AECL EACL

Licensing Package

Renewal (2007) of the Dedicated Isotope Facilities (MAPLE 1 & 2 Reactors and the New Processing Facility) Operating Licences-Information Presented for the Day Two CNSC Public Hearing (2007 September 12)

Licensing - Dedicated Isotope Facilities (DIF)

6400-00521-LP-002
Revision 0

2007 September

UNRESTRICTED

2251 Speakman Drive
Mississauga, Ontario
Canada L5K 1B2

septembre 2007

ILLIMITÉ

2251, rue Speakman
Mississauga (Ontario)
Canada L5K 1B2

AECL EACL

Licensing Package

Renewal (2007) of the Dedicated Isotope Facilities (MAPLE 1 & 2 Reactors and the New Processing Facility) Operating Licences-Information Presented for the Day Two CNSC Public Hearing (2007 September 12)

Licensing - Dedicated Isotope Facilities (DIF)

6400-00521-LP-002
Revision 0

Prepared by
Rédigé par
DIF/MMIR Safety & Licensing Team

Reviewed by
Examiné par
D. Garrick,
Manager, DIF Safety & Licensing

Approved by
Approuvé par
D. Taylor,
Director, DIF Operations

2007 September
UNRESTRICTED

septembre 2007
ILLIMITÉ

2251 Speakman Drive
Mississauga, Ontario
Canada L5K 1B2

2251, rue Speakman
Mississauga (Ontario)
Canada L5K 1B2

AECL EACL

Revision History Liste de révisions

UNRESTRICTED
ILLIMITÉ

CW-511300-FM-168 Rev. 0

CW-511300-PRO-161

Document No. / Numéro de document:	6400	00521	LP	002
	Doc. Collection ID ID de la collection de doc.	SI Répertoire du sujet	Section	Serial No. N° de série

Document Details / Détails sur le document

Title Titre	Total no. of pages Nbre total de pages
Renewal (2007) of the Dedicated Isotope Facilities (MAPLE 1 & 2 Reactors and the New Processing Facility) Operating Licences-Information Presented for the Day Two CNSC Public Hearing (2007 September 12)	40

For Release Information, refer to the Document Transmittal Sheet accompanying this document. / Pour des renseignements portant sur la diffusion, consultez la feuille de transmission de documents ci-jointe.

Revision History / Liste de révisions

Revision / Révision					
No./N°	Date (yyyy/mm/dd)	Details of Rev. / Détails de la rév.	Prepared by Rédigé par	Reviewed by Examiné par	Approved by Approuvé par
D0	2007 August	Draft for Review and Comment	DIF/MMIR Licensing Team	A. White A. Lee L. Lupton D. Garrick D. Taylor	
R0	2007 August	Issued for Use	DIF/MMIR Licensing Team	D. Garrick	D. Taylor

FIGURES

APPENDICES

1. INTRODUCTION

1.1 Scope

This document has been prepared to assist the Canadian Nuclear Safety Commission (CNSC) or Commission members in their assessment of the application from Atomic Energy of Canada Limited (AECL) to renew the operating licences for the Multi-purpose Applied Physics Lattice Experimental (MAPLE) Reactors 1 and 2 [1-1] and the New Processing Facility (NPF) [1-2], collectively known as the Dedicated Isotope Facilities (DIF). This document has been compiled following consideration of the discussions that took place at the CNSC Day One Public Hearing held in Ottawa 2007 June 22 and recent discussions with CNSC staff. Furthermore, this document includes an update of key developments at the DIF since the Day One Public Hearing.

1.2 Purpose of this Submission

The principal purpose of this document is to provide information in support of AECL's application for a 47-month licence renewal period for MAPLE and NPF operating licences, with a proposed expiry date of 2011 October 31, under one single licence. This will align MAPLE and NPF licence renewal periods with Chalk River Laboratories (CRL) site licence period. Aligning the licence periods and combining the licences will facilitate inclusion of MAPLE and NPF facilities within the CRL site licence, Nuclear Research and Test Establishment Operating Licence, NRTEOL-01.00/2011 [1-3], following CRL site licence renewal in 2011 October.

The application for renewal has been made in accordance with applicable Commission Member Documents [1-4] and [1-5]. Reference [1-4] identifies guidelines for a licence period up to five years or longer, and AECL's view is that these guidelines have been met, as supported by the information contained herein and previously submitted for consideration at the CNSC Day One Public Hearing [1-6].

1.3 Conclusion

AECL believes that its operations of DIF has and will continue to make adequate provisions for health, safety, security and the environment, and met Canada's international obligations. This submission meets AECL's commitments for providing supplemental information for the Day Two Public Hearing; furthermore this information supports AECL's request for a 47-month licence.

1.4 References

[1-1] "Non-Power Reactor Operating Licence- MAPLE 1 and 2 Nuclear Reactors." Licence Number NPROL-62.00/2007, Expiry Date: 2007 November 30.

[1-2] "Nuclear Substance Processing Facility Operating Licence – New Processing Facility." Licence Number NSPFOL-03.00/2007, Expiry Date: 2007 November 30.

[1-3] "Nuclear Research and Test Establishment Operating Licence, Chalk River Laboratories", Licence Number NRTEOL-01.00/2011, Expiry Date: 2011 October 31.

[1-4] "New Staff Approach to Recommending Licence Periods", CMD 02-M12, 2002 March.

[1-5] "New Staff Approach to Recommending Licence Periods (Supplementary Information)", CMD 02-M12.A, 2002 March.

[1-6] "Renewal (2007) of the Dedicated Isotope Facilities (MAPLE 1 & 2 Reactors and the New Processing Facility) Operating Licences – Information Presented for the Day One CNSC Public Hearing (2007 June 22)", 6400-00521-LP-001, (CMD-07-H16.1), Revision 0, 2007 May.

2. INFORMATION REQUESTED AT DAY 1 HEARING

Itemized below are the topics that were raised by Commission members at the CNSC Day One Public Hearing held on 2007 June 22, where further follow up was required or where AECL indicated that further information would be provided at the Day Two Public Hearing.

In the following sections these matters are grouped as overall topics as each one received several questions as per the Day One Transcript.

2.1 Organization

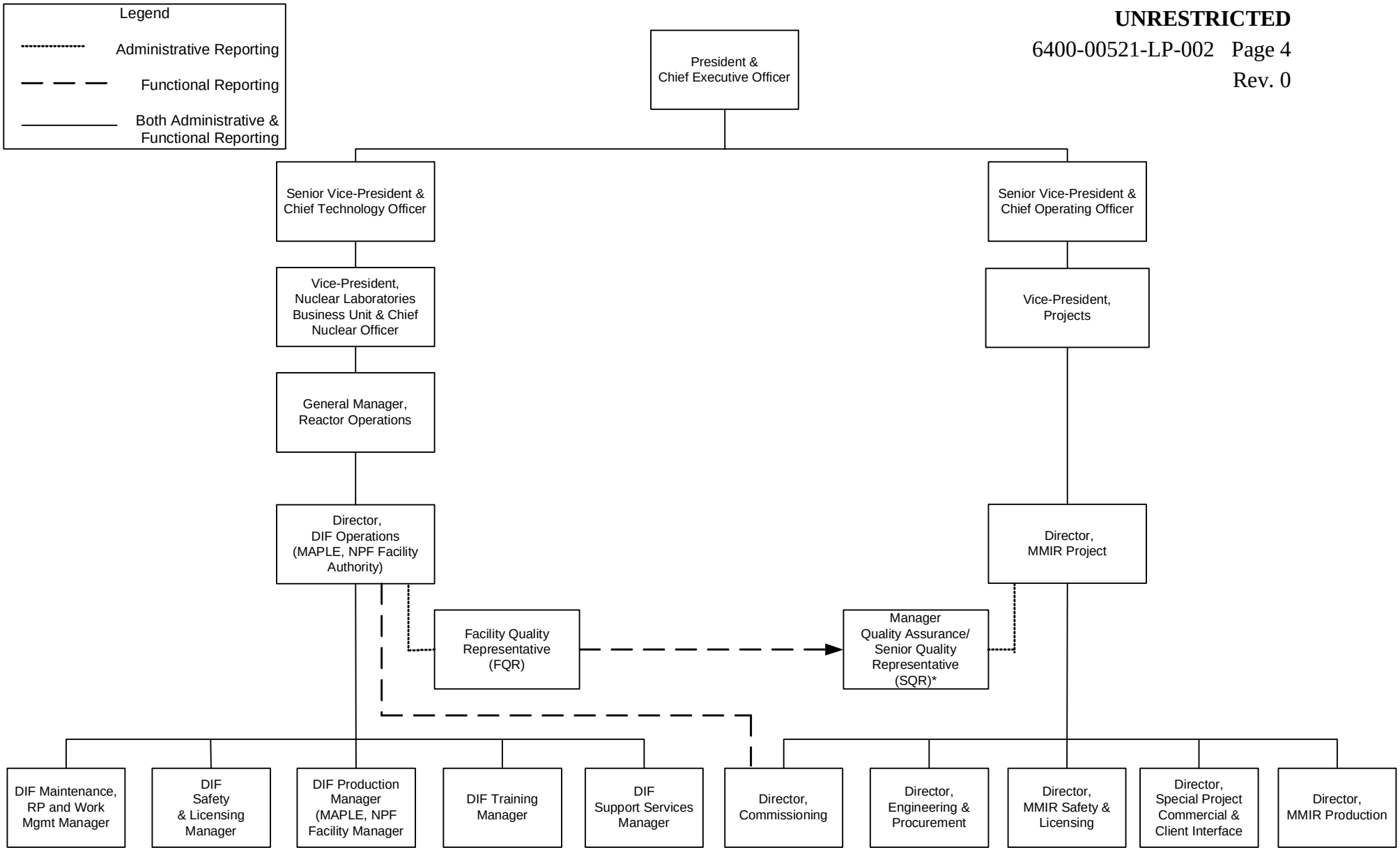
The Commission members requested a high-level integrated organization chart that shows the link between the MDS Nordion Medical Isotopes Reactor (MMIR) Project and DIF Operations and to show the reporting relationship for Quality Assurance.

AECL is the owner of all nuclear facilities, including DIF, at its Canadian sites. The President and CEO of AECL is responsible for the owner's duties as defined in the CAN/CSA N286.0 Standard. The President has assigned the responsibility and authority for the Commercial Operations to the Senior Vice-President, Chief Operating Officer (COO) and for Technology Development to the Senior Vice-President, Chief Technology Officer (CTO). The COO has further delegated responsibility for the MMIR Project to the Vice-President Projects and the CTO has further delegated responsibility for operation of DIF to the Vice-President Nuclear Laboratories and Chief Nuclear Officer.

The MMIR Project group is responsible for procurement, design, construction and commissioning activities of the various systems in DIF. Once those systems have been commissioned, they will be turned over to DIF Operations.

DIF Operations has physical control of the plant and has the responsibility for the day-to-day operation and maintenance of DIF. Also, DIF Operations has been delegated the N286.0 Owner's role for DIF. MMIR Project is a key participant to DIF Operations; therefore, DIF Operations must authorize any physical activity performed by MMIR Project in DIF.

The integrated DIF Operations and MMIR Project organizational structure is shown in Figure 1. The roles and responsibilities for the key positions are presented in the sections immediately after.



*This position reports to Director, Corporate Standard & CANDU Products and Services QA

Figure 1: Integrated Organization Chart for DIF Operations and MMIR Project

2.1.1 Organizational Structure and Responsibilities

2.1.1.1 DIF Operations Organizational Structure and Responsibilities

Vice-President Nuclear Laboratories and Chief Nuclear Officer

The Vice-President Nuclear Laboratories leads the Nuclear Laboratories Business Unit and reports to the Senior Vice-President and CTO. The Vice-President is responsible and has authority for the overall management for the safe operation, maintenance and use of the AECL licence-listed facilities including nuclear programs with all applicable codes, standards, laws, regulations and licences. The mandate of the Vice-President unit is to:

- Operate AECL's nuclear sites and facilities safely, responsibly, and cost-effectively
- Maintain and advance the technology for AECL reactor products and services
- Manage decommissioning and waste management responsibilities on behalf of AECL and the Government of Canada
- Manage the production and sales of isotopes
- Manage the transition in isotope production from NRU/MPF to DIF
- Support the commercial application and development requirements of other AECL business units (e.g., ACR, new products and services)

General Manager Reactor Operations

The General Manager Reactor Operations reports to the Vice-President Nuclear Laboratories and Chief Nuclear Officer. The General Manager Reactor Operations is responsible for developing and implementing plans to address strategic business issues such as the transfer of short-lived medical radioisotope target irradiation and processing from NRU/MPF to DIF, future operation/refurbishment of NRU, MPF monitoring/safe shutdown, and implementing and maintaining a sustainable staffing strategy for the facilities/isotope production stream. The General Manager ensures the implementation of the company management systems, quality assurance programs, and nuclear programs in a consistent manner across Reactor Operations.

Director DIF Operations

The Director DIF Operations reports to GM Reactor Operations within NLBU. The Director DIF Operations is the Facility Authority for the MAPLE 1 and MAPLE 2 reactors, per the MAPLE Reactors Operating License [2-1], and the Facility Authority for NPF, per the NPF Operating Licence [2-2] and their referenced documents.

The Director DIF Operations is responsible for the operation, maintenance, safety and licensing, technical support, and support services for the MAPLE Reactors, MAPLE Iodine Production Facility (MIPF) and NPF. This includes ensuring the operational readiness of the facilities and the management of their licenses and associated commitments. The Director is assigned the requisite authority to carry out the duties assigned with respect to the designated facilities and DIF Operations QA Program.

DIF Operations Line Managers

DIF Maintenance, Radiation Protection, and Work Management, Safety & Licensing, Production, Training, and Support Services managers all report to the Director DIF Operations.

The DIF Facility Quality Representative (FQR) and the Director of MMIR Commissioning also report to the Director DIF Operations. The DIF FQR reports administratively to the Director DIF Operations and functionally to the Manager DIF Quality Assurance. The Director MMIR Commissioning reports directly to the Project Director MMIR Project but reports to the DIF Facility Authority for the maintenance of a safe operating envelope and work environment, and for coordinating the execution of the commissioning activities by DIF Operations staff.

2.1.1.2 MMIR Project Organizational Structure and Responsibilities

Vice-President Projects

The Vice-President Projects reports to the Senior Vice-President and COO. The Vice-President Projects leads the Projects business unit. The unit is responsible for a number of New-Build and Refurbishment/Retube projects, including the MMIR Project.

Director MMIR Project

The Director MMIR Project is responsible for all aspects of the tasks undertaken by the MMIR Project personnel. The Director has the overall line management responsibility and accountability for the effective implementation of the MMIR Project QA Program. The Project Director reports to Vice-President Projects.

Reporting to the Director MMIR Project

The Directors of Commissioning, Safety and Licensing, Engineering and Procurement, Production, and Special Projects Commercial and Client Interface all report to the Director MMIR Project.

The Manager QA/Senior Quality Representative (SQR) reports administratively to the Director, MMIR Project and functionally to the Director Corporate Standards & CANDU Products and Services QA.

2.1.1.3 Organizational Structure and Role of Quality Assurance (QA)

Director Corporate Standards & CANDU Products and Services QA

The Director Corporate Standards & CANDU Products & Services QA is responsible for establishing corporate standards in terms of the suite of Corporate QA programs and procedures as needed to support AECL's business objectives and achieve compliance with regulatory requirements related to quality assurance.

Manager DIF Quality Assurance

The Manager DIF Quality Assurance is the Senior Quality Representative for DIF Operations as well as for the MMIR Project. As stated above, the Manager, DIF Quality Assurance reports administratively to the MMIR Project Director and functionally to Director, Corporate Standards & CANDU Products and Services QA.

The Manager DIF Quality Assurance has the authority and responsibility to report conditions adverse to quality, that are not resolved within the line organization in a timely manner to the Director, Corporate Standards & CANDU Products & Services QA and to the Director, MMIR Project

Facility Quality Representative

The DIF FQR reports administratively to the Director, DIF Operations and functionally to the Manager, DIF Quality Assurance. The FQR is responsible for preparing the DIF Operations Quality Assurance Manual, DIF quality procedures, and the DIF Audit Program Plan. Also, the FQR accepts quality processes and procedures upon review for conformance to the DIF Operations QA Program and applicable Company quality procedures. Furthermore, the FQR monitors the implementation of the quality program for compliance and effectiveness.

2.1.2 Operations Oversight

DIF Operations has, and exercises, the authority for carrying out and overseeing all activities that take place within the facility, including all project activities.

All fieldwork carried out in the facility is controlled by procedures developed to meet the DIF Operations Quality Assurance manual, and approval for work to proceed is ultimately controlled by the Facility Authority. It should be noted that there is no distinction within the facility between MMIR Project work and DIF Operations work.

Both commissioning and construction activities follow the DIF operations work management procedure. The key elements of this procedure are that work is planned, scheduled and approved by the Facility Manager prior to execution.

In regards to design changes to the facilities, DIF Operations staff participate in the design change process to ensure that design modifications take into account both operations and maintenance considerations. The Facility Authority is a required signatory on all change requests (i.e. all change requests must be accepted by the Facility Authority).

2.2 Schedule

This section presents information regarding the project milestones for completing the activities required to bring the DIF to service, and further clarifications with respect to the schedule and licensing activities required to be completed prior to obtaining regulatory approvals, in response to questions from Commission members during the 2007 Day One Public Hearing.

2.2.1 Project Milestones

The overall logic chart showing the plan to bring the DIF to service is provided in Figure 2. This figure identifies the key milestones for each of these facilities. These milestones have been developed in accordance with CNSC staff acceptance criteria documented in CNSC Commission Member Documents (CMD) issued in 2004 [2-3], 2005 [2-4], [2-5], and 2007 [2-6].

The objectives and licensing activities associated with each key milestone for DIF have been described in Section 4 of [2-7]. For each key milestone, operation of the facilities requires approval of the Commission or a person authorized by the Commission in accordance with the current licences for the MAPLE reactors [2-1], NPF [2-2], and the proposed draft licence for DIF [2-8] attached to [2-6]. Details on the types of regulatory approvals required for each key milestone are presented in Appendix A. For key milestones which are to be completed during the next licence period starting 2007 December 01, the types of approvals may change based on the decision of the Commission on the proposed operating licence for DIF.

Figure 3 shows the logic chart of the outstanding licensing prerequisites that AECL is required to complete to obtain regulatory approvals associated with the key milestones for the MAPLE 1 reactor. Details on the deliverables that AECL has produced or plans to produce to address each licensing prerequisite were provided in Appendix B of [2-7].

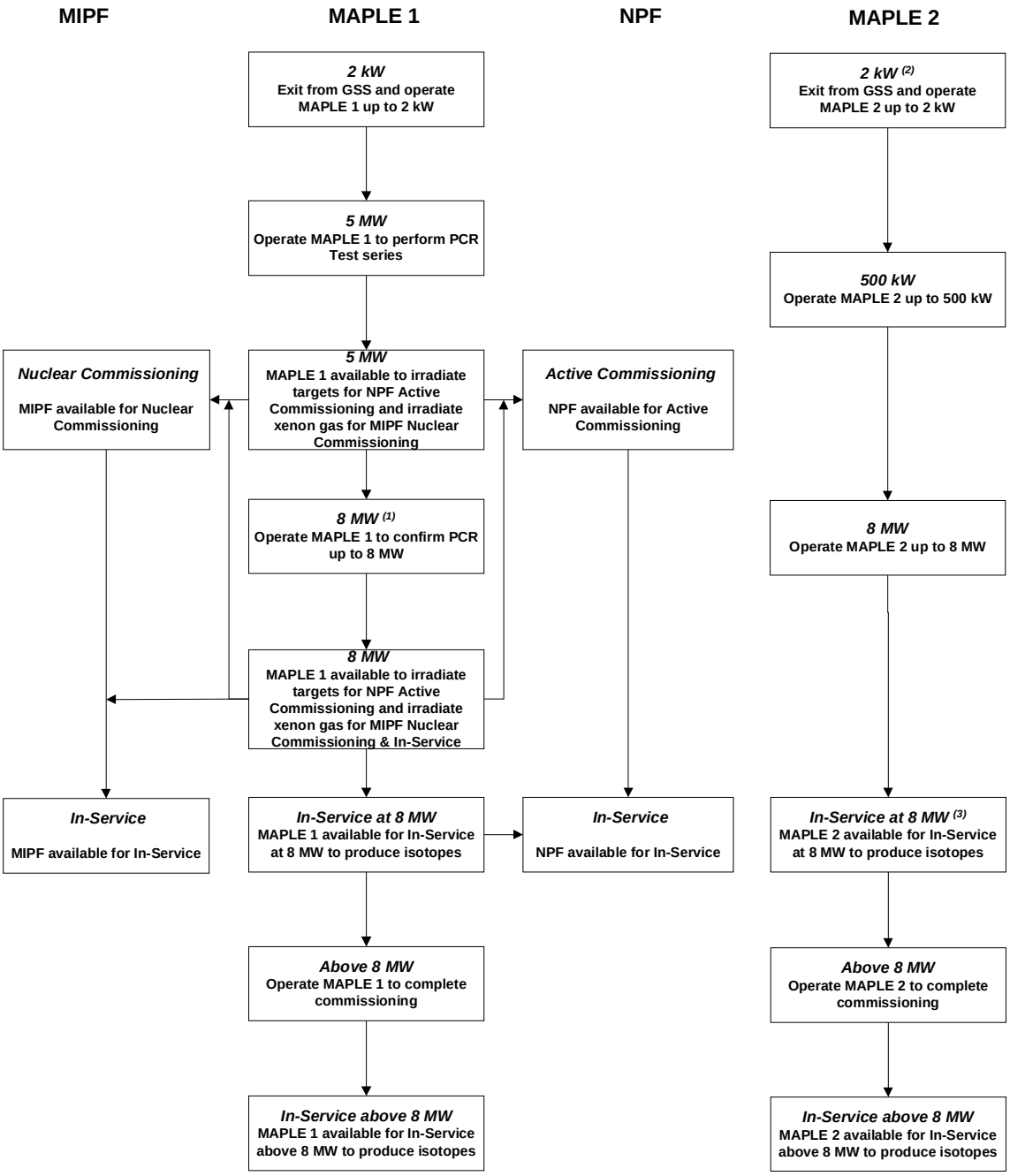
During the 2007 Day One Public Hearing, clarifications were requested with respect to the plans and timing for the validation of the computer codes for the MAPLE reactors. The CNSC CMD [2-6] includes the computer code validation as a licensing prerequisite with associated acceptance criteria for obtaining regulatory approval to operate the MAPLE 1 reactor above 8 MW and before declaring in-service at 10 MW. As AECL's current strategy is to place the MAPLE 1 reactor in-service at 8 MW to produce radioisotopes, AECL will complete work to address this licensing prerequisite as part of the request for approval to declare the MAPLE 1 reactor in-service at 8 MW (see box "Computer Code Validation" in Figure 3). To address the computer code validation acceptance criteria, AECL will submit the following:

- Assessment of Code Validation Results from MAPLE 1 Commissioning up to 8 MW and Impact on Final Safety Analysis Report (FSAR). This assessment document will compare the measured parameters to their respective value assumed in the FSAR, and assess the impact of differences.
- Validation Manual (after the code validation exercises for the MAPLE 1 Phase C commissioning tests at 8 MW are completed). The Validation Manual will summarize the results provided in a series of Validation Reports. A number of Validation Reports have already been generated and submitted to CNSC staff. The remaining Validation Reports will be generated for code validation-related commissioning tests conducted prior to the request to place MAPLE 1 in-service at 8 MW.

To support the updates to the safety analysis after in-service, a number of validation-related tests are planned to be performed after an extended period of operation at 8 MW. The associated reports will be produced after declaring MAPLE 1 in-service at 8 MW.

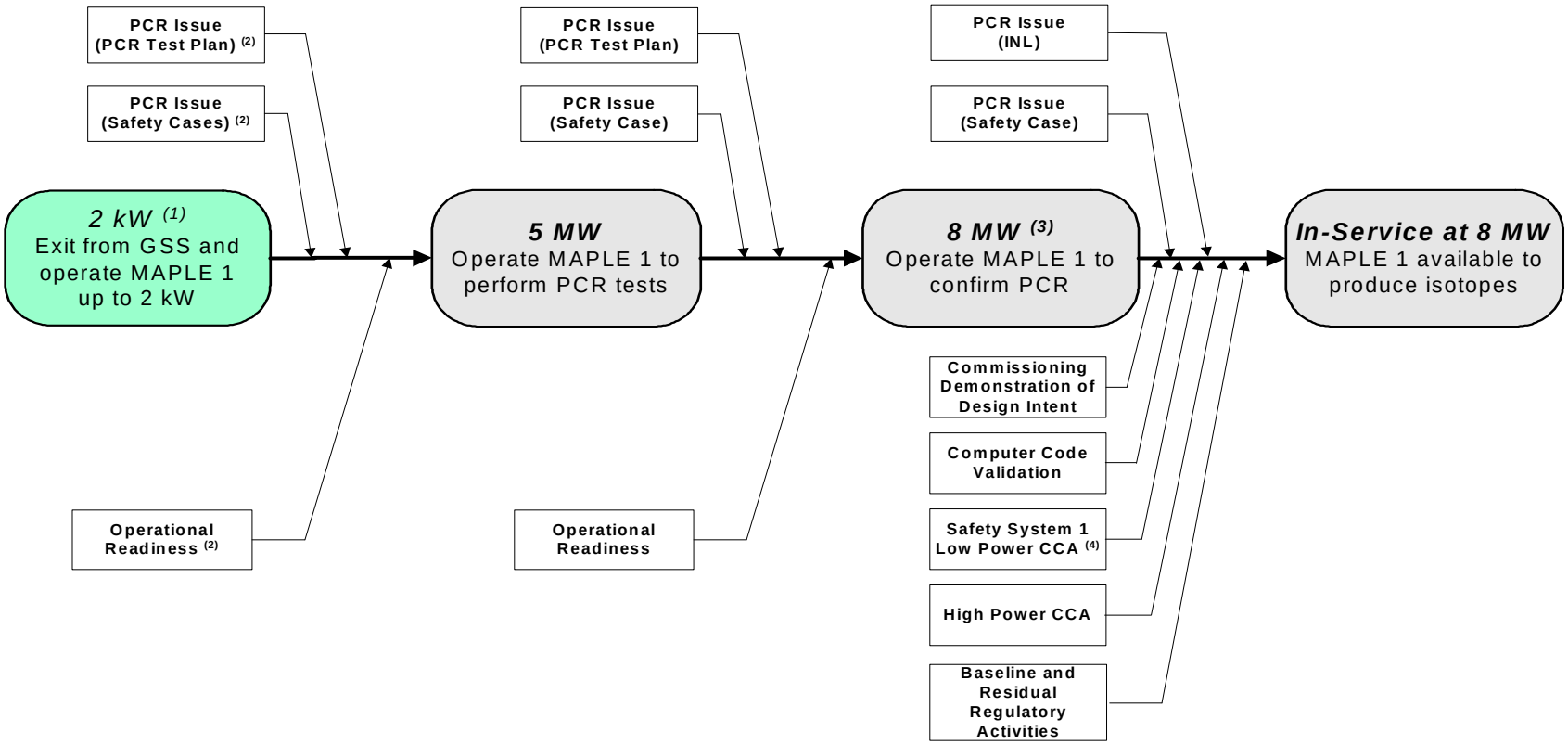
During the 2007 Day One Public Hearing clarifications were also requested with respect to the timing of the work performed by external organizations such as Idaho National Laboratory (INL), U.S.A., Brookhaven National Laboratory (BNL), U.S.A., and INVAP, Argentina, in support of addressing the positive Power Coefficient of Reactivity (PCR) issue. Resolution of this issue is required prior to obtaining approval to declare the MAPLE 1 reactor in-service.

The INL, BNL, and INVAP work is performed during various stages of operation of the MAPLE 1 reactor prior to in-service. The BNL and INVAP reviews were completed prior to obtaining regulatory approval to re-measure the PCR at 5 MW during Series 300 tests. The INL analyses are completed, as required, to provide independent results to support AECL's planning for each stage of operation of the MAPLE 1 reactor. The final INL analyses will be completed prior to placing the MAPLE 1 reactor in-service (see box "PCR Issue (INL)" in Figure 3). Details with respect to the progress made and status of the work have been provided in Appendix B of [2-6] and further clarification is provided in Section 2.3 of this document.



Notes:
(1) The design changes to address the PCR issue will be implemented prior to operating the MAPLE 1 reactor up to 8 MW to perform confirmatory tests
(2) The commissioning of the MAPLE 2 reactor will resume after a resolution to the PCR issue will be implemented in the MAPLE 1 reactor.
(3) Operation of the MAPLE 2 reactor will be as a backup of the MAPLE 1 reactor.

Figure 2: Project Milestones



Notes:
(1) Completed
(2) Incremental during the PCR testing (currently in preparation for the 400 Series PCR tests).
(3) The licensing prerequisites are the same for obtaining approvals for interim operation of the MAPLE 1 reactor at 5 MW and 8 MW
(4) CCA is Commissioning Completion Assurance

Figure 3: Logic Chart of Outstanding Licensing Prerequisites for the MAPLE 1 Reactor

2.2.2 Schedule Comparison and Path Forward

To address a Commission request during the 2007 Day One Public Hearing, copies[1] of the schedules presented at the 2005 Day Two Public Hearing are shown in Figure 4 for the MAPLE 1 reactor and in Figure 5 for NPF, respectively. These were noted in References [2-9] and [2-10] as being "work schedules" which contained significant uncertainties associated with the positive PCR and the work to be performed beyond the PCR testing up to 5 MW in the MAPLE 1 reactor. The 2005 schedules presented an in-service date of 2007 October for the MAPLE 1 reactor and NPF. In 2006 February, the entire project was redefined when AECL assumed ownership of DIF. The schedule was reviewed and revised and the target in-service date moved to 2008 October. This rendered the 2005 schedule after 2006 February no longer applicable, as reflected by the light yellow activities in Figure 4 for the MAPLE 1 reactor and similarly in Figure 5 for the NPF. CNSC staff was kept apprised of this change and the Commission was informed at the mid-term update in 2006 December.

The progress made from 2006 February to date is shown in Figure 6 for the MAPLE 1 reactor, along with activities planned for the coming months. The path forward for the next several months is to complete the Series 400A and 400A-1 PCR tests in the MAPLE 1 reactor and to continue, in parallel, the design and commissioning activities required for the start of NPF Active Commissioning. The schedule for NPF is dependent on the MAPLE 1 schedule as the start of Active Commissioning in NPF (i.e., commissioning with irradiated targets) relies on irradiation of these targets in the MAPLE 1 reactor. The schedules for MIPF and the MAPLE 2 reactor are also dependent on the MAPLE 1 schedule.

It is expected that the outcome of the Series 400A and 400A-1 PCR tests will help to determine a design solution to resolve the PCR issue. The recently completed Series 300 tests show that phenomena associated with the HEU targets contribute to the positive PCR, but are not the sole contributors. The Series 400A test will demonstrate the effect of moderator water heating, and the Series 400A-1 tests will demonstrate the effect of modified LEU driver fuel on the positive PCR. The testing logic is discussed in more detail in Section 2.3.

[1] These are marked-up copies of the 2005 schedules showing the redefinition of the project in 2006 February.

The details of the path forward after these tests may change either somewhat or significantly as more data and analysis related to PCR become available from the tests performed at 5 MW. The overall strategy following these tests remains, however, unchanged from the strategy presented during Day One Public Hearing. After additional data have been analyzed and progress has been made in the determination of the cause of the PCR, the project schedule to completion will be revised to reflect the path forward beyond 5 MW.

In light of the fact that any schedule for activities past the upcoming PCR tests has inherently large uncertainties, AECL proposes to present an update at a public meeting of the Commission after the Series 400A and 400A-1 tests are completed and we have a clearer picture of how the PCR issue will be resolved. At that time, we would describe the outcome of the PCR tests, provide an updated plan for completion of the project, and provide an updated schedule.

In the interim, AECL will continue to keep CNSC staff apprised of progress and our more detailed working schedule forecasts. This will facilitate CNSC staff resource planning and provide advance notice of requests for approval. Figures 7 and 8 are examples of the types of detailed work schedules that are provided to CNSC staff. The schedule, as shown in Figure 7 for the MAPLE 1 reactor, indicates the dates at which requests for approval will be submitted to CNSC staff, and it typically assumes one month for CNSC staff review and comment, comment disposition, and approval. Based on discussions with CNSC staff, this is consistent with CNSC staff expectations for these types of approvals.

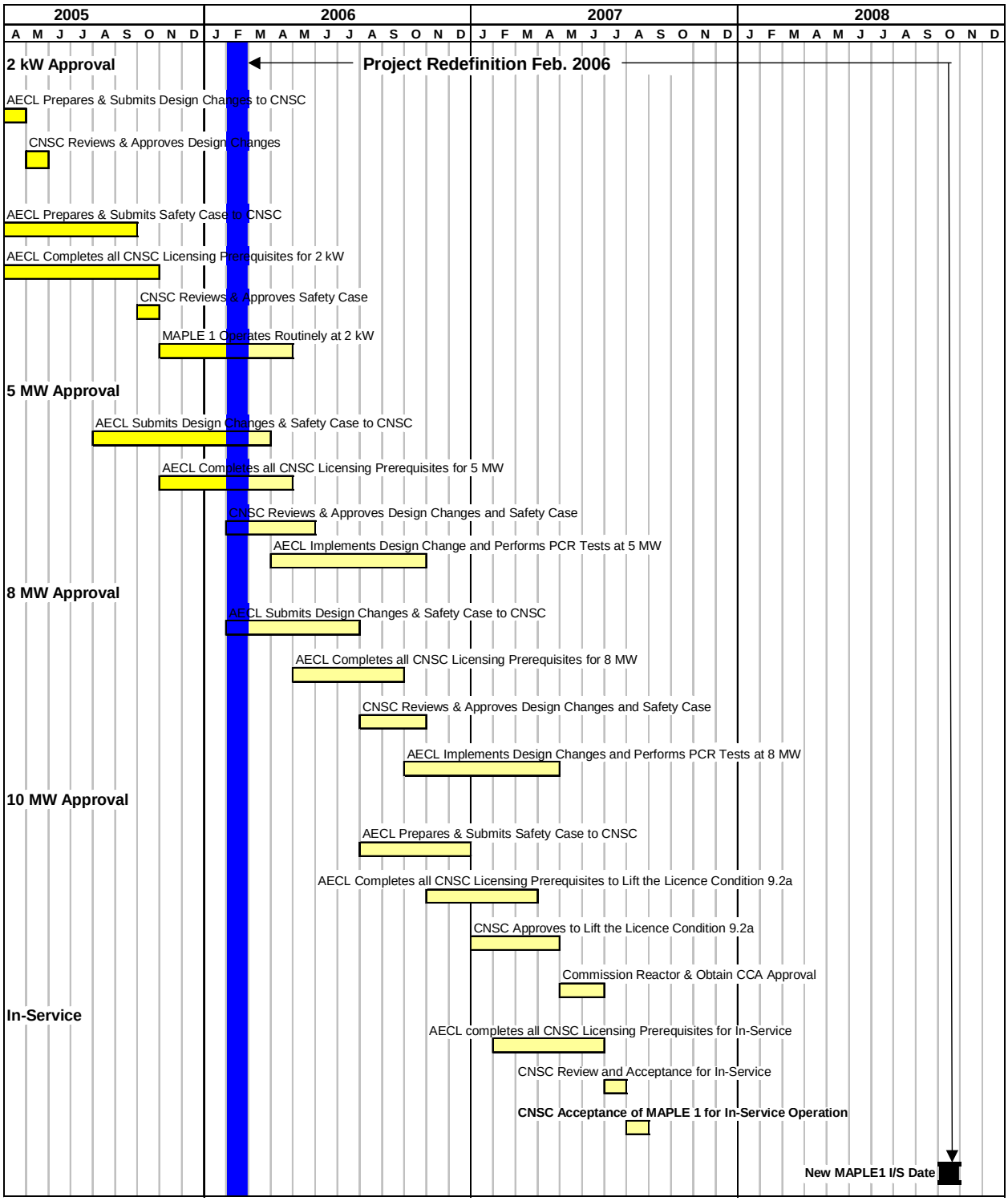


Figure 4: 2005 Schedule for the MAPLE 1 Reactor

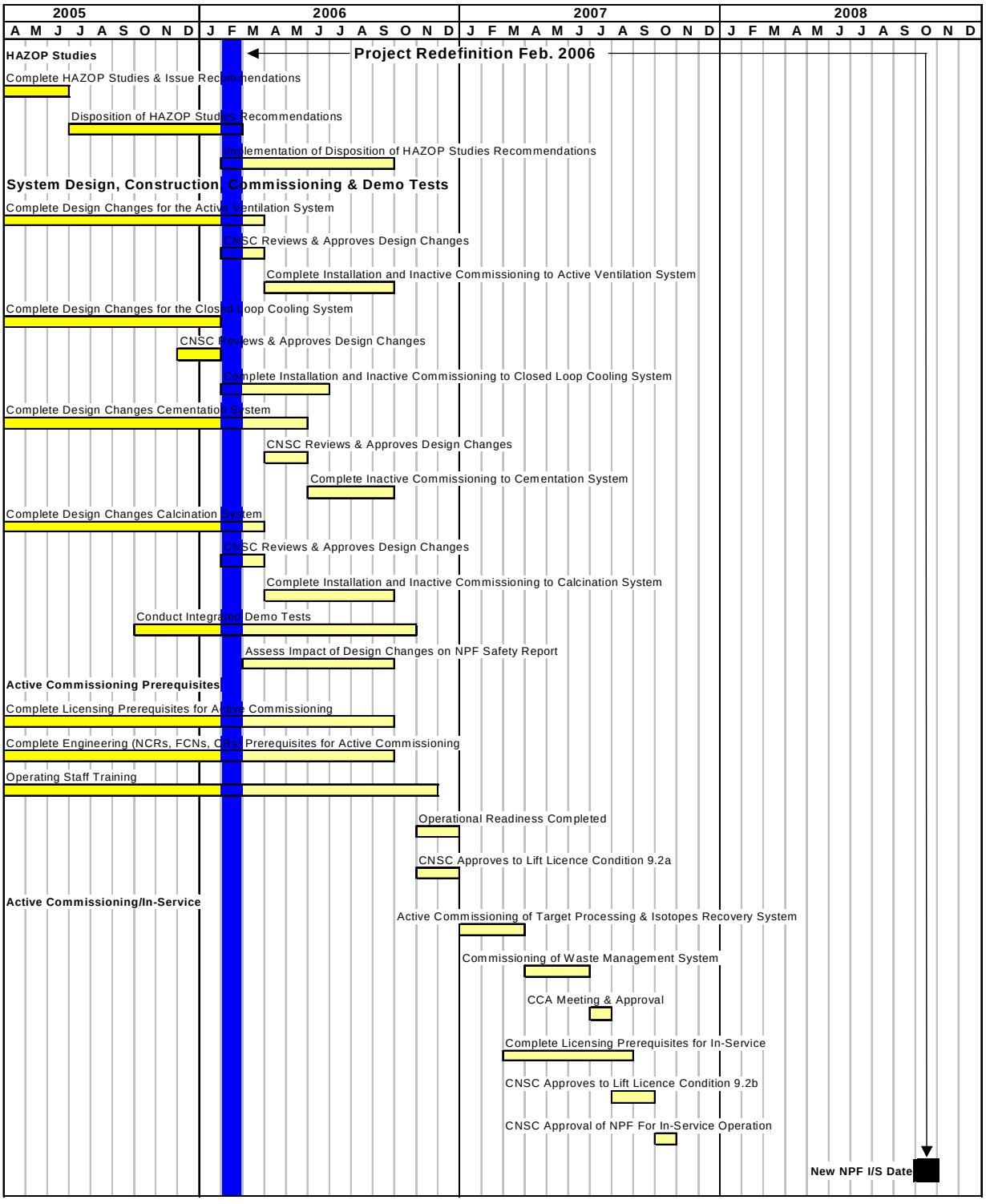


Figure 5: 2005 Schedule for NPF

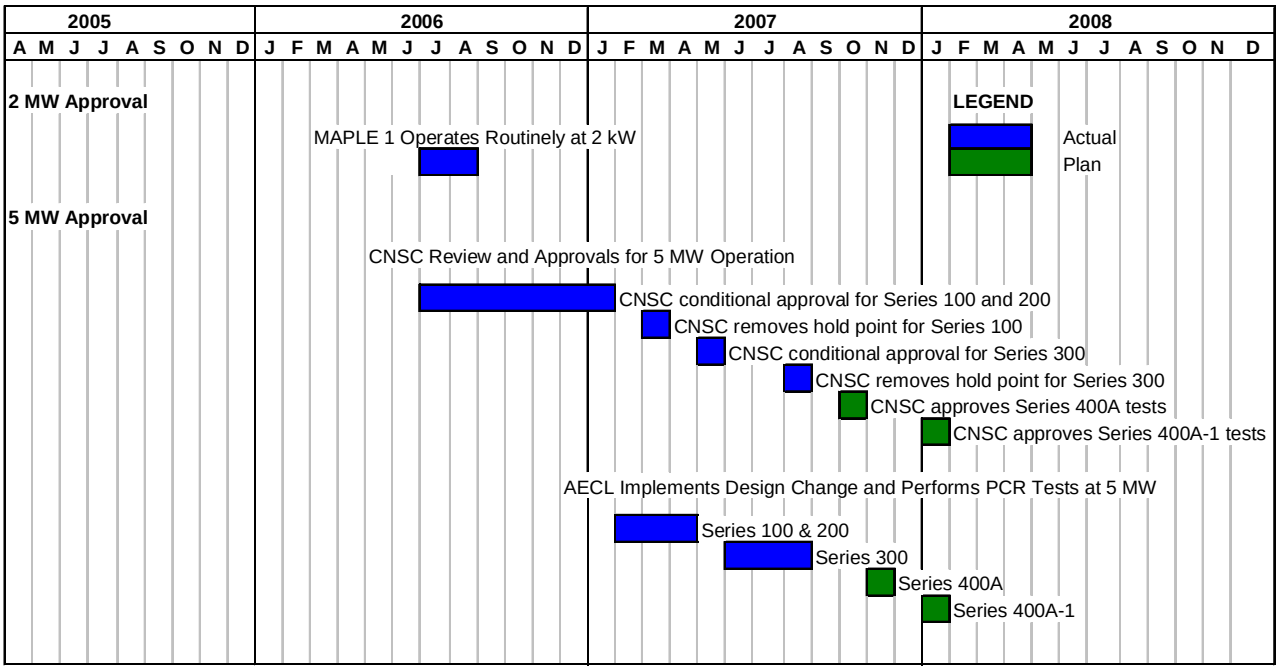


Figure 6: MAPLE 1 Progress and Short Term Plan

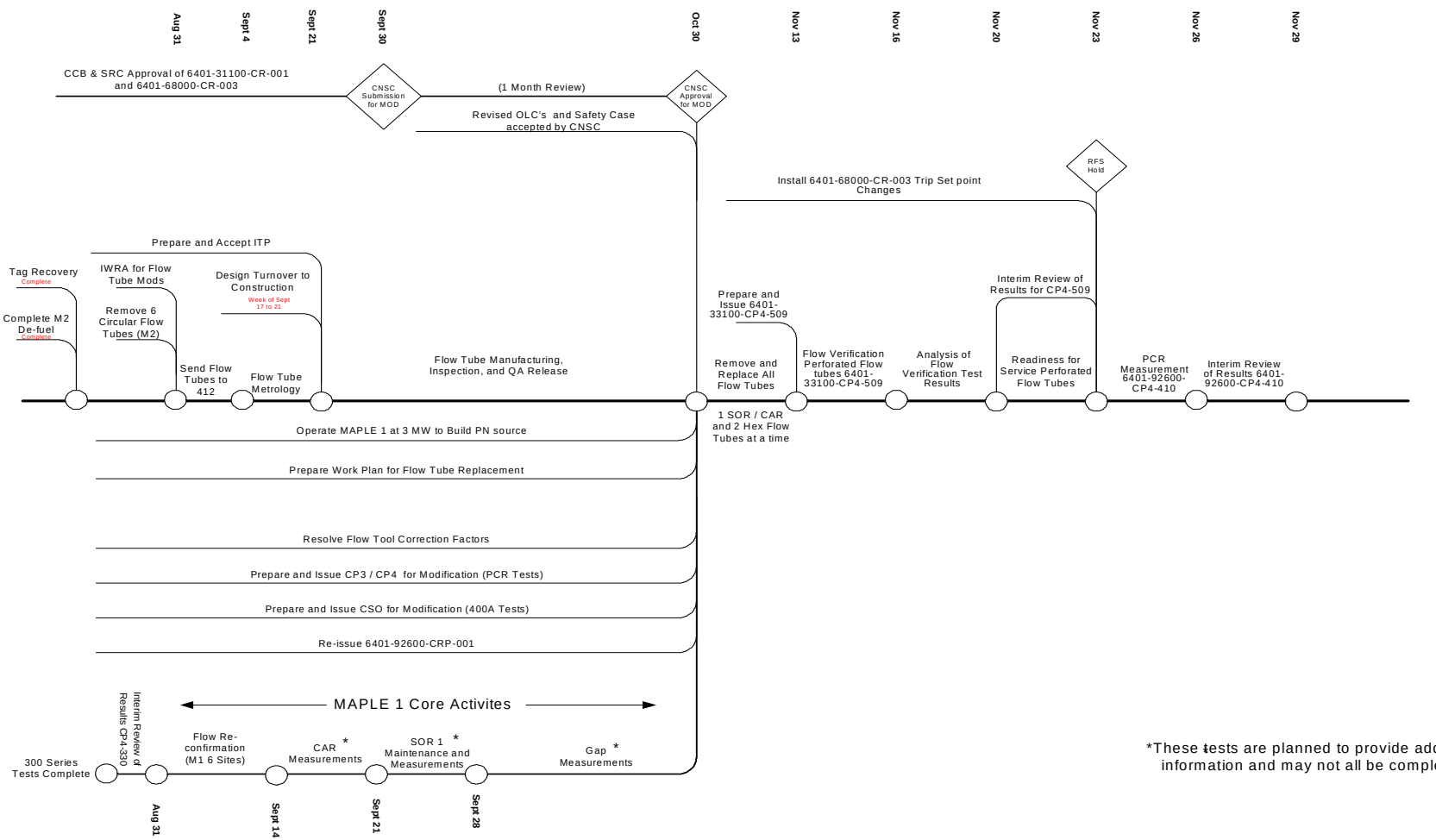


Figure 7: PCR Testing Plan (Work Schedule)

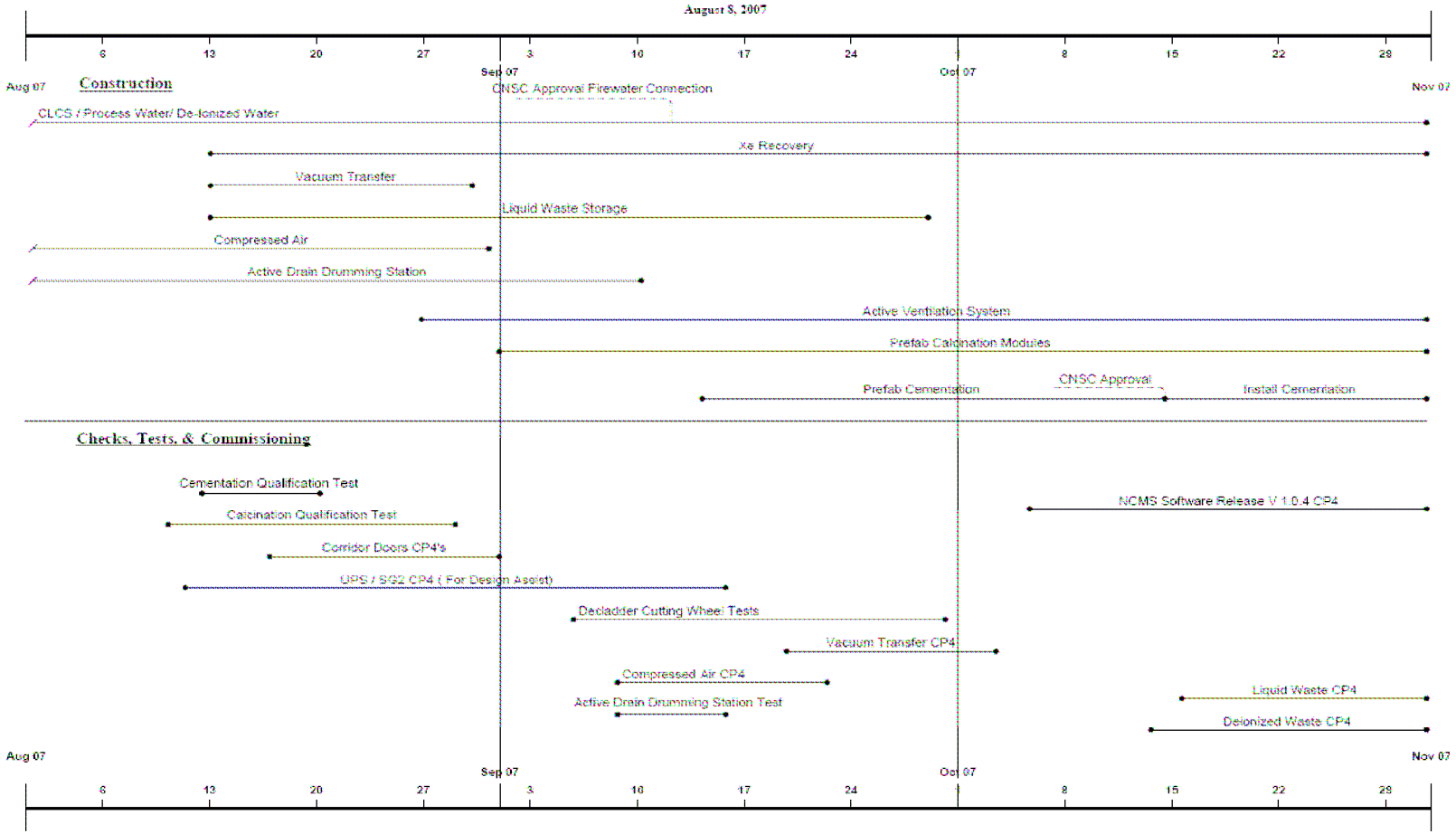


Figure 8: NPF Plan (Work Schedule)

2.3 Power Coefficient of Reactivity (PCR)

This section presents an update on the PCR issue strategy and current status of the testing, as requested during the 2007 Day One Public Hearing.

2.3.1 PCR Strategy and Resolution Program

The MAPLE reactors were designed to have a negative PCR. The PCR represents the integrated effect of a change in power on the temperature and density induced changes in reactivity associated with the fuel, coolant, moderator, reflector, and structural components. The expected PCR value, based on the MAPLE Final Safety Analysis Report (FSAR), was -0.12 mk/MW ± 0.02 mk/MW. In 2003 June, during Phase C commissioning of the MAPLE 1 reactor, the PCR value was measured to be about 0.28 ± 0.12 mk/MW.

On 2003 July 16, AECL presented to the Commission the plan to address the positive PCR issue. A revised plan was developed and submitted to CNSC staff for information in 2004 October. This plan was developed in conjunction with a revised strategy for resuming the nuclear commissioning of the MAPLE 1 reactor and it is based on a comprehensive approach to:

- Understand the discrepancy between the PCR value inferred from the measurements and that predicted
- Re-measure the PCR and confirm the original PCR measurements
- Identify possible cause(s) of the positive PCR
- Find ways to remedy and/or mitigate the positive PCR
- Commit to the implementation of a long-term mitigation strategy or specific change if required

This revised strategy was communicated to the Commission during the public hearings for the MAPLE reactors licence renewal in 2005. The plan to address the positive PCR issue as communicated to the Commission in 2005 is presented in Appendix B. The overall strategy has remained unchanged since 2005, however, some of the details have been revised as more information has been acquired.

The overall plan for resolution of the positive PCR issue is presented in Figure 9. As shown at the top of the main flowchart, the investigation into the positive PCR issue has been carried out in parallel to:

1. Review the measurements and analyses
2. Review the PCR predictions

The first step of 1 was to recheck the PCR measurements and data; the correctness of their acquisition, processing, analyses, etc. This was done internally by AECL and externally by independent contractors, Brookhaven National Laboratory (BNL) in the U.S.A. and INVAP in Argentina. In addition, CNSC staff contracted Prof. A.I. Hawari of North Carolina State University in the U.S.A. for an independent review. These reviews concluded that all measurements and data analyses were done correctly.

The first step of 2 was to recheck the PCR analyses. AECL staff verified their predictions and performed new predictions using different physics codes, different nuclear libraries and introducing several modifications and enhancements to the existing physics and thermal hydraulics models. The new results confirmed the original predictions, i.e., predictions of a negative PCR. AECL contracted with Idaho National Laboratory (INL) in the U.S.A. to perform fully independent PCR calculations. INL predictions also produced similar negative PCR values thus confirming AECL's prediction methods. From these analyses it was concluded that unmodelled phenomena must be causing the positive PCR.

To identify the potential sources of the positive PCR, several reviews were performed:

- A Phenomena Identification and Ranking Table (PIRT) study was done to identify the leading potential contributors to a positive PCR
- BNL and INVAP were contracted to perform independent reviews of the likely phenomena and to provide recommendations for follow up tests to confirm the phenomena

The PIRT study and the independent reviews by BNL and INVAP identified the following most likely contributors to a positive PCR:

- Thermal bowing of target and driver fuel elements
- Bowing of driver fuel elements by constrained axial expansion
- Void production in the core moderator, external to the flow tubes, by boiling, radiolysis and/or deaeration

AECL also conducted an Options study to identify potential solutions to mitigate or remedy the effects of the previously identified contributors to the positive PCR. Recommendations from the independent reviews and analyses by INL, BNL and INVAP supported the results from the Options study.

For the three most likely contributors to the positive PCR, AECL defined a program of analytical work, out of reactor testing, design remedies and in-reactor testing to identify and mitigate the causes of the positive PCR. INL has been contracted to provide independent analyses to support the AECL analyses.

Along with the analytical work, out-reactor tests have been carried out in parallel to validate the analysis methods. For example, target-bowing analyses by the ANSYS code have been supported by out-reactor tests at CRL. Also adiabatic flow tests in the Full Scale Hydraulic Test Rig (FSHTR) and the Two-Channel Test Rig (TCTR) at Sheridan Park have provided validation data for the FLUENT code simulations.

As shown in Figure 9, a PCR Test Plan has been defined from the results of all of the preceding work. The PCR Test Plan also includes recommendations from INL, BNL and INVAP. Each test series in the PCR Test Plan has been supported by specific safety analyses and test procedures.

The closure of the positive PCR issue will be achieved when the PCR tests with implemented design remedies produce an acceptable PCR value.

AECL notes that CNSC staff review and approve the performance of each test series.

2.3.2 Logic of the PCR Testing

The logic for the PCR Test Plan, shown in Figure 10, is based on the following:

- Series 100 Tests: Re-measure the PCR at reactor power of 2 MW and calibrate reactor thermal power at 3 MW
- Series 200 Tests: Re-measure the PCR at reactor power of 5 MW, with and without covers on the irradiation sites to determine the contribution to positive PCR from stagnant water in the reflector tank irradiation sites, and calibrate reactor thermal power at 5 MW
- Series 300 Tests: Measure the PCR for a Low Enriched Uranium (LEU) core, without Highly Enriched Uranium (HEU) targets, at reactor power of 5 MW to determine the contribution to positive PCR from HEU targets
- Series 400A Tests: Measure the PCR for LEU core, without HEU targets, and with modified flow tubes for an upward moderator water flow, at reactor power of 5 MW to determine the contribution to positive PCR from moderator water heating. The PCR is to be determined by the tests
- Series 400A-1 Tests: Measure the PCR value after replacing the LEU driver fuel bundles with modified LEU driver fuel bundles to prevent binding of the LEU fuel pins in the top plate, for an LEU core, without HEU targets, and with modified flow tubes for an upward moderator flow, at a reactor power of 5 MW, to determine the contribution to positive PCR from binding the LEU driver fuel pins in the driver fuel bundle top plate. The PCR is to be determined by the tests

- Series 400B Tests: Measure the PCR for start-up core with HEU targets restrained in a modified target cluster holder and with modified flow tubes for an upward moderator water flow, at reactor power of 5 MW to confirm the PCR value for isotop production configuration. The PCR is to be determined by the tests
- Series 500 Tests: Measure the PCR up to 8 MW with design changes based on the outcome of the Series 400 Tests

The decision points during the overall PCR testing are shown in Figure 10. Whether or not each of these test series will be conducted will depend, in part, on the PCR measured in the previous test series.

The decision to complete the commissioning of the MAPLE 1 reactor up to 10 MW will be dependent on the final outcome of the PCR Test Plan up to 8 MW.

2.3.3 Status of PCR Testing

During the first half of 2007, the PCR was measured several times in the MAPLE 1 reactor in the Series 100 and 200 tests. The objectives of the tests were:

- to verify that the value had not changed from the last measurements in 2003
- to verify that the current value of the PCR was within the safety case
- to reduce the uncertainty on the PCR
- to provide a definitive baseline value as the reference against which the efficacy of various core modifications could be judged

The PCR was measured as 0.28 mk/MW ±0.03 and essentially constant from 1 to 5 MW within these uncertainty bounds. This measurement is consistent with the value previously measured.

The first core modification test, i.e., removing all HEU targets and replacing them with LEU fuel bundles, was executed on 2007 August 24 as part of the Series 300 tests. The test was completed safely.

The purpose of this Series 300 test was to determine the contribution to the positive PCR from the HEU target sites. The preliminary value of the PCR for this core is 0.18 mk/MW, a reduction of almost 30% to the value measured in the Series 100 and 200 tests. The actual contribution from the HEU targets has not yet been quantified and will be resolved through future planned tests and analysis.

This result supports the hypothesis of a contribution from the HEU target sites. It thus contributes to understanding the positive PCR (target bowing can affect the PCR) as well as demonstrating that this core loading, which is the basis for two of the tests planned to follow, has a much higher margin than that assumed in the safety case (i.e., PCR value of 0.402 mk/MW).

Visualization tests in the Two-channel test Rig and the FSHTR have confirmed the potential for reduced moderator flow between the core and the reflector tank wall. This could lead to increased moderator water heating, which is a phenomenon postulated to contribute to a positive PCR. The next planned test (Series 400A), which removes flow circulation patterns in this area and causes the water to flow upwards uniformly, will demonstrate the contribution to the positive PCR from the postulated phenomenon and indicate whether this modification is an appropriate remedy.

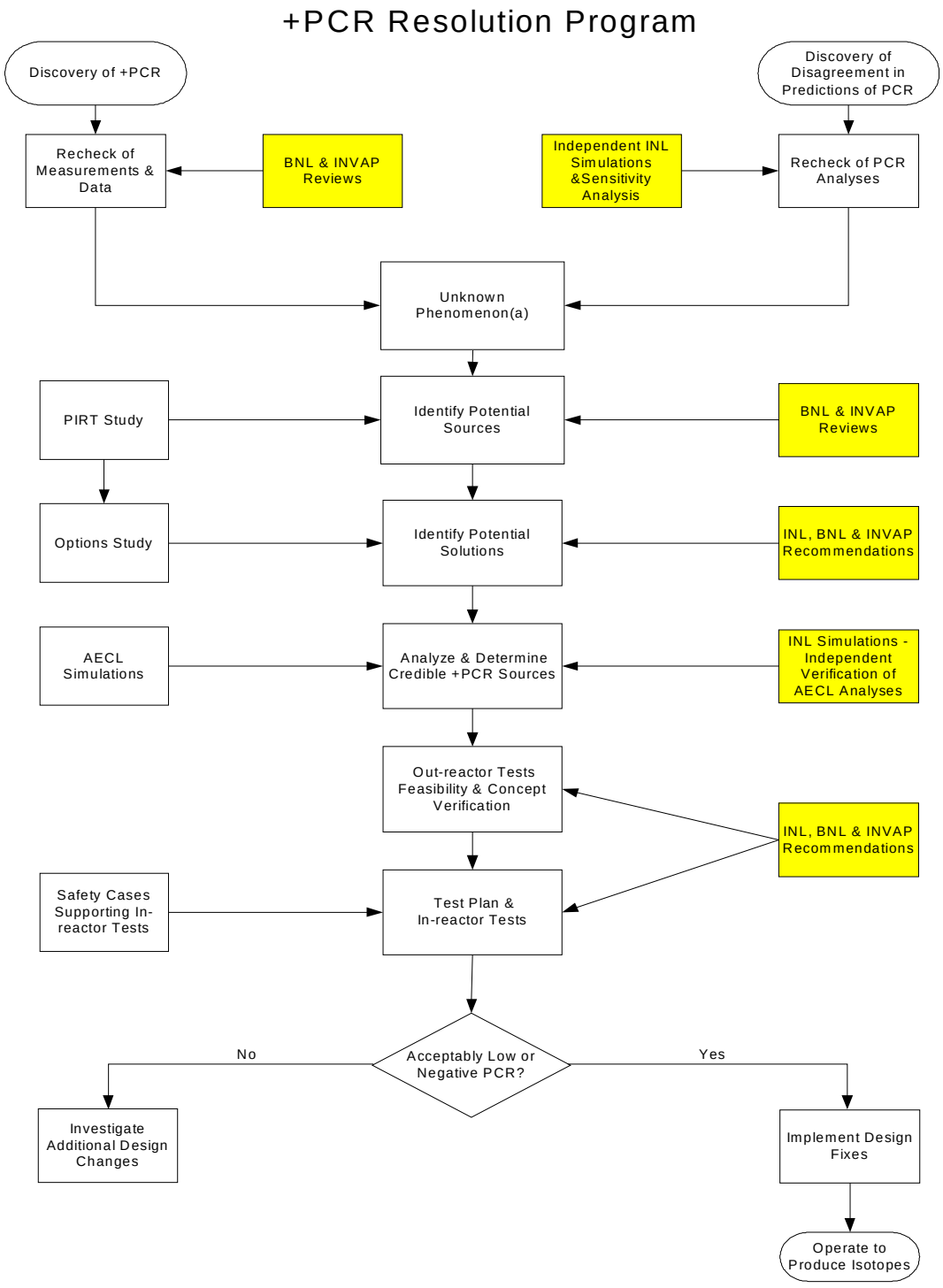


Figure 9: Positive PCR Resolution Program

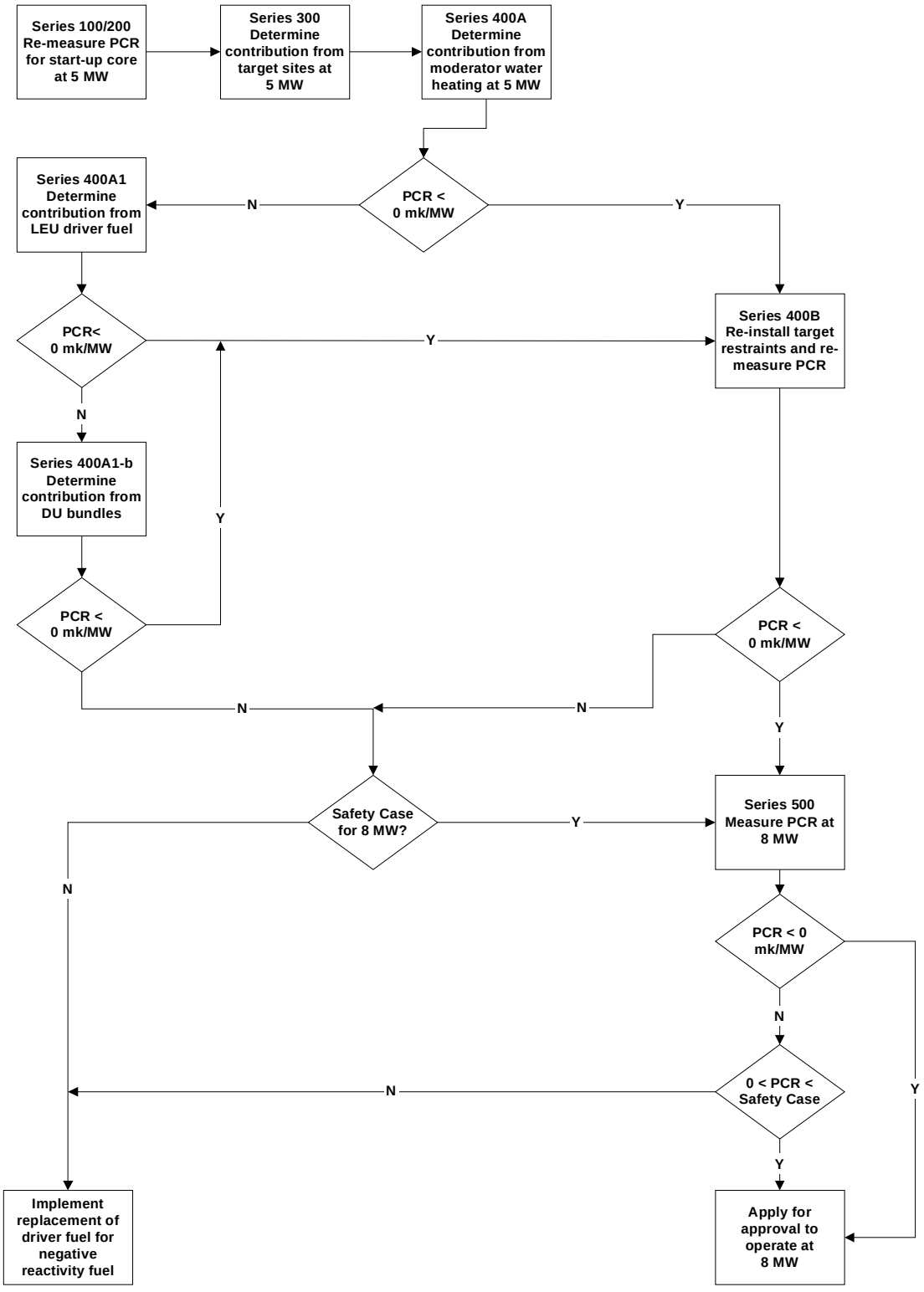


Figure 10: PCR Testing Logic Chart

2.4 References

[2-1] "Non-Power Reactor Operating Licence- MAPLE 1 and 2 Nuclear Reactors", Licence Number NPROL-62.00/2007, Expiry Date: 2007 November 30.

[2-2] "Nuclear Substance Processing Facility Operating Licence", Licence Number NSPFOL-03.00/2007, Expiry Date: 2007 November 30.

[2-3] "Information from Canadian Nuclear Safety Commission Staff Regarding Outstanding Issues for the MDS Nordion Medical Isotopes Reactor Project, Status Report on the Actions and Resolution Criteria and Progress towards Resolving the Outstanding Issues", CMD 04-M28, 2004 July 08.

[2-4] "Information from Canadian Nuclear Safety Commission Staff Regarding Atomic Energy of Canada Limited Renewal of the Operating Licence for the MAPLE Reactors at the Chalk River Laboratories, Public Hearing Day One", CMD 05-H20, 2005 August 18.

[2-5] "Information from Canadian Nuclear Safety Commission Staff Regarding Atomic Energy of Canada Limited Renewal of the Nuclear Substance Processing Facility Operating Licence for the New Processing Facility (NPF) at the Chalk River Laboratories, Public Hearing Day One", CMD 05-H21, 2005 August 18.

[2-6] "Information and Recommendations from Canadian Nuclear Safety Commission Staff in the Matter of Atomic Energy of Canada Limited Renewal of the Operating Licence for the MAPLE Reactors and Renewal of the Nuclear Substance Processing Facility Licence for the New Processing Facility and replacement of these individual licences with one licence for the Dedicated Isotope Facilities at the Chalk River Laboratories, Public Hearing Day One", CMD 07-H16, 2007 June 22.

[2-7] "Renewal (2007) of the Dedicated Isotope Facilities (MAPLE 1 & 2 Reactors and the New Processing Facility) Operating Licences - Information Presented for the Day One CNSC Public Hearing (2007 June 22)", 6400-00521-LP-001, (CMD 07-H16.1), Revision 0, 2007 May.

[2-8] "Dedicated Isotope Facilities – MAPLE 1 and MAPLE 2 Nuclear Reactors, New Processing Facility", Licence Number NPROL-62.00/2011, Expiry Date: 2011 October 30 **(Proposed Licence, Draft included in CMD 07-H16)**

[2-9] "Supplemental Information In Support Of Licence Renewal For The MAPLE Reactors Public Hearing Day 2 Submitted by AECL on 2005 October 11".

[2-10] "Supplemental Information In Support Of Licence Renewal for the New Processing Facility Public Hearing Day 2 Submitted by AECL on 2005 October 11".

3. UPDATE ON ACTIVITIES SINCE DAY 1

3.1 MAPLE 1

As detailed in the preceding section, the most recent changes in the MAPLE 1 reactor involved replacing the High Enriched Uranium targets in the MAPLE 1 core with Low Enriched Uranium fuel. This replacement was done to allow testing to determine the contribution that the High Enriched Uranium targets make to the positive PCR. (i.e., Series 300 tests). Following these changes, a series of tests were run to confirm the characteristics of the modified core, e.g. reactivity worth of Shut-off Rods & Control Absorber rods. These tests were successfully completed.

Further tests were executed to measure the flow distribution in the new core in preparation for operating the core up to 5 MW for the PCR measurement.

Finally, a test was performed to measure the PCR up to 5 MW. The results are discussed in more detail in Section 2.3.3.

3.2 MAPLE 2

The MAPLE 2 reactor has been placed in the Alternate Guaranteed Shutdown State configuration. In the Alternate Guaranteed Shutdown State, the reactor core is fully de-fuelled and the transfer key is placed under the administrative control of the Facility Authority.

3.3 New Processing Facility (NPF)

Field modifications and commissioning work have been progressing steadily within NPF. Most of the work within the facility has focused on updates to some of the support systems, e.g. modifications to the Closed Loop Cooling System, Process Water System, and Compressed Air System. This work has focussed on removing and replacing piping and the associated valves. This work is a pre-cursor to the work that is planned for later in the current licence period and during the early part of the next licensing period, e.g., refitting of the Calcination and Cementation Systems.

With regards to the Calcination and Cementation Systems, qualification tests of the new designs are currently underway. Following successful completion of these tests, approval will be requested from the CNSC staff to begin installation and commissioning of these systems in NPF.

3.4 Update on the Improvement Action (ImpAct) Process

The ImpAct process within DIF was described in the information provided at the Day One Public Hearing, and so is not repeated in this document. However, a brief update on the ImpAct process is provided. From 2007 January 01 to 2007 August 29, a total of 692 ImpAct reports have been raised. Over 72% of these were Level 4 (low level) events, 26% were Level 3, 2% were Level 2, and there were no Level 1 events (Level 1 is the most safety significant, Level 4 the least).

Following the implementation of the ImpAct process within DIF, AECL staff carried out a self-assessment of the process. The self-assessment was performed in March 2007. The results of the self-assessment highlighted 6 areas in need of improvement. These key areas of improvement are: the transition to the ImpAct process, the use of ImpAct reports to accompany work requests with respect to work on problem items, documentation, training, accountability and timeliness of processing ImpAct reports, and the software that supports the ImpAct process.

CNSC staff performed a Type 1 Inspection of the DIF Commissioning Quality Assurance Program in 2007 April. The audit, documented in CNSC report number MSD-AECL-DIF-2007-T9320-T1, consisted of the following eight inspection elements:

- 2003 Commissioning Inspection Directive and Action Notice
- Follow-up and Closure
- Design Change Control
- Commissioning Procedures
- Commissioning Reports
- Commissioning Completion Assurance
- Turnover from Commissioning to Operations
- ImpAct

As a result of the audit, specifically with respect to the Improvement Action (ImpAct) Process, the CNSC staff stated that “The inspection team was encouraged by the introduction of the ImpAct process with the objective to capture a wider net of deficiencies, including low-level pre-cursors” however, CNSC staff did note a number of areas with the ImpAct process where improvement was needed.

There were no directives issued as a result of the CNSC Type 1 Inspection, however five action notices and one recommendation were issued to AECL to address deficiencies noted in the audit conclusions.

AECL has prepared an action plan to address the CNSC findings and is currently executing the plan and implementing actions.

3.5 Safe Working Environment

Operations within the MAPLE 1 and MAPLE 2 reactors, and commissioning work within NPF, have continued to be executed safely since the Day One Public Hearing. There have been no lost time accidents and no Event Free Day Resets within DIF. Reporting culture remains a key focus within DIF Operations, with over 220 ImpActs having been raised since the Day One Public Hearing, of which 150 were Level 4 (lowest significance level) and 60 were Level 3.

4. CONCLUSION

This CMD has provided additional information to support AECL's application for a 47-month renewal of the MAPLE and NPF licences, with a proposed expiry date of October 31, 2011. AECL has also proposed that the licences be combined into a single operating licence.

The CMD includes information requested at the Day One Public Hearing as well as an update on progress since the Day One Public Hearing.

With respect to the DIF facilities, AECL has and will continue to provide adequate provision for health, safety, security and the environment, and Canada's international obligations. AECL believes that the information presented supports the application for a 47-month licence renewal. AECL notes and accepts the proposed CNSC staff approval points for the PCR tests, as well as the proposed licence conditions requiring CNSC staff and Commission approvals as described in Sections 10 an 11 of the draft licence in CNSC staff CMD 07-H16.

Appendix A
Types of CNSC Approvals Required for DIF Key Milestones

Facility	Key Milestones			Planned AECL Activities to Address the Milestone
	Milestone	**Objectives**	**Types of CNSC Approvals Required**	
MAPLE 1	2 kW	Exit from Guaranteed Shutdown State (GSS) and operate MAPLE 1 up to 2 kW	• CNSC staff approval required to exit GSS and operate up to 2 kW	Completed
	5 MW	Operate MAPLE 1 to perform the PCR Test series	• CNSC staff approvals required to install modifications • CNSC staff approval required for the Revision 3 of the 5 MW PCR Test Plan (based on current MAPLE operating licence) • CNSC staff approvals required to perform each series of the PCR testing • Commission approvals required for changes to documents listed in Appendix B of the proposed DIF Operating Licence resulted from design changes required to install for performing PCR testing [A-1]	See Section 4.1.1 of [A-2]
	5 MW	MAPLE 1 available to irradiate targets for NPF Active Commissioning and irradiate xenon gas for MIPF Nuclear Commissioning	• CNSC staff approval required to operate MAPLE 1 to irradiate targets for NPF Active Commissioning • CNSC staff approval required to operate MAPLE 1 to irradiate xenon gas for MIPF Nuclear Commissioning • Commission approvals required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.1.1 of [A-2]
	8 MW	Operate MAPLE 1 to confirm the PCR up to 8 MW	• CNSC staff approvals required to install modifications • CNSC staff approvals required to perform the PCR testing up to 8 MW • Commission approvals required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.2.1 of [A-2]
	8 MW	MAPLE 1 available to irradiate targets for NPF Active Commissioning and irradiate xenon gas for MIPF Nuclear Commissioning and In-Service Operation	• CNSC staff approval required to operate MAPLE 1 to irradiate targets for NPF Active Commissioning • CNSC staff approval required to operate MAPLE 1 to irradiate xenon gas for MIPF Nuclear Commissioning and In-Service • Commission approvals required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.2.1 of [A-2]

Facility	Key Milestones			Planned AECL Activities to Address the Milestone
	Milestone	**Objectives**	**Types of CNSC Approvals Required**	
	In-Service at 8 MW	MAPLE 1 available for In-Service at 8 MW	• Commission approval required in accordance with L.C. 10.3 of the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.2.1 of [A-2]
	Above 8 MW	Operate MAPLE 1 for the first time above 8 MW to complete the commissioning	• Commission approval required in accordance with L.C. 10.2 a) of the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.2.1 of [A-2]
	In-Service above 8 MW	MAPLE 1 available for In-Service above 8 MW	• Commission approval required in accordance with L.C. 10.3 of the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.2.1 of [A-2]
MIPF	Nuclear Commissioning	MIPF available for Nuclear Commissioning	• Approval by Commission or person authorized by the Commission required to introduce xenon gas into MIPF in accordance with L.C. 11.1 of the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.1.2 of [A-2]
	In-Service	MIPF available for In-Service	• Commission approval required for changes to documents listed in Appendix B of the proposed the proposed DIF Operating Licence [A-1]	See Section 4.2.2 of [A-2]
MAPLE 2	2 kW	Restart MAPLE 2 and resume commissioning up to 2 kW	• Approval by Commission or person authorized by the Commission required in accordance with L.C. 11.2 of the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of the proposed the proposed DIF Operating Licence [A-1]	See Section 4.2.3 of [A-2]
	500 kW	Operate MAPLE 2 above 2 kW and up to 500 kW	• Commission approval required in accordance with L.C. 10.2 b) of proposed the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of proposed the proposed DIF Operating Licence [A-1]	See Section 4.2.3 of [A-2]

Facility	Key Milestones			Planned AECL Activities to Address the Milestone
	Milestone	**Objectives**	**Types of CNSC Approvals Required**	
	8 MW	Operate MAPLE 2 above 500 kW and up to 8 MW	• Commission approval required in accordance with L.C. 10.2 c) of proposed the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of proposed the proposed DIF Operating Licence [A-1]	See Section 4.2.3 of [A-2]
	In-Service at 8 MW	MAPLE 2 available for In-Service at 8 MW	• Commission approval required in accordance with L.C. 10.3 of the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.2.3 of [A-2]
	Above 8 MW	Operate MAPLE 2 above 8 MW	• Commission approval required in accordance with L.C. 10.2 d) of the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.2.3 of [A-2]
	In-Service above 8 MW	MAPLE 2 available for In-Service above 8 MW	• Commission approval required in accordance with L.C. 10.3 of the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.2.3 of [A-2]
NPF	Active Commissioning	NPF available for Active Commissioning	• Approval by Commission or person authorized by the Commission to start Active Commissioning in accordance with L.C. 10.4 a) of the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.1.3 of [A-2]
	In-Service	NPF available for In-Service	• Approval by Commission or person authorized by Commission required in accordance with L.C. 10.4 b) of the proposed DIF Operating Licence [A-1] • Commission approval required for changes to documents listed in Appendix B of the proposed DIF Operating Licence [A-1]	See Section 4.2.4 of [A-2]

[A-1] Dedicated Isotope Facilities – MAPLE 1 and MAPLE 2 Nuclear Reactors, New Processing Facility, Licence Number NPROL-62.00/2011, Expiry Date: 2011 October 30 **(Proposed Licence, Draft included in CMD 07-H16).**

[A-2] Renewal (2007) of the Dedicated Isotope Facilities (MAPLE 1 & 2 Reactors and the New Processing Facility) Operating Licences - Information Presented for the Day One CNSC Public Hearing (2007 June 22), 6400-00521-LP-001, Revision 0, 2007 May.

Appendix B
Plan to Address the Positive PCR Issue Communicated to the Commission in 2005

(Excerpt from "Supplemental Information in Support of Licence Renewal for the MAPLE Reactors", Public Hearing Day Two, Submitted by AECL on 2005 October)

B.1 Plan to Address the Positive PCR

AECL has developed a multi-faceted plan to demonstrate that all practical options of design and operation have been considered to remedy the positive PCR. This plan includes the following steps:

Phase 1:

1. As part of the investigation of the discrepancy between the measured and predicted values of the PCR, a PIRT study has been performed and submitted to the CNSC [B-1]. This is a systematic formal review of all phenomena that could cause a positive PCR and a ranking in order of importance. The output is a ranked list of plausible phenomena that could cause the positive PCR, and this output is being used as input into the testing and selection of practical design and operation changes to remedy the positive PCR. The PIRT study concluded that the deviation from the expected result was most likely due to one or more unmodelled phenomena.
2. A follow-up PCR Options study was issued and submitted to the CNSC, identifying the list of physically feasible (but not necessarily practical) options for mitigating the positive PCR.
3. In parallel with the work performed by the PCR task team at AECL, INL has been contracted by AECL to perform independent calculations to predict the PCR using independent data models and code calculations.
4. AECL has also contracted BNL to perform an independent review of AECL's work on the PCR.

Phase 2:

As indicated in [B-1], Phase 2 of the options study will refine the options, based on the information gathered during Phase 1. The work will involve the following:

1. Re-measuring the PCR at high power in the MAPLE 1 reactor and completing other PCR tests.
2. Defining and committing to implement a mitigation strategy or specific change, if a practical one (technically and economically feasible) exists. The results of these investigations will be documented and submitted to the CNSC.
3. Implementing the measures defined in the step above to resolve the positive PCR.

B.1.1 Reference

[B-1] CMD 05-H20.1, Information in Support of Licence Renewal for the MAPLE Reactors, 2005 July 15.