Business Case Summary

Liquid Relief Valve Modifications to Reduce Waterhammer 16 - 38933 (OM&A)
Partial Release Business Case Summary D - BCS - 63310 - 10003 - R000

Name / Title / Phone	Location	Action	Signature	Date
Dianne Gaine Director, Darlington Projects 703-1330	D08ES3	Prepare BCS	Dianne Gaine	May 30/11
Sandy Stock Director, Station Engineering 703-7584	D08ES3	Review BCS	S.D. Stock	31 May 2011
Phil Smith Director, Projects Design 702-5430	P82-2	Review BCS		Jun 1/2011.
Randy Leavitt JAMIE LACUNE A DIRECTOR INVESTMENT MGT VP, Nuclear Finance 702-5177	P82-3-318	Review BCS		JUNE 13/2011 June 13, 2011
Stu Seedhouse SVP, Darlington 703-7499	D08ES3	Submit BCS		June 21/2011
Wayne Robbins Chief Nuclear Officer 702-5294	P82-6A	Review BCS		2011-06-17
Donn Hanbidge SVP & Chief Financial Officer 400-2395	TCH19F27	Approve BCS		2011-07-05
Tom Mitchell President & CEO 400-2121	TCH19A24	Approve BCS		2011-07-05
Carolyn Sicard Nuclear Investment Management 702-4082	P82-3B6.2	Return for Distribution		

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1/ RECOMMENDATION:

We recommend a Partial Release of an additional $8.282 Million OM&A to fund Detailed Engineering and facilitate a long lead material procurement contract for the design, testing, and fabrication of five (5) new Nuclear Class 1 LRV valves for the Darlington Liquid Relief Valve (LRV) Modification project. Approval of this request will bring the total to date funding to $10.876 Million including a contingency of [redacted] Million. The total project is estimated to cost $ 21.609 Million (including [redacted] Million contingency) with an estimated completion date of 12/31/2025

The Business Objective of this Regulatory project is to address long term valve and piping degradation due to valve induced waterhammer, and ensure valve, piping and pipe support stresses are within allowable limits for design basis transients in which the LRVs operate. Replacement of the LRVs will mitigate rapid opening and closing times and eliminate waterhammer effects, while maintaining overpressure protection requirements. Continued operation has been justified via the Discovery Issue Resolution Process (DIRP) and subsequent Discovery Issue Assessment NK38-DIA-00531-10002 issued in 2006, which defined the nuclear safety risk associated with pipe failure as a result of LRV induced water hammer. Routine LRV piping and support inspections during planned outages (supporting the DIRP) have been implemented to confirm structural integrity remains intact for continued operation of the Heat Transport System (HTS) until the replacement valves are installed. Additionally the Engineering Decision Making (EDM) process was invoked in 2010 to reconfirm the conclusions of the DIRP for continued safe operation to further quantify the DNGS Site Management Board (SMB) decision to defer the installation of the LRVs concurrent with refurbishment due to economic, nuclear safety, and personnel dose concerns. The EDM Committee concluded it is technically acceptable to defer LRV replacement until the Darlington refurbishment outages with the issuance of a decision memorandum, NK38-CORR-33100-0362965 and technical memorandum, NK38-CORR-33100-0363511. The OPG decision to defer the installation phase concurrent with refurbishment is contingent upon obtaining CNSC acceptance of this proposed strategy, which is expected before end of Q2 2011.

The following deliverables will be completed during this release:
1. Design, test, and procure the new LRVs,
2. Complete the Detailed Design by April 2014, and
3. Place the project in deferment until refurbishment detailed planning for the first unit is complete, and then remove the project from deferment in ~ 2015 to prepare the next Partial Release BCS for first unit installation.

Installation of the new LRVs will begin in first unit refurbishment outage (~2017) with project completion concurrent with completion of last unit refurbishment outage (~2024).

$000's (Incl contingency)	Type	LTD Dec 2010	2011	2012	2013	2014	2015	2016	Later	Total
Currently Released	Partial	1,301		1,056	264					2,621
Adj to Current Release	Adjustments	(242)	1,535	(1,056)	(264)					(27)
Requested Now	Partial		(565)	3,008	2,873		333		2,633	8,282
Future Funding Req'd	Full								10,733	10,733
Total Project Costs		1,059	970	3,008	2,873	-	333	-	13,366	21,609
Non Project Costs										-
Grand Total		1,059	970	3,008	2,873	-	333	-	13,366	21,609
Investment Type: Regulatory		Class: OM&A		NPV: -$9.67M			IRR: N/A		Discounted Payback: N/A	

Submitted By: (Date)

Rick Amoco June 21/2011

Stu Seedhouse
SVP, Darlington

Financial Approval By: (Date)

T D Hanbidge July 5/2011

Donn Hanbidge
SVP and Chief Financial Officer

(OAR Element 1.1 Project in Budget)

Line Approval By: (Date)

2011-07-11

Tom Mitchell
President and CEO

2/ BACKGROUND & ISSUES:

To ensure overpressure protection of the Heat Transport System (HTS) Darlington NGS contains four 100% power actuated Liquid Relief Valves (LRVs) in each unit, two per loop sharing common piping. Each loop has been designed and instrumented for both valves to open simultaneously on high loop pressure.

During commissioning of Darlington, performance of the LRVs was identified as less than adequate. It was discovered that the opening force of the valve was only designed for zero power hot conditions, which was not adequate to overcome the operating conditions of the PHT system at full power nor was the high flow rates due to the large differential pressure across the valve accounted for. Modifications were completed in two stages. This first stage involved installing larger tubing to allow more rapid depressurization of the air operated actuator to increase the valve opening speed. The second stage involved modification to the pilot plug and the pilot holes to provide larger flow capability and faster depressurization of the top of the main plug under hot conditions. The LRVs were also instrumented with displacement and force transducers to measure the valve stem movement and the actuator force. Following the changes, LRV performance was monitored to demonstrate availability and acceptable operation. Based on data recorded, Darlington LRVs are opening and closing faster than that assumed in the original design basis. This condition of fast opening/closing of the LRVs has the potential for higher than designed waterhammer load on the HTS piping.

In the event of an extremely rare set of circumstances occurring (i.e. design basis transients in which LRVs operate simultaneously), OPG is unable to definitively demonstrate that pipe and support stresses are within ASME code allowable limits, as is required by the Operating License, and is therefore unable to prepare and certify an Analysis of Record. However, on-going inspection of the HTS piping system has found no sign of pipe or support degradation. Additionally, as required by N-PROC-RA-0094, a DIRP was used to define the nuclear safety risk associated with pipe failure as the result of LRV induced waterhammer. The DIRP assessment (NK38-DIA-00531-10002) concludes that continued operation of the units until the modifications are installed is acceptable because the risk of pipe failure remains very low and the consequences are bounded by the existing safety report.

In addition, the Engineering Decision Making (EDM) process was invoked in 2010 to reconfirm the conclusions of the DIRP for continued safe operation to further quantify the DNGS Site Management Board (SMB) decision to defer the installation of the LRVs concurrent with refurbishment due to economic, nuclear safety, and personnel dose concerns. The EDM Committee concluded it is technically acceptable to defer LRV replacement until the Darlington refurbishment outages with the issuance of a decision memorandum, NK38-CORR-33100-0362965 and technical memorandum, NK38-CORR-33100-0363511. The economic, nuclear safety, and personnel dose concerns are reduced significantly by completing installation and commissioning during refurbishment since the HTS will be drained. Specifically, the economic impact is in the range of $64M - $93M if this project was installed and commissioned during regular unit outages due to the estimated critical path extension impact, which is 46 (up to 66) days total. Furthermore, the SMB and EDM Committee agreed that design and procurement of the LRVs must be completed now (and not delayed any further) to mitigate the risk of potentially needing to advance the installation schedule if signs of pipe or support degradation is found during regularly scheduled inspections.

The adopted solution is to replace the existing LRVs with new LRVs which will address the valve opening and closing times to mitigate undesirable waterhammer effects while maintaining overpressure protection requirements. Based on operating experience (OPEX), demonstrated through modifications at Cernavoda B, Wolsung, and Quinshan, this will resolve the existing potential waterhammer problem associated with LRV operation. Additionally, the LRV warming line will be relocated. The present location of the warming line for the current LRV is too far away to maintain the fluid temperature upstream of the valve. Field measurement has indicated the fluid temperature at the inlet to the LRV is substantially lower than the design basis and as such the stainless steel to carbon steel weld upstream of the valve will be subjected to a much higher thermal transient when the LRV is lifted. This could lead to premature fatigue failure at the transition weld. The purpose of the relocation of the warming line is to reduce (as far as practicable) the local thermal fatiguing that is occurring near the LRV inlet due to geometry of the current warming line connection point, and the presence of the resulting cooler water dead leg. Qualification/performance testing of the new valve by an external vendor will be performed to confirm elimination of waterhammer due to valve operation.

In February 2009, OPG submitted the proposed two-part strategy to resolve the LRV waterhammer issue (NK38-CORR-0053-14465) to the CNSC, thus closing out REGM AR 28082043. Part 1 includes removal of the existing LRVs and local piping to the LRVs and replacement with new “flow to open” LRVs. Part 2 involves implementing an inspection process appropriately suited for on-going validation of the pressure boundary integrity of the existing HTS piping and supports. After two rounds of correspondence requesting additional information and clarifications the CNSC responded in June 2010 that

the CNSC agrees, in principle, to the proposed strategy however a new Action Item 28116373 was opened to track the completion of OPG undertakings as described in NK38-CORR-00531-15055. Quarterly meetings with the CNSC have been implemented and will continue on a regular basis until all issues are resolved.

A Value Engineering session was conducted during the Conceptual Phase to identify a short list of key project strategies and associated risks. These strategies were later explored in greater detail to define the Preferred Alternative.

A total of sixteen (16) Nuclear Class 1 valve / actuator sets and commissioning spares will be purchased, and an additional one (1) Non-Nuclear Class valve will be purchased and subjected to full qualification testing. Since the removed valves will be highly contaminated and their remaining life difficult to quantify, the valves have no salvage value.

Funding released by this BCS will be used to complete detailed design, perform an independent review of detailed design, perform extensive modeling, hydraulic, and stress analysis by a Design Agency, procure long lead materials (5 LRVs), qualification/seismic/performance testing of one (1) non-nuclear class valve, and preparation of the next Partial Release BCS.

3/ ALTERNATIVES & ECONOMIC ANALYSIS:

$ 000's	Base Case	Alt 1 (Recommended)		Alt 2	Alt 3	Alt 4	Alt 5
		Full Cost	Incremental Cost				
Revenue							
Base OM&A							
Outage OM&A							
Project OM&A		(21,610)	(20,334)				
Total OM&A	0	(21,610)	(20,334)	0	0	0	0
Capital							
Present Value (PV)		(10,567)	(9,674)				
Net Present Value (NPV)	**N/A**	**(10,567)**	**(9,674)**				
Internal Rate of Return (IRR) %	N/A						
Discounted Payback (Yrs)	N/A						

Base Case: × *Not Recommended* - **Status Quo**

This alternative is not recommended as OPG is unable to definitively demonstrate that pipe and support stresses are within ASME code allowable limits, as is required by the Operating License, and is therefore unable to prepare and certify an Analysis of Record. This does not satisfy the requirement for a long term solution to address operating outside of ASME code, as required by Discovery Issue Resolution Process N-PROC-RA-0094 Table 3, per the assessed conclusions of DIRP NK38-DIA-00531-10002. Thus this option has not been financially evaluated.

Alternative 1: ✓ *Recommended* - **LRV Replacement**

Based on OPEX (operating experience), valve replacement (with flow to open design) will reduce the waterhammer problem associated with the LRV operation to an acceptable level. This has been demonstrated through modification at Cernavoda B and installation of new valves at Wolsung and Quinshan. In addition to the OPEX on flow to open design, replacing the valve will also allow relocation of the warming line to keep the valve warm as postulated in the original design basis. The new valves/actuators will be ordered with reducers and piping spools attached to minimize installation time.

Alternative 2: × *Not Recommended* - **Delay Project**

Installation is presently scheduled to start in Refurbishment (~2017). Delaying any further is not recommended since the possibility of a HT piping failure could increase, and the CNSC may direct OPG to take action to mitigate the water hammer problem if a further delay is imposed. Thus this option has not been financially evaluated.

Alternative 3: ***× Not Recommended -*** **Minor Modifications to the LRV/Actuator**

This alternative is not recommended considering the minor modification will not completely eliminate the waterhammer problem. This is due to the fact that the present set up of the LRVs makes it difficult to control or to predict the valve behavior. Thus this option has not been financially evaluated.

Alternative 4: ***× Not Recommended -*** **Reversal of Existing Valve Body and Replacement of Trim, Valve, Internals, and Actuator**

This alternative is not recommended. Similar to the Recommended Option, OPEX indicates that reversal of the valve could correct the waterhammer problem. However, the existing valve internals, trim, and actuators would require replacement if the valves were reversed. Valve testing prior to installation is not possible. As a result, there are numerous uncertainties, reliability issues and a lack of confidence surrounding this option. Additionally, the remaining life of the valve bodies is difficult to quantify as they may have been subjected to waterhammer loads in the past. Thus this option has not been financially evaluated.

Alternative 5: ***× Not Recommended -*** **Perform Analysis to Demonstrate Piping Integrity**

After more than two years of analysis using both standard and non-standard methods of analysis, the piping designers concluded that the magnitude of waterhammer load in the event of an extremely rare set of circumstances occurring (under worst case scenario) would be unacceptably high and that stresses cannot be brought within ASME code allowable limits. Further analysis alone would not be beneficial. Therefore this is not a viable option. Thus this option has not been financially evaluated.

Alternative 6: ***× Not Recommended -*** **Replace all Potentially Over-Stressed Piping in Conjunction with Valve Alternative 1, 3, or 4**

Replacement of all affected HTS piping has not been demonstrated to be necessary at this time. This option is not recommended since the cost of undertaking such a large replacement of the HTS piping would be extremely high and require extensive time to install. Thus this option has not been financially evaluated.

4/ THE PROPOSAL

Major activities completed under the previous Developmental and Partial BCS Releases included the following:

1) Valve tendering specification was submitted and a budgetary estimate for valve procurement was received,
2) Preliminary design was completed and preliminary LRV opening/closing limits were established,
3) Valve design technical specification was issued,
4) Modeling, hydraulic/stress analysis Scope of Work was issued,
5) Two (2) Request For Proposals (RFPs) were issued and successful proponents selected for:
    a. Valve procurement, and
    b. Modeling, hydraulic and stress analysis.
6) 3rd Party Independent Technical Review of "Darlington Technical Position on Primary Heat Transport Liquid Relief Valve Piping was completed and report NK38-REP-33100-10028 issued,
7) Measurements of the HTS piping associated with the waterhammer issues were collected from each unit during the DNGS VBO,
8) Front End Planning was completed, and
9) PEP NK38-PEP-63310-03364450 was approved.

The Scope of Work proposed under this Partial Release BCS release is summarized below:

1) Project Management:
    a. Project Administration
    b. Project Reporting – Schedule, Cost, Risk
    c. Design Agency & Valve vendor Contract Management
    d. CNSC Updates

2) Project Management Office:
    a. Project Reporting – Schedule, Cost, Risk

3) Partial Release (for 1st Unit Installation):
    a. Business Case Summary
    b. Basis of Estimate
    c. Risk Management Plan
    d. Project Execution Plan

4) Installation Contract:
    a. SOW
    b. Issue RFP
    c. Bid Evaluation

5) OPG Design:
    a. Design Agency deliverables review and acceptance
    b. Valve Vendor review and acceptance
    c. Mechanical Design EC
    d. Civil Design EC
    e. I&C Design EC
    f. Over Pressure Report
    g. Final Thrust Calculation
    h. ASME Section XI Fatigue Analysis
    i. Independent Design Review
    j. CNSC Acceptance
    k. TSSA Registration/Reconciliation

6) Design Agency Contract – Certified Hydraulic & Stress Analysis Report

7) Valve Manufacturer Contract – Design & delivery of 5 Class 1 LRV Valves and 1 Commercial Test Valve for OPG Training Department

Future BCS Releases will facilitate installation activities in Darlington four (4) units concurrent with refurbishment outages.

5/ QUALITATIVE FACTORS

The successful completion of this project will address the following:

1) Establish acceptable limits for LRV opening and closing operation.
2) Confirm that valve operation effectively reduces waterhammer to acceptable levels.
3) Maintain Station Operating License.
4) Satisfy regulatory issues.
5) Decrease risk of piping failure.
6) Decrease the rate of equipment aging due to fatigue which could potentially impact on plant life extension.

6/ RISKS ANALYSIS (See Attachment D for details)

Low 1 to 3	Medium 4 to 9	High 10 to 25

Probability \ Impact	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Risk Description	Mitigating Activities	Mitigation	Probability X Impact: Finance	Schedule	Quality	Corporate Reputation	Regulatory	Health & Safety	Environmental	Nuclear Safety	Risk Rating (1 to 25)
Original valve manufacturer selected withdrew their proposal and is no longer willing to supply the valves due to the Fukushima event. Second preferred valve vendor is being pursued. Long Lead Material PO may not be awarded as per Project Schedule due to second preferred valve vendor not possessing proper C of A for Class G valves. New RFP may be required due to C of A issue.	Projects, Design and Supply Chain is working with the second preferred valve vendor to resolve the C of A issue to avoid the need for another RFP which would delay the project by approx. 4 months.	Before	5	20							20
		After	4	10							10
Cost for Performance and Certification valve testing is higher than anticipated. (i.e. Test Facility may have to be rescheduled due to delays)	1. Design to clarify testing requirements with vendor as actioned in PO pre-award meeting. (complete) 2. Design to issue Valve Tech Spec R01. (complete) 3. Issue new RFP to proponents and obtain updated, confirmed pricing from vendors. 4. Update BCS to change funding required. 5. Build some contingency time into the schedule to allow for delays.	Before	9								9
		After	1								1
Long Lead Material - Valve procurement cost exceeds contract due to: 1) specification changes required as a result of factory testing 2) OPG Model Analysis results 3) Cost of C of A equivalency exceeds estimate	1. Extensive technical meetings held with preferred vendor to establish minimal required testing, which was incorporated into the Design Specification. (Complete) 2. Selected proponent proposal costs incorporated into this release estimate. 3. Risk identified and contingency funding allotted in Risk Management Plan.	Before	12								12
		After	4								4

Long Lead Material Contract & LRV Procurement Canadian cost goes up due to US exchange rate fluctuation	Add contingency for US exchange rate fluctuations.	Before	12							12
		After	6							6
Risk of CNSC not accepting OPG adopted strategy to complete design but defer installation concurrent with refurbishment.	1. EDM quorum to provide concurrence on DNGS SMB recommendation for installation deferral to Refurbishment before submission to CNSC. (Complete) 2. Strategy to be communicated to CNSC informally via quarterly update to obtain initial feedback. 3. Solid Technical justification to be submitted to CNSC.	Before	6	12			6			12
		After	4	8			4			8
Project Installation schedule advanced due to CNSC direction or pipe failure in DN units.	1. Formal letter submitted to CNSC for concurrence with installation in Refurbishment. 2. EDM quorum validated the DIRP through Refurbishment period and agreed that it is safe to operate until Refurbishment with a very low risk of pipe failure.	Before	9				8		5	9
		After	3				2		3	3
Final Analysis on models identifies valve opening/closing time to be unacceptable after performance testing of commercial test valve is already complete.	1. Engineering Services to perform scoping modeling runs to assess reduction in waterhammer loads with preliminary valve design provided by Vendor. Confirm new valve design is acceptable. (Complete) 2. Confirmation of valve weight and computer generated Cv curve to be requested from vendor on PO issue.	Before	4	16						16
		After	2	8						8

Delay in material fabrication and/or delivery by vendors. (New valve lead time may be excessive or delayed)	1. Maintain communication/coordination with vendor and expedite when necessary. 2. Place long lead material PO's early, and expedite as required. Place order for valves well in advance of required delivery date. (Vendor has identified 52 weeks lead time) 3. Examine Flow Diagram changes - materials, elbow tap vs. valve tap. 4. CNSC agreement required - obtain during Detailed Design. 5. Allow adequate time for Design to implement any changes. 6. Monthly update meetings with Vendor. 7. Obtain vendor Schedule for deliverables. 8. Expedite OPG turnaround time.	**Before**		20						20
		After		6						6
Long Lead Material PO or Design Agency PO not awarded as per Project Schedule. (i.e. New RFP is required due to NV/C of A issues)	1. Work with Supply Chain & Design to expedite. 2. Obtain Testing requirements and revise Tech Spec and SOW. (Complete) 3. Finalize Terms & Conditions.	**Before**		12						12
		After		4						4
OPG Detailed Design/Analysis takes longer than anticipated to complete. Specific factors which may contribute to this are additional failure modes identified during model runs and/or changes to the piping technical specification. Note: Residual risk was still rated high due to the potential possibility of more than one modeling run iteration being required during the detailed hydraulic and stress analysis to mitigate emergent model identified issues.	1. Ensure resourcing and schedule durations are provided and agreed to by support groups, vendor, and design agency. 2. Expedite required vendor and design agency information. 3. Coordinate schedule between OPG, vendor, and design agency to meet Design milestones.	**Before**	10	20						20
		After	8	12						12

Design EC's not issued per schedule	1. Expedite valve manufacturing and testing. 2. Coordination with all workgroups to ensure schedule and milestones are met. 3. CNSC concurrence of project scope to expedite design concessions at end of Detailed Design Phase.	Before	4	16							16
		After	2	8							8
Mitigation of any concerns identified by Independent Design review takes longer than originally anticipated.	Design to engage Independent Reviewer early in Detailed Design and submit documentation/models for review as it is available.	Before	3	12							12
		After	2	8							8
Valve testing or contract deliverables are not submitted/completed as per schedule and/or initial test results may not meet standards or technical requirements. Note: Residual risk was still rated high based on OPEX identified by Supply Chain on selected valve vendor timeliness issues on several recent contracts.	1. Testing is to be completed as part of PO for valves. 2. Expedite valve testing. 3. Expedite OPG drawing & Inspection & Test Plan (ITP) acceptance turnaround time. 4. Confirm testing schedule with vendor.	Before	8	20	20						20
		After	6	15	15						15
External stakeholders (TSSA, CNSC) require re-registration of HTS to maintain operating license. Note: Re-registration of the HTS may be required if CNSC/TSSA invokes ASME Section III analysis requirements on this project. However, ASME Section III analysis cannot be completed unless the entire HTS is replaced (including all piping).	Communications with CNSC have resulted in a formal agreement in principle of invoking ASME Section XI analysis instead of ASME Section III analysis to finalize the detailed design. (Ref: NK38-CORR-00531-15146)	Before	12	15			9				15
		After	2	4			2				4
Modifications to LRVs exceed seismic weight limitations - piping analysis requires downstream pipe/support changes.	Complete analysis during Detailed Design Phase to ensure weights acceptable.	Before	2	10	6						10
		After	1	2	1						2
Valves and actuators may not physically fit	1. Conduct detailed walkdown (including drawing confirmation) during D1041 / D1021. Field measurements will be taken. (Complete) 2. Vendor will supply final dimensions of new valve and actuator Q3 2011. 3. Potential use of mock-up (included in contingency).	Before		12	9						12
		After		4	4						4

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Risk of additional failure modes	1. Examine Darlington Probability Risk Assessment in Detailed Design. 2. Collect additional OPEX from other stations and vendor. (Complete) 3. Complete modeling during detailed design phase.	**Before**	2	5	5					5
		After	1	2	2					2
Lack of Senior Designers with extensive Nuclear Class 1 experience and/or Engineering Mechanics Modeling Experience to review Design Agency deliverables. - Review of stress analysis takes longer than originally anticipated by ES. Note: Residual risk is still rated as high because: - Review will stop on models/analysis by ES if forced outage occurs in Darlington/Pickering. - Valve test results are not what is expected. Large impact on modeling may occur during last modeling runs.	1. Contract out Modeling and Stress/Hydraulic Analysis to an External Design Agency with extensive knowledge to support Design and Modeling Runs throughout Detailed Design. (RFP sent to two qualified External Design Agencies.) 2. Get commitment from ES for review of Design Agency Deliverables.	**Before**	3	15						15
		After	2	10						10
Code Effective Date (CED) to allow installation through last unit in Refurb (~ 2023) using design completed in April 2014 not approved by CNSC. Ability to invoke N-PROC-MP-0090 rev 006 for LRV execution thru 2023 not approved by site DA.	1. After refurbishment CED is established and accepted by the CNSC, our project will request formal CNSC concurrence for CED. 2. Request DA approval for use of N-PROC-MP-0090 rev 006 thru to 2023 following CED acceptance by CNSC.	**Before**	5	5			5			5
		After	2	2			2			2
Reconciliation of Design from 2007/2008 Code Effective Date (CED) to Refurbishment CNSC accepted CED may be required.	1. Follow-up with Refurbishment organization to stay informed on CED issue. 2. After refurbishment CED is established and accepted by the CNSC, request the Design Agency to reconcile the hydraulic and stress analysis from 2007/2008 to said CNSC accepted CED.	**Before**	5	12						12
		After	5	9						9
Darlington Plant Design SME cannot support the review of project deliverables on time.	Get commitment from Plant Design to meet the scheduled completion dates for project deliverables	**Before**		12						12
		After		4						4

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The LRV warming lines stress analysis fail in the initial detailed runs. Note: Residual risk was still rated high based on the warming line stress analysis failing during the scoping runs completed by OPG Engineering Services.	The SOW and Piping TS is written such that the Design Agency is responsible for re-designing these lines, if required.	Before	10	15							15
		After	8	12							12
Qualification of software required to complete modeling analysis.	Project will give preference to Design Agency with already qualified STANPIPES and PTRAN software programs, per evaluation criteria.	Before			10						10
		After			2						2
Valve vendor does not have a design with a ~linear Cv vs Flow curve (as acceptable by OPG) for both valve opening and valve closing.	OPG Design to verify that Cv vs Flow curve provided by valve vendor is acceptable.	Before			12						12
		After			4						4
Installed and Approved ECs and other data are missing from piping models for either Unit 1, 2, 3, or 4. i.e. Discrepancies between drawings and models.	SOW and Piping Design Specification is written in such a way that the Design Agency is responsible to disposition these discrepancies without delaying to the completion of the deliverables. (Complete) Three memos were approved by Design outlining the discrepancies in the systems (PHT, PI&C, SDC). (Complete)	Before			9						9
		After			3						3
No Engineering Services resources available for Nozzle re-qualification (analysis).	Projects and Design to get commitment from ES to complete nozzle qualification.	Before	12	9							12
		After	4	4							4
Future Releases											
Material procurement cost exceed initial material estimates (including NC1 pipe and elbow costs, and bungs)	1. Expedite DBOM into earlier phase of design. 2. Order materials in 2012 (for D1321) or 2015 (for Refurb).	Before	6								6
		After	4								4

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Risk of increased inventory costs	1. Get spare parts list from vendor. 2. Finalize inventory with maintenance SPOC. 3. Spare parts will be procured and reorder point specified to ensure adequate stock on site.	Before	6								6
		After	4								4
Discovery work and/or rework is required during installation	1. Conduct detailed walkdown (including drawing confirmation) during VBO & D1041. (complete) 2. Ensure scope adequately captured to mitigate possibility, and allot contingency for discovery work. 3. Work closely with CMO and station support to capture potential surprises in advance. 4. Examine possibility of constructing mock-up for rehearsal. 5. Qualified workers will be hired for the job and adequate training will be conducted.	Before	6	9							9
		After	4	6							6
Replacement parts may not be readily available	1. Tech Specs require vendor to identify spare parts. 2. Procure replacement parts with valves and ensure reorder points are identified in advance. 3. Design to prepare EBOM.	Before		9							9
		After		6							6
Execution window exceeds Outage window	1. Conduct detailed walkdown (including drawing confirmation) during D1041. (complete) 2. Adequate preparations and pre-fabrication to meet outage window. 3. Present to SMB recommended solution - deferral to Refurbishment (2016~2023) (complete) 4. Get CNSC concurrence with path forward strategy (deferral to Refurbishment)	Before	15	20							20
		After	3	3							3

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Delay in material fabrication and/or delivery by vendors. (New valve lead time may be excessive or delayed) Note: Residual risk was still rated high based on OPEX identified by Supply Chain on selected valve vendor timeliness issues on several recent contracts.	1. Maintain communication/coordination with vendor and expedite when necessary. 2. Place long lead material PO's early, and expedite as required. 3. Examine Flow Diagram changes - materials, elbow tap vs. valve tap. 4. CNSC agreement required - obtain during Detailed Design.	**Before**		16						16
		After		12						12
Station delays may impact installation progress via: - station resources are not available, - poor communication and hand offs, - potential delays if permits are not issued on time.	1. Identify requirements and interfaces with Station well in advance. Work plan will identify interface requirements. Station will review and sign. Tasks will be scheduled. 2. Notify Station of upcoming work and proposed Outage/Refurb windows in advanced to ensure adequate support available. 3. Obtain commitments in advance. 4. Prepare commissioning plan, prepare logic with handoffs identified. 5. Hold project meetings with all work groups. 6. Follow Outage/Refurb schedule processes (prepare permits in advance). 7. Follow up with stakeholders, as required.	**Before**		8						8
		After		4						4
The unique valve design may strain existing resources: - additional training and qualifications, - new valve may require additional maintenance.	1. Give conventional valve to OPG Maintenance for training purposes. 2. Complete a training assessment to identify requirements for training and qualifications. 3. Prepare documents and align resources to conduct training. 4. Design to minimize maintenance.	**Before**	3	6						6
		After	2	4						4
Qualified contractor personnel are not available to perform the work	Contractor should be in contact with Union Hall well in advance. Identify critical nature of this job in the contract.	**Before**		9						9
		After		3						3

High dose rates require additional contractor staff to complete the work	1. Conduct detailed walkdown with H&S Rep during VBO to discuss potential issues. (complete) 2. ALARA principle will be used. Training will ensure minimum unplanned dose. 3. Potential use of mock up. 4. Obtain historic dose rates from RP. 5. Ensure adequate workers hired.	Before	4								4
		After	3								3
LRV's are located in congested space. Therefore, during installation, there is a potential for Health and Safety issues to arise as employees are exposed to hazards. Accessibility around the valves may be more limited.	1. Conduct detailed walkdown (including drawing confirmation) during D1041. (complete) 2. Prepare Human Factors forms to identify and address concerns 3. Current processes and procedures will be followed (event free tools, etc.) 4. Potential use of mock up.	Before						9			9
		After						3			3
Issues encountered with valve following installation.	Spare NC1 valve to be procured. Spare parts for commissioning to be procured.	Before			9						9
		After			6						6
New valves may: - be more prone to passing (leakage), - be less reliable (open/close), - not accommodate routine testing.	1. Collect additional OPEX from other stations and vendor. 2. Tech Spec includes seat leakage requirements. 3. To be verified during valve testing. 4. To be analyzed during Detailed Design.	Before			6						6
		After			4						4
Temporary installation conditions may require excessive analysis (eg. Slinging, Jacking/Spreading)	Assessments will be complete by EMD (or Design Agency - Managed Task) to identify requirements well in advance.	Before	6	9							9
		After	4	6							6

7/ POST IMPLEMENTATION REVIEW

Type of PIR:	Targeted Final AFS Date:	Targeted PIR Approval Date	PIR Responsibility (Sponsor Title)
Simplified	29-Dec-23	31-Dec-25	Director, Station Engineering

	Measurable Parameter	Current Baseline	Targeted Result	How will it be measured?	Who will measure Person / Group?
1.	Acceptable LRV opening and closing limits established.	Current opening / closing time is < 0.05 seconds	Opening / closing times between 1.0-3.0 seconds	Through valve/actuator testing and commissioning following each unit's installation	Vendor / Contractor / MC
2.	Confirm by analysis that valve operation effectively reduces waterhammer to acceptable levels under all design basis events for which the LRVs are called to operate, with consideration to the full range of design and operating conditions.	Cannot be demonstrated that piping meets ASME Section III stress and fatigue limits under all design basis events for which the LRVs are called to operate, with consideration to the full range of design and operating conditions.	Perform ASME Section XI flaw tolerance evaluation to demonstrate piping condition is acceptable under all design basis events for which the LRVs are called to operate, with consideration to the full range of design and operating conditions.	Hydraulic and Stress Analysis modeling to be used as input into Section XI analysis, to be completed during Detailed Design Phase.	Design Agency / OPG Engineering Services / Projects Design
3.	Outage inspections of piping and support.	Piping and supports are inspected every planned outage	Reduce number of inspections to every 2nd or 3rd planned outage per inspection	Reduced inspection frequency as derived by Engineering Services per ASME Section XI.	OPG Engineering Services / Projects Design
4.	Relocation of LRV warming line to mitigate large temperature gradient (as high as 80°C) condition upstream of LRVs due to stagnant fluid.	Current LRV warming line is located on the vertical run of pipe upstream of the LRVs. Due to this configuration, a portion of fluid immediately upstream of the LRVs remains stagnant and cools due to natural convection.	By relocating LRV warming line closer to LRVs with the connection to the horizontal run, fluid will circulate this dead leg region and ensure temperature gradient does not develop.	Temperature will be measured immediately upstream of the LRV inlet and compared with temperature measured at a location further upstream. Temperature measurements are expected to be within 20°C.	Vendor / Contractor / MC

APPENDIX "A' GLOSSARY (acronyms, codes, technical terms)

ASME	American Society of Mechanical Engineers
BCS	Business Case Summary
CNSC	Canadian Nuclear Safety Commission
CED	Code Effective Date
DIRP	Discovery Issue Resolution Process
HT	Heat Transport
HTS	Heat transport System
LRV	Liquid Relief Valve
TBD	To Be Determined
PEP	Project Execution Plan
SMB	Site Management Board
EDM	Engineering Decision Meeting
OPEX	Operating Experience
ITP	Inspection and Test Plan
SOW	Scope of Work
ES	Engineering Services

APPENDIX "B" Comparison of Total Project Estimates

$ 000's		This Appendix compares the Total Project Estimate for each BCS										
			Total Project Estimate (by Year incl Contingency)									
BCS Type	Class	Mth	Yr	2009	2010	2011	2012	2013	2014	2015	Later	Total Project Est
Developmental	OM&A	Dec	2008	680	1,090	528	3,528	6,966	3,606			16,398
Partial	OM&A	Oct	2009	550	1,651	444	3,127	5,682	2,989			14,443
Partial	OM&A	May	2011	462	597	970	3,008	2,873		333	13,366	21,609
												0
												0
												0

LTD Spent	OM&A	Apr	2011	462	597	217						1,276
LTD Spent												0
LTD Spent												0

Comments:

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APPENDIX "C" FINANCIAL MODEL – ASSUMPTIONS

Financial Assumptions:

Discount Rate:	7%	Cost Escalation (Yr)	2%	SR&D Opportunity	Yes
Progress Payments	No	Foreign Currency	Yes	Retainer Fee	No
Depreciation Rate (Capital)	N/A	PST	No	Interest Rate (Capital)	OM&A N/A
Revenue Rate	N/A	Leasing	No	Indexed Priced Contract	No

Comments:
This Project has been classified as OM&A funding. Per Finance, 2% inflation rate was used for cost escalation for years 2016 to 2024.

Project Cost Estimate:

Design Complete:	Zero to Minimal	Fixed Price Contract	No	3rd Party Estimate	Yes
Quality of Estimate	Budget +30% to -15%	OPEX used	Yes	Lessons Learned	No
Similar Projects	Yes	Budgetary Quote	Yes	First Unit Actual Used	N/A
Firm Vendor Proposal	Yes	Cost Sharing	No	Competitive Bid	Yes
Reviewed by Sponsor	Yes	Fee for Service	No	Contracts in place	No

Comments:
A budgetary vendor proposal was received for the valve design, testing, and fabrication of five (5) Nuclear Class Valves. A budgetary estimate was received for the remaining eleven (11) Nuclear Class Valves. A firm vendor proposal was received for the modeling, hydraulic and stress analysis scope of work. Budgetary estimates were received for the installation & commissioning of the valves.

Rationale for Capital Cost Classification:

N/A

Generation Plan Assumptions:

Station	Unit	EOL or Refurb	MW	Planned Outages for Project Work						
Pickering A	1	Jun-20	515							
	4	Jun-20	515							
Pickering B	5	Nov-18	516							
	6	Nov-18	516							
	7	Jun-20	516							
	8	Jun-20	516							
Darlington	1	Sep-16	878							
	2	Feb-18	878							
	3	Sep-19	878							
	4	Jan-21	878							

Comments:
Installations will be completed during the following Refurbishment Outages:

- First Unit - ~ 2017
- Second Unit - ~ 2019
- Third Unit - ~ 2021
- Fourth Unit - ~ 2023

APPENDIX "D" FINANCIAL MODEL – ASSUMPTIONS
Impact on Operations

NPV Assumptions

This is the complete set of assumptions used in the calculation of NPVs for the BCS, Part A and Part B.

Base Case
- As this is a Regulatory project, the Base Case option has not been financially evaluated, and thus the PV is, by default, zero.

Alt 1 Recommended Alternative
- The PV was arrived at by using a simple NPV calculation of the costs in the Project Cost Summary (Attachment A)

Alt 2 and all subsequent Alternatives - Not Recommended
- As none of these options would meet the regulatory requirements, they have not been financially evaluated.

APPENDIX "E" *PROJECT DELIVERABLES (for this release)*

Item	Description	Deliverable	Cost ($000's)
1	Project Management	Project Administration	539
		Project Reporting - Schedule, Cost, Risk	
		DA & Valve Vendor Contract Management	
		CNSC Updates	
2	Project Management Office	Project Reporting - Schedule, Cost, Risk	98
3	Partial Release	Business Case Summary	38
		Basis of Estimate	
		Risk Management Plan	
		Project Execution Plan	
4	Installation Contract	SOW	22
		Issue RFP	
		Bid Evaluation	
5	OPG Design	DA deliverables review and acceptance	670
		Valve Vendor review and acceptance	
		Mechanical Design EC	
		Civil Design EC	
		I&C Design EC	
		Over Pressure Report	
		Final Thrust Calculation (ACE)	
		ASME Section XI Fatigue Analysis	
		Independent Design Review	
		CNSC Design Acceptance	
		TSSA Registration/Reconciliation	
6	Design Agency Contract	Certified Hydraulic & Stress Analysis Report	2100
7	Valve Manufacturer Contract	Design & Delivery of 5 Class 1 LRV Valves	[redacted]
8	Overheads	Training	
		Travel	
		Project Support Allocation	
9	Contingency		
Total			**8,282**

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ATTACHMENT "A" PROJECT COST SUMMARY

$ 000's OM&A		LTD Dec 2010	2011	2012	2013	2014	2015	2016	Later	Total
Accounting Basis	Project Mgmnt & Support	319	358	364	365		250		1,400	3,056
	Engineering	690	452	679	505		28		301	2,655
	Procurement			630	270				5,844	6,744
	Construction									
	Other									
	Design Agency									
	Interest (Capital Project)									
	Project Costs									
	General Contingency									
	Specific Contingency									
	Project Costs	1,059	970	3,008	2,873	-	333	-	13,366	21,609

$ 000's OM&A			LTD Dec 2010	2011	2012	2013	2014	2015	2016	Later	Total
Funding Basis	Current Release	Project Costs									
		Contingency									
		Total									
	Adj to Current Release	Project Costs									
		Contingency									
		Total									
	This Release	Project Costs									
		Contingency									
		Total									
	TTD Released	Project Costs									
		Contingency									
		Total									
	Future Releases	Project Costs									
		Contingency									
		Total									
	Project Funding										
	Contingency Funding										
	Total Funding		1,059	970	3,008	2,873	-	333	-	13,366	21,609

Budget	2011 - 2015 Business Plan		970	2,606	4,735	2,491				10,802
	Variance to Budget	1,059	(160)	(93)	(2,335)	(2,491)	278	0	11,734	7,992
Other	**Removal Costs (above)**									-
	Inventory W / O									-
	Spare Parts in Invent									-

Reviewed by: (Date)
Ricardo Fiorini — 27-MAY-2011
Ricardo Fiorini
Project Manager

Approved by: (Date)
George Makdessi — 27 May 2011
George Makdessi
Strat IV Manager

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ATTACHMENT "B" PROJECT VARIANCE ANALYSIS

	$ 000's OM&A	LTD Apr 2011	Total Project Last BCS Oct 2009	Total Project This BCS May 2011	Variance	Comments
Scores Basis	Project Mgmnt & Support	375	2,506	3,056	550	Support costs during installation increased.
	Engineering	851	1,377	2,655	1,278	Detailed Design scope significantly more complex and detailed than originally estimated.
	Procurement		4,020	6,744	2,724	RFP actual contract costs for design and procurement of LRVs was significantly higher than the budgetary quoted received in 2009. Significant cost increase for valve testing following Tech Spec issuance to vendor with RFP. Cost of NC1 piping and fittings have been added.
	Construction	[redacted]				Installation in Refurbishment Outages. Budgetary estimates received from contractors. Installation costs increased slightly.
	Other					This includes the contracts with ANRIC Enterprises and Faithful & Gould, 3rd party estimator.
	Design Agency					Design Agency required for hydraulic and stress analysis.
					-	
					-	
					-	
	Interest (Capital Project Only)				-	
	Project Costs (Scores Basis)	[redacted]				
	General Contingency					
	Specific Contingency					
	Project Costs (Scores Basis)	**1,276**	**14,443**	**21,609**	**7,166**	

Other	**Removal Costs included above**				-	
	Inventory to be written off				-	
	Spare Parts in Inventory				-	

Comments:

ATTACHMENT "C" **SCHEDULE**

Key Milestones

Completion Date	Description
19-May-11	PEP Approved
1-Sep-11	Long Lead Material Contracts Awarded
30-Apr-14	Detailed Design Complete
31-Dec-15	Partial Release BCS Approved
Click here to enter a date.	
Click here to enter a date.	
Click here to enter a date.	
Click here to enter a date.	
Click here to enter a date.	
Click here to enter a date.	
Click here to enter a date.	

A Project Execution Plan (PEP) will be approved by 19-May-11

In Service Declarations: (Capital only)

Date	Description	$000's (Total = Project Cost incl contg)	% In Service (= 100%)
Click here to enter a date.			
Click here to enter a date.			
Click here to enter a date.			
Click here to enter a date.			
Click here to enter a date.			
Click here to enter a date.			
Click here to enter a date.			
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Click here to enter a date.			
Click here to enter a date.			

Comments:

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Risk Probabilities Chart

Likelihood	Improbable	Unlikely	Possible	Likely	Probable
Probability	<= 1 in 100	About 1 in 100	About 1 in 10	About 1 in 5	>= 3 in 4
Rank	1	2	3	4	5

Risk Impact Chart

Impact Rating	Financial	Project Schedule 12 month	Quality	Corporate Reputation	Regulatory / Legal	Health & Safety	Environment	Nuclear Safety
5	>80% of Total Project $	> 90 day delay	Significant, unacceptable non-conformance requiring extensive rework	National and international adverse coverage or impacts	Non-compliance with potential for significant implications for personnel, potentially large damages or Criminal Charges OR Potential loss of operating licenses	Potential for fatality(s)	Spill or release causing immediate and extended impact with off-site impacts, e.g.:Clean-up costs > $15MCat. A spill (>55 pts)	Loss or serious degradation of a safety system
4	30% - 80% of Total Project $	30 - 90 day delay	Unacceptable non-conformance requiring some rework, but not major	Long-term local or national impact	Legislative non-compliance with potential for fines, charges, and damages ORMajor degradation of reputation with regulatory bodies	Potential for life-threatening critical injury or permanent total disability, including occupational disease	Exceedances resulting in charges or Director's OrderCat. A spill (45 - 55 pts)Public complaints with OPG implications Explosion and/or major fire	Reduced effectiveness of a safety system
3	15% - 30% of Total Project $	10 - 30 day delay	Non-conformance bordering design tolerances, potential to require rework	Major local impact or minor national impact.Minor local damage	Systematic non-compliance with potential for finesORPotential to cause strained relationship with regulator, increased surveillance and/or regulations	Potential for less serious critical injuries (e.g. fractures), permanent partial disabilities and temporary total disabilities of a significant nature	Cat. B spills Emission in excedance of regulatory or legal limits Field orders or AMP's Public complaints with OPG implications Danger to health, life, or property	Reduced effectiveness of redundant safety system components
2	5% - 15% of Total Project $	3 - 10 day delay	Acceptable non-conformance, within design tolerances, no rework required	Complaints from local officials / politicians	Systematic non-compliance with impacts to project scheduleORPossibility of regulatory / legal implications	Potential for less serious temporary disabilities and injuries requiring off-site medical attention other than first-aid. Complete recovery by worker.	Cat. C spills - reportableAdministrative infractionsPublic Complaints with plant level implications	Impact on a safety support or safety related system
1	<5% of Total Project $	< 3 day delay	Minimal impact on qualityRoutine non-conformance, can be easily dispositioned	Complaints from local public	Isolated non-complianceORRoutine approval / notification	No medical attention beyond first aid, no impairment to worker or complete recovery of worker	Administrative, non-reportable eventsCat. C spills non-reportable and spills resulting from Acts of God	