS	Pickering Nuclear Generating Station
TOC	Total Organic Carbon
US	United States
WTP	Water Treatment Plant
WANO	World Association of Nuclear Operators

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For Internal Project Cost Control

Type 3 Business Case Summary

Appendix A: Summary of Estimate										
Project Number:	16-31535		**Facility:**	DNGS						
Project Title:	Dngs Water Treatment Plant Replacement Project									
Estimated Cost in k$										
	LTD	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Future**	**Total**	**%**
OPG Project Management	0	42	426	409	517	477	348	-	2219	5
OPG Engineering	-	81	312	216	163	163	93	-	1028	2
Permanent Materials	-	-	-	540	5420	7540	-	-	13500	30
[redacted]										
Total		**143**	**1518**	**6737**	**19805**	**26312**	**3301**	**-**	**57816**	
Removal Costs Included										

Notes			
Project Start Date	2012-10-22	**Project Completion or In-Service Date**	2016-11-25 for new WTP 2017-06-30 to de-commiss old WTP
Interest Rate	5.25%	**Escalation Rate**	2.00%
Definition Cost Included	$4,550 k	**Estimate at Completion**	[redacted]

Prepared by:		Approved by:	
John Ferrari FOR Brian Graham Section Manager Darlington Projects	2012-10-17 YYYY-MM-DD	George Makdessi Manager Darlington Projects	2012-10-17 YYYY-MM-DD

Type 3 Business Case Summary

Appendix B: Comparison of Total Project Estimates										
Phase	Release	Date (YYYY-MM-DD)	Total Project Estimate in M$ (by year including contingency)						Later	Total Project Estimate
			2012	2013	2014	2015	2016	2017		
Definition	Full	2012-10-22	0.14	1.52	6.74	19.81	26.31	3.30		57.82

Project Variance Analysis					
Estimated Cost in k$					
k$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management					N/A (This is the first Capital BCS)
OPG Engineering					N/A
Permanent Materials					N/A
Design and Construction					N/A
Consultants					N/A
Other Contracts/Costs					N/A
Interest					N/A
Subtotal					
Contingency					
Total					
Removal Costs Included					

Type 3 Business Case Summary

Appendix C: Financial Evaluation Assumptions

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

Project Cost:

(1)
(2)
(3)

Financial:

(1)
(2)
(3)

Project Life:

(1)
(2)
(3)

Energy Production:

(1)
(2)
(3)

Operating Cost:

(1)
(2)
(3)

Other:

(1)
(2)
(3)

Attach further detail as appropriate from the Financial Evaluation spreadsheet.

Appendix D: References

[Ref 1] NK38-REP-74000-0325065
[Ref 2] NK38-DRT-74000-10001
[Ref 3] NK38-REP-74000-10001

Type 3 Business Case Summary

This Guidance section should be deleted prior to submission of the BCS.

Guidance for Completing this Type 3 Form:

Always use the latest revision of the Form!
Verify this is the latest revision through PowerSearch,
or Finance BCS Toolkit intranet website.

Final Security Classification

Determine the Final Security Classification of the BCS from the drop-down list before both the Executive Summary and Recommendations and Part A. Refer to OPG-STD-0030 Classification, Protection and Release of Information.

Executive Summary and Recommendations

Records File Information

Refer to OPG-PROC-0019, Records and Document Management for the requirements and expectations of record filing after the BCS is submitted.

The SCI used for record filing should be:

- *00120.3* for Nuclear BCSs.
- *08707.021* for BCSs of all other business units and corporate groups.

Submitted BCSs shall also be filed according to local BU governance, which may require different SCIs.

Project Overview

State the following:

- What needs to be done and why it needs to be done.
- When the investment/project will be completed.
- Key business objectives.
- Expected benefits of the investment/project.
- Whether the investment/project is within the original scope as specified in the approved Business Plan and/or Life Cycle Plan.
- Brief history of previous releases.
- Level of confidence for current request.
- If critical to the decision, any constraints on the investment/project or its timing.

Project Cash Flows

This table in the Executive Summary and Recommendations section is the same as the table in Part D: Project Cash Flows. See guidance for Part D: Project Cash Flow.

Approvals

Provide the title and name of the individuals making the three required signatures: the Project Sponsor, the individual providing Finance Approval, and the Approver of the BCS per the OAR. The Comments cell is to allow brief hand-written comments. For example, "see comment on Part D", which would refer to a hand-written comment later in the BCS document. These comments would be minor in nature; otherwise a reviewer would require revisions to the BCS before signing the document.

Type 3 Business Case Summary

Business Case Summary

Part A: Business Need

This section describes the business needs or opportunities that gave rise to the investment. It provides background and context for the investment including: the investment's purpose, what's driving the investment, why the investment needs to be addressed now, what are the impacts of not proceeding, key assumptions, identification of any subsequent commitments or obligations, and the benefits or constraints that the investment will create. Provide studies, experience or lessons learned from similar investments, if available. If this submission relates to a subsequent approval, provide a quick overview of investment history.

If the investment is a subset of a program, or if the issue to be addressed is symptomatic of a broader issue that requires additional response, provide the context and identify the related response, whether planned or anticipated.

Part B: Preferred Alternative

This section describes expected business results and objectives, including resourcing requirements, when the investment will be completed, and any major milestones. The proposal section must put the investment into the proper context by providing the link between the investment and the business strategy for the asset and/or other planned investments in that asset.

Describe the link between this investment and business strategy or other investments. Disclose if the resourcing is in place. Alternatively, if the investment is not in the business plan, or if the scope has changed relative to the Business Plan, reasons for the change(s) must be provided.

State the expected benefits and what is being delivered, without specifying vendor name(s). Describe briefly project execution strategy, regulatory approvals, third party agreements, project management, and basis for the cost and schedule contingencies, if applicable. Highlight any constraints on the investment or on its timing, and any constraints or obligations created by the investment.

Deliverables

In the Deliverables section, list the project deliverables and target completion dates, including associated milestones (such as unit in-service dates and external or regulatory milestones).

Part C: Other Alternatives

This section describes viable alternatives considered, including associated risks. At minimum, include a Base Case: Status Quo – No Project. Other alternatives may include:

- Deferring the project.
- Different means to meet the same business need.
- Completing partial scope.
- Alternatives with additional scope.

Part D: Project Cash Flows

This table in Part D: Project Cash Flows is very similar to the table under Project Cash Flows in the Executive Summary and Recommendations section.

This table provides a yearly breakdown of estimated project costs, including amounts currently released from earlier BCSs if applicable, the new amounts being requested now in this BCS, and estimated future requirements not currently requested. Contingency shall be included in these amounts.

The new amounts being requested are for actual work to be completed and for any costs that will be committed to through that work. For example, if an equipment purchase is bundled with a maintenance contract for a committed period, the committed payments under the maintenance contract must be included in the current request. Ongoing Costs include any costs related to the investment that would not be part of the project budget, including ongoing incremental operating costs, and acquisition of inventory.

The Future column is the sum of expected future cash flows beyond the last year shown in the table.

Estimate Class

Estimate Class is a cost estimate classification system developed by the Association for the Advancement of Cost Engineering International (AACE) which defines the estimate "quality" based on the input information used and the project's stage of development. AACE uses five estimate classes with Class 5 being the least accurate, and Class 1 being the most accurate.

Estimate Class	Class 5	Class 4	Class 3	Class 2	Class 1
Phase	**Identification**	**Initiation**	**Definition**	**Execution**	**Execution**
Level of Project Definition (%)	0% to 2	1 to 15	10 to 40	30 to 75	65 to 100
Expected Accuracy Range (%)	-50 to +100	-30 to +50	-20 to +30	-15 to +20	-10 to +15

OAR Approval Amount

For BCSs up to and including Definition Phase work, the OAR Approval Amount is the cumulative total actual and committed cost to date, not the estimated total investment/project cost. For Execution Phase BCSs or BCSs that cover multiple phases including Execution, the OAR Approval Amount is the estimated total investment/project cost, including cumulative cost to date.

Additional Information on Project Cash Flows (optional)

Relevant information such as the delta between approved business plan cash flows and requested release, may be entered into this open-field table cell.

Part E: Financial Evaluation

This section describes and compares the key alternatives considered. Only the most relevant alternatives shall be listed in this table for comparison. The analysis includes financial evaluations, economic analysis, and comparisons of the alternatives based on total project cost, after-tax NPV, and any other financial metric deemed appropriate by the project sponsor (e.g., IRR, discounted payback, etc.) The BCS Financial Evaluation Model is available on the Finance website and is updated periodically to help facilitate financial analysis. Attach further detail as appropriate from the Financial Evaluation spreadsheet.

Summary of Financial Model Key Assumptions

List key assumptions used in the Financial Evaluation. For Part E, provide a brief summary of the most important assumptions that are listed in Appendix C.

Part F: Qualitative Factors

Qualitative factors gained (or lost) from the investment and how an initial specification will be measured within the post implementation review (to the extent feasible). Qualitative factors could include: sustainable energy development impacts; community, government, and customer relations; staff relations issues, technical or operational considerations, reliability, health and safety issues, and other intangibles.

Part G: Risk Assessment

This section identifies the risks associated with the investment and the plans to manage or mitigate these risks. Refer to OPG-STD-0062, Project Risk Management Standard and local business unit standards for guidance on completing and documenting risk assessments. Each BU can add risk areas specific to its business.

Extra Risk Classes may be added by changing "Other" to a specific risk class and/or inserting extra rows to the table.

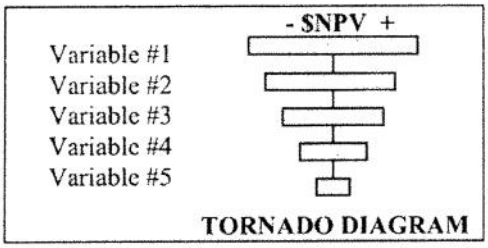
The Risk Analysis section discusses, as appropriate for the project, quantitative risk factors that relate to the project financial evaluation, including considerations such as:

- Present and discuss material impacts/consequences of variations in the basic assumptions, e.g., price of electricity used for revenue, sales forecast, service life, etc. Discuss likelihood of occurrence.

- Based on risks identified and mitigation measures implemented, indicate whether the financial analysis completed for the recommended alternative includes the contingency required for OPG residual risks, and their impact on the estimated in-service date.

- The extent of the risk assessment and the risk analysis techniques employed should be commensurate with the magnitude of the cash flows and the degree of uncertainty associated with the critical assumptions upon which the investment is based.

- For Major Projects, the risk analysis section will typically include sensitivities of the investment to various risk factors or scenarios, and a discussion of their likelihood of occurrence. A convenient way of presenting the results of the risk assessment on the variability of the NPV to changes in the critical variable is to include a graph or tornado diagram as shown below.



- For larger investments, more advanced risk analysis techniques such as Monte Carlo may be suitable. These techniques require analysts with appropriate training; contact your local Finance support to discuss applicability and to arrange Finance analytical support if required. The limitations of Monte Carlo or any other risk assessment technique must be considered in their application, and require a time commitment from the project team and stakeholders to develop and estimate model inputs.

Part H: Post Implementation Review (PIR) Plan

PIR plan is a succinct description of the project benefits using measurable parameters. The PIR plan should clearly specify what is to be measured, who is responsible for measuring it, and when the measurement should take place, along with any requirements for establishing pre-project baseline information for comparison purposes.

Extra PIR metrics may be added by inserting extra rows to the table.

The PIR plan should contain the following five main elements:

- What: Key deliverables or benefits of the project clearly defined in measurable parameters, including a clear description of the reference or baseline from which the incremental benefits or changes due to the project are to be measured.

- How: A brief description of how each parameter is going to be measured.

- Who: The name of the group, department, or individual that will be measuring the benefits.

- When: When the measurement of the benefits will take place.

In addition, the Project Sponsor and key stakeholders may specify other items such as the types of lessons learned and recommendations to be captured during the execution of the PIR.

Part I: Definitions and Acronyms

Define key technical terms and list acronyms to assist reviewers of the document.

Appendix A: Summary of Estimate

Note: All content from Appendix A onwards, including this Guidance section, contains a level of detail that is intended for OPG internal use only and should be removed before a copy of a BCS is released to an external party.

To assist the reviewer in understanding the cost estimate in the BCS, this table provides a breakdown of various cost components by year, with explanatory notes as appropriate.

Note: The label "Project Completion or In-Service Date" is intended to provide flexibility for projects that do not have a specific "In-Service Date", such as engineering studies in future decisions or for future regulatory documents.

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

This section provides the history of past releases and their associated estimates, with explanations of changes as appropriate.

Appendix C: Financial Evaluation Assumptions

This section is intended to provide a reviewer with an overall understanding of the key assumptions used in the financial evaluation, to help a reviewer confirm that relevant drivers and appropriate assumptions were used in the analysis. The main considerations in the economic evaluation of the alternatives are outlined below:

Cost and Schedule Estimates

The work breakdown structure (WBS) of the project usually provides detailed information on the cost of the project and should be referred to while estimating the costs and schedule. Best practices in project cost and schedule estimating should be applied wherever possible including using lessons from similar experiences and benchmarks. Requests for quotations from competitive sources are another option to obtain detailed estimates. Schedule and cost estimates must obtain stakeholders' inputs and be reviewed by the key stakeholders of the project before being finalized.

Taxes

All investments must be assessed on an after-tax basis. Users will be required to properly classify the capital assets for Capital Cost Allowance (CCA) purposes. The financial evaluation model provided on the Finance website will compute the initial income tax impacts for most types of investments; the model also contains the latest CCA rates for most types of investments. For further information on CCA, sales taxes and tax shields, please contact your local Finance support group.

Cost of Capital

An appropriate cost of capital or discount rate must be used to ensure that an adequate return is provided to shareholders. For investments related to the manufacturing and processing of electricity for regulated nuclear and base-loaded hydroelectric facilities, the discount rate is generally lower than for unregulated facilities. This is partly due to regulated assets having a more predictable revenue stream, and hence lower risk than unregulated generation facilities.

For projects and business opportunities that are clearly outside of OPG's core business, or are not related to the manufacturing and processing of electricity, the project's cost of capital should be used, instead of OPG's cost of capital. Updated rates for OPG's core business are posted in the BCS Financial Evaluation Model. Contact Investment Planning for assistance.

Revenue Forecasts

The revenue forecast from generation assets must be based on the OPG System Economic Values (SEVs). The appropriate SEVs for the applicable time frame are selected based on the characteristics of the generation asset being evaluated (e.g., peaking vs. baseload). Contact your local Finance support group for further guidance on using SEVs.

Appendix D: References

Type 3 Business Case Summary

The reference documentation and attachments contain the detailed numbers, calculations, and any other analysis done probing the need and substantiating the justification for the investment. This documentation includes: cost estimates, financial evaluation sheets, risk assessment tables, modeling assumptions, project execution plan, technical studies, and any other specific studies related to the investment.

Additional Attachments

Additional documents be prepared as separate documents and enclosed with the BCS for reviews and approvals (e.g., multiple file attachments to e-mails).

The final signed version of the BCS may then be combined with all the attachments in a single PDF file.

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Records File Information:
Records SCI/USI Retention
- See Guidance Section

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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 #:	16-31542	**Document #:**	NK38-BCS-51000-10001
Project Title:	DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST		
Class:	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	**Investment Type:**	Sustaining
Phase:	Execution	**Release:**	Full
Facility:	Darlington	**Target In-Service or Completion Date:**	Dec-2018

Project Overview

We recommend the removal of High Voltage Bushing Monitoring (HVBM) from project scope.

The estimated total project cost under this full release is $22,719k (including [redacted] of contingency). The quality of the estimate for this release and for the total project is Class 2.

The previous partial release had a total project estimate of $26,719k (including [redacted] contingency) which included a Class 5 estimate of $4,000k (including [redacted] contingency) for the High Voltage Bushing Monitoring scope. This scope is now estimated at $7,200k. The increase in this cost estimate has contributed to the recommendation to remove this scope from the project.

This scope reduction is an acceptable risk, as it is planned to replace the transformer high voltage bushings during the refurbishment outages (Refurb DSR TS570-20 for Unit 2, and Operations DSR TS2320-1 for Units 3,1,4).

Many transformer failures occur because monitoring programs do not identify degraded conditions in time for corrective actions to be taken before failure. The use of on-line Multi-Gas Analysers (MGA) on transformers is intended to provide an early indication of impending electrical faults. Transformer conditions can change rapidly and in some cases transfer from a normal state to a failure state in a very short time frame. Automatic or Manual removal from service for equipment protection and limiting transformer damage and preventing catastrophic failure is the business objective of this project.

Problem Statement/Business Need:

OPG has committed to improve monitoring of the Main Power Output transformers (MOT, UST, and SST) to present industry standards as documented in WANO SOER 2011-1 Large Power Transformer Reliability.
Continuous gas analyzers installed on transformers provide a substantially better indication of problems than existing installed manual oil sampling or electrical tests done at intervals. Root cause faults may be determined by the gas signature.

Summary of Preferred Alternative:

- Install New Multi-Gas Analyzers (MGA) on Main Output Transformers (MOT), System Service Transformers (SST) and Unit Service Transformers (UST).
- This shall include Alarm Signals and Data Inputs to the DCC.

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

Type 3 Business Case Summary

Project #: 16-31542 Document #: NK38-BCS-51000-10001
Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <Full> <Execution> Release

Project Overview

History of BCS releases and project cost estimates:

Previous Approved D-BCS-51000-10003 was $26719K including [redacted] of contingency. It includes budgetary estimate of $4000K including contingency [redacted] to complete High Voltage Bushing Monitoring (HVBM) installation on Unit 1, Unit 2, Unit 3 and Unit 4 MOT and SST. It was identified in previous approved BCS that the addition of HVBM installation would be assessed and included if prudent in next phase BCS. As per performance engineering assessment and confirmation, HVBM installation scope is no longer required in this project in part due to increased cost estimates. So the total project cost is now reduced to $22719K ([redacted] project cost + [redacted] contingency) to install MGA on U1, U2, U3 and U4.

History of scope and schedule changes:

As per unit condition D1531 has been extended to start from April 2015 to September 2015 and Unit 3 SST outage has been advanced from 2015WW38 to 2015WW28. Accordingly D1531 MGA Installation activities will be extended and AFS milestone is requested to extend from 30Sep2015 to 31Mar2016. Similarly Unit 3 SST MGA Installation activities will be advanced.

It was identified in previous approved D-BCS-51000-10001 & D-BCS-51000-10003 that the addition of a bushing monitoring system would be assessed and included (if required) in the next phase BCS. It was confirmed by sponsor performance engineering in Nov 2014 that High Voltage Bushing Monitoring (HVBM) installation is no longer required due to estimated project cost ($7.2M) based on ESMSA vendor budgetary quote for local indication only is higher than included in previous BCS ($4M) and approved in project screening committee. So $4M budget for HVBM and associated activities included in last BCS will be removed from total project cost and schedule. As a result project close out will be advanced from 31Dec2022 to 31Dec2018.

Key Assumptions and Risks:

Multi Gas Analyzer Installation Scope is well defined. Unit 2 MGA installation on MOT and UST was completed in D1321 and declared in service. Unit 1 MGA installation on MOT and UST was completed in D1411 and declared in service. Unit 1 MGA installation on SST was completed in IPG and declared in service on 17Dec2014.

Project Cash Flows, NPV, and OAR Approval Amount

k$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	11,146	5,478	5,756	318	21				22,719
Requested Now									
Future Required									
Total Project Cost	11,146	5,478	5,756	318	21				22,719
Ongoing Costs									
Grand Total	11,146	5,478	5,756	318	21				22,719

Estimate Class:	Class 2	**Estimate at Completion:**	[redacted]
NPV:	NA	**OAR Approval Amount:**	$22,719 k

Additional Information on Project Cash Flows (optional):

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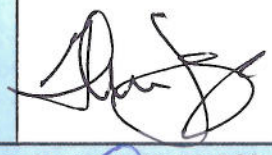
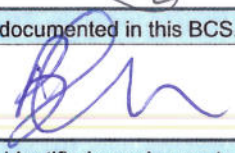
Type 3 Business Case Summary

Project #: 16-31542
Document #: NK38-BCS-51000-10001
Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <Full> <Execution> Release

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): Glenn Jager President OPG Nuclear, Chief Nuclear Officer			30APR2015
I concur with the business decision as documented in this BCS.			
Finance Approval: Beth Summers CFO			11 MAY 2015
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: Tom Mitchell President and CEO, per OAR 1.1			11 May 2015

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Type 3 Business Case Summary

Project #: 16-31542
Document #: NK38-BCS-51000-10001
Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <Full> <Execution> Release

Business Case Summary

Part A: Business Need

OPG has committed to improve monitoring of the Main Power Output transformers (MOT, UST, and SST) to present industry standards as documented in WANO SOER 2011-1 Large Power Transformer Reliability.

Many transformer failures occur because monitoring programs do not identify degraded conditions in time for corrective actions to be taken before failure. Analyzing transformer oil to detect and measure the concentration of fault gases allows Darlington to diagnose and correct incipient faults before they happen. Continuous gas analyzers installed on transformers provide a substantially better indication of problems than manual oil sampling or electrical tests done at intervals. Root cause faults may be determined by the gas signature (presence of specific gases, trending gas concentrations, and ratios of gas concentrations). This is not possible with the previous HYDRAN technology.

EPRI report 1021892_C09 (EPRI Transformer Guidebook Development: The copper Book, Chapter 9: Monitoring and Diagnostics, section 9.5.18.1.5 Life extension) frames the business need succinctly:

> *Power transformers have a nominal expected life of 40 to 60 years and a depreciated life of 40 to 60 years. While early loss of a less than fully depreciated transformer represents a write-off for the utility, the early replacement of a fully depreciated power transformer represents a sizeable investment that could be deferred, allowing replacement funds to be used for another important capital project. Being able to obtain full technical life from a power transformer without increasing risk or sacrificing reliability is a significant benefit that makes installation of on-line monitoring on aged units, a good business decision.*

The use of on-line Multi-gas Analyzers on Transformers is intended to provide an early indication of impending Electrical faults. Transformer conditions can change rapidly and in some cases transfer from a Normal state to Failure state in a very short time frame. Automatic or Manual removal from service for equipment protection and limiting transformer damage and preventing catastrophic failure is the business objective of this project.

This is especially relevant to transformers that are substantially loaded and/ or at an advanced age in their life cycle. This is applicable to all the intended transformers (MOT, SST & UST). In addition, the monitors presently installed on the MOT & SST are deemed inadequate and are obsolete. The UST has no monitor installed.

Part B: Preferred Alternative: Install Multi Gas Analyzer

Description of Preferred Alternative

To install New Multi-Gas Analyzers on all (12) Main Output Transformers (MOT), all (4) System Service Transformers (SST) and all (4) Unit Service Transformers (UST).

This shall include Alarm Signals and Data Inputs to the DCC. The MOT & SST have existing DCC inputs and shall be re-used as much as possible, however, the UST shall be a new installation.

Major activities completed under the previous BCS (D-BCS-51000-10001 R000) Phase I

1. Multi Gas Analyzers installation MOT/UST/SST preliminary engineering.
2. Multi Gas Analyzers for Unit 1, 2, 3 and 4 MOT, UST and SST procured and received.
3. Unit 1, Unit 2, Unit 3, Unit 4 Multi Gas Analyzers Installation detail designs.
4. Unit 2 MOT and UST Multi Gas Analyzers Installation AFS.
5. Unit 1 MOT and UST Multi Gas Analyzers Installation AFS.
6. Unit 1 SST Multi Gas Analyzers Installation AFS.

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Type 3 Business Case Summary

Project #: 16-31542
Document #: NK38-BCS-51000-10001
Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <Full> <Execution> Release

Part B: Preferred Alternative: Install Multi Gas Analyzer

Description of Preferred Alternative

Major activity still remaining under the previous BCS (D-BCS-51000-10001 R000) Phase I and is in progress for completion:

1. Unit 2 SST Multi Gas Analyzers Installation AFS: 16Dec2016

Major activities remaining under the previous BCS (D-BCS-51000-10003 R000) Phase II and is in progress for completion:

1. **Unit 3 MOT and UST Multi Gas Analyzers Installation and AFS: 31Mar2016 (D1531 rescheduled to fall)**
2. Unit 3 SST Multi Gas Analyzers Installation and AFS: 29Jan2016
3. Unit 4 MOT and UST Multi Gas Analyzers Installation and AFS: 30Sep2016
4. Unit 4 SST Multi Gas Analyzers Installation and AFS: 31Jan2017
5. **Project Closeout: 31Dec2018 (Advanced from 31Dec2022 due to HVBM scope removal)**

Deliverables:	Associated Milestones (if any):	Target Date:

Part C: Other Alternatives

Alternative 2: Do Nothing More

Abandon future installations. OPG would have incomplete multi gas analyzer coverage of its major transformers and not meet present industry standards per WANO SOER 2011-1 Large Power Transformer Reliability.

Alternative 3: Increase the frequency of oil sampling and IR thermography

Increasing the frequency of Transformer Oil Sampling could be used to reduce the probability of an undetected condition leading to a failure. Manual sampling is not considered to be as effective as online sampling due to aging, off gassing, temperature changes and increased opportunity for contamination of the oil sample. This approach would require oil sampling 'on power' with an approximate cost of $600 per analysis (X 20 transformers).

This would not meet the recommendations of the WANO SOER 2011-1 that recommends all plants install On-Line Gas Analyzers on their large transformers.

Alternative 4: Update existing equipment

The existing Hydran detectors to be replaced with a newer model of the same technology for which spare parts would be available. While costing slightly less for equipment, the Hydran and similar equipment, represent an earlier generation of monitors. These provide a composite indicator rather than individual specific values for all of the gases of interest, (eight) for use in assessment of a fault condition and would require a manual sample to facilitate any assessment of the fault condition.

The recommendation of WANO SOER 2011-1 specifically calls for Multi-Gas analyzers.

Type 3 Business Case Summary

Project #: 16-31542 Document #: NK38-BCS-51000-10001
Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <Full> <Execution> Release

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

k$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	11,146	5,478	5,756	318	21				22,719
Requested Now									
Future Required									
Total Project Cost	11,146	5,478	5,756	318	21				22,719
Ongoing Costs									
Grand Total	11,146	5,478	5,756	318	21				22,719

Estimate Class:	Class 2	**Estimate at Completion:**	[redacted]
NPV:	NA	**OAR Approval Amount:**	$22,719 k

Part E: Financial Evaluation

k$	Preferred Alternative	Base Case	Delay Work	Alternative 4	Alternative 5
Project Cost	22,719	NA	NA	NA	NA
NPV	NA	NA	NA	NA	NA
Other (e.g., IRR)	NA	NA	NA	NA	NA

Summary of Financial Model Key Assumptions or Key Findings:

Financial evaluation is optional for sustaining project as per OPG-STD-0076.

Part F: Qualitative Factors

Darlington is committed to improving the on-line monitoring capability of the main power output system in line with WANO SOER 2011-1.

Personnel safety hazards exist in the areas surrounding the MOT/UST/SST as documented in OPG report NK38-REP-51520-0394063 – Personnel Hazard Analysis Related to Large Power Transformers. Implementation of this project will reduce this risk. The risk reduction is described in section 9.5 of the EPRI report as: *"Another key advantage is that on-line monitoring usually provides for the accessibility of data remotely, which enables utility personnel to assess the hazard of approaching a potentially faulty transformer. For example, for any abnormal indication or alarm such as a Buchholz gas alarm, a check can be made of the transformer condition from the on-line monitor before entering the transformer compound."*

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	There is a risk of actual contract value could increase.Project estimate is based on a vendor submitted performance fee quote.	Based on three declared in service similar installations, appropriate contingency have been allocated.	Low	Low
Scope	There is a risk of increase in scope due to field discoveries.	Detail design field walk downs and work order assessment will address field discoveries. Project team has good understanding from completed MGA installation on MOT and UST in D1321, D1411 and Unit 1 SST.	Low	Low
Schedule	There is a risk of schedule extention or impact to project milestones. The exact timing of U4 SST outage after D1641 is not	SST outages are assumed to immediately follow the associated unit outages. Any deviation from this will be considered a directed change.	Low	Low

Type 3 Business Case Summary

Project #: 16-31542 Document #: NK38-BCS-51000-10001
Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <Full> <Execution> Release

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
	available at this time.			
Resources	There is a risk to receive support to drain transformer oil level to install MGA and to grab oil sample after transformer energization to test and finalize MGA set point.	Contract adminstrator has been included in project stake holder.	Low	Low
Quality/ Performance	There is a risk that installed equipment does not meet performance expectation.	Equipment is well proven in other applications & is standard off-the-shelf. Manual transformer grab oil sample analysis will be performed prior to finalize MGA set points.	Low	Low
Technical	There is a risk of new software introduction.	The analyzer software has been categorized as category 4.	Low	Low

Part H: Post Implementation Review (PIR) Plan

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Simplified PIR	2018-12-31	2018-12-31

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Continuous gas analysis per WANO SOER 2010-1	Combined Hydran Gas Alarm	Continuous gas analysis	Project AFS	Manager, Performance Engineering
Multi gas analysis to assist in root cause fault determination	Not possible with HYDRAN	Multi-gas analysis	Project AFS	Manager, Performance Engineering
Monitoring of all large power transformers	MOT – covered SST – covered UST – not covered	MOT – covered SST – covered UST – covered	Project AFS	Manager, Performance Engineering
Personnel Safety Risk Reduction	Personnel may have to approach transformers to assess status	On-line condition monitoring can provide remote status assessment	Remote condition assessment data	Manager, Performance Engineering

Part I: Definitions and Acronyms

MOT – Main Output Transformer
SST – System Service Transformer
UST – Unit Service Transformer
WANO – World Association of Nuclear Operators
MDR - Modification Design Requirement
TSDS – Technical Specification Data Sheet
MGA – Multi Gas Analyzer
HVBM – High Voltage Bushing Monitor
SOER-Significant Operating Experience Report
AFS-Available For Service

Type 3 Business Case Summary

Project #: 16-31542 Document #: NK38-BCS-51000-10001
Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <Full> <Execution> Release

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Type 3 Business Case Summary

Project #: 16-31542 Document #: NK38-BCS-51000-10001

Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <Full> <Execution> Release

For Internal Project Cost Control

Type 3 Business Case Summary

Project #: 16-31542 Document #: NK38-BCS-51000-10001
Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <Full> <Execution> Release

Appendix A: Summary of Estimate										
Project Number:	16-31542									
Project Title:	DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST									
k$	**LTD**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Future**	**Total**	**%**
OPG Project Management	[redacted]									
OPG Engineering (FE, Performance and Design)	575	253	185						1013	4
OPG Procured Materials										
OPG Other (CMO, CM, Operation)	225	100	72						397	2
Design Contract(s)										
Construction Contract(s)										
EPC Contract(s)	[redacted]									
EPC CORE TEAM										
Other Contracts/Costs (Hydro One and Kinectrics)										
Interest										
Subtotal										
Contingency										
Total	**11146**	**5478**	**5756**	**318**	**21**				**22719**	**100**

Notes			
Project Start Date	2012-10-01	**Total Definition cost** (excludes unspent contingency for Nuclear)	[redacted]
Target In-Service (or AFS) Date	2017-01-31	**Contingency included in this BCS** (Nuclear only)	
Target Completion Date	2018-12-31	**Total contingency released plus contingency in this BCS** (Nuclear only)	
Escalation Rate	2%	**Total released plus this BCS without contingency** (Nuclear only)	
Interest Rate	5%	**Total released plus this BCS with contingency** (Nuclear only)	$22,719 k
Removal Costs	NA	**Estimate at Completion** (includes only spent contingency for Nuclear)	[redacted]

Prepared by:		**Approved by:**	
Shailesh Shah Project Manager Darlington Projects	Date 2015-04-27	Ricardo Fiorini Section Manager Darlington Projects	Date 2015-04-27

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Type 3 Business Case Summary

Project #: 16-31542
Document #: NK38-BCS-51000-10001
Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <Full> <Execution> Release

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
			2012	2013	2014	2015	2016	2017		
Definition & Execution	Partial	2012-09-20	543	6858	4116	1715	1587	338		15157
Definition & Execution	Partial	2014-05-09	143	7258	5213	5766	4872	1011	2456	26719
Execution	Full	2015-04-30	52	6285	4809	5478	5756	318	21	22719

Type 3 Business Case Summary

Project #: 16-31542 Document #: NK38-BCS-51000-10001
Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <Full> <Execution> Release

Project Variance Analysis

k$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management	654	1,232	1,346	114	Additional OPG oversight required due to field discoveries from D1411 and U1 SST MGA Installation.
OPG Engineering (including Design)	575	894	1,013	119	Additional OPG oversight required due to field discoveries from D1411 and U1 SST MGA Installation.
OPG Procured Materials					
OPG Other	225	330	397	67	Additional OPG oversight required due to field discoveries from D1411 and U1 SST MGA Installation.
Design Contract(s)	[redacted]				
Construction Contract(s)					
EPC Contract(s)					
EPC Core Team					
Other Contracts/Costs					
Interest					
Subtotal					
Contingency					
Total	**11,146**	**26,719**	**22,719**	**(4,000)**	As per sponsor-performance engineering confirmation, HVBM installation is not required. Accordingly $4M budget for HVBM and associated activities have been removed.

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Type 3 Business Case Summary

Project #: 16-31542
Document #: NK38-BCS-51000-10001
Project Title: DNGD Install Multi-Gas Analyzers on Transformers MOT/ SST/ UST, <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:

(1) Project will be an EPC contract
(2) [redacted] contingency cost is included.

Financial:

Financial evaluation is not required (optional) for sustaining project as per OPG-STD-0076

Project Life:

This monitoring equipment is expected to last the life of the station.

Energy Production:

This is an early warning monitoring system on transformer condition and has no role.

Operating Cost:

Financial evaluation is optional for sustaining project as per OPG-STD-0076.

Other: None

Appendix D: References

D-PCH-51000-10002 Project Charter
NK38-MDR-51520-10002 Modification Design Requirements
NK38-REP-51520-0394063 Personnel Hazard Relating to Large Power Transformers
NK38-DRT-51520-10001 Conceptual Design Report - Transformer High Voltage Bushing Monitor
N-OVH-26187-00005 Continuous Training Cycle 17 SOER 2011-1 Large Power Transformer Reliability.

Type 2 Business Case Summary

Final Security Classification of the BCS: **OPG Confidential**

To be used for investments/projects meeting Type 2 criteria in OPG-STD-0076.

Part A: Project Information					
Project #:	16-31544	**Title:**	DN Radiation Detection Equipment Obsolescence		
Phase:	Definition	**Release:**	Partial	**Records File:**	D-BCS-61200-10003
Facility:	Darlington	**Class:**	Capital	**Investment Type:**	Sustaining

Business Need:

We recommend the release of $1,150k ([redacted] base cost plus [redacted] contingency) to begin the Definition Phase of the Darlington Radiation Detection Equipment Obsolescence project.

The total project estimate is $46,875k ([redacted] base cost plus [redacted] contingency).

Many of the radiation detection systems that are required to ensure regulatory compliance, protect the public and facilitate daily operation are past the end of their useful service life. Equipment performance is unsustainable and continually degrading due to obsolescence and aging management issues. Equipment replacement of the following seven (7) systems is necessary for continuing operation of the stations.

(1) Stack Monitoring, SCI 67989

Monitoring of stack emissions is a station Power Reactor Operating Licence (PROL) requirement. The monitoring equipment, programmable logic controllers and computers in particular are in an unsustainable, deteriorated state (obsolete and past end of life). There would be implications with the CNSC should the stack monitoring reliability degrade further. The system is not Seismically Qualified

(2) Post Accident Radiation Monitoring System (PARMS). SCI 67375

PARMS provides post-accident monitoring capability to facilitate reporting to the public and calculation of evacuation zones. The failure of this system in a Level 3 Impairment of Containment. The equipment (detectors and computers) are obsolete in an unsustainable state and past end of life. There have been multiple failures of the NGIPAM (Noble Gas Iodine Particulate Analysis Module) detectors (13 Functional Failures of Recording Equipment #RE526 & 7 Functional Failures of Recording Equipment RE506 since 2000). Continued operation in a level 3 impairment of containment (RE526 and 506 failures) may also have significant regulatory implications. The system is Seismically Qualified.

(3) Moderator Cover Gas Radiation Monitors, SCI 67989

This Criticality 1 equipment is obsolete and is no longer supported by original equipment manufacturer (OEM). The electronics are aging and there are limited spares. These monitors provide Containment Boundary design function in event of in-core Loss of Coolant Accident.

(4) Fixed Area Alarming Gamma Monitors (FAAGMs), SCI 62330

FAAGMs support radiation protection safety through their primary function of alerting personnel of changes in radiation levels. Detectors and rate-meters significantly are degraded (electronics/radioactive sources) and they are obsolete. There are limited refurbished spares and the equipment is no longer supported by the OEM.

(5) Active Liquid Waste (ALW) Liquid Effluent Monitor (LEM), SCI 67978

The CNSC expects the station to provide control and monitoring functions for radioactive liquid effluent discharges. The original equipment is suffering from degraded electronics and is obsolete with no OEM support. It is predicted that in 2 years or less system will lose essential function to perform control monitoring of ALW discharges, thereby risking regulatory sanction.

(6) Online Gas Chromatographs, SCI 63485

The online gas chromatograph system is a Criticality 2 system that provides continuous indication of various reactor system cover gas stream concentrations (Moderator, Liquid Zone, Primary Heat Transport Storage Tank, and Primary Heat Transport Collection Tank). Gas chromatograph availability is a prerequisite for surrendering the Guaranteed Shutdown State prior to unit start-up. Unavailability has resulted in delay of Unit start-up/Outage extension. There has been significant increase in corrective maintenance and instrument

Type 2 Business Case Summary

unavailability in the past 2 years.

(7) D_2O in H_2O Leak Detection System SCI 63862

This system uses a Fourier Transform infra-red spectrophotometer to detect leakage into Primary Heat Transport and Moderator system heat exchanger cooling water to detect leaks before significant releases of tritium to the environment occurs. The leak detection equipment is experiencing degradation of the optics and electronics. The main system board is obsolete and not supported by the Original Equipment Manufacturer (OEM). If unavailable, significant tritium releases to the environment could go undetected for quite a while before regular sampling would indicate a problem.

Preferred Alternative: Complete Replacement of all Seven Systems

It is proposed to replace all obsolete monitoring equipment with modern updated electronics and current software in the 7 systems mentioned above. Where possible the systems shall be re-engineered to use interchangeable components such that common spares can be stocked. As part of the proposals the current foot print will be re-used.

Base Case: Status Quo – No Project

Do nothing is not an option. The station needs to monitor all effluent discharging into the environment. This alternative could lead to a violation of the conditions of the station PROL and regulatory sanctions. Furthermore, it would impact on the public's perception of operations at Darlington.

Alternative 2: Delay Work

This alternative should not be considered. The monitoring equipment is past its expected service life and needs to be replaced expeditiously.

Alternative 3: Reduce Scope

The alternative to complete the replacement on a subset of the seven systems is not recommended at this time. Following the completion of scope definition, more information will be available and this option can be re-evaluated if required.

Alternative 4: N/A.

Deliverables:	Milestones:	Target Date:
Prepare the Modification Design Requirements (MDR) for each System.	Scope Definition Complete	June 15th 2015
Prepare the Modification Outline and Modification Scoping Documents for each system.	Prepare the BCS for the next phase.	Oct 30th 2015
Prepare the scope of work documents for each system		

References:

(1) D-2011-06168
(2) D-2011-06158
(3) Project Charter D-PCH-67989-10001-R00.

Type 2 Business Case Summary

Part B: Project Cash Flows									
k$	LTD	2014	2015	2016	2017	2018	2019	Future	Total
Currently Released	-	-	-	-	-	-	-	-	-
Requested Now	-	575	575	-	-	-	-	-	1,150
Future Required	-			1,620	7575	12901	11958	11671	45,725
Total Project Cost		575	575	1,620	7575	12901	11958	11671	46,875
Ongoing Costs	-								
Grand Total		575	575	1,620	7,575	12,901	11,958	11,671	46,875

Estimate Class[1]:	Class 5	Estimate at Completion[1]:	[redacted]	OAR Approval Amount:	1,150

Additional Information on Project Cash Flows (optional):

Part C: Financial Evaluation					
k$	Preferred Alternative	Base Case	Delay Work	Alternative 3	Alternative 4
Project Cost	40,877	N/A	N/A	N/A	N/A
NPV (after tax)					
Other (e.g., LUEC)					

Summary of Financial Model Key Assumptions (see Guidance on this Type 2 BCS Form):

As per OPG-STD-0076 an economic evaluation not required for sustaining projects.

Part D: Risk Assessment				
Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	There is a risk that cost will increase The current class 5 estimates are based on conceptual studies and preliminary estimates.	Accept Risk. When preliminary and detailed engineering are completed a more accurate cost estimate will be available.	Medium	Medium
Scope	Scope Defintion there is risk the scope of the project can change owing to discovery work.	Accept Risk. However project team to work with contractor to minimize the impact on schedule. Detailed field walkdowns are planned to identify such instances.	Medium	Medium
Schedule	There is a risk that the schedule will be impacted due to unknowns.	Mitigate - Walkdowns will be scheduled early in the scope definition phase to identify issues.	Low	Medium

[1] Estimate Class and Estimate at Completion are to be stated if known. Other supporting documentation such as a Summary of Estimate (SoE) may be attached. The SoE template can be found on the Finance BCS Toolkit website.

Type 2 Business Case Summary

Part D: Risk Assessment				
Resources	There is a risk that there will not be enough resources to support this project. During the exection phase, this project will be competeing with others for Technical Skills i.e. Electricians,I&C and station support.	For phase 1 this is not an issue however during detailed engineering and execution phases this project will be competeing with Rehab work and Bruce retube. The plan is to mitigate this risk by engaging the contractor early to ensure the skills are available.	Low	High
Quality/ Performance	Quality of Work and Equipment may not be acceptable to OPG	OPG Project Team to work with Equipment Suppliers and Contrctors to ensure OPG Standards are met.	Medium	Medium
Technical	Reliability Issues; New electronic equipment can fail early i.e.Bath Tub type failure' sensors, circuit boards.	All new equipment to be tested and test reports filed before shipping to site.	Medium	Medium
Labour	Jurisdictional Issues. The majority of this work involves Electrical Trades, depending on how this work is allocated can have an impact on project schedule.	Transfer this risk to the EPC contractor to resolve.	Low	Medium
Project Management	There is a risk that this project may prove to be complex to manage during the AFS/ close out phase; 7 systems across 5 Units.	During the planning phases the project team to work with Stakeholders DOM, DA and Station Personnel to devise a plan acceptable to all. An AFS strategy memo to be prepared.	Medium	Medium
Other	Material Cost. There is a risk material sourced outside Canada is subjected to foreign currency fluctuation.	Accept. This risk can be hindrance or an opportunity. High exchange rate will mean high material costs. Alternatively low exchange rates means lower material costs	Low	Medium

The risks listed in the table above are based on the "known unknowns" that may or may not materialize during the entire project. These risks are subjected to change as the project move from one phase to another.

Part E: Post Implementation Review (PIR) Plan				
Type of PIR		**Target Project In Service Date**		**Target PIR Completion Date**
Simplified		TBD		TBD
Measurable Parameter	**Current Baseline**	**Target Result**	**How will it be measured?**	**Who will measure it? (person/group)**
Number of Failures per year	Current yearly Failure rate for each system	Zero failures after installation	By recording the No: of failures over a specific period for each system	Performance Engineering working with Control Maintenance
Cost	Present Annual cost to maintain each system	Lower future maintenance cost on each system with new replacements	Dollars / Year	Control Maintenance / Performance Engineering.
Manufactures / Suppliers Support	No Support	Fully Supported	Replacement Component Delivery Time	Control Maintenance / Performance Engineering.

Type 2 Business Case Summary

Part F: Review/Approvals			
	Signature	**Comments**	**Date**
This BCS represents the best option to meet the validated business need in a cost effective manner.			
Recommended by: D. Muir Project Sponsor			13 Jan 2014
I concur with the business decision as documented in this BCS.			
Finance Approval: C. Carmichael VP Nuclear Finance			Jan 8/14
I confirm this project will address the business need, is of sufficient priority to proceed, and provides value for money.			
Approved by: S. Stock Director Station Engineering, per OAR 1.1			14 JAN 2014

OPG-FORM-0075-R003*

Type 2 Business Case Summary

Appendix A: Summary of Estimate (Numbers may not add up due to rounding.)										
Project Number:										
Title:	Facility & Project Title									
k$ or M$	LTD	2014	2015	2016	2017	2018	2019	Future	Total	%
OPG Project Management	-	210	86	108	77	210	181	260	1,132	2
OPG Engineering (including Design)	-	277	133	28	150	7	-	-	595	1
OPG Procured Materials	-	-	-	-	2,000	8,272	7,280	6,200	23,752	51
OPG Other	-	-	-	-	-	-	-	-	-	-
Design Contract(s)	[redacted]									
Construction Contract(s)										
EPC Contract(s)										
Consultants										
Other Contracts/Costs										
Interest										
Subtotal										
Contingency										
Total	-	575	575	1,620	7,575	12,901	11,958	11,671	46,875	100
Removal Costs Included										

Notes			
Project Start Date	2014-01-15	Definition Cost Included (includes contingency only if spent)	[redacted]
Final In-Service (or Final AFS) Date	TBD	Contingency Included in this Release	
Project Completion Date	TBD	Total-to-Date Contingency	
Escalation Rate	2%	Total-to-Date Released (excluding contingency)	
Interest Rate	5%	Total-to-Date Released (including contingency)	$1150 k
		Estimate at Completion (includes contingency only if spent)	[redacted]

Prepared by:	Approved by:
08 JAN 2014	08 Jan. 2014
B Graham	D Somerville
Section Manager	Manager
Darlington Projects	Darlington Projects

ONTARIO POWER GENERATION

Records File Information:
Records SCI/USI Retention
- See Guidance Section

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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 #:	16-31552	**Document #:**	D-BCS-71110-10002
Project Title:	DN-CCW and LPSW Travelling Screen Replacement		
Class:	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	**Investment Type:**	Sustaining
Phase:	Execution	**Release:**	Partial
Facility:	Darlington	**Target In-Service or Completion Date:**	30JUN2018

Project Overview

We recommend the partial release of $13,713K including [redacted] of contingency to replace 6 Condenser Cooling Water (CCW) and 6 Low Pressure Service Water Travelling Screens across the Darlington units. This will bring the total-to-date release for this project to $27,496K including [redacted] of contingency. The estimated total project cost is $37, 620K including [redacted] of contingency. This is a class 3 estimate based on actuals from the first installation of Unit 1 CCW screens.

Problem Statement/Business Need:

Significant degradation has been discovered on the underwater stationary components of Condenser Cooling Water (CCW) and Low Pressure Service Water (LPSW) Travelling Screens during inspections performed in recent years. Much of the degradation has been due to corrosion and excess pressure on the chain guides from the carriage chain rollers resulting in significant erosion of material. The degradation experienced is as expected as the Travelling Screen life expectancy is 25 years as per OEM. Although, periodic maintenance has been completed on all the moving components (e.g. chain, foot shaft, baskets), the stationary components, like the frame and the guides, have never been replaced and are approaching end of life.

Degradation of the Travelling Screens is recorded as operating Margin # 35 with respect to Design Basis and Operational Requirements. This low margin concern is on the official Margin Management List and will be removed after all Travelling Screens are replaced and commissioned under this project.

Objective / Summary of Preferred Alternative:

The scope of this project is to replace the CCW and LPSW Travelling Screens (32 screens in total) with an upgraded screen supplied by the Original Equipment Manufacturer (OEM). The new screen is the present day equivalent to the existing screen. It has the same design but with upgrades to materials of certain components to make them more resistant to wear and corrosion.

To date, the project has replaced two CCW screens on Unit 1 (1-71110-SC5/SC6) under the previous release and replacement of the next two screens (1-71110-SC3/SC4) is in progress. Replacement of the last two CCW screens on Unit 1 (1-71110-SC1/SC2) will be completed by Jun 30, 2015.

Due to the significant installation cost increase, the project no longer has sufficient funding to support the installation of Unit 3 LPSW screens as committed in the previous release. The remaining funding in the previous release has been committed for the procurement of all remaining screens and to complete the installation of Unit 1 CCW Travelling Screens only. Therefore, the replacement of Unit 3 LPSW Travelling Screens is being added to the scope of this partial release along with other ten screen replacements.

The remaining fourteen screens will be replaced under a subsequent future release.

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

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Type 3 Business Case Summary

Project #: 16-31552
Document #: D-BCS-71110-10002
Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

Project Overview

History of BCS releases and project cost estimates:

Previous Release:
The following scope was included in the previous release:

1- Procurement of all 32 Travelling Screens
2- Complete Detail Design for Unit 1 CCW Travelling Screens & Unit 3 LPSW Travelling Screens replacements
3- Replacement of all six CCW Travelling Screens on Unit 1
4- Replacement of two LPSW Travelling Screens on Unit 3

$13,783K (including [redacted] of contingency) was approved in the previous release, [redacted] of contingency was requested and released to complete the procurement of all Travelling Screens. To date, the project has spent $4,854K and the remaining funding is committed for the procurement of all remaining Travelling Screens and completion of Unit 1 CCW screen replacements.

This Partial Release:
An additional funding of $13,713K (including [redacted] of contingency) is being requested in this partial release to install the next set of twelve Travelling Screens (6 LPSW and 6 CCW).

Future Release:
Based on the current estimates a future funding of $10,124K (including [redacted] of contingency) will be required for the remaining fourteen screens (2 LPSW and 12 CCW) that will be replaced under the next full release.

Total Project Costs:
The total project cost is now estimated at $37,620K (including [redacted] of contingency) compared to $24,353K, plus [redacted] of contingency in the previous release. Variances, as shown below, are due to additional scope, discovery work, underestimation of the installation costs, OPG's resources and contractor's delay charges due to multiple gantry crane failures on the first installation. Actuals from the first installations have been used to estimate future installation costs of all units.

History of scope and schedule changes:
Project scope has been significantly increased since the previous BCS release, thereby increasing overall project costs. Variances are due to the followings:

Scope additions:
$225K ($95K spent + $130K future estimated) additional for the removal of lighting fixtures and abandoning cables in place.

Discovery Work:
$1,540K ($342K spent + $1,198K future estimated) additional for replacements of anchor bolts and 600 volts cables.

Underestimation
$11,248K ($1460K spent + $9,788K future estimated) additional for project management, construction, and material costs.

Contractor's estimated delay charges:
$3,580K ([redacted] spent + [redacted] future estimated) additional for delays due to gantry crane unavailability and extreme weather conditions.
Note: Future estimated delay charges ([redacted]) have been included in the total project contingency amount.

Key Assumptions and Risks:

- Station will inspect the gantry crane prior to each installation and repair as required.
- Equipment vendor will use lessons learned from the first installation to improve performance on future installations.

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Type 3 Business Case Summary

Project #: 16-31552
Document #: D-BCS-71110-10002
Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

Project Overview

Project Cash Flows, NPV, and OAR Approval Amount

k$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	2,675	4,601	2,400	2,350	1,757	0	0	0	13,783
Requested Now		5,622	5,466	2,445	180	0	0	0	13,713
Future Required		0	1,069	4,046	4,830	180	0		10,124
Total Project Cost	2,675	10,223	8,934	8,841	6,767	180	0	0	37,620
Ongoing Costs									
Grand Total	2,675	10,223	8,934	8,841	6,767	180	0	0	37,620

Estimate Class:	Class 3	Estimate at Completion:	[redacted]
NPV:	N/A	OAR Approval Amount:	$37,620

Additional Information on Project Cash Flows (optional):
Refer to Part D on page 3 of this BCS.

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): Glenn Jager, Chief Nuclear Officer			4 June 2015
I concur with the business decision as documented in this BCS.			
Finance Approval: Beth Summers, Chief Financial Officer			JUNE 19, 2015
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: Tom Mitchell, President & Chief Executive Officer per OAR 1.1			22 JUN 2015

Note

ONTARIO POWER GENERATION

Records File Information:
Records SCI/USI Retention
- See Guidance Section

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Type 3 Business Case Summary

Project #: 16-31552
Document #: D-BCS-71110-10002
Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

Business Case Summary

Part A: Business Need

Significant degradation has been discovered on the underwater stationary components of Condenser Cooling Water (CCW) and Low Pressure Service Water (LPSW) Travelling Screens during inspections performed in recent years. Much of the degradation has been due to corrosion and excess pressure on the chain guides from the carriage chain rollers resulting in significant erosion of material. In addition, the frame and bolt connections are badly corroded causing loosening of the screen frame. The degradation experienced is as expected as the travelling screen life expectancy is 25 years as per OEM. Although, periodic maintenance has been completed on all the moving components (e.g. chain, foot shaft, baskets), the stationary components, like the frame and the guides, have never been replaced and are approaching the end of life.

Degradation of the Travelling Screens is recorded as operating Margin # 35 with respect to Design Basis and Operational Requirements. This low margin concern is on the official Margin Management List and will be removed after all Travelling Screens are replaced and commissioned under this project.

The Travelling Screens are a major component in both CCW and LPSW systems as their function is to remove the debris from the lake water that is then used as the process fluid for the system. Failure of the screens to perform its function will have an adverse impact on the operation of the system and the unit as there would be insufficient flow.

For the CCW system, loss of one Travelling Screen would require shutdown of the corresponding CCW pump which would result in loss of generation (up to 40 MWe during summer months). In the event two Travelling Screens fail on the same unit, two CCW pumps would be shutdown leading to a subsequent shutdown of the unit. Since LPSW is a safety related system, failure of one of two LPSW Travelling Screens would result in a unit shutdown.

The objective of this project is to address the issue of degraded CCW and LPSW Travelling Screens that are reaching their end of life. The recommended alternative will ensure the Travelling Screens maintain their design function, improve equipment reliability and mitigate potential failures causing unit de-ratings and forced outages.

Part B: Preferred Alternative: Proactively Replace all CCW and LPSW Travelling Screens

Description of Preferred Alternative

The proposed scope of this alternative is to replace the CCW and LPSW Travelling Screens (32 screens in total) with an upgraded screen supplied by the OEM. The upgraded screen is the present day equivalent to the existing screen. It has the same design but with upgrades to materials of certain components to make them more resistant to wear and corrosion (e.g. changing basket frame material from metal to a high strength composite).

This alternative is being recommended for the following reasons:

- Upgraded screens would have components made of materials that are more durable and less susceptible to corrosion issues that have plagued the old screens. This will result in less routine maintenance required on these components (i.e. the screen baskets will not need to be replaced as frequently).
- OPEX has been obtained from other OPG sites (Pickering A and Lambton) that have used these upgraded screens and the feedback has been positive with no issues to report.
- Cost for the upgraded screen is not significant for better performance

To date, the project has replaced two CCW screens (1-71110-SC5/SC6) on Unit 1 under the previous release and the replacement of the remaining 4 screens (1-71110-SC1/2/3/4) is in progress with a target completion date of June 30th, 2015. Due to the significant installation and material cost increase, the project no longer has sufficient funding to support the installation of Unit 3 LPSW screens as committed in the previous release. The remaining funding under the previous release has been committed for the procurement of all remaining screens and to complete installation of Unit 1 CCW Travelling Screens only. Therefore, the replacement of Unit 3 LPSW Travelling Screens is being added to the scope of this partial release along with other ten screens replacements.

This partial release will include the replacement of the next 12 Travelling Screens. The remaining 14 Travelling Screens will be replaced under a subsequent Full Release.

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

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Type 3 Business Case Summary

Project #: 16-31552 Document #: D-BCS-71110-10002
Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

Part B: Preferred Alternative: Proactively Replace all CCW and LPSW Travelling Screens

Description of Preferred Alternative

Proposed schedule:

- Unit 3 - LPSW (2 screens) Fall 2015 (D1531)
- Unit 2 - CCW (6 screens) DEC2015 - MAR2016 (Online)
- Unit 4 - LPSW (2 screens) Spring 2016 (D1641)
- Unit 3 - CCW (6 screens) NOV2016 - MAR2017 (Online)
- Unit 1 - LPSW (2 screens) Spring 2017 (D1711)
- Unit 4 - CCW (6 screens) NOV2017 - MAR2018 (Online)
- Unit 2 - LPSW (2 screens) APR2018 (DNRU2)

Note:
As part of the preferred alternative we recommend that Unit 2 LPSW Travelling Screens replacement be completed in DNRU2 in order to complete the project by 2019. If Unit 2 LPSW Travelling Screens Replacement is not approved in the DNRU2 scope, the project schedule will be extended until 2022 during the next Unit 2 planned outage D2221. Project costs will also increase accordingly due to additional Project Management, Interest and Escalation fees. Specific contingency has been added to project cashflows if this risk is realized in future years.

Deliverables:	Associated Milestones (if any):	Target Date:
This Partial Release:		
Unit 3 LPSW Travelling Screen replacement (two screens)	AFS – Unit 3 LPSW Replacement	22DEC2015
2nd Unit CCW Travelling Screen replacement (six screens)	AFS – 2nd Unit CCW Replacement	30MAY2016
Unit 4 LPSW Travelling Screen replacement (two screens)	AFS – Unit 4 LPSW Replacement	07JUL2016
Unit 1 LPSW Travelling Screen replacement (two screens)	AFS – Unit 1 LPSW Replacement	07JUL2017
Prepare Full Release BCS	Full Release BCS approved	15SEP2016
Full Release:		
3rd Unit CCW Travelling Screen replacement (six screens)	AFS – 3rd Unit CCW Replacement	TBD
4th Unit CCW Travelling Screen replacement (six screens)	AFS – 4th Unit CCW Replacement	TBD
Unit 2 LPSW Travelling Screen replacement (two screens)	AFS – Unit 2 LPSW Replacement	TBD

Part C: Other Alternatives

Alternative 2: Base Case – No Project

Not recommended. This is not an alternative as the Travelling Screens are reaching end of life. Failure of the screens will result in forced outages.

Alternative 3: Delay Work – Delay all the replacements until Refurbishment outages

Not recommended. Delaying the replacements to the refurbishment outages could mean waiting another 5 to 8 years to replace a majority of the screens. Existing Travelling Screens are significantly degraded. Continued operation with the existing screens will put station at risk of forced de-ratings and unit outages should Travelling Screens fail to operate.

Alternative 4: Replacement of Travelling Screens with new design

Not recommended. Replacing the Travelling Screens with a new design would increase the total project costs significantly as the new design would need to be approved through the Engineering Change Control process. Modifications (Electrical, I&C, Mechanical and Civil) would also need to be made to the station to facilitate this new screen design. The additional cost for the screen would not be justified as the existing screen has met the station's expectation with no significant issues. Pursuing a different design would also introduce a number of risks and unknowns as it would be unproven if the new design would be any better than the existing design.

Alternative 5: N/A

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Type 3 Business Case Summary

Project #: 16-31552
Document #: D-BCS-71110-10002
Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

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

k$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	2,675	4,601	2,400	2,350	1,757	0	0	0	13,783
Requested Now		5,622	5,466	2,445	180	0	0	0	13,713
Future Required		0	1,069	4,046	4,830	180	0		10,124
Total Project Cost	**2,675**	**10,223**	**8,934**	**8,841**	**6,767**	**180**	**0**	**0**	**37,620**
Ongoing Costs	-								
Grand Total	**2,675**	**10,223**	**8,934**	**8,841**	**6,767**	**180**	**0**	**0**	**37,620**

Estimate Class:	Class 3	**Estimate at Completion:**	[redacted]
NPV:	N/A	**OAR Approval Amount:**	**$37,620**

Additional Information on Project Cash Flows (optional):

The cash flows in the above table include [redacted] of contingency to cover the completion of the project. For more details see the Summary of Estimate (SoE) attached.

Estimate at Completion includes base costs, plus spent contingency thus far.

Part E: Financial Evaluation

Choose an item.	Preferred Alternative	Base Case	Delay Work	Alternative 4	Alternative 5
Project Cost	N/A				
NPV					
Other (e.g., IRR)					

Summary of Financial Model Key Assumptions or Key Findings:

Financial Evaluation is not required as this is a sustaining type investment to replacement end of life.

Part F: Qualitative Factors

This alternative to replace the Travelling Screens with an upgraded screen of similar design from the OEM is being recommended for the following reasons:

- Upgraded screens would have components made of materials that are more durable and less susceptible to corrosion issues that have plagued the old screens. This will result in less routine maintenance required on these components.
- Cost for the upgraded screen is not significantly higher for a better performance.
- OPEX has been obtained from other OPG sites (Pickering A and Lambton) that have used these upgraded screens and the feedback has been positive with no issues to report.
- Station stakeholder preference is to utilize the OEM. OEM has had a good working relation with the Station staff and has provided support required when called upon.
- Upgraded screen is similar to the old screen therefore many spares in-stock can be salvaged for future maintenance.

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	There is a risk that station's gantry crane required to replace the screens may not be available due to component failure or extreme weather conditions. This could have a significant impact on contractor's delay charges.	• Inspection of the gantry crane prior to each installation and repair as required • Station will use the new synthetic oil in the gear box of the crane to prevent it from freezing during the winter months	Medium	Medium

Type 3 Business Case Summary

Project #: 16-31552 Document #: D-BCS-71110-10002
Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
		• Contingency has been included to address this risk.		
Scope	There is no scope risk identified for the project.	• Not applicable.		
Schedule	Failure of gantry crane and incorrect material deliveries will impact project schedule.	• Gantry crane will be inspected prior to start of each installation. • Feedback has been provided to the vendor on material discrepancies from the first installation • Early material inspection	Medium	Medium
Resources	There is no resource risk identified for the project.	• Not applicable.		
Technical	There is no technical risk identified for the project.	• Not applicable.		
Schedule	Project schedule will be extended until D2221 if Unit 2 LPSW Travelling Screen replacements are not accepted in DNRU2 Refurbishment scope for 2018.	• Request for scope addition will be presented to Refurbishment Scope Review Board. • Contingency has been included if the request is not approved and project schedule is extended until D2221.	Low	Medium

Additional Risk Analysis:

None

Part H: Post Implementation Review (PIR) Plan

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Simplified PIR	30JUN2018	30JUN2019

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
System Health Indicators • Equipment Degradation Indicator • Low Margin Concern • Aging Management	Current Indicators are Yellow.	Replacement will drive indicators to White	System Performance Monitoring following final screen replacement.	System Engineering

Part I: Definitions and Acronyms

1.1 AFS – Available for Service
1.2 CCW – Condenser Cooling Water
1.3 LPSW – Low Pressure Service Water
1.4 OEM – Original Equipment Manufacturer
1.5 OPEX – Operating Experience
SoE – Summary of Estimate

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Type 3 Business Case Summary

Project #: 16-31552 Document #: D-BCS-71110-10002

Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

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Type 3 Business Case Summary

Project #: 16-31552
Document #: D-BCS-71110-10002
Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

For Internal Project Cost Control

Internal Use Only
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Type 3 Business Case Summary

Document #: D-BCS-71110-10002

Project #: 16-31552
Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

Appendix A: Summary of Estimate										
Project Number:	16-31552									
Project Title:	DN-CCW and LPSW Travelling Screen Replacement									
k$	**LTD**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Future**	**Total**	**%**
OPG Project Management	651	876	732	647	452	80			3,438	10
OPG Engineering	57	50	43	51	45	0			246	1
OPG Procured Materials	625	2,437	2,440	2,440	1,830	0			9,772	28
Construction Contract(s)	[redacted]									
Interest										
Subtotal										
Contingency										
Total	**2,675**	**10,223**	**8,934**	**8,841**	**6,767**	**180**	**0**	**0**	**37,620**	
Removal Costs	100	400	400	400	300		0	0	1,600	

Notes			
Project Start Date	JUN 2013	**Total Definition cost** (excludes unspent contingency for Nuclear)	[redacted]
Target In-Service (or AFS) Date	JUN 2018	**Contingency included in this BCS** (Nuclear only)	
Target Completion Date	JUN 2019	**Total contingency released plus contingency in this BCS** (Nuclear only)	
Escalation Rate	3.0%	**Total released plus this BCS without contingency** (Nuclear only)	
Interest Rate	5%	**Total released plus this BCS with contingency** (Nuclear only)	$27,496K
Removal Costs	$300K	**Estimate at Completion** (includes only spent contingency for Nuclear)	[redacted]

Prepared by:	**Approved by:**
22 May 2015 Date	22 May, 2015 Date
Brian Graham Project Manager	Name: Ray Balachorek Title: Manager, Design Projects

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Type 3 Business Case Summary

Project #: 16-31552
Document #: D-BCS-71110-10002
Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

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
			2013	2014	2015	2016	2017	2018		
Execution	Partial 1	May 2013	286	4,051	5,194	5,736	4,476	2,816	1,794	**24,353**
Execution	Partial 2	July 2015	100	2,575	10,223	8,934	8,841	6,767	180	**37,620**

Project Variance Analysis

k$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management	651	1,134	3,438	2,304	To date, Project has spent $835K on Project Management costs. These include Project Leader, Field Engineering, Contract Management Office, and Project Controls. Based on this actual, Project Management costs have been re-estimated for future years and an additional $2,603K will be required to complete the project.
OPG Engineering	57	307	246	-61	To date, the Project has spent $77K on preparation of Engineering Change packages for Unit 1 CCW and Unit 3 LPSW screens. There are no significant changes expected for the EC packages of remaining screens and $169K will be required to complete the remaining Engineering scope of work.
OPG Procured Materials	625	8,800	9,772	972	Travelling screens were previously estimated at $275K per screen, however, actual costs are $30K higher for each screen.
Construction Contract(s)	[redacted]				

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Type 3 Business Case Summary

Project #: 16-31552
Document #: D-BCS-71110-10002
Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

Project Variance Analysis					
k$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
					[redacted]
Interest	[redacted]				
Subtotal					
Contingency					
Total	2,675	24,353	37,620	13,267	

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Type 3 Business Case Summary

Project #: 16-31552 Document #: D-BCS-71110-10002

Project Title: DN-CCW and LPSW Travelling Screen Replacement, <Partial> <Execution> Release

Appendix C: Financial Evaluation Assumptions
Key assumptions used in the financial model of the Project are (complete relevant assumptions only):

Project Cost:
N/A

Financial:

The costs associated with this project should be capitalized in accordance with FIN-STD-006. FIN-STD-0006 defines the replacement of existing asset as a capital expenditure when an asset has reached end of useful life and requires replacement to extend its service. In the case of the LPSW screens, the life expectancy of the screens is 25 years based on the asset code. As the LPSW screens are reaching end of life, completing the replacement would be consistent with the FIN-STD-0006 definition of a capital expenditure.

In the case of the CCW screens, the life expectancy of the asset is 55 years as per the asset code. As the CCW screens are not expected to last 55 years, this would not be considered a capital expenditure. However, there is an exception within FIN-STD-0006, Appendix A that indicates- for equipment that was installed prior to April 1, 1999, the financial value of this equipment was written down to nominal values by OPG. By doing so, the equipment would be considered retired and would longer hold any future value. Replacement of retired equipment (i.e. CCW screens in this case) would be a new asset with the associated costs considered a capital expenditure.

The removal of lights and the cable abandonment cannot be capitalized and will be written off.

Project Life:
N/A

Energy Production:
N/A

Operating Cost:
N/A

Other:
N/A

List further detail below as appropriate from the Financial Evaluation:
N/A

Appendix D: References
Project Charter: D-PCH-71110-10001
Project Management Plan: NK38-PLAN-71110-0458532
Partial BCS: D-BCS-71110-10001

Type 3 Business Case Summary

Final Security Classification of the BCS: **OPG Confidential**

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

Executive Summary and Recommendations

Project Information			
Project #:	16-31710	**Document #:**	D-BCS-39780-10003
Title:	Darlington Shutdown Cooling Heat Exchanger Replacement		
Class:	Capital	**Investment Type:**	Sustaining
Phase:	Definition and Execution	**Release:**	Partial
Facility:	Darlington	**Target In-Service or Completion Date:**	2019-05-16 (Project Completion)

Project Overview

We recommend the release of $37,392 k, including [redacted] of contingency.
The estimated total project cost is $56,085 k, including [redacted] k of contingency.

Total-to-date released is $38,829 k, including [redacted] of contingency.

The quality of the estimate for this release is Class 3, and for the total project is Class 3.
This release will fund the following scope of work:

- Award Phase 2 of an engineer-procure-construct (EPC) contract to the successful vendor for the following scope:
  - Procurement of all eight (8) shutdown cooling heat exchangers (SDC HX's). Two (2) per reactor unit and for installation in Phase 2 (Unit 2, Unit 1) and Phase 3 (Unit 3, Unit 4).
  - Complete detailed engineering for Unit 1, Unit 2, Unit 3 and Unit 4.
  - Complete execution (installation planning, installation, commissioning, & engineering change control (ECC) close-out) for the Unit 2 and Unit 1 set of SDC HX replacements.
- Provide updated schedule for Phase 3 execution in Unit 3 and Unit 4.
- Update Project Management Plan (PMP), and prepare Full Execution Release Business Case Summary (BCS).

Problem Statement/Business Need:
The baffle supports in all SDC HX's are deteriorated due to microbiologically induced corrosion (MIC). Consequently, the SDC HX tubing is susceptible to damage arising from flow induced vibrations, tube fretting and circumferential cracking. To date, no tubes have leaked; however, as baffle plate corrosion continues, the risk of a tube leak will increase. A tube leak would result in significantly increased emissions of tritium to the lake, which would be a violation of the environmental and radiation protection requirements of the station Power Reactor Operating License.

Ultrasonic testing (UT) of the SDC HX shells indicate that the shell wall thickness is reduced in locations due to pitting caused by MIC. Based on the currently estimated corrosion rates for the SDC HX's with the greatest amount of corrosion, the minimum allowable shell wall thickness could be reached at isolated pit locations within 3.5 years (from the time of inspection in 2012), resulting in the operation of the Shutdown Cooling system outside of the design basis.

In order to prevent the onset of additional corrosion pits in the shell and baffle supports, the operating procedure has been revised to enable continuous service water flushing of the SDC HX's during the chlorination season. This improvement will mitigate the onset of MIC in new locations due to stagnant water conditions; however, it will not stop or slow down the corrosion of the SDC HX's at existing pit locations. Eddy Current inspections are planned for some of the SDC HX's in 2014 and 2015 to identify any tubes that have degraded due to pitting or fretting. Degraded tubes will be plugged to prevent tube leaks, and additional inspections on other SDC HX's may be performed based on the extent of degradation found. These actions will help to mitigate the risk of a shell or tube side leak; however, they will not eliminate the risk.

A tube or shell side leak would require the SDC HX to be taken out of service, isolated, and repaired, which would be a loss in redundancy of the Shutdown Cooling system and a reduction in system reliability. A tube side leak could also cause a forced shutdown of a reactor unit, resulting in a loss of production and increasing the Unit Forced Loss Rate. Furthermore, for any planned outage, the unavailability of a SDC HX would increase the time for Primary Heat Transport (PHT) system cool down, thereby extending outage duration and further increasing the forced loss rate.

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

Key Business Objectives:

The Darlington Shutdown Cooling System is a Safety Related system normally used to cool the Primary Heat Transport system during normal reactor shutdowns, as well as cooling the Primary Heat Transport system under certain emergency operating conditions, and long term following a postulated Loss of Coolant Accident. Accordingly, the system is required to have high availability under all operating conditions.

The SDC HX's have a service life of 30 years, consequently, replacement of the existing Darlington SDC HX's is required to ensure the continued and reliable operation of the Shutdown Cooling system until the end of station design life (approximately 2055), and thus, support the continued and safe operation of the Darlington reactor units in compliance with the licensing and design basis.

Replacement of the SDC HX's is also a regulatory requirement for completion before the end of the Darlington Life Extension Window, as identified in the Darlington Integrated Implementation Plan [R-5].

Summary of Preferred Alternative:

In order to address the ongoing corrosion of the Shutdown Cooling Heat Exchangers and the impending end of service life, a complete replacement of all eight (8) SDC HX's is recommended. Replacement of the SDC HX's will be performed as soon as possible (dependant on the long lead delivery time of the SDC HX's). The new SDC HX's will be dimensionally compatible with the existing heat exchangers, and nearly identical from a thermal and hydraulic performance point of view. There will be no change to the tubing (I-800) or shell material (SA516 GR70), and the material chosen for the internal components (segmental baffle plates, tie rods, etc.) will be changed from carbon steel to a material more resistant to MIC. The new SDC HX's will have an increased service life of 40 years, thereby ensuring their availability until the end of station life following refurbishment, approximately 2055.

A phased approach to funding approvals will be used for implementing the preferred alternative and managing the risk. Multiple funding releases will be utilized as follows:

Phase 1: Previous Release - Partial Definition BCS Release

- Completion of Modification Outline and Modification Design Requirements by OPG.
- Award Phase 1 of an EPC contract to successful vendor for the following scope:
  - Complete preliminary engineering, & prepare design specification for replacement SDC HX's.
  - Provide firm pricing and fabrication/delivery schedule for SDC HX's (excluding purchasing of material).
  - Provide performance fee pricing and schedule for Phase 2 & 3 design and construction activities.
- Update PMP and prepare Partial Definition & Execution Release BCS.

Phase 2: This Release - Partial Definition & Execution BCS Release

- Award Phase 2 of an EPC Contract to successful vendor for the following scope:
  - Procurement of all eight (8) SDC HX's. Two (2) per reactor unit and for installation in Phase 2 (Unit 2, Unit 1) and Phase 3 (Unit 3, Unit 4).
  - Complete detailed engineering for Unit 1, Unit 2, Unit 3 and Unit 4.
  - Complete execution (installation planning, installation, commissioning, & ECC close-out) for the Unit 2 and Unit 1 set of SDC HX replacements.
- Provide updated schedule for Phase 3 Execution in Unit 3 and Unit 4.
- Update PMP and prepare Full Execution Release BCS.

Phase 3: Future Release - Full Execution BCS Release

- Award Phase 3 of an EPC contract to successful vendor to complete execution (installation planning, installation & commissioning, and ECC close-out) for Unit 3 and Unit 4.
- Complete Project Close-out.

History of BCS releases and project cost estimates:

The total project cost is now estimated at $ 56,085 k (including [redacted] of contingency), compared to $47,529 k (including [redacted] of contingency) in the previous release. Key variances are:

- Estimated OPG resource costs have increased from approximately $3.4M to $10.6M. The variance is a result of increased resource requirements to support a longer HX replacement duration. The previous HX replacement duration was based on a 2 week installation period working 24/7, and a 6 week installation period working 40hrs/week. The new project cost

estimate is based on a 30 day installation period working 24/7 for removal/installation activities and 6 weeks working 40hrs/week for pre and post-requisite activities. The installation schedule durations will be challenged during the installation planning phase, and the final schedule will be presented to the stakeholders prior to making the final schedule commitment.

- Estimated ES MSA vendor costs have increased from approximately $29M to $36.2M. The previous project cost estimate was based on a third party estimate for design and construction services and a budgetary quotation for major material. The new project cost estimate is based on performance fee pricing for design and construction services and a firm fixed price for major material (SDC HX's).
- Estimated Interest costs have decreased from approximately $3M to $0.9M. The previous project cost estimate showed the cost of the HX's being charged to the project once fabrication commenced, and as a result, interest charges were incurred from the start of HX fabrication to the completion of the HX in-service declaration (not consistent with OPG accounting policies). The new project cost estimate only realizes the cost of capital when the HX's are delivered on-site (just-in-time delivery), and therefore interest is charged over a much shorter period of time, thereby, reducing the interest expense.

History of scope and schedule changes:

There have been no scope or schedule changes since the previous BCS.

Key Assumptions and Risks:

The isolation valves on the service water (shell) side of the SDC HX's are in a degraded condition and require replacement or overhaul in all four reactor units. If the valves are not replaced / overhauled prior to the start of the SDC HX replacements, then there is a risk that the HX's cannot be fully isolated. Alternate means of isolation are being evaluated; however, there is no definite solution at this time. If isolation cannot be obtained, the HX's replacement activities will need to be deferred to the Darlington Refurbishment window or beyond.

Refer to Part G: Risk Assessment for further details.

Project Cash Flows, NPV, and OAR Approval Amount

k$	LTD	2014	2015	2016	2017	2018	2019	Future	Total
Currently Released	516	921	0	0	0	0	0	0	1,437
Requested Now	-	1,348	6,255	17,645	7,145	5,000	0	0	37,392
Future Required	-	0	0	84	7,460	8,502	1,210	0	17,256
Total Project Cost	516	2,268	6,255	17,728	14,605	13,502	1,210	0	56,085
Ongoing Costs	-	0	0	0	0	0	0	0	0
Grand Total	516	2,268	6,255	17,728	14,605	13,502	1,210	0	56,085

Estimate Class:	Class 3	**Estimate at Completion:**	[redacted]
NPV:	$(37,566) k	**OAR Approval Amount:**	$37,392 k

Additional Information on Project Cash Flows:

The summation of yearly cash flows may not add up to the 'Total' values due to rounding.

OPG-FORM-0076-R004

Type 3 Business Case Summary

Project #: 16-31710

Document #: D-BCS-39780-10003

Title: Darlington Shutdown Cooling Heat Exchanger Replacement

Approvals			
Project #:	16-31710	**Document #:**	D-BCS-39780-10003
Title:	Darlington Shutdown Cooling Heat Exchanger Replacement		
Phase:	Definition and Execution	**Release:**	Partial

	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: Glenn Jager Chief Nuclear Officer Project Sponsor			5 MAR 2014
I concur with the business decision as documented in this BCS.			
Finance Approval: Robin Heard Interim Chief Financial Officer			24 MAR 2014
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: Tom Mitchell President & CEO, per OAR 1.1			2 April 2014

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

Business Case Summary

Part A: Business Need

The Shutdown Cooling System is required to remain operational and available through the design life of the station, with no impact on Darlington reliability and safety targets due to equipment failures and/or tritium leaks to the environment.

The baffle supports in all HX's have deteriorated due to MIC. Consequently, the SDC HX tubing is susceptible to damage arising from flow induced vibrations, tube fretting and circumferential cracking. To date, no tubes have leaked; however, as baffle plate corrosion continues, the risk of a tube leak will increase. A tube leak would result in significantly increased emissions of tritium to the lake, which would be a violation of the environmental and radiation protection requirements of the station Power Reactor Operating License.

Ultrasonic testing (UT) of the SDC HX shells indicate that the shell wall thickness is reduced in locations due to pitting caused by MIC. Based on the currently estimated corrosion rates for the SDC HX's with the greatest amount of corrosion, the minimum allowable shell wall thickness could be reached at isolated pit locations within 3.5 years (from the time of inspection in 2012), resulting in the operation of the Shutdown Cooling system outside of the design basis.

In order to prevent the onset of additional corrosion pits in the shell and baffle supports, the operating procedure has been revised to enable continuous service water flushing of the SDC HX's during the chlorination season. This improvement will mitigate the onset of MIC in new locations due to stagnant water conditions; however, it will not stop or slow down the corrosion of the SDC HX's at existing pit locations. Eddy Current inspections are planned for some of the SDC HX's in 2014 and 2015 to identify any tubes that have degraded due to pitting or fretting. Degraded tubes will be plugged to prevent tube leaks, and additional inspections on other SDC HX's may be performed based on the extent of degradation found. These actions will help to mitigate the risk of a shell or tube side leak; however, they will not eliminate the risk.

The onset of a tube or shell side leak would require the HX to be taken out of service, isolated, and repaired, which would be a loss in redundancy of the Shutdown Cooling system and a reduction in system reliability. A tube side leak could also cause a forced shutdown of a reactor unit, resulting in a loss of production and increasing the Unit Forced Loss Rate. Furthermore, for any planned outage, the unavailability of a SDC HX would increase the time for PHT SYSTEM cool down, thereby extending outage duration and further increasing the forced loss rate.

The SDC HX's have a service life of 30 years, consequently, replacement of the existing Darlington SDC HX's is required to ensure the continued and reliable operation of the Shutdown Cooling system until the end of station design life (approximately 2055), and thus, support the continued and safe operation of the Darlington reactor units in compliance with the licensing and design basis.

Replacement of the SDC HX's is also a regulatory requirement for completion before the end of the Darlington Life Extension Window, as identified in the Darlington Integrated Implementation Plan [R-5].

Part B: Preferred Alternative: Full Replacement of the Shutdown Cooling Heat Exchangers Prior to Refurbishment

Description of Preferred Alternative

In order to address the ongoing corrosion of the Shutdown Cooling Heat Exchangers and the impending end of service life, a complete replacement of all eight (8) SDC HX's is recommended. The new SDC HX's will be dimensionally compatible with the existing heat exchangers, and nearly identical from a thermal and hydraulic performance point of view. There will be no change to the tubing (I-800) or shell material (SA516 GR70), and the material chosen for the internal components (segmental baffle plates, tie rods, etc.) will be changed from carbon steel to a material more resistant to MIC. The new SDC HX's will have an increased service life of 40 years, thereby ensuring their availability until the end of station life following refurbishment.

Replacement of the SDC HX's will be performed as soon as possible (dependant on the long lead delivery time of the SDC HX's) and in accordance with the integrated on-line work process. In alignment with the requirements of the Project Charter, the SDC HX's will be fully replaced and placed back in service prior to the corresponding reactor unit refurbishment outages. The existing SDC HX's will be prepared for disposal as radioactive material. Disposal will be performed by Nuclear Waste Management Division (NWMD).

A phased approach to funding approvals will be used for implementing the preferred alternative and managing the risk. Multiple funding releases will be utilized as follows:

Phase 1: Previous Release - Partial Definition BCS Release

- Completion of Modification Outline and Modification Design Requirements by OPG.
- Award Phase 1 of an EPC contract to successful vendor for the following scope:
  - Complete preliminary engineering, & prepare design specification for replacement SDC HX's.
  - Provide firm pricing and fabrication/delivery schedule for SDC HX's (excluding purchasing of material).
  - Provide performance fee pricing and schedule for Phase 2 & 3 design and construction activities.
- Update PMP and prepare Partial Definition & Execution Release BCS.

Phase 2: This Release - Partial Definition & Execution BCS Release

- Award Phase 2 of an EPC Contract to successful vendor for the following scope:
  - Procurement of all eight (8) SDC HX's. Two (2) per reactor unit and for installation in Phase 2 (Unit 2, Unit 1) and Phase 3 (Unit 3, Unit 4).
  - Complete detailed engineering for Unit 1, Unit 2, Unit 3 and Unit 4.
  - Complete execution (installation planning, installation, commissioning, & ECC close-out) for the Unit 2 and Unit 1 set of SDC HX replacements.
- Provide updated schedule for Phase 3 Execution in Unit 3 and Unit 4.
- Update PMP and prepare Full Execution Release BCS. The BCS will be prepared following the completion of Unit 1 Installation activities. This will enable the actual costs and schedule durations from Unit 2 Installation to be used as the basis for the Full Execution BCS. The BCS preparation and approval will take place in parallel with the Unit 1 Installation work. This strategy should enable BCS approval to line up with the completion of Unit 1 Installation work, and allow for Phase 3 activities to start without any stoppage in work while the Project waits funding. This strategy will minimize the overall project installation timeline and improve retention of vendor resources between Phase 2 and 3.

Phase 3: Future Release - Full Execution BCS Release

- Award Phase 3 of an EPC contract to successful vendor to complete execution (installation planning, installation & commissioning, and ECC close-out) for Unit 3 and Unit 4.
- Complete Project Close-out.

Deliverables:	Associated Milestones (if any):	Target Date:
Phase 2 - This Release • EPC Contract Awarded for Phase 2 of Project • Design Documents Approved & Issued for Unit 2 • Design Documents Approved & Issued for Unit 1 • Design Documents Approved & Issued for Unit 3 • Design Documents Approved & Issued for Unit 4 • Delivery of eight (8) SDC HX's for all four (4) units. • Unit 2 Installation • Unit 1 Installation • Full Execution Business Case Summary	***Phase 2 - This Release*** 1. Design Contract Awarded 2. Design Complete – Unit 2 3. Design Complete – Unit 1 4. Design Complete – Unit 3 5. Design Complete – Unit 4 6. Available for Service Completed - U2HX1 7. Available for Service Completed - U2HX2 8. Available for Service Completed - U1HX1 9. Available for Service Completed - U1HX2 10. BCS Approved	***Phase 2 – This Rls.*** 1. 2014-May-09 2. 2015-Jan-19 3. 2015-Mar-17 4. 2015-May-14 5. 2015-Jul-13 6. 2016-Mar-03 7. 2016-Jun-29 8. 2016-Oct-26 9. 2017-Feb-22 10. 2016-Dec-08
Phase 3 - Future Release • EPC Contract Awarded for Phase 3 of Project • Unit 3 Installation • Unit 4 Installation • Project Complete Milestone	***Phase 3 - Future Release*** 1. Installation Contract Awarded 2. Available for Service Completed - U3HX1 3. Available for Service Completed - U3HX2 4. Available for Service Completed - U4HX1 5. Available for Service Completed - U4HX2 6. Plan Complete (PCM)	***Phase 3– Fut. Rls.*** 1. 2017-Jan-10 2. 2017-Sep-22 3. 2018-Jan-19 4. 2018-May-17 5. 2018-Sep-13 6. 2019-May-16

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

Part C: Other Alternatives

Summarize all reasonable alternatives considered, including pros and cons, and associated risks. Other alternatives may include different means to meet the same business need, and a reduced or increased scope of work, etc.

Base Case: Status Quo – No Project

The option of Status Quo (Do Nothing) is not recommended. Choosing not to pursue a Shutdown Cooling Heat Exchanger replacement, and instead implementing repairs as required, does not represent a permanent solution to corrosion of the shell and internal components, and carries significant Nuclear Safety and Environment Risk.

As the SDC HX's continue to degrade, the likelihood of SDC HX failures due to shell or tube side leaks will increase. A single or simultaneous failure of multiple SDC HX's on one or several reactor units could result in significant tritium emissions to the environment, a reduction in redundancy of the SDC system, and could significantly impair the ability of the SDC system to perform its credited safety function.

Following repair of any HX failure, it cannot be guaranteed that future SDC HX failures will not occur with the same results as identified above. When the number of tubes plugged is more than available margin (60 U-Tubes), the efficiency of the HX will be affected, resulting in increased duration to cool PHT D2O down, hence delaying any planned outage.

This alternative was considered and eliminated, therefore, not included in the financial evaluation.

Alternative 2: Delay Work – Delay Work – Replacement of SDC HX's during Darlington Refurbishment

The option of delaying the work until Darlington Refurbishment is not recommended.

In order to replace the SDC HX's with the reactor unit online, one SDC HX would be unavailable, while the second SDC HX would be available for use. During replacement of each HX, the SDC system would have a complete loss of redundancy, which could potentially impair the ability of the SDC system to perform its credited safety function. Therefore, the SDC HX's could be scheduled for replacement during Darlington Refurbishment, thereby preventing any loss of redundancy in the SDC system during replacement activities.

Replacement could be scheduled during the reactor unit refurbishment outages (U2 in 2016, U1 in 2018, U3 in 2020 and U4 in 2021). However, this would result in a significant period of time (2 to 7 years) before SDC HX replacements activities are started. Based on the degraded condition and the estimated rate of corrosion of the SDC HX's, there is significant risk of a heat exchanger failure occurring during this timeframe. The project was initially scheduled for Darlington Refurbishment; however, based on the urgency to replace the SDC HX's as soon as possible, the project was re-scheduled to take place prior to the start of Darlington Refurbishment.

This alternative was considered and eliminated, therefore, not included in the financial evaluation.

Alternative 3: N/A

Alternative 4: N/A

OPG-FORM-0076-R004

Type 3 Business Case Summary

Project #: 16-31710

Document #: D-BCS-39780-10003

Title: Darlington Shutdown Cooling Heat Exchanger Replacement

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

k$	LTD	2014	2015	2016	2017	2018	2019	Future	Total
Currently Released	516	921	0	0	0	0	0	0	1,437
Requested Now	-	1,348	6,255	17,645	7,145	5,000	0	0	37,392
Future Required	-	0	0	84	7,460	8,502	1,210	0	17,256
Total Project Cost	516	2,268	6,255	17,728	14,605	13,502	1,210	0	56,085
Ongoing Costs	-	0	0	0	0	0	0	0	0
Grand Total	516	2,268	6,255	17,728	14,605	13,502	1,210	0	56,085

Estimate Class:	Class 3	**Estimate at Completion:**	[redacted]
NPV:	$(37,566) k	**OAR Approval Amount:**	$37,392 k

Additional Information on Project Cash Flows (optional):

The summation of yearly cash flows may not add up to the 'Total' values due to rounding.

Part E: Financial Evaluation

k$	Preferred Alternative	Base Case	Delay Work	Alternative 3	Alternative 4
Project Cost	56,085	N/A	N/A	N/A	N/A
NPV	(37,566)	N/A	N/A	N/A	N/A
Other (e.g., IRR)	N/A	N/A	N/A	N/A	N/A

Summary of Financial Model Key Assumptions or Key Findings:

1. Discount rate (WACC) of 7 %
2. Annual Interest rate of 5% on Capital costs.
3. The NPV amount is based on a 2014$ Present Value. LTD (2013) was treated as sunk cost in NPV calculation.

Part F: Qualitative Factors

The modification supports Darlington's "Zero Emissions" cornerstone initiative. Interest in nuclear power plant tritium emissions in other countries is expected to generate increased public and regulatory scrutiny going forward. A significant tritium emission to the lake as a result of a tube leak would have a detrimental impact on public support for nuclear power in the community.

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Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	There is a risk that the quality of the vendor's estimate for design and construction services is too low.	Mitigate: Project to provide oversight and escalate to management early any potential increases in price. EPC vendor to perform operational experience (OPEX) reviews and detailed walk downs during Phase 1 and Phase 2 prior to the start of installation in order to eliminate as much discovery work as possible.	Medium	Medium
Cost	There is a risk that the existing heat exchangers cannot be dried sufficiently within the planned duration. Additional time would be required to dry the HX's before they can be removed from containment. This would delay the installation schedule, and impact nuclear safety as it would increase the unavailability of the SDC System.	Accept: Assign [redacted] specific contingency based on a budgetary estimate for the design and fabrication of a custom designed vacuum drying system (similar in design to what is being procured for Refurbishment for drying the PHT System, Moderator System, etc) or similar equipment. This contingency will be requested during detailed design if it is determined that there is no other option for drying (based on OPEX reviews of existing options) the HX's within the timeframe for acceptable SDC HX unavailability.	Medium	Low
Cost	There is a risk that the SDC HX Procurement Cost increases as a result of currency exchange rate fluctuations and tubing material pricing in the material market.	Accept: EPC Vendor will secure an advance purchase order (PO) with the HX manufacturer to mitigate any pricing increases due to material/currency price fluctuations. In addition, the project will carry specific contingency equivalent to [redacted] of the overall procurement cost.	Low	Medium
Cost	There is a risk that the ES MSA vendor performance is excellent, and as such they are awarded an additional [redacted] of the contract value in profit.	Accept: The project will carry specific contingency equivalent to [redacted] of the contract value.	Low	Low
Schedule	There is a risk that degraded Powerhouse Upper Level Service Water (PULSW) system isolation valves are not replaced prior to SDC HX replacements. The PULSW system isolation valves for HX1 (PV11, PV57) and HX2 (PV12, PV60) are in a degraded condition and require overhaul / replacement prior to the SDC HX Replacement. If the valves are not replaced during a PULSW outage prior to SDC HX replacement, then the project will likely not be able to isolate the HX's, and therefore the Project execution will have to be deferred until the Isolation valves can be replaced. The use of ice plugs as an alternate means of isolation may also not be possible due to several limitations (will require the procurement of pipe freezing jackets for 16" diameter piping,	Mitigate: 1. Identify the issue to station management and requested PULSW outages are added to every Unit Outage prior to SDC HX Replacement, to allow for PULSW isolation valve replacement. 2. Requested EPC Vendor to evaluate alternate contingency means of isolation on the service water side and to provide an Isolation Strategy Report. The Project will then obtain approval from the station to have the EPC vendor design, fabricate, and install any approved alternate means of isolation. 3. The project will carry a specific contingency of [redacted] to enable the ES MSA Vendor to provide an alternate means of isolation in Unit 1 and Unit 2.	High	High

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	a continuous supply of LN2 for the installation duration (30 days), a new feeder freezing penetration on the south side of the reactor (to enable ice plugging on PV11 pipe work inside containment) and minimal fluid flow in the pipe work (difficult with passing isolation).			
Schedule	There is a risk that the vendor identifies discovery work during installation, commissioning, and waste preparation activities. The cost of the EPC contract may increases due to the identification of work that is outside the scope of work.	Accept: 1. Discovery issues/items to be resolved via Change Management Process as necessary. 2. The project will carry specific contingency to cover the estimated cost of this risk.	Medium	High
Schedule	There is a risk that the installation timeline conflicts with other work being done inside the station. Work of higher priority may be in execution inside the station that will interfere with the project, be it conflict in resource allocation, use of space, or use of equipment. A key concern is with Refurbishment related activities, which may be scheduled to take place in parallel with this project.	Mitigate: 1. The installation timelines will be added to the station Cycle Plan as major on-line work in order to give it increased focus in view of other station and project work. The project team will attend Cycle Plan meetings as required. 2. The project team will initiate discussions with the refurbishment organization to evaluate any potential conflicts during the planned installation windows. 3. Sponsor organization will be notified of any major conflicts and support from Senior Management will be requested to maintain priority on SDC HX replacement. 4. Ensure the work is scheduled in accordance with MA-022 to ensure work stays on the station work plan.	Medium	Medium
Schedule	There is a risk that PULSW piping condition is unacceptable for welding to the new SDC HX nozzles. The PULSW piping at the HX tie-in points (shell side supply and discharge nozzles) is in a degraded condition due to microbiologically induced corrosion (MIC), and is approaching the minimum allowable wall thickness at certain pit locations. There is a risk that the piping is in such a degraded state, that it is unsuitable for welding to the nozzles on the new SDC HX's.	Accept: 1. WO's were initiated and executed to have PULSW piping at the tie-in point inspected by IMS using UT to determine the extent of pitting and wall loss. Results indicate the average wall thickness is still above the minimum allowable wall thickness. 2. EPC Vendor was engaged to review the UT results and comment on the piping acceptability for welding. Vendor confirmed that piping condition is acceptable for welding and that weld build-up could be used if required to address pitting at tie-in location. 3. SDC HX / MIC Component Engineer was requested to have PULSW piping replaced by the Station prior to SDC HX Replacement.	Low	Medium

Schedule	There is a risk that the assumed radioactive waste characterization of the SDC HX's (used to determine design requirements for shipping container) is incorrect. If a shipping container is designed and fabricated based on the incorrect characterization, then a new container will need to be designed and fabricated, which will significantly delay the removal of the old HX's from the Darlington site.	Mitigate: An external vendor has developed a waste strategy Report, in which all the different options for HX characterization and shipment have been evaluated. Based on the evaluation performed, it is believed that the HX's will be characterized as Surface Contaminated Objects Level II (SCO-II) or as a Low Specific Activity (LSA) object. Based on this characterization, a specific type of shipping container is required (Type IP-2 package) and will be designed and fabricated in advance. Based on OPEX, and available radiological data, it is unlikely that the waste characterization following HX removal will differ from the assumed characterization.	Low	Medium
Schedule	There is a risk that late delivery of long lead material (SDC HX's), will delay the start of installation. This risk is highest for the first HX, as the start of installation is very close to the completion of fabrication. For the remaining three HX's installed under this release, there is low risk of late delivery.	Mitigate: 1. EPC Vendor to ensure material is ordered well in advance to support installation timeline. OPG has recommended the EPC Vendor to award an advance PO with the HX manufacturer to reserve fabrication windows with tubing supplier. 2. EPC Vendor oversight of the HX Manufacturer to make sure the committed delivery dates are met. 3. Advance the award of the OPG Phase 2 PO for detailed design by 3 months, to minimize risk of late HX delivery due to fabrication delays.	Low	Medium
Schedule	There is a risk that the HX and/or other equipment/material is damaged due to improper storage by vendor, poor handling during shipment/installation, or exposure to harsh environmental conditions.	Transfer: 1. Transfer the financial impact for repairs/replacements to the vendor (per terms and conditions of the master services agreement); however, OPG would incur the financial impact due to any schedule delays, outage extension or force outage resulting from the damaged equipment. 2. The EPC vendor will prepare a procurement plan and material management plan that will identify the storage and warehousing of the SDC HX's. OPG will review and accept the plans, in order to ensure OPG's expectations for storage and shipment are met. 3. Prior to OPG acceptance (AFS) all equipment must be in good working condition. 4. Once declared in service, a two year warranty is in effect per master services agreement. In the event of failure, 1 year warranty clock extension upon replacement/repair. 5. OPG to provide oversight during fabrication and installation activities. OPG will review the installation work	Low	Medium

		plans for lifting and rigging details, to ensure appropriate measure are being taken to mitigate damage to the HX's.		
Schedule	There is a risk that the installation timeline is delayed due to the vendor missing the integrated on-line work schedule milestones for detailed design, work plans and assessing.	Mitigate: 1. OPG Project Team is working to advance contract award to enable design and installation planning completion with sufficient float and time to meet the MA-22 milestones. 2. Project to provide oversight of the vendor (accountable for detailed design, work plans and assessing) and will notify management early of any potential schedule delays. Vendor will be accountable to prepare recovery plans & present status updates daily at Project Control Center (PCC) meeting.	Low	Medium
Schedule	There is a risk of accessibility issues during execution activities. The SDC HX rooms are located inside containment, and are accessed through equipment air locks only. Coordination with and approval from Operations and the main control room are required to access the SDC HX rooms. Logistical issues will exist for sequencing the removal of the existing HX's and bringing in the new HX's due to the limited space available on the 92.5el, 100el, and transport through the equipment air locks. Breathing Air and Suit Communication systems will be used for all work performed inside containment, and issues with either system will delay the work.	Accept: 1. Vendor schedule to address accessibility issues during modification planning and detailed design via the Constructability, Operability, Maintainability, and Safety (COMS) review process as required per the Engineering Change Control governance. 2. Vendor to allot sufficient time into the Execution Schedule to address all activities, and minimize delays following the start of installation.	Low	Medium
Schedule	There is a risk that the Project cannot obtain permission from Reactor Safety and Operations to exceed the 'maximum amount of acceptable unavailability for SDC HX's per year' (72 days per year per unit or 288 days per year per station [R-6]). The estimated time of each SDC HX's unavailability during replacement is 40 days, and therefore in a given year only 1 HX per unit could be replaced. This may prevent the SDC HX's from being replaced in order of age, with Unit 2 first, followed by Unit 1, Unit 3 and finally Unit 4.	Accept: 1. If an increase in the acceptable unavailability cannot be provided, then the Project will stagger the installations. For example, instead of installing both HX's in a unit back to back (U2HX1→U2HX1→U1HX1→U1HX2); the Installation would alternate between units following each replacement (U2HX1→U1HX1→U2HX2→U1HX2).	Low	Low
Resource	There is a risk that availability of skilled trade labour is insufficient to support execution activities. The approximate timing of the U2 SDC HX Installations and U1 SDC HX Installations occur within the same time as Darlington U2 Refurbishment pre-requisites and execution. In addition, there is the D1641 planned outage in Mar'16 and	Accept: 1. OPG to award contract as early as practical and avoid to the extent possible any subsequent delays as phased work is released to vendor. 2. Vendor is responsible to work with Union Halls and staff project appropriately to support execution schedule.	Medium	High

	Bruce Power's planned refurbishment of U4 starting in August '16. These work packages will likely require a large number of skilled trade's labourers, and will reduce the pool of available experienced trade's personnel to support the SDC HX Installation in U2 and U1.	3. During periods of inactivity on this project, the vendor will attempt to retain skilled resources by assigning them to different projects that are in execution.		
Resource	There is a risk that OPG resources (Operations, Maintenance, Design, Field Engineering, Contract Management Office, Radiation Protection, etc.) are unavailable to provide support during 2 month long 24/7 execution periods that are back to back (1 .5 month gap in between). In addition, if replacements occur at the same time as a planned Unit Outage, or during Refurbishment, there will be a lower pool of individuals to support.	Mitigate: 1. Communicate and engage affected OPG work groups well in advance to ensure support will be available during the required time. 2. Schedule tasks where possible when resources will be available. (I.e. outside of planned outages). 3. Ensure WO's are provided to Work Control in accordance with the N-PROC-MA-0022 timelines for Project Work.	Low	Medium
Technical	There is a risk that the new SDC HX's do not meet thermal performance requirements. As the new SDC HX's cannot be fully commissioned following installation (cannot place the SDC system in operation outside a planned or forced unit outage), it is possible they do not meet thermal performance requirements when placed in service for the first time.	Mitigate: 1. Vendor to perform all required calculations and HX testing prior to installation as per the Design Specification, to ensure thermal performance requirements can be met. 2. Enhanced COMS and Enhanced AFS to be performed in accordance with the ECC process for non-commissionable modifications in order to apply additional rigor and oversight to ensure equipment is designed and fabricated to meet the technical requirements. 3. Transfer the financial impact for repairs/improvements to the vendor; however, OPG would incur the financial impact due to any outage extension or force outage resulting from the failure to meet the performance requirements.	Low	Medium
Quality	There is a risk that the EPC Vendor's Design Engineering Change (EC) Packages are of poor quality and lack the necessary detail, thus leading to delays because of rework.	Mitigate: 1. Ensure involvement of OPG Design reviewers/stakeholders in the design process, including a detailed design COMS meeting and 90% Design Review meeting. 2. A third party review of design documentation is required as part of the Contract.	Medium	Low
Other	There is a risk of Environmental Releases during execution activities (HX draining and drying activities) to the lake and air.	Mitigate: 1. EPC vendor to ensure all requirements outlined in the Environmental Impact Worksheet are captured in the installation work plans. Darlington Environmental Compliance work group will review all work plans before they are routed for approval. 2. Coordinate closely with ALARA regarding the drying and transport of the HX's within the station (inside and outside). ALARA work group will review	Low	Low

		all work plans before they are routed for approval. 3. Oversight as per Integrated Project Oversight Plan.		
Management	There is a risk of Health and Safety incidents during Construction activities. Construction activities will involve cutting, welding, hoisting and rigging, material handling and pressure boundary (nitrogen fill of HX's) work. The majority of these activities will take place inside containment and in radiological work areas, which require the use of plastic suits, breathing air lines and suit communication systems. As a result there is an increased risk to the workers for slips, trips, falls, cuts and serious injury due to reduced visibility, communications and mobility. Vendor will likely be cutting piping that has passing isolation on the service water side, which could result in increased hazardous working conditions due to large volumes of water coming out of the piping.	Mitigate: 1. Ensure Vendor is in compliance with master service agreement terms and conditions regarding safety standards and reporting requirements. 2. Implementation of Integrated Project Oversight Plan. 3. Requirement of EPC Vendor to adhere to all OPG corporate and site specific safety rules, including requirements for Critical Lift Plans. 4. Work plans to address all safety concerns as identified during COMS. 5. Vendor JSA's to address all safety concerns and hazards.	Low	Low

Additional Risk Analysis:

Monte Carlo Analysis was used to define Specific Contingency allotted for this release.
See Risk Management Plan included in the Project Management Plan for more detail [R-2].

Part H: Post Implementation Review (PIR) Plan

☐ It is determined appropriate that only a Project Closure Report (PCR) is needed as the PIR for this project due to its straight forward deliverables, which do not require any measures other than confirmation of completion or delivery.

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Comprehensive PIR Report	2019-05-16 (Project Completion)	2020-05-16

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Replace all SDC HX's (Qty=8) in all four Darlington Units (1, 2, 3 &4)	Current SDC HX's have experienced accelerated degradation of internal tube support structures and shell material due to MIC.	Replace all SDC HX's with new HX's of existing design. Only replacing internal components (tube support structure, except shell & tubing) with more MIC resistant material.	Installation of new SDC HX's containing internal components (tube support structures) with greater resistance to MIC.	Darlington Components & Equipment Engineering
Operation of SDC HX's	The operation of the SDC HX's does not limit the SDC system's ability to cool down the PHT system, or limit its ability to provide maintenance cooling.	The operation of the SDC HX's does not limit the SDC system's ability to cool down the PHT system, or limit its ability to provide maintenance cooling.	Evaluation of the SDC system operation during its first use following replacement of a SDC HX.	Darlington Components & Equipment Engineering

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OPG-FORM-0076-R004

Type 3 Business Case Summary

Project #: 16-31710

Document #: D-BCS-39780-10003

Title: Darlington Shutdown Cooling Heat Exchanger Replacement

Part I: Definitions and Acronyms
BCS – Business Case Summary
COMS – Constructability, Operability, Maintainability and Safety
EC – Engineering Change
ECC – Engineering Change Control
EM - Equipment Manufacturer
EPC - Engineer Procure Construct
ES MSA – Extended Services Master Service Agreement
HX - Heat Exchanger
PHT– Primary Heat Transport
IMS – Inspection & Maintenance Services
MIC - Microbiologically induced corrosion
NWMD - Nuclear Waste Management Division
PMP – Project Management Plan
PO - Purchase Order
SDC - Shutdown Cooling
UT - Ultrasonic Testing
WWMF – Western Waste Management Facility

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OPG-FORM-0076-R004

Type 3 Business Case Summary

Project #: 16-31710

Document #: D-BCS-39780-10003

Title: Darlington Shutdown Cooling Heat Exchanger Replacement

For Internal Project Cost Control

OPG-FORM-0076-R004

Type 3 Business Case Summary

Project #: 16-31710

Document #: D-BCS-39780-10003

Title: Darlington Shutdown Cooling Heat Exchanger Replacement

Appendix A: Summary of Estimate (Numbers may not add up due to rounding.)										
Project Number:	16-31710									
Title:	Darlington Shutdown Cooling Heat Exchanger Replacement									
k$ or M$	**LTD**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Future**	**Total**	**%**
OPG Project Management	132	249	301	1,344	1,263	933	279	0	4,500	8
OPG Engineering (including Design)	23	77	55	135	187	127	37	0	642	1
OPG Procured Materials	0	0	0	0	0	0	0	0	0	0
OPG Other	[redacted]									
Design Contract(s)										
Construction Contract(s)										
EPC Contract(s)										
Consultants										
Other Contracts/Costs										
Interest										
Subtotal										
Contingency										
Total	**516**	**2,268**	**6,255**	**17,728**	**14,605**	**13,502**	**1,210**	**0**	**56,085**	**100**
Removal Costs	0	0	0	351	3,461	2,572	2,473	0	8,857	16

Note: NWMD is responsible for the transport of the SDC HX's off-site to either the Western Waste Management Facility (WWMF) for long term storage, or to an external vendor for recycling and waste volume reduction. These expenditures are not included in the Estimate at Completion, or in the Removal Costs.

Notes			
Project Start Date	2012-06-29	**Definition Cost Included** (includes contingency only if spent)	[redacted]
Target In-Service (or AFS) Date	2018-09-13 Final AFS (Unit 4, HX 2)	**Contingency Included in this Release**	
Target Completion Date	2019-05-16 Project Completion	**Total-to-Date Contingency**	
Escalation Rate	2.90%	**Total-to-Date Released** (excluding contingency)	
Interest Rate	5.0%	**Total-to-Date Released** (including contingency)	$38,829 k
Removal Costs	$8,857 k included.	**Estimate at Completion** (includes contingency only if spent)	[redacted]

Note: Total-to-Date funds include this release.

Prepared by:	**Approved by:**
James Philipps Project Leader Darlington Design Projects FEB 25, 2014 Date	Ricardo Fiorini Section Manager Darlington Design Projects FEB 25, 2014 Date

Type 3 Business case Summary

Appendix B: Comparison of Total Project Estimates										
Phase	Release	Date	Total Project Estimate in k$ (by year including contingency)						Future	Total Project Estimate
			2012	2013	2014	2015	2016	2017		
Definition	Partial	Nov 2012	19	1,314	18,858	15,977	6,505	3,696	1,160	47,529
Definition & Execution	Partial	March 2014	5	511	2,268	6,255	17,728	14,605	14,713	56,085

Project Variance Analysis					
k$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management	132	1,915	4,500	2,585	OPG Project Management cost during heat exchanger installations has increased based on the increased installation durations for oversight activities.
OPG Engineering (including Design)	23	1,012	642	(370)	OPG Engineering cost estimate has been reduced based on review of actual expenditures during the previous release.
OPG Procured Materials	-	-	-	-	No OPG procured materials.
OPG Other	[redacted]				
Design Contract(s)					
Construction Contract(s)					
EPC Contract(s)					
Consultants					
Other Contracts/Costs					
Interest					
Subtotal					
Contingency					
Total	**516**	**47,529**	**56,085**	**8,556**	

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Type 3 Business Case Summary

Appendix C: Financial Evaluation Assumptions

Key assumptions used in the financial model of the Project are:

Project Cost:

1. The replacement heat exchangers will be identitical in design to the existing heat exchangers (except for internal supports changed to MIC resistant material), and therefore there will be no changes to the current thermal and stress analysis of the shutdown coolilng heat exchangers. The shell material will remain unchanged [R-3].

2. OPG internal cost estimate was developed in house and covers all phases of the project.

Financial:

1. Annual Interest Rate of 5% on capital costs.

Project Life:

1. The new Shutdown Cooling Heat Exchangers shall have a 40 year design life so that they remain operational until the end of station life following refurbishment, approximately 2055.

Energy Production:

1. N/A

Operating Cost:

1. N/A

Other:

1. N/A

List further detail below as appropriate from the Financial Evaluation:

N/A

Appendix D: References
[R-1] D-PCH-33410-10001, Project Charter
[R-2] NK38-PLAN-39780-0489198, Project Management Plan
[R-3] NK38-CORR-33410-0444878, Memo Re: SDC HX Replacement Project
[R-4] NK38-REP-33410-10016-R004, CCA 001465-system 0067 Shutdown Cooling-heat Exchangers
[R-5] NK38-REP-03680-10185-R000, Darlington NGS – Integrated Implementation Plan (IIP)
[R-6] NK38-CORR-33410-0462000, Project 16-31710- RS Impact Of Unavailability Of Shutdown Cooling Hx's During Replacement

This Guidance section should be deleted prior to obtaining signatures

Guidance for Completing this Type 3 Form:

Always use the latest revision of the Form!
Verify this is the latest revision through PowerSearch, or PowerNet → Finance → Investment Planning → BCS Toolkit
It is recommended that the preparers of BCS be familiar with the BCS Standard OPG-STD-0076.

Final Security Classification

Refer to OPG-STD-0030 Classification, Protection and Release of Information. Select the Final Security Classification just once on the first page of the *Execution Summary and Recommendations* and it will be automatically populated on the first page of the body of the *Business Case Summary*. Perform a Print Preview function if it does not appear to be updated.

Executive Summary and Recommendations

Project Information

Document #

Refer to OPG-PROC-0019, Records and Document Management for the requirements and expectations of record filing after the BCS is submitted. The recommended document number format assigned to each BCS should be: [Facility Code]-BCS-SCI-Sequence#, e.g., NK30-BCS-21500-00002. The final signed copy becomes an official OPG record and should be submitted to a central record repository of each business unit/functional group. Notify the stakeholders once the BCS is filed to Records.

Target In-Service Date or Completion Date

Target In-Service Date is usually the key date, but for projects that do not have a specific "In-Service Date", such as engineering studies in future decisions (e.g., Nuclear FCLE project), the Target Completion Date becomes the key date.

Business Case Summary

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

This table provides a yearly breakdown of estimated project costs, including amounts currently released from earlier BCSs if applicable, the new amounts being requested now in this BCS, and estimated future requirements not currently requested. **Contingency shall be included in these amounts.**

The new amounts being requested are for actual work to be completed and for any costs that will be committed to through that work. For example, if an equipment purchase is bundled with a maintenance contract for a committed period, the committed payments under the maintenance contract must be included in the current request. The Future column is the sum of expected future cash flows beyond the last year shown in the table.

Currently Released

Currently Released should match the sum of previous releases including contingency.

LTD

Life-to-date (LTD) is defined as the costs incurred up to the end of the previous fiscal year including the last fiscal week of the preceding year. The first column labelled 20xx is a combination of year-to-date actual (starting at the first fiscal week of the present year) plus forecast of the remainder of the present year-end (including the last fiscal week).

Ongoing Costs

Ongoing Costs include any relevant incremental ongoing costs to which OPG is also committed as a result of the investment/project. It would not be part of the project cost estimate but an appropriate portion of it shall be included in the *OAR Approval Amount*.

Estimate Class

Estimate Class is a cost estimate classification system developed by the Association for the Advancement of Cost Engineering International (AACE) which defines the estimate "quality" based on the input information used and the project's stage of development. AACE uses five estimate classes with Class 5 being the least accurate, and Class 1 being the most accurate.

Estimate Class	**Class 5**	**Class 4**	**Class 3**	**Class 2**	**Class 1**
Project Phase	**Identification**	**Initiation**	**Definition**	**Execution**	**Execution**
Level of Project Definition (%)	0% to 2	1 to 15	10 to 40	30 to 75	65 to 100
Expected Accuracy Range (%)	-50 to +100	-30 to +50	-20 to +30	-15 to +20	-10 to +15

Estimate at Completion

Total project cost **excluding** unspent contingency.

OAR Approval Amount

For BCSs up to and including Definition Phase work, the *OAR Approval Amount* is the cumulative total actual and committed cost to date, not the estimated total investment/project cost.

For Execution Phase BCSs or BCSs that cover multiple phases including Execution, the *OAR Approval Amount* is the estimated total investment/project cost (including contingency), **plus any relevant incremental ongoing costs** to which OPG is also committed as a result of the investment/project.

Ongoing Costs are usually not being approved as part of the release (unless specified, such as a 2-year maintenance contract), but are included in the *OAR Approval amount* to make the approvers aware of that OPG is being committed to an increase in ongoing annual costs by approving the project.

A rule of thumb is to include 5-10 years of ongoing costs.

Additional Information on Project Cash Flows (optional)

Any relevant information that cannot be accommodated in the cash flow table may be entered into this textbox.

Part G: Risk Assessment

Overview

This section identifies the risks associated with the investment/project and the plans to manage or mitigate these risks. Refer to local business unit standards for guidance on completing and documenting risk assessments. Each BU or Functional Group can add risk areas specific to its business.

Refer to the BCS Standard OPG-STD-0076 Appendix A: Document Relationships for Risk governance or contact Investment Planning for further assistance.

Instructions

Describe discrete risks within each class. For example, there may be several possible risk events that could occur related to cost and they should be listed for that class. Risks should be the uncertain events that have the potential to affect the achievement of objectives. The "objectives" must include those of the project itself but may also consider objectives of the ongoing business that the project might put at risk. Risks should be concisely stated as a singular event, such as "x may happen." Elaboration or background for risks may be included; however each should be separate and appear after the concise risk event statement.

Risk mitigation strategies should identify specific actions planned to prevent the corresponding risk event from occurring. The plans may also identify approaches for minimizing the impact should the event actually occur (for example contingency, insurance, specific back-up plans etc.).

The expected probability of the risk event occurring should be rated assuming all of the corresponding mitigation actions are executed, i.e. post-mitigation:

- Low (event is unlikely)
- Medium (event is possible)
- High (event is likely)

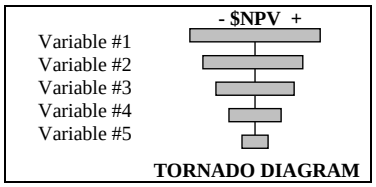
The potential impact, if the risk event were to occur, should be rated:

- Low (<10% cost/schedule/scope variance, minor injury)
- Medium (10-20% cost/schedule/scope variance, disabling injury)
- High (>20% cost/schedule/scope variance, death)

Additional Risk Analysis

The extent of the risk assessment and the risk analysis techniques employed should be commensurate with the magnitude of the cash flows and the degree of uncertainty associated with the critical assumptions upon which the investment is based.

For major projects, the risk analysis section will typically include sensitivities of the investment to various risk factors or scenarios, and a discussion of their likelihood of occurrence. A convenient way of presenting the results of the risk assessment on the variability of the NPV to changes in the critical variable is to include a graph or tornado diagram as shown below.



For larger investments, more advanced risk analysis techniques such as Monte Carlo may be suitable. These techniques require analysts with appropriate training; contact your local Finance support to discuss applicability and to arrange Finance analytical support if required. The limitations of Monte Carlo or any other risk assessment technique must be considered in their application, and require a time commitment from the project team and stakeholders to develop and estimate model inputs.

Part H: Post Implementation Review (PIR) Plan

PIR plan is a succinct description of the project benefits in terms of measurable parameters. The PIR plan should clearly specify what is to be measured, who is responsible for measuring it, and when the measurement should take place, along with any requirements for establishing pre-project baseline information for comparison purposes. The Project Sponsor and key stakeholders shall measure whether the project fulfills the business need, and may specify other items such as the types of lessons learned and recommendations to be captured during the execution of the PIR.

Refer to the BCS Standard OPG-STD-0076 Appendix A: Document Relationships for PIR governance or contact Investment Planning for further assistance.

The PIR plan should contain the following elements:

- *Type of PIR Report*: Simple, Comprehensive, or Not Applicable
  Specify the type of PIR report to be completed. If it is determined by the Project Sponsor (with the concurrence of the Finance Approver) that only a Project Closure Report (PCR) is needed as the PIR, put a checkmark in the box and select "Not Applicable" for *Type of PIR Report*.

- *Target In-Service or Completion Date* and *Target PIR Completion Date*: These two dates may be omitted if the project is in the Definition Phase, but they shall be specified if the scope of work includes Execution Phase activities.

- *Measurable Parameter*: Key deliverables or project benefits clearly defined in measurable terms.

- *Current Baseline*: A clear description of the reference or baseline from which the incremental benefits or changes due to the project are to be measured.

- *Who*: The name of the entity, group, department, or individual that will be measuring the benefits.

- *When*: When the measurement of the benefits will take place.

Appendix A: Summary of Estimate

To assist the reviewers in understanding the cost estimate in the BCS, the Summary of Estimate (SoE) table provides a breakdown of various cost components by year, with explanatory notes as appropriate.

If the BCS includes approval for multiple projects, the top SoE table shall be a consolidation of all the projects, followed by SoE tables for each project. For adding more tables, copy the SoE table provided and paste after the *Notes* table.

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

This section provides the history of past releases and their associated estimates, with explanations of changes as appropriate.

Appendix C: Financial Evaluation Assumptions

This section is intended to provide a reviewer with an overall understanding of the key assumptions used in the financial evaluation, to help a reviewer confirm that relevant drivers and appropriate assumptions were used in the analysis. The main considerations in the economic evaluation of the alternatives are outlined below:

Cost and Schedule Estimates

The work breakdown structure (WBS) of the project usually provides detailed information on the cost of the project and should be referred to while estimating the costs and schedule. Best practices in project cost and schedule estimating should be applied wherever possible including using lessons from similar experiences and benchmarks. Requests for quotations from competing sources are another option to obtain detailed estimates. Schedule and cost estimates must obtain stakeholders' inputs and be reviewed by the key stakeholders of the project before being finalized.

Taxes

All investments must be assessed on an after-tax basis. Users will be required to properly classify the capital assets for Capital Cost Allowance (CCA) purposes. The financial evaluation model provided on the Finance website will compute the initial income tax impacts for most types of investments. The model also contains the latest CCA rates for most types of investments. For further information on CCA, sales taxes and tax shields, please contact your local Finance support group.

Cost of Capital

An appropriate cost of capital or discount rate must be used to ensure that an adequate return is provided to shareholders. For investments related to the manufacturing and processing of electricity for regulated nuclear and base-loaded hydroelectric facilities, the discount rate is generally lower than for unregulated facilities. This is partly due to regulated assets having a more predictable revenue stream, and hence lower risk than unregulated generation facilities.

For projects and business opportunities that are clearly outside of OPG's core business, or are not related to the manufacturing and processing of electricity, the project's cost of capital should be used, instead of OPG's cost of capital. Updated rates for OPG's core business are posted on the Finance website. Contact Investment Planning for assistance.

Revenue Forecasts

The revenue forecast from generation assets must be based on the OPG System Economic Values (SEVs). The appropriate SEVs for the applicable time frame are selected based on the characteristics of the generation asset being evaluated (e.g., peaking vs. baseload). Contact your local Finance support group or Investment Planning for the SEVs and for further guidance on using SEVs.

Additional Attachments

More Appendices could be added if considered essential to be included in the BCS document.

Other additional documents be prepared as separate documents and enclosed with the BCS for reviews and approvals (e.g., multiple file attachments to e-mails).

ONTARIO POWER GENERATION

Records File Information:
Records SCI/USI Retention
- See Guidance Section

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Type 2 Business Case Summary

To be used for investments/projects meeting Type 2 criteria in OPG-STD-0076.

Project Information			
Project #:	16-31716	**Document #:**	D-BCS-68000-10004
Project Title:	DN NOP & IC Amplifier Replacement (RRS, SDS1 & SDS2)		
Class:	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	**Investment Type:**	Sustaining
Phase:	Definition	**Release:**	Full
Facility:	Darlington	**Target In-Service or Completion Date:**	2022-07-04

Project Overview

We recommend the release of $5,254 k, including [redacted] of contingency, to continue with the Neutron Over Power (NOP) & Ion Chamber (IC) Amplifier replacement project.
The estimated total project cost is $17,664k, including [redacted] of contingency.

The quality of the estimate for this release is Class 3, and for the total project is Class 4.

The initial Definition Partial release led to the completion of the preliminary design work. This included approving the modification design requirement and the technical specification documents. In addition to this, the RFP package was sent to the vendors, which in turn led to evaluating the vendor proposals and selecting the equipment vendors for the project.

This Definition Full release will cover both the equipment vendor costs and the OPG oversight/support costs to develop the replacement amplifier equipment. The scope of work in this release includes completing the vendor's designs for the pre-production equipment, fabricating and qualifying the pre-production units, and delivering the qualified pre-production units to OPG. This also includes the completion of the detailed design by OPG to integrate the amplifiers into the station (first channel of first unit) using the engineering change control process.

Following this release the Partial Execution release will include manufacturing and factory acceptance testing the production equipment, installation of the first channel of each system in one unit, as part of commissioning, and detailed design for remaining channels and units. Finally, the Full Execution release will include manufacturing and installing the rest of the amplifiers for all units.

History of BCS releases and project cost estimates:

The total project cost is now estimated at [redacted] of contingency, compared to [redacted] of contingency in the previous release.

The completion of Scope Definition and receipt of vendor proposals has resulted in a better estimate. The last BCS was a Class 5 estimate.

History of scope and schedule changes:

No scope change.

Reason for schedule change: The Request for Proposal (RFP) for engineered equipment was dissolved due to technical exceptions taken by some vendors, and the RFP was reissued. This delayed the definition full BCS completion date, but does not affect the overall project schedule.

Target In-Service (or Available for Service (AFS)): The project Target completion date has not been changed.

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

Type 2 Business Case Summary

Project #: 16-31716
Project Title: DN NOP & IC Amplifier Replacement (RRS, SDS1 & SDS2), Full Definition Release

Part A: Business Need

In-Core Flux Detector (ICFD) amplifiers and the Ion Chamber (IC) amplifiers convert very small current signals from neutron detectors into voltage signals used by the Shutdown System #1 (SDS1), Shutdown System #2 (SDS2) and Reactor Regulation System (RRS) computers. The amplifiers are a critical component of these systems that regulate and shut down the reactor.

The existing amplifiers are obsolete and becoming unreliable. Spare units and parts are limited. The original equipment manufacturers no longer exist or no longer support the old technology. As the amplifiers age and approach end of life, the number of failures will increase, which has been experienced by older plants. Darlington Operating Experience (OPEX) shows a long history of next to no failures, followed by a sudden increase in failures over the past several years. Aging and condition assessments of Darlington's amplifiers indicate that the amplifiers need to be replaced after 30 to 40 years of service. The existing amplifiers and spare parts are adequate to reach station end of life, but are not adequate for extended life after refurbishment.

The potential consequence of multiple concurrent failures is either de-rating or shutting down and resulting loss of generation. With a large number of flux detector amplifiers in each channel (14 per channel on RRS, 18 per channel on SDS1, and 17 per channel on SDS2) there is an increasing risk of forced de-rating or shutting down as the amplifiers age. Ion Chamber amplifiers deal with extremely low level signals, and typically experience a very steep wear-out region of the bathtub curve as they approach the end of their useful life. As there is no redundancy for the ion chamber amplifiers, one amplifier per channel, this situation must be avoided.

Component condition assessments and industry OPEX clearly indicate the existing amplifiers will not be reliable for extended station life. Spare parts are limited, and are no longer available for purchase. Due to the large number of amplifiers in service (568 across the station), it will not be practical to maintain the existing equipment as the number of failures begin to increase steeply. The amplifiers must be replaced, for Darlington to continue operating over its extended life after refurbishment.

Part B: Preferred Alternative: Replace IFCD and IC Amplifiers for RRS, SDS1 & SDS2

Description of Preferred Alternative

Replace the existing ICFD and IC amplifiers on SDS1, SDS2 and RRS systems on-line. No design changes or improvements will be made. The replacement of RRS, SDS1 and SDS2 amplifiers will have a very positive impact on the plant by improving on the following business drivers, through increased amplifier and system reliability:

1. Maintain and improve system health, with an increase in the Equipment Reliability Index (ERI).
2. Maintain and operate a safe plant.
3. Positive impact on electricity production reliability, with reduced probability of a forced unit outage or de-rating. This will decrease forced loss rate for future years.

Deliverables:	Associated Milestones (if any):	Target Date:
This Release	This Release	
Engineered Equipment Contract Awarded	Engineered Equipment Contract Awarded	30-Nov-2015
Detailed Design for First Channel of First Unit	Detailed Design Complete for First Channel of First Unit	30-Nov-2017
Execution Partial BCS	Execution Partial BCS Approved	20-July-2017
Future Releases	Future Releases	
Installation of First Channel Amplifiers	Start of Installation (SOI) for First Channel Amplifiers	16-July-2018
Commissioning & Available for Service for First Channel Amplifiers	AFS for First Channel Amplifiers	20-Aug-2019
Execution Full BCS	Execution Full BCS Approved	03-July-2019
Project Closeout	Project Closeout	30-Dec-2022

References

1) Engineering Specification for ION Chamber Amplifier (RRS & SDS1): NK38-TS-63740-10002 R001
2) Engineering Specification for Neutron Overpower (NOP) Amplifier (SDS1): NK38-TS-68231-10001 R001.

Type 2 Business Case Summary

Project #: 16-31716
Document #: D-BCS-68000-10004
Project Title: DN NOP & IC Amplifier Replacement (RRS, SDS1 & SDS2), Full Definition Release

Alternative 2: Base Case – No Project; Maintain Existing Equipment

This alternative is not recommended. Component condition assessments and industry OPEX clearly indicate the existing amplifiers will not be reliable for extended station life. Spare parts are limited, and are no longer available for purchase. Due to the large number of amplifiers in service (568 across the station), it will not be practical to maintain the existing equipment as the number of failures begin to increase steeply. The amplifiers must be replaced, for Darlington to continue operating over its extended life after refurbishment.

Alternative 3: Delay Work – (Not Recommended)

This alternative is not recommended. This type of project (designing, validating, and fabricating custom electronics) normally requires approximately 5 years to begin installation. There are significant risks that may delay the project. Ion Chamber amplifiers typically experience a very steep wear-out region of the bathtub curve, as they approach the end of their useful life. There may not be sufficient time to react to the increased number of failures in the future. The amplifiers should be replaced before or immediately after the refurbishment outage for each unit. Even if the project were started today, it would not be possible to complete installation in some units prior to the refurbishment outage.

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

$k	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	209	29							238
Requested Now	-	641	3,469	1,144					5,254
Future Required	-			408	931	3,432	4,400	3,001	12,172
Total Project Cost	209	670	3,469	1,552	931	3,432	4,400	3,001	17,664
Ongoing Costs*	-					1,180			1,180
Ongoing Costs**	-						50		50
Grand Total	209	670	3,469	1,552	931	4,612	4,450	3,001	18,894

Estimate Class:	Class 4	**Estimate at Completion:**	$17,664 k
NPV:	N/A	**OAR Approval Amount:**	$18,894 k

Additional Information on Project Cash Flows (optional):

*Life time spare amplifiers and parts with a value of $1.18M will be purchased and placed into OPG inventory.

** Existing amplifiers will be stored until successful commissioning. Cost for disposal/recycling of existing amplifiers.

Part E: Financial Evaluation

$k	Preferred Alternative	Base Case	Delay Work	Alternative 4	N/A
Project Cost	17,664	N/A	N/A	N/A	N/A
NPV	N/A	N/A	N/A	N/A	N/A
Other (e.g., IRR)	N/A	N/A	N/A	N/A	N/A

Summary of Financial Model Key Assumptions or Key Findings:

As per OPG-STD-0076, an economic justification is not required for sustaining investments/projects.

Type 2 Business Case Summary

Project #: 16-31716
Project Title: DN NOP & IC Amplifier Replacement (RRS, SDS1 & SDS2), Full Definition Release

Part F: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	Although all vendors have demonstrated that they have the capability to deliver the required equipment, one of the vendors has not produced this type of equipment in the past. There is a risk that if the vendor has underestimated the effort, then cost could increase.	The contract will be fixed price. The Project is conducting pre-award clarification meetings with the vendors to ensure that they have a complete understanding of the requirements. Remaining risk is accepted, and contingency is allocated in the budget.	Low	Low
Scope	NA	NA	NA	NA
Schedule	There is risk that the long range execution plan can be affected by changes in future outage schedules and Darlington Refurbishment schedule.	Schedule will include additional time to address possible shifting outage dates.	Low	Medium
Resources	NA	NA	NA	NA
Quality/ Performance	Since the amplifiers will be custom designed, their quality will not have been proven. There is a risk that premature failures may occur. The consequences of premature failure could be spurious reactor trip or failure to trip during adverse conditions.	The risk will be mitigated and reflected in the installation strategy by replacing one channel per system in one unit. The first channel in one unit will be evaluated for up to one year before installing the remaining channels and units.	Medium	Medium
Technical	CANDU Owners Group (COG) experience reports indicate that Engineers providing design oversight may potentially lack the technical expertise for this specialized design/technology.	Engineers will be instructed to clearly communicate to decision makers when their expertise is exceeded.	Low	Medium
Technical	Based on the experiences of other CANDU facilities and the complexity of the design, if the design requirements are incorrect or if the product is designed/fabricated incorrectly, then the delivered product may fail testing or commissioning. There is a risk that failure during testing and commissioning will delay the schedule and increase cost.	Based on risk assessment, the technical specifications will be reviewed by a third party (early in detailed design phase) to identify potential gaps in the requirements. Implement enhanced oversight over the entire life of product development and production. Introduce a rigorous testing protocol, and ensure OPG stakeholders witness equipment qualification, and factory acceptance testing for all production amplifiers.	Low	Medium

Type 2 Business Case Summary

Project #: 16-31716
Project Title: DN NOP & IC Amplifier Replacement (RRS, SDS1 & SDS2), Full Definition Release

Part F: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
Technical	The equipment vendors have indicated that the Electromagnetic Compatibility (EMC) requirements are more stringent than other customers. There is a risk that if the effort of meeting/demonstrating EMC compliance is greater than estimated, then the schedule may be delayed and the cost may increase.	This risk cannot be mitigated, and is covered by contingency in the schedule and budget.	Medium	Medium

Part G: Post Implementation Review (PIR) Plan

☐ It is determined appropriate that only a Project Closure Report (PCR) is needed as the PIR for this project, due to its straight forward deliverables, which do not require any measures other than confirmation of completion or delivery.

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Simplified	2022-07-04	2023-07-30

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Number of functional failures	Approximately five failures per year across all systems and across all Units.	Less than or equal to two failures per year, across all systems, and across all Units.	Review and analysis of Station Condition Record (SCR) database, and work requests in Asset Suite.	System Responsible Engineer (Performance Engineering)
Spare Amplifiers readily available	No spare amplifiers available in inventory	Enough spare amplifiers to reach end of station extended life	Review spare amplifiers inventory upon installation of all amplifiers	System Responsible Engineer (Performance Engineering)

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): J. Lehman, Director Engineering, Darlington	J. Lehman	as per PAC.	Sept 22/15
I concur with the business decision as documented in this BCS.			
Finance Approval: J. Sawler, Director Controllership, Darlington	A Brooks for John Sawler.	ARSC approved.	Oct 1/15
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: B. Duncan, SVP Darlington	Brian Duncan	None	Oct 2/2015

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Type 2 Business Case Summary

Document #: D-BCS-68000-10004

Project #: 16-31716
Project Title: DN NOP & IC Amplifier Replacement (RRS, SDS1 & SDS2), Full Definition Release

Appendix A: Summary of Estimate										
Project Number:	16-31716									
Project Title:	DN NOP & IC Amplifier Replacement (RRS, SDS1 & SDS2)									
$k	**LTD**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Future**	**Total**	**%**
OPG Project Management	9	51	199	153	117	129	131	303	1,092	6
OPG Engineering (including Design)	194	99	494	195				308	1,290	7
OPG Procured Materials	[redacted]									
OPG Other										
Design Contract(s)										
Construction Contract(s)										
EPC Contract(s)										
Consultants										
Other Contracts/Costs										
Interest										
Subtotal										
Contingency										
Total	209	670	3,469	1,552	931	3,432	4,400	3,001	17,664	**100**

Notes			
Project Start Date	2013-10-01	**Total Definition cost** (excludes unspent contingency for Nuclear)	[redacted]
Target In-Service (or AFS) Date	2022-07-04	**Contingency included in this BCS** (Nuclear only)	
Target Completion Date	2023-01-30	**Total contingency released plus contingency in this BCS** (Nuclear only)	
Escalation Rate	2.00%	**Total released plus this BCS without contingency** (Nuclear only)	
Interest Rate	5.00%	**Total released plus this BCS with contingency** (Nuclear only)	$5,492 k
		Estimate at Completion (includes only spent contingency for Nuclear)	[redacted]

Prepared by:	Approved by:
Bassam Alawi 09-09-2015	
Bassam Alawi Modification Team Leader Darlington Projects & Mods Date YYYY-MM-DD	Rajbir Singh Section Manager Darlington Projects & Mods Date YYYY-MM-DD 2015-09-16

Type 2 Business Case Summary

Project #: 16-31716
Project Title: DN NOP & IC Amplifier Replacement (RRS, SDS1 & SDS2), Full Definition Release

Document #: D-BCS-68000-10004

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
			2013	2014	2015	2016	2017	2018		
Definition	Partial	July-2013	43	240	1108	1206	6290	11142	1,606	21,635
Definition	Full	Oct-2015	21	188	670	3,469	1,552	931	10,833	17,664

Project Variance Analysis

$k	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management	9	668	1,092	424	The project manager cost estimate has been revised upon completion of Scope Definition. This project will be a modification instead of a non-identical component replacement.
OPG Engineering (including Design)	194	486	1,290	804	The Engineering estimate has been revised upon completion of Scope Definition. This project will be a modification instead of a non-identical component replacement.
OPG Procured Materials	[redacted]				
OPG Other					
Design Contract(s)					
Construction Contract(s)					
EPC Contract(s)					
Consultants					
Other Contracts/Costs					
Interest					
Subtotal					
Contingency					
Total	209	21,635	17,664	(3,971)	