Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

Research and Support Program 2001-2002 Performance Report and 2002-2003 Program

September 12, 2002

Canada

RESEARCH AND SUPPORT PROGRAM
2001-2002 PERFORMANCE REPORT AND
2002-2003 PROGRAM

PREPARED BY
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Executive Summary

The Canadian Nuclear Safety Commission funds an extramural Research and Support Program (Program) to obtain knowledge and information needed to support its regulatory mission. The Program gives access to independent advice, expertise and experience through contracts placed in the private sector and with other agencies and organizations in Canada and elsewhere. The Program is compiled by the Research and Support Group from project proposals submitted by clients across the CNSC.

This submission presents information on the objectives and management of the Program during fiscal year 2001-02 as well as the financial performance of the program. Brief summaries are given of a selection of projects from across the CNSC which either completed in 2001-02 or which have been continuing for several years. The report reviews the performance of the Program for fiscal year 2001-02; the changes made in planning for fiscal years 2002-03 and 2003-04; and presents the 2002-03 Research Program.

During fiscal year 2001-02, a budget of $1,520K was originally allocated to the Program. On one occasion during the year, a special request was made by one of the proponents, to Executive Committee, to elevate the status of a level 2 project; therefore increasing the RSP budget to $1,560K, of which $1,417K was spent. The original program plan was to fund fifty-nine projects, of which thirty-four had been in-progress at the start of the year. Changes during the year resulted in a total of sixty-three projects being active.

The 2002-03 Program consists of fifty-five projects with a total budget requirement of $1,900K.

Since the reorganization of April 2002, the Research and Support Group is now part of the Regulatory Standards and Research Division; its mandate is unchanged.

Introduction

Each year, the CNSC funds an extramural Research and Support Program (Program) whose mission is to generate knowledge and information to support CNSC staff in its regulatory mission. The Program provides access to independent advice, expertise and experience through contracts placed in the private sector and with other agencies and organizations in Canada and elsewhere.

The annual Program is compiled from project proposals made prior to the start of the year. Proponents define their specific needs for contracted-out research or support work, provide justification for the proposed work and outline the intended use of the results. The Regulatory Standards and Research Division (RSRD) staff compiles the draft Program and submits it for review and approval by the Research and Support Committee (RSC). The RSC decides which proposals to recommend for funding based on an assessment of their merit and bearing in mind corporate strategies and priorities and specific objectives that are set each year for the Program. The RSC then advises the Operations Management Committee (OMC) on the funding requirement for the Program. The extent to which the work can be completed depends on the funding allocated.

Subject to availability of funds, new project proposals may be considered for funding at any time during the annual program cycle.

To initiate work on an approved project, the client division prepares a Statement of Work and either a sole source justification or criteria for evaluation of proposals. The Senior Research Program Officer, RSRD, assists in the preparation of this material and reviews the completed Contract Request Form. A contracting officer prepares the supporting documentation and forwards the Request for Proposals to Public Works and Government Services Canada (PWGSC) or advertises directly on MERX (the government's on-line open bidding service) in accordance with Treasury Board policy. Proposals received from potential contractors are evaluated by the client division and the Senior Research Program Officer. The contracts officer (PWGSC or CNSC) then prepares and issues the contract.

Once a contract is awarded, the proponent is responsible for project management, including arranging meetings, reviewing deliverables, certifying invoices, and ensuring that the contractor meets the objectives specified in the Statement of Work. The Senior Research Program Officer is responsible for arranging contract amendments requested by the client division and for performance of other non-technical work associated with the contract. At the end of the project, the client division reviews and accepts the final report produced by the contractor.

Finally, public reports from the Program are allocated an RSP number by the Research Program Assistant, RSRD, and listed in the on-line CNSC Documents Catalogue. Copies of non-restricted reports are provided on request to outside bodies or the public.

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1 Performance Report on Fiscal Year 2001-2002

1.1 Objectives and Organization of the Program

The objectives set for the Program for fiscal year 2001-02 were to:

- Support timely regulatory judgements and decisions through the acquisition of independent expertise, advice, and information;
- Assist the resolution of health, safety, security, and environmental issues by developing capability tools;
- Assess the significance of emerging issues by performing exploratory studies; and
- Support regulatory and corporate activities within the CNSC.

The sub-program approach was abolished this year as the objective of the program was instead clearly aligned with helping meet the CNSC's corporate strategic and operational objectives. To aid transition, a number of specific objectives were also set and the proponents asked to demonstrate which of them their proposals were designed to meet:

- to prepare staff to discharge new responsibilities under the NSCA
- to address issues raised by the Office of the Auditor General
- to support regulatory decision-making or to refine a regulatory position
- to contribute to the independence of the regulator
- to address problems of potential safety significance
- to supplement staff's knowledge with specialist expertise
- to induce a licensee to follow a course of action

The traditional grouping by Mission Object for reporting purposes was also abandoned and will eventually be replaced by Service Line or Technical Line groupings, as are used for Strategic Planning and Cost Recovery purposes.

The Call for Proposal resulted in sixty-two new proposals, which when combined with the projects already in-progress resulted in a demand totally $3,993K. At its meeting in February 2001, the RSC recommended approval of fifty-nine projects worth a total of $2,320K, with a recommended budget of $2,020K. The difference between the two amounts was a deliberate over-commitment which would serve to help the RSG manage the Program in the face of any contracting difficulties or project delays. In April 2001, Executive Committee approved a budget of $1,520K. The RSC revisited the program and the revised Research and Support Program was presented to the Commission for information in CMD 01-M51B at the October 3, 2001 Meeting.

As indicated in CMD 01-M51B, RSC changed the approval process for proposals. Those which most strongly indicated that they met one or more of the program objectives where granted Level 1 approval with immediate funding. Others that also met the objectives, were granted Level 2 approval but subject to funds becoming available during the program year. An additional fifteen proposals were included in the program but placed on Hold because

either the proponent indicated that they would not be ready to start the project during the program year or they were a low priority compared to the others.

The status of some projects changed during the year as new, urgent projects displaced others of lower priority, thus ensuring that the most pressing regulatory needs received the necessary attention.

1.2 Program Performance

At the start of the fiscal year, the Program contained thrity-four projects that were already in-progress (that is, carrying over from FY00/01), which were expected to require $904K or 60% of the allocated budget of $1,520K.

Although some carryovers are planned multi-year projects, in many cases they occur because a project is initiated too late to be completed in the same fiscal year, due to the time needed to develop a Statement of Work, advertise for bids and select a contractor. Once a contract has started, in some cases the scope of work needs to be changed or difficulties are encountered which cause the schedule to slip into the next fiscal year. Due to the program management changes made by RSG, the levels of unplanned carryovers has declined considerably since they are now only the result of unexpected project delays which occur late in the fiscal year. Figure 1 shows the timelines of the projects in the 2001-02 Program and reveals the multi-year nature of the majority of the projects funded from it.

A special request, to Executive Committee, by one of the proponents resulted in the funding of a level 2 project and an increase in the allocated RSP budget to $1,560K. Actual spending lagged behind the plan, the final expenditure being $1,417K, with $143K being lapsed (rounded to nearest $1K). Actual expenditures on projects carried-over from the previous fiscal year were $861K or 61% of the total expenditures. Expenditures for the year were as follows:

a)	Research and Support projects, including staff travel for project management	$1,359.6K	87%
b)	Contributions to international projects	$ 57.7K	4%
c)	Amount lapsed	$ 142.6K	9%

The breakdown of expenditures between in-progress, planned and new projects can be seen in Table 1. The completed projects are listed in Appendix A, along with the actual expenditures on each. A brief description is given in Appendix B of the value to the organization of a selection of projects which completed during the year and others which have been in-progress for several years. Seventeen research reports were published during the year, some of which were from projects which had completed in the previous fiscal year; these are listed in Appendix C.

Table 1 Breakdown of Expenditures

Project Source	Number of Projects		Expenditure ($K)
In-progress projects	Completed	21	475
	On-going	11	370
New Projects in Program	Completed	3	88
	On-going	9	215
Projects advanced from Level 2 approval	Completed	0	
	On-going	3	59
Unplanned Carry-overs	Completed	2	16
	On-going	0	
New Projects not in Program	Completed	8	106
	On-going	6	88
Total		63	1,417

1.3 Comparison with Previous Years

The budget, expenditure, lapse and proportion spent on in-progress projects in fiscal year 2001-02, compared with previous years, were:

Table 2 Financial Comparison with Previous Years

	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02
Final Budget	3075	2473	2020	2320	1784	1560
Expenditure	2932	2224	1861	2146	1730	1417
Lapse	143	249	159	174	54	143 *
Lapse (%)	4.7	10.1	7.9	7.5	3.0	9.1 *
In-progress projects	1844	891	907	1055	798	861
In-progress projects %	58	36	45	49	46	61

* The lapse would have been $62K, or 4% had one project not failed to start late in the year.

The size of the lapse is a measure of the efficiency with which the Program has been managed, since funds unspent in one year must be found from the following year's budget. The target is to achieve a lapse of less than 5%, since this is the maximum percentage of funds that the organization as a whole can carry forward to the next fiscal year, although the Program itself is not permitted to carry-forward lapsed funds. The greater the proportion of the budget committed to projects carried-over from the previous year, the less is the ability of the Program to respond to requests for new work.

The 9% lapse is large compared to the previous year due to a major multi-year contribution project with the US NRC which was delayed as a result of the events of September 11, 2001. Unfortunately this project was not able to be initiated prior to the end of the fiscal year, resulting in an unexpected lapse of $81K. Had this project been started, the overall lapse for the year would have been $62K, or 4%, which is under the program target.

1.4 Program Effectiveness Review

The 2001-02 Program addressed a high demand for research and support work, comprising sixty-three active projects, of which thirty-four had been in-progress at the start of the year. A total of thirty-four projects were completed during the fiscal year, although one of them was actually terminated early as it was evident that it was not going to meet the objectives of the project.

The number of unplanned carryovers included in the 2001-02 Program was two. This was a great improvement over previous years, for example the 2000-01 Program included eleven unplanned carryovers. The reduced number in unplanned carryovers was a result of the changes made by RSG to improve program management. The number of unplanned carryovers from fiscal year 2001-02 into 2002-03 is also two.

Originally only sixteen projects (over and above those already in progress) were planned in the Program (i.e., Level 1 approval). However delays in the initiation or project schedule of the twelve that actually started resulted in funds being available for additional projects. As a result, fourteen new projects and three with Level 2 approval were started in FY01/02. The number of new projects was comparable to previous years. The decision to fund these new proposals over those already approved as Level 2 in the Program was based on the urgency of the project or because of their greater ability to start late in the fiscal year.

Of the twenty-five Post Project Evaluations which have been received from the proponents, nineteen rated the quality of their final report as Very Good or Excellent. When ranking the outcome (for which more than one vote was permitted) eighteen felt that their project had contributed to the knowledge base of staff; twelve that they created contacts with experts outside the CNSC; eight that results would be used to resolve issues or refine staff positions; 6 that they would contribute to the preparation of a Regulatory Policy, Standard, Procedure or Guide; and six that the results would be published in a scientific or engineering meeting abstract, proceedings or journal.

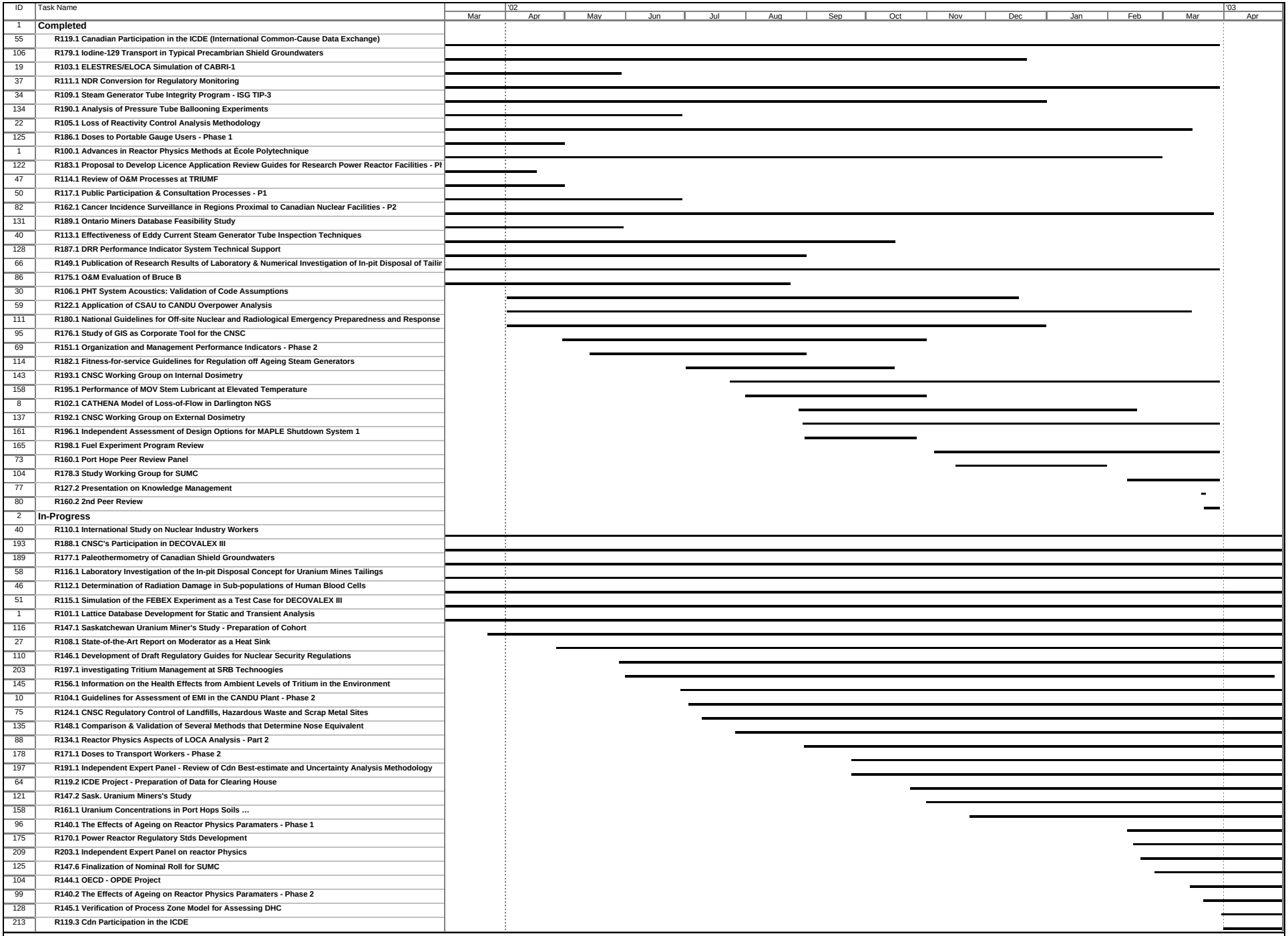

Figure 1: Timeline of Projects in Research and Support Program for Fiscal Year 2001-02

2 The Research and Support Program for Fiscal Year 2002-2003

2.1 Objectives and Organization of the Program

To improve planning and recognizing the multi-year nature of many projects, the RSC decided to issue a two-year Call for Proposals, i.e., proposals were requested for Fiscal Year 2002-03 and 2003-04, even though budget allotment is on a single fiscal year basis. Planning two years ahead will also help meet the requirements of the CNSC's new cost recovery proposal.

The objectives of the program, for the two years, are the same as those from last year (2001-02), i.e., aligned with helping meet the CNSC's corporate strategic and operational objectives.

2.2 Program Approval and Budgeting Process

At its meetings on December 10 and 17, 2001, the Research and Support Committee decided to adopt a Risk Management approach when reviewing the submissions for inclusion in the 2002-03 and 2003-04 Research and Support Program. Proponents were asked to demonstrate how their proposals addressed the risks and objectives which the CNSC faces and to which the Research and Support Program could be used to respond. The factors which the proponents were asked to address were:

Health and Safety	OAG Recommendation
Environment	Support Regulatory Decisions
Stakeholder Confidence	DFCMR Priority
Efficiency and Effectiveness	DRR Priority
Openness and Transparency	Risk of Not Doing (e.g. Legal)
NSCA New Responsibility	Other (asked to specify)

The choice of organizational risks was based on:

- The corporate risk profile from the draft Risk Management Policy (BITS 990016). From this, the categories of Health & Safety, Environment, Stakeholder Confidence and Legal were retained. The other risks were excluded for various reasons. Security because it was likely to receive separate direct funding; International because a separate Safeguards Support Program exists and no proposals were expected in the area of Non-Proliferation; Organizational because the RSP is aimed at the CNSC regulatory mission, not internal (or organizational) purposes; and Governmental because the Program is not intended to address political issues.
- The CNSC's corporate strategic objectives, which is the primary objective of the Research and Support Program. From these, 'Efficiency and Effectiveness' and

'Openness and Transparency' were included but attracting and retaining excellent staff was not as it is not within the mandate of the Program.

- The other objectives of the Research and Support Program, that is: new responsibilities under the NSCA; findings from the OAG report of December 2000; and supporting regulatory decisions. The other objectives where excluded because they were essentially re-definitions of 'Support Regulatory Decisions'.
- The outcomes of meetings held earlier with the senior management teams of the 'licensing' Directorates (DFCMR and DRR), where they were asked to indicate their priority areas from a top-down, and strategic point of view.

The DFCMR research priorities identified were:

- Assistance in defining our regulatory requirements in new areas of responsibility or concern, rather than the more traditional research and support work of anticipatory or confirmatory work on potential or known health and safety issues;
- Back fit strategy (regulatory requirements, acceptance criteria, link to life extension);
- International oversight of research reactors in lesser-developed countries;
- Policy on Periodic Inspection / Periodic Safety Review (strategic direction, regulatory requirements, link to longer licence terms or revised licensing basis);
- Environmental protection (for example, effluent limits, requirements for a monitoring program, acceptance criteria);
- Support our response to PSL-2 when implemented. Also possible that we can work jointly with industry to decide how to deal with some prohibited substances, such as sediments;
- Waste management; e.g. long-term on-ground storage, institutional control and abandonment licences, waste rock piles, release limits from regulatory control, remediation techniques (licensees; not CNSC);
- Geographic information system; and
- Risk management (public concern may override ALARA).

The DRR research priorities identified were:

- Reactor physics;
- Generic action items; and
- Focus on resolving existing issues, not looking for new ones.

The demand for research and support work for the new Program years was high with a total of fifty-five new proposals being received. Four of these indicated that they anticipated the projects to start only in FY03/04. In addition twenty-nine projects were continuing from the

previous fiscal year, one of which was an approved Level 1 which failed to find a successful contractor on the first RFP attempt and was going to be reissued (R127.1).

The Research and Support Committee met on February 1, 2002 to review the completed risk matrices prepared by proponents regarding their proposals for next year's Research and Support Program. Because of the ongoing re-organization, the Committee decided only to approve projects which were ongoing (i.e., continue into fiscal year 02/03), as well as the next phase (R109.2, R119.3) of two of the completed projects, which were of high priority based on the Risk Management approach. The RSC decided to defer making a decision on the remainder of the program until such time as the continued existence of a central Research and Support Program was confirmed and the role and membership of the Research and Support Committee clarified.

In late April 2002, Executive Committee confirmed that the mandate of the Research and Support Program was unchanged for this fiscal year and a new Research and Support Committee was formed. In May a budget of $2,320K was approved by Executive Committee for the Research Program of which $300K was specially marked for Security related projects. The Committee then met on May 31, 2002 to decide on the balance of the Program. RSC members decided to only look at those proposals that had submitted their risk justification information. This resulted in sixteen projects being granted Level 1 approval, one proposal being withdrawn and eight placed on Hold. The proponents of those proposals which lacked risk justifications were given one more month to submit the information.

On July 18, 2002 the Committee met to consider funding the eighteen remaining proposals of which twelve had the required risk justification information. The six with missing risk information were given one more month. The Committee approved four at Level 1, five at Level 2, placed one on Hold and rejected two that did not met the objectives of the Program.

On September 10, 2002 the Committee met to make the final decision on the Program. An additional four projects (2 of which were new proposals) were granted level 1 approval.

The final disposition of the proposals received for the Research and Support Program for fiscal year 2002-03 is as follows:

In-progress (from FY01/02) projects:	26
Unexpected carry-overs (from FY01/02):	2
Level 1 approved (with funding):	28 (includes R127.1)
Level 2 approved (no funds):	5
On Hold:	13
Withdrawn by proponent:	9
Rejected:	2

The fifty-five projects (with approved funding) result in a total budget required of approximately $1,990K. As a result, $420K of the original Research budget ($2,320K) is being returned to Finance for redistribution within the CNSC, of which $160K is from the special Security funds.

Appendix D lists those projects that are already in-progress or have completed this fiscal year. Appendix E lists those projects that have been granted Level 1 approval and waiting initiation by the proponent.

3 Future Intentions

The Program is in the process of being re-vamped in order to better align it with corporate strategic and operational objectives. Attempts are also being made to coordinate the Program with work being done by the power reactor licensees, to review the adequacy of research work in areas other than power reactors and to encourage collaborative research with outside parties.

Appendix A:
Projects Completed in Fiscal Year 2001-2002

R100.1	$29K	Advances in Reactor Physics Methods at École Polytechnique
R102.1	$50K	CATHENA Model of Loss-of-Flow at Darlington NGS
R103.1	$0K	ELECTRES/ELOCA Simulation of CABRI-1 *
R105.1	$39K	Loss of Reactivity Control Analysis Methodology
R106.1	$15K	PHT System Acoustics: Validation of Code Assumptions
R109.1	$9K	Steam Generator Tubes Integrity Program – Phase 2
R111.1	$5K	National Dose Registry Conversion for Regulatory Monitoring
R113.1	$28K	Effectiveness of Eddy Current Steam Generator Tube Inspection Techniques
R114.1	$6K	Review of Organizational and Management Processes at TRIUMF
R117.1	$42K	Public Participation and Consultation Processes
R119.1	$18K	Canadian Participation in the ICDE (Contribution)
R122.1	$32K	Application of CSAU to CANDU Overpower Analysis
R127.2	$16K	Presentation on Knowledge Management
R149.1	$1K	Publication of Research Results of Laboratory and Numerical Investigation of In-pit Disposal of Tailings
R151.1	$22K	Organizational and Management Performance Indicators – Phase 2
R160.1	$2K	Peer Review Panel for the Port Hope Community Health Status Assessment Study (Standardized Mortality Ratio)
R160.2	$4K	2nd Peer Review of the Port Hope Community Health Status Assessment Study (Standardized Mortality Ratio)
R162.1	$12K	Cancer Incidence Surveillance in Regions Proximal to Canadian Nuclear Facilities – Phase 2

R175.1	$136K	Organizational and Management Evaluation of OPG's Bruce B Nuclear Generating Station
R176.1	$16K	Study of GIS as Corporate Tool for CNSC
R178.3	$6K	Study Working Group for the Saskatchewan Uranium Miners' Cohort
R179.1	$3K	Iodine-129 Transport in Typical Precambrian Shield Groundwaters
R180.1	$8K	National Guidelines for Off-site Nuclear and Radiological Emergency Preparedness and Response (Phase 2)
R182.1	$64K	Fitness-for-service Guidelines for Regulation of Aging Steam Generators
R183.1	$4K	Proposal to Develop Licence Application Review Guides for Research Reactors Facilities – Phase 2
R186.1	$16K	Doses to Portable Gauge Users – Phase 1
R187.1	$6K	Performance Indicator System Technical Support
R189.1	$2K	Ontario Miners Database Feasibility Study
R190.1	$14K	Analysis of Pressure Tube Ballooning Experiments
R192.1	$6K	CNSC Working Group on External Dosimetry
R193.1	$17K	CNSC Working Group on Internal Dosimetry
R195.1	$24K	Performance of Motor Operated Valve (MOV) Stem Lubricant at Elevated Temperature
R196.1	$10K	Independent Assessment of Design Options for MAPLE Shutdown System 1
R198.1	$24K	Fuel Experimental Program Review

Total expenditure in fiscal year 2001-02 on projects which ended during the year = $686K.
Values above have been rounded to the nearest $1K.

Appendix B:
Description of Selected Projects

A brief description is given below of a selection of projects which completed in fiscal year 2001-02 or have been in-progress for several years, to demonstrate their value to CNSC staff. The projects described are:

R101.1	$65K	Lattice Database for Static and Transient Analysis
R102.1	$50K	CATHENA Model of Loss-of-Flow at Darlington NGS
R105.1	$39K	Loss of Reactivity Control Analysis Methodology
		Combined O&M Series
R114.1	$6K	Review of Organizational and Management Processes at TRIUMF
R151.1	$22K	Organizational and Management Performance Indicators – Phase 2
R175.1	$136K	Organizational and Management Evaluation of OPG's Bruce B Nuclear Generating Station
R147.1/2/6	$68K	Saskatchewan Uranium Miner's Study
R179.1	$3K	Iodine-129 Transport in Typical Precambrian Shield Groundwaters
R180.1	$8K	National Guidelines for Off-site Nuclear and Radiological Emergency Preparedness and Response (Phase 2)
R186.1	$16K	Doses to Portable Gauge Users – Phase 1
R196.1	$10K	Independent Assessment of Design Options for MAPLE Shutdown System 1

R101.1 – Lattice Database for Static and Transient Analysis

The current reactor physics methodology, employed in safety analyses, relies upon the accuracy of lattice cell calculations. These calculations are used to generate homogenized cross sections and basic data for calculation of incremental cross sections, reactivity coefficients, kinetics data, and bundle radial power distributions.

The Canadian industry is currently involved in an extensive validation and replacement program looking at reactor physics codes used in safety analyses of CANDU reactors. A key element of this program is the validation of *WIMS-IST*, which is proposed to replace the

current lattice cell code *POWDERPUFS-V*. The validation of *WIMS-IST* is based on comparison against available differential and integral experiments and benchmarking against more accurate methods.

The objective of this work was to: generate the necessary data for steady-state and transient diffusion core calculations based on *HELIOS* simulations of perturbations to operating parameters describing the lattice cell conditions in a CANDU core; and generate the necessary data for code-to-code comparisons and perform a limited assessment of results of *HELIOS* and *WIMS-IST* simulations of perturbations to coolant density, fuel temperature and coolant temperature.

The work consisted of generating two-group CANDU lattice cell data (homogenized cross sections, discontinuity factors, and kinetics data) as a function of operating parameters describing lattice conditions (1,800 states) with the transport code HELIOS for use in core calculations performed by a core diffusion code, and generating 45-group HELIOS data to be used with the DRAGON-IST code in order to develop incremental control and structural material cross sections. Additional work consisted of generating a master library of lattice cell data, and developing a lattice data interpolator (LDI) code, for accessing the database efficiently and performing interpolation calculations, to be used by CNSC.

A subset of the lattice cell data generated by *HELIOS* was compared to similar data from *WIMS-IST*. It was found that the void (coolant density) reactivity agreed well. The agreement in the coolant temperature reactivity was, in general, good. Certain discrepancies were noted with increasing fuel burnup and fuel temperature perturbation. The *WIMS-IST* code consistently underestimated the void reactivity, underestimated the coolant and fuel temperature reactivities at the fresh fuel condition, and overestimated the coolant and fuel temperature reactivities with burnup, as compared to *HELIOS*.

The results of the study are used by the CNSC staff in the review and evaluation of licensees' submissions related to validation of the reactor physics codes under GAIs 98G02 and 99G02, treatment of positive void reactivity in LOCA analysis, GAI 95G04, and the overall accuracy of the industry's safety analysis-related transport and diffusion calculations for CANDU cores.

R102.1 - CATHENA Model of Loss-of-Flow at Darlington NGS

Safety analyses of CANDU reactors, regularly submitted by the licensees to CNSC for review, contain results of numerical simulations of various postulated accident scenarios, which are used to demonstrate safe operation of these reactors within specified limits. These simulations are conducted with a variety of computer codes, many of which were developed by the Canadian nuclear industry to address the specificity of hypothetical accident scenarios in CANDU nuclear plants. Among these codes, two thermalhydraulic system codes, TUF and CATHENA, play a prominent role in assessing the behaviour of reactor systems during such events as Loss-of-Coolant Accident (LOCA) or Loss-of-Flow (LOF). The TUF code, developed by the technical staff of the former Ontario Hydro (OH), is used by Ontario Power

Generation (OPG) to analyze transient behaviour of all their nuclear generating stations. The CATHENA code is used by AECL and New Brunswick Power Commission to support their licensing activities. Both TUF and CATHENA are based on the same theoretical premises for modeling two-phase flow, and their capabilities to simulate CANDU-type reactors are very much comparable.

In its assessment of licensee submissions, CNSC staff occasionally carries out code simulations to develop sound opinion on certain aspects of submitted analyses. Most often these simulations are limited re-runs of cases submitted by the licensees, but they may involve modifications to the plant models built by them (sensitivity assessments). When in-house analyses uncover areas where the licensee's methodology or assumptions are questionable, usually not much can be done to resolve such issues quickly. However, for analyses using system thermalhydraulic codes, the parallel capabilities of TUF and CATHENA offer the possibility of cross-checking the code results submitted by the licensees. Since this verification process can strengthen the basis of the decisions and/or recommendations made by CNSC staff, it is viewed to be a valuable aid in the review of safety-analysis reports.

The objective of this research project was to expand CNSC staff means to cross-check OPG's TUF code results by developing a suitable CATHENA model of the Darlington NGS heat-transport system. An input deck corresponding to the latest release of the CATHENA code has been developed, and configured to simulate Darlington LOF scenario under specified conditions. To assure meaningful inter-code comparisons, the CATHENA model (represented by this deck) aimed to have similar complexity to the corresponding TUF model used by OPG. Several subtle modeling issues, previously unknown to CNSC staff, were uncovered during testing of the new model. These issues have been communicated to the industry, and their potential impact on the quality of licensing simulations is being assessed. Full resolution of these issues may require further investigation, and may warrant a next phase of this research project.

Despite its preliminary nature, the CATHENA model resulting from this development has been already used by CNSC staff as a scoping tool to investigate the adequacy of primary relief capacity for complete loss of heat-sink events in Darlington NGS. This study arises from CNSC work on the response of CANDU reactors to extreme events.

R105.1 - Loss of Reactivity Control Analysis Methodology

The power generated in the fuel at any location in the CANDU reactor core depends upon the neutron flux shape and the overall reactor power. Control of reactivity is required to keep the reactor power at the specified level and to compensate for changes in reactivity that occur due to effects such as refuelling and fuel burnup. Spatial control of reactivity is required to keep the reactor flux shape close to flat so as to avoid local power peaking and thus maximize the power produced while not exceeding operating power limits.

Overall, the treatment of spatial effects on reactivity change, flux shape and local overpower is either stylized or disregarded in the current licensees' methodology. The analyses of recent loss of Class IV events at Gentilly-2, 1995, and Point-Lepreau, 1997, have shown limitations of current licensees' methods to appropriately predict the changes in reactivity.

The objectives of the work were to: review and assess the licensees' current methods and compare against current state of the art solution methods, such as the nodal methods; perform transient calculations of the 1995 loss of Class IV event at Gentilly-2 using plant data and SOPHT-G2 predictions of the thermal-hydraulic transient; and assess the results and make recommendations concerning the treatment of spatial effects in safety analyses of loss of reactivity control events.

This was accomplished by completing simulations of the 1995 Class IV event at Gentilly-2 using the NESTLE space-time kinetics core simulator utilizing different cross-sections sets, spatial discretization treatment and time-step sizes and comparing the results against the licensee simulations.

From the sensitivity studies completed, it was concluded that for the 1995 Class IV event at Gentilly-2 analyzed that the coolant density distribution is the prominent core property that determines the reactivity behavior and hence total prompt thermal power transient. Given the predicted sensitivity of peak core power to the change in coolant density from initiation of the transient, it was concluded that an accurate evaluation of the time and spatially dependent coolant density distribution is required to accurately predict the core power transient.

Since licensees' current safety analyses are based upon the point kinetics approach, the importance of spatial effects on the core's reactivity and power distribution were examined. The importance of spatial effects on core reactivity was evaluated using NESTLE by determining the coolant density reactivity coefficient and change in core reactivity from initiation of the transient as a function of time for the actual and uniform spatially dependent coolant density distributions. This study revealed the potential for a strong sensitivity of the coolant density reactivity coefficient to actual core conditions.

The importance of the spatial evolution of the channel relative power distribution was evaluated using NESTLE by determining the change in power distribution from initiation of the transient for both transient and steady state determined power distributions. The study confirmed the expected behaviour that for rapid transients, steady state and transient channel relative power distributions can be quite different. This implies that a "state point" approach to determining the power distribution, where point kinetic determined core inlet conditions and power level are utilized in a steady-state core simulator evaluation will not produce an accurate prediction of the transient power distribution. The power distribution differences also indicate the difficulty of determining reactivity coefficients, even when based upon 3-D core simulations, because of differences in initial, steady state "state point", and transient flux and power distributions along with impact on other core properties' conditions, e.g. coolant density distribution. Because of the complexity of spatial effects, both neutronics and thermalhydraulic effects, it was recommend that to verify the conservatism of the point

kinetics approach, 3-D space-time neutronic and thermalhydraulic simulations be completed for the different classes of transients.

The results of this study are used by the CNSC staff in assessing the adequacy of the current licensees' methodology used in analyses of loss of reactivity control and loss of flow events. The results of the study are also used in the review and evaluation of the licensees' submissions related to validation and replacement of reactor physics codes under GAI 99G02, and the overall accuracy of the industry's safety analysis-related transport and diffusion calculations for CANDU cores.

R114.1 - Review of Organizational and Management Processes at TRIUMF

R151.1 - Organizational and Management Performance Indicators – Phase 2

R175.1 - Organizational and Management Evaluation of OPG's Bruce B Nuclear Generating Station

The CNSC has developed a method and process for assessing the effects of organizational influences on nuclear safety performance, using the Organization and Management Review Method. The method includes a model of the organization, called the Canadian Adaptive Machine Model (CAMM), and examines the human organizational characteristics that influence safety in a Canadian nuclear facility. The model postulates that a nuclear organization can be configured into five components that include the Strategic Apex (to set the corporate vision, goals, and policies and translate them into site goals, and policies), a Middle Line (to oversee activities related to operations, maintenance and service), a Technostructure (to standardize work processes, outputs and the skills of the operating professionals), an Operating Core (to accomplish the work of the organization) and Support Staff (to facilitate work and minimize any disruptions to the flow of work). Hypotheses related to the organizational and management functions, and processes related to safety can then be generated and measured.

By mid-2002, having developed and validated the Review Method, we have completed baseline assessments for most of the major CNSC licensees, including all nuclear power plants and a number of other nuclear facilities such as a research reactor, a uranium mine/mill facility, an accelerator, and a conversion facility. FY01/02 saw the completion of the O&M review at TRIUMF and Bruce B as well as preliminary work on O&M performance indicators. Data is beginning to emerge which confirms that nuclear facilities in Canada belong to a small population of organizations known as "high reliability organizations". Behaviors that would be exhibited in high reliability organizations have been grouped together in what has been termed a Constructive cultural style that includes high affiliative and humanistic-encouraging attributes, as well as a high emphasis on safety. All Canadian nuclear facilities evaluated to date exhibit high reliability characteristics.

Ongoing monitoring of all of those licensees will continue into the future, as part of the CNSC Compliance Program. Subsequently it is the intention to periodically revisit and re-evaluate those sites in order to monitor them for any changes to their organizational profiles.

In the long term, the goal is to use these tools in order to predict when safety in a nuclear facility is likely to decline. By identifying and correlating O&M performance indicators (from the baseline data collected from facility assessments) with other existing/developing performance indicators, it is the intention that, in the future, those data will be predictive of situations that are harder to discriminate in terms of safety performance. Although the CNSC is not yet at the point where, based on these few O&M evaluations alone, it can decide that action needs to be taken to stop a decline in safety standards, the use of all of its O&M evaluation data, combined with other information provided by inspections and audits, provides the CNSC with a profile of the organization that it can and does use in its oversight and boundary monitoring of its nuclear licensees. If other key results areas are acceptable, then we can conclude that the organization and management profiles are likely to be acceptable as well. The other key areas are defined in the eighteen Technical Programs of the CNSC's Compliance Program and include, for example, Criticality Safety, Emergency Preparedness, Radiation Protection, Human Factors, Environmental Protection, Fire Protection, Quality Management, and Training Program Evaluation.

It is important to note that organizational change can occur over a long period of time and through informal processes, as well as through planned and managed change initiatives. It is felt that it is imperative that the CNSC keep a close watch on O&M issues on a continuous basis as part of the normal regulatory overview. If a nuclear facility's O&M profile changes from the theoretical characteristics of a high reliability organization, resulting in a potential narrowing of the safety margin, other technical information can be examined to provide some insight into the causes of those changes. Regulatory action can then be taken, based on the objective analysis of all of those data.

R147.1/2/6 - Saskatchewan Uranium Miner's Study

In 1993, the Joint Federal-Provincial Panel on Uranium Mining Development in Northern Saskatchewan recommended that an ongoing epidemiological study of all Saskatchewan uranium miners (past, present, and future) begin and the results be promptly communicated to the public.

The CNSC (then the AECB), the government of Saskatchewan and industry supported these recommendations and proceeded in 1995 to set up a study group, comprised of these organizations, to plan the details of this undertaking. The study group agreed to divide the study into two parts. Part I was to address the past by providing additional mortality follow-up and reanalysis of the historical Beaverlodge cohort of miners. This meant a total of almost 50 years of follow-up of these miners; an additional 18 years since the last analysis. Part II was to address the modern mine era, beginning in 1975 onward. It would try to address the impact of other occupational exposures, such as arsenic, nickel and diesel fuels, as well as address the relationship between tobacco smoking and radon progeny on the development of lung cancer among modern miners.

So far only work on Part I of the overall project has begun. The current Beaverlodge Study follows up the historical Beaverlodge miners' cohort (conducted in 1982) to determine

mortality to the present time, revise exposure estimates, and reanalyze the cohort to reinvestigate the relationship of radon progeny exposure and lung cancer. Employee information during the last few years of Beaverlodge operation has been added to the nominal roll, work histories are being updated and errors have been corrected in the original database. Two separate contracts had been issued (projects R147.1 and R147.6) to do this work. In addition, the linkage of the cohort to the Canadian Mortality Database (CMDB) is well underway (project R147.2).

Part I of the overall project is about two thirds complete with approximately one hundred thousand dollars ($100,000) being spent, by the CNSC, to date for data collection and data linkage. Approximately one hundred and thirty thousand ($130,000) is still required in order perform the analysis of the data. The Saskatchewan Government and industry have agreed to share the cost of the additional work with the CNSC.

Part II of the overall study remains to be initiated. On March 5, 2002, the CNSC's Vice President of Operations Branch meet with Saskatchewan Labour, Saskatchewan Health, Saskatchewan Cancer Agency, COGEMA, and CAMECO. At the meeting all parties agreed in principle to co-fund the Saskatchewan Uranium Miners' Study (1/3 CNSC, 1/3 industry, 1/3 Saskatchewan government). However, Part II will need to take a phased approach beginning with a feasibility study.

R179.1 - Iodine-129 Transport in Typical Precambrian Shield Groundwaters

Post-closure performance assessments by AECL indicate that long term doses to the public from a spent fuel repository, which may be constructed in the Canadian Shield in the future, will be dominated by the long-lived radionuclide iodine-129 that is present in the fuel. However, relatively little is known about background levels of either stable iodine-127 or iodine-129 in groundwaters on the shield with which to compare predicted releases to groundwater from spent fuel. In this project, iodine concentrations were measured in a shallow groundwater flow system in the Sturgeon Falls watershed in central Ontario as well as in deep groundwaters from various mines across the Canadian Shield. It was found that in the shallow groundwaters, iodine-129 concentrations are dominated by I-129 in present-day precipitation that is significantly elevated from pre-nuclear levels due to on-going releases from global nuclear fuel re-processing plants. However, a major component of the precipitation I-129 is taken up by organic soils during infiltration such that groundwaters have lower I-129 levels than predicted based on its concentration in precipitation. This information on stable iodine and I-129 concentrations in shallow groundwaters should enable more credible dose calculations in the long term performance assessment of future high level radioactive waste facilities that may come before the CNSC for licencing.

Deep mine groundwaters in the shield are highly saline and stable iodine concentrations are greatly elevated due to the concentrated seawater origin of these waters. These groundwaters also have I-129 concentrations greater than those in shallow groundwater due to the time-dependent ingrowth of I-129 from the fission of naturally occurring uranium-238 present in the host rocks. This study has shown that it is possible to use the time dependent ingrowth of

I-129 to calculate the subsurface residence of the groundwater. Information on groundwater "age" at a potential site for a spent fuel repository will be an important factor in any future CNSC licencing decision as to whether the site is "safe" for the construction of the repository.

The results of this study are presented in the contractor's report (RSP-0146) for this project prepared by the University of Ottawa. Furthermore, a paper describing the iodine geochemistry and iodine-129 concentrations in shield mine waters will be published in the July, 2002 issue of the scientific journal *GEOLOGY.*

R180.1- National Guidelines for Off-site Nuclear and Radiological Emergency Preparedness and Response (Phase 2)

In 1998, the CNSC received a request from the province of Ontario to develop and establish national guidelines in the area of off-site nuclear emergency preparedness. Legal opinions provided to the CNSC (AECB at that time) indicated that, although there is a division of responsibilities between the federal government and the provinces, off-site contingency planning for nuclear facilities lies in an area overlapping the two jurisdictions. There are mutual interests involving not only nuclear energy, but also public health, safety, security and the environmental protection. The CNSC acceded to the request and with the support of the federal, provincial and territorial partners, sponsored the development of a set of national guidelines.

The guidelines were to assist people and organizations that have a key role in the development, review, audit and evaluation of off-site emergency response planning, by providing them with an evaluation tool with which they could draw appropriate conclusions on the adequacy of their individual off-site preparedness and response capabilities.

Phase 1 of the project established the general scope for "National Guidelines for Off-site Nuclear and Radiological Emergency Preparedness and Response". The purpose of phase 2 was to separate the original proposed guideline into two entitled "General Guidelines for Off-Site Emergency Preparedness and Response, Nuclear"; and "General Guidelines for Emergency Preparedness and Response, Radiological". The first report is for events involving large nuclear facilities and the second report for those involving smaller facilities and radioactive sources. In each case, the proposed guidelines address the development, evaluation and enhancement of off-site emergency response arrangements, infrastructure and capabilities to limit risks to the health and safety of persons and the environment. The guidelines are intended to be consistent with recognized international principles, and are purposely generic in nature to accommodate regional differences in emergency response arrangements.

The CNSC has recently sent a letter to its federal, provincial and territorial partners soliciting their comments on the need to enhance the reports with a security aspect; and it is also seeking their advice on how best to promulgate these guidelines.

R186.1 - Doses to Portable Gauge Users – Phase 1

Portable gauges typically contain a gamma emitter Cs-137 at 370 MBq at the tip of an extendable steel rod and a neutron source Am-241/Be at 1850 MBq located at the bottom of the plastic gauge body. The doses from these sources are minimized by appropriate shielding. When handled properly, a gauge poses minimal exposure risk either to gauge operators or to the public.

Possession and use of portable gauges in Canada is regulated by the CNSC. A CNSC licence to use a portable gauge is issued to a qualified applicant, who must have an adequate radiation protection program. Some important components of the radiation protection program for portable gauge licensees are: Radiation Safety Officer; workers training in radiation protection and transportation of dangerous goods; physical security; leak testing; and appropriate emergency procedures for theft, fire, traffic accidents and other incidents.

The need to better define exposure levels to portable gauge users was recognized by the CNSC (then AECB) in 1988, when a study was commissioned. The field study, conducted by the AECL involved 23 operators and maintenance personnel. The conclusion was that an annual exposure higher than 5 mSv was unlikely for an operator but could be a factor for maintenance personnel. The problem with the 1988 study was that it used too few subjects for a significant result and did not make any attempts to address any of the confounding variables, such as education, gender, age, etc.

In 2000, the new CNSC Radiation Protection Regulations set a threshold of 1mSv/year for designating workers as Nuclear Energy Workers (NEWs). In addition, pregnant NEWs must not exceed 4 mSv for the balance of their pregnancy. Given these lower regulatory limits, there was a concern that portable gauge users may need to be designated as NEWs.

At present there are approximately 2,800 portable gauge devices licensed by the CNSC (see BMD 99-168). If one was to assume a one-to-one correspondence between the number of devices and the number of users, there is an estimated 2,800 portable gauge users at any time in Canada. The proper sample to study occupational exposure in such population needs to be defined on the basis of the population characteristics.

In the current research project a survey of portable gauge users throughout Canada was conducted in order to determine the doses from a number of measurements, which includes transport of portable gauges. The survey enabled better characterization of the population of portable gauge users. The survey found that:

- 96% of portable gauge operators were male;
- 82% had college or higher education;
- 74% were over 30 years of age;
- 62% had more than 5 years of experience;
- significant number (33%) use computer based training; and

- 59% used the gauge for up to 6 months per year (which coincides with the construction season).

The survey also showed that the distribution of gauge use was multimodal, with three broad categories of users: one at less than a 1000 shots per season; second averaging at about 2500 shots per season; and third at over 5000 shots/season.

Combined with the result of the 1988 study, which gives an average dose at 1 μSv/shot, it appears that a significant number of portable gauge users, i.e. ~45%, will need to be designated as NEWs because their occupational doses exceed the regulatory limit of 1 mSv/yr. Approximately 13% of portable gauge operators will be required to wear appropriate dosimetry, because their dose is above 5 mSv/yr. Currently, CNSC staff are reviewing the implication of the findings on the licensing of portable gauges in light of dose limits in the Radiation Protection Regulations.

R196.1 - Independent Assessment of Design Options for MAPLE Shutdown System 1

MAPLE 1 is an isotope production reactor that is located in the AECL-CRL site. During commissioning, from March to July 2000, MAPLE 1 experienced a series of shutoff rods failures. These failures consisted of a shutoff rod not fully dropping into the core, or failing to move up for the poising position. The reactor subsequently was put in a shutdown state until the problem was found and resolved.

Despite the safety design features, CNSC staff considered shutoff rod failures to be serious event as a common mode failure involving the shutoff rods and control absorber rods could reduce the defence-in-depth to an unacceptable level. The design was vulnerable to small particulates, either entrained from the outside or internally generated. If an accident (such as a seizure of the coolant pump) occurred, the consequences of such a fast transient with failure to shut down could be severe and could lead to a core disassembly. Thus, the shutdown systems are designed with a stringent reliability requirement, to ensure reactor shutdown when necessary. Repeated SOR failures for the year 2000 represent non-compliance with the AECL's reliability requirement.

AECL investigated to find out the causes of these failures, and concluded that particles were entrained from the outside, migrated into the tight clearance between the shutoff rod and the bearing, and caused jamming. AECL subsequently undertook a number of activities to address the shortcomings identified, including a re-design of the shutoff rod system.

CNSC staff's assessment concluded that despite of the design improvements the shutoff rods still had intrinsic weaknesses (tight clearances and moving parts subjected to side forces). AECL was asked to consider alternate design options for the shutoff rod system, and to propose the most viable option. AECL responded with a conclusion that the current design based on the hydraulic system was the most viable option, and that the changes made to the current design (e.g., increased clearance for the main piston) improved the performance sufficiently that the modified design will meet all performance and reliability requirements.

CNSC staff continued to take a position that the basic design weakness remained, and that the current design, even with improvements, was still vulnerable to failure. CNSC then decided to engage an independent contractor to provide staff with advice as to whether AECL had considered all practical design solutions, and that their evaluation of design options was technically sound. It was recognized that any design solution should be practical enough to be implemented into the small core allowing its access for manual fuelling, and also in the state of MAPLE 1 construction.

The independent assessment concluded that the modified shutoff rod system was capable of meeting the design requirement reliably if modified further, operated, tested and maintained with suitable procedures. Alternatively, it could be replaced with a simpler electromagnetic system, without interfering with fuel handling. Up and down sensing could be directly accomplished by various means. It was noted that the implementation would, however, result in considerable delay.

CNSC staff used the results of this assessment as one factor in recommending commissioning to recommence (See CMD 01-H35).

Appendix C:
Reports Issued in Fiscal Year 2001-2002

RSP-0134, Establish a Sound Process for Determining the Adequacy of the Design of Uranium Facilities, I.L. Herbert, Eutech

RSP-0135, Cancer Surveillance in Proximity to Nuclear Facilities - Phase 1, Environmental Risk Assessment and Case Surveillance Division, Cancer Bureau, Centre for Chronic Disease Prevention and Control, Health Canada

RSP-0136, Study of the Potential Implications of Adopting Single Failure/Severe Accident Licensing Requirements, R.A. Brown, R.A. Brown and Associates Ltd.

RSP-0137, The Combined Effects of Alpha Radiation, Nickel and Arsenic - Exposure on Human Fibroblasts, B.P. Smith, R.E.J. Mitchel, Atomic Energy of Canada Limited – CRL, Chalk River

RSP-0138, Review of the Coverage Limit in the Canadian Nuclear Liability Act - Phase 1 Development of the Methodology, P. Butler, Magellan Engineering Consultants Incorporated

RSP-0139, Analysis of Pu-239/240 and Am-241 in Urine Samples: Report on a Method Development Project Conducted for the Canadian Nuclear Safety Commission, R. Falcomer, M.L. Zamora, Radiation Protection Bureau, Health Canada

RSP-0140, Evaluation of Safety Technician Training Programs at Ontario Power Generation Inc. Bruce NGS≅B≅ Facility, W. Gutzzman, CTECH RMM

RSP-0141, Physical and Numerical Modelling of an In-Pit Tailings Management Facility, Duke Engineering & Services (Canada) Inc.

RSP-0142, Survey of Canadian Portable Gauge Users, T.J. Jamieson, P.M. Lord, A. Mastilovic, D. Newman, Science Applications International Corporation (SAIC Canada)

RSP-0143, PHT System Acoustics: Validation of Code Assumptions, Dr. D.S. Weaver, Department of Mechanical Engineering, McMaster University

RSP-0144, Community Relations Exploratory Research Focus Groups, SAGE Research Corporation

RSP-0145, Study of Geographic Information Systems as a Corporate Tool for the CNSC, AMEC Technologies

RSP-0146, ^{129}I in the Environment: Phase II - the Fate of Atmospheric ^{129}I in a Shallow Sand Aquifer System at Sturgeon Falls, Ontario, Canada, I. Clark, R. Renaud, Earth Sciences, University of Ottawa; T.G. Kotzer, Atomic Energy of Canada Ltd.; G.M. Milton, Deep River, Ontario

RSP-0147, Review of CANDU Steam Generator Fitness-for-Service Guidelines and Darlington Life Cycle Management Plan, J.E. Harris, J.A. Gorman, Dominion Engineering Inc.

RSP-0148, Safety Report Review Guide for Research and Radioisotope Production Reactor Facilities - Phase 2, Suretech Development Limited

RSP-0149, Ontario Miners Database Feasibility Study, Dr. L.D. Marrett, S.-M. Nahm, Department of Public Health Science, University of Toronto

RSP-0150, Assessing the Uncertainty in the Pressure Tube Ballooning Predictions Using Safety Code, S.N. Kariyawasam, C-FER Technologies

Appendix D:
Projects In-progress in Fiscal Year 2002-2003
Objective and Scope of Work

Changes to the CNSC internal systems have required a new project numbering system to be used starting in FY01/02; the old project numbers, for those projects that started prior to then, are noted in brackets. The expenditures given for each project are the actual expenditure in FY01/02 and the anticipated expenditure in FY02/03, including CNSC Project Manager's travel where applicable

R101.1 (2.271.4)
$66K
$3K

Lattice Database Development for Static and Transient Analyses

Objective: To review and assess the validation of the WIMS-IST code and the overall accuracy of the industry's safety analysis-related transport-diffusion calculations for CANDU cores.

Scope of Work: A matrix of cases covering a specified range of expected accident conditions is to be run using the lattice cell code HELIOS. The contractor will: Develop a library of two-group homogenized cross-sections and related data as a function of burnup, coolant density, coolant temperature, and fuel temperature; and compare and report the differences between the WIMS-IST and HELIOS predictions of the two-group homogenized cross sections and the reactivity coefficients at CNSC specified conditions.

R104.1
$19K
$56K

Guidelines for Assessment of Electromagnetic Interference (EMI) in the CANDU Plant – Phase 2

Objective: Collection and analysis of EMI emission data at a CANDU Nuclear Power Station in order to assist in the establishment of the EMI limiting guidelines for the safe operation of CANDU reactors.

Scope of Work: EMI emission data collection will be performed at site in accordance with the conclusions of the first phase (Guidelines for Assessment of Electromagnetic Interference in the CANDU Plant). The data collected will be analyzed to establish the EMI limiting guidelines for the safe operation of CANDU reactors.

R108.1 **State-of-the-art Report on Moderator as a Heat Sink**
(2.615.2) **Objective**: To support an assessment of the acceptability of the moderator as a
$59K heat sink as the basis for various accident scenarios in the SR and PSA and to
$10K identify any outstanding actions that could be required of the licensees.
Scope of Work: Perform a critical review of the current experimental knowledge on fuel channel behaviour during high temperature transients and the capabilities of current analysis tools. Identify any developments in analysis tools and/or methods and/or experimental data required to produce a validated case for the moderator as a heat sink that covers all the phenomena and accounts for uncertainties in experimental data, models, and operating conditions.

R110.1 **International Study on Nuclear Industry Workers (Contribution)**
(7.200.2) **Objective**: To provide information for direct testing of the validity and
$10K accuracy of the various extrapolation models currently used for risk estimates
$10K and for the setting of radiation protection standards.
Scope of Work: The International Collaborative Study of Cancer Risk among Nuclear Industry Workers is a study of the health effects from long-term low-level radiation exposures and is sponsored by the international community. The study includes a population of some 900,000 nuclear industry workers drawn from twelve participating countries (Australia, Belgium, Canada, Finland, France, Germany, Japan, Spain, Sweden, Switzerland, UK, and USA).

R112.1 **The Determination of Radiation Damage in Sub-populations of Human**
(7.223.4) **White Blood Cells**
$46K **Objective**: To investigate whether the comet assay or the flow cytometry assay
$23K can be used as biological dosimeters in situations where the time of exposure is not precisely known, and sample collection may be days to weeks post exposure.
Scope of Work: Test the apoptotic fraction of $CD8^+$ and $CD4^+$ T-cells pre and post, at various time intervals, exposure to I-131.

R115.1 **Simulation of the FEBEX Experiment as a Test Case for DECOVALEX**
(5.603.1) **III**
$26K **Objective**: To provide staff with fundamental, updated understanding of the
$30K parameters that affect the near-field safety of the in-room option of disposal of nuclear fuel wastes.
Scope of Work: Further develop and verify the FRACON computer code. Use the code to simulate the FEBEX experiment as defined by the DECOVALEX secretariat. Some laboratory experimentation may be necessary to determine the values of parameters in constitutive relationships.

R116.1 **Laboratory Investigation of the In-pit Disposal Concept for Uranium**
(5.610.1) **Mines Tailings**
$28K **Objective**: To further the understanding of in-pit disposal of tailings.
$20K **Scope of Work**: Physically and numerically simulate more complex field situations to better represent the conditions encountered across Northern Saskatchewan than those done in Project 4.428.1. The contractor will examine a variety of pit configurations and host rock fracture patterns to assess their influence on ground water flow and contaminant transport.

R119.2 **ICDE Project - Preparation of Data to be Submitted to the Clearing House**
$36K **Objective**: To fulfil Canada's obligation to the ICDE project and to provide the
$15K CNSC with a means to cross-check the licensee's reliability models and Probabilistic Risk Assessments for their correctness and completeness.
Scope of Work: Gather data on failures of specific components (centrifugal pumps; safety and relief valves; and motor operated valves), analyse it for detection of Common Cause Failures and prepare records according to the ICDE specific coding guidelines. The data will be gathered from all Nuclear Power Plants in Canada and unless otherwise indicated by the CNSC project manager, will be limited to failures between 1990/01/01 and 1999/12/31 (10 years).

R119.3 **Canadian Participation in the ICDE (International Common-Cause Data**
$0K **Exchange) (Contribution)**
$25K **Objective**: The objectives of the ICDE projects are to: collect and analyze CCF events over the long term so as to better understand such events, their causes, and their preventions; generate qualitative insights into the root causes of CCF events which can be used to derive approaches or mechanisms for their prevention or for mitigating their consequences; establish a mechanism for the efficient feedback of experience gained in connection with CCF phenomena, including the development of defences against their occurrence, such as indicators for risk based inspections; and record event attributes to facilitate quantification of CCF frequencies when so decided by the project working group. By participating in the project the CNSC will be able to assess the correctness of the licensees' unavailability and PRA models; obtain qualitative insights on the causes of CCFs in order to prioritize and improve inspections; and verify the adequacy of licensees' actions to prevent occurrence of CCFs.
Scope of Work: The ICDE project includes all possible events of interest, including both complete and partial CCF events. The project covers the key components of the main safety systems (for example centrifugal pumps, diesel generators, and motor operated valves) with the specific items being determined by the project working group. The project will also develop a procedure for updating the CCF database.

R124.1 **CNSC Regulatory Control of Landfills, Hazardous Waste and Scrap Metal Sites**

$40K

$10K

Objective: A number of previously unlicensed sites across Canada require an assessment to determine if they need to come under the regulatory control of the CNSC. The objective of the project is to assist the CNSC determine if any of these currently unlicensed landfill, hazardous waste and scrap metal sites will fall under our regulatory control.

Scope of Work: Identify and create a database of all operating and non-operating landfill, hazardous waste and scrap metal sites in Canada and their current regulatory authority (if applicable).

R131.1 **Probabilistic Assessment of Leak Rates Through Steam Generator Tubes**

$0K

$60K

Objective: To provide the experimental data and the predictive correlations and models needed to permit the CNSC to independently evaluate the integrity of steam generator tubes as plants age and degradation proceeds, new forms of degradation appear, and as new defect-specific management schemes are implemented.

Scope of Work: Investigate CANDU steam generator tube degradation mechanisms (pitting, fretting, and cracking) and develop probabilistic failure and fracture mechanics models. Obtain experimental data on CANDU steam generator representative tube samples for the characterization of the two-phase critical flow through pits, frets and cracks. Develop the leak flow models based on the flaw opening area and the flaw morphology. Integrate CANTIA probabilistic fracture mechanics model and leak flow model into a methodology for probabilistic assessment of steam generator tube inspections and predictions of SG tube leak rates

134.1 **Reactor Physics Aspects of LOCA Analysis Phase 2**

$80K

$21K

Objective: To assess the sensitivity of LOCA power pulse margin parameters to uncertainties in reactor physics modelling parameters and SDS1 speed, based on NESTLE transient calculations of a CANDU core; the sensitivity of LOCA power pulse margin parameters to modelling uncertainties in predicted thermal hydraulic parameters; and the treatment of uncertainties in relation with margin parameters and make recommendations for the physics analysis of LOCA power pulse in order to assist the CNSC make regulatory decisions.

Scope of Work: An independent review of the appropriateness of the licensees' current LOCA methodology regarding reactor physics analysis and conservatism built into analysis results shall be completed. The contractor will support the review with numerical simulations of a CANDU core using an independent method and compare and assess the results against licensees' method predictions. The contractor will identify areas of potential improvements, and make recommendations with respect to uncertainty

allowances recommended for safety analyses.

R139.1 **Review of the Coverage Limit in the Canadian Liability Act – Phase 2**
$0K
$85K
Objective: To quantify the hard cost associated with postulated nuclear accidents, including design basis events and severe accidents in order to assist the CNSC refine the formula used to determine basic nuclear insurance coverage.
Scope of Work: The contractor will: identify reference accidental release categories (including design-basis and severe, but extremely unlikely events) and their associated frequencies for a selected Canadian nuclear power plant; quantify the elements that need to be quantified in the cost evaluation; calculate the radiological consequences of the reference accidents in terms of dose to members of the public and contamination; translate the radiological consequences into cost based on agreed element costs; and evaluate the sensitivity of the calculated cost to the cost elements used in the analysis. The scope of this proposed project is limited to the evaluation of selected tangible cost components, for the selected representative accident scenarios and accident conditions, so that an *illustrative* evaluation of the potential hard component can be made.

R140.1 **The Effects of Ageing on Reactor Physics Parameters - Phase 1**
$0K
$56K
Objective: To assess the sensitivity of key reactor physics parameters due to core ageing and to assess the significance of ageing effects on these parameters so that the CNSC will be able to validate the current licensees' models that involve core ageing.
Scope of Work: A set of HELIOS calculations of a sub-region of CANDU core will be performed to assess the impact of reactor physics-related core aging effects. The detailed model will include pressure tube creep and sag, and bundle shift in the channel. The impact of reactor physics-related core aging effects on flux shape, bundle and pin power distribution and reactivity coefficients will be investigated.

R140.2 **The Effects of Ageing on Reactor Physics Parameters - Phase 2**

$0K
$40K

Objective: To assess the sensitivity of key reactor physics parameters due to core ageing and to assess the significance of ageing effects on these parameters so that the CNSC will be able to validate the current licensees' models that involve core ageing.

Scope of Work: Complete an independent sensitivity study of the core ageing effects based on numerical simulations. Estimation of the perturbations to the whole core properties will require three dimensional simulation of a sub-region of the core to represent the differential distortion of the pressure tube between the channels using the code Monte Carlo N-Particle (MCNP).

R144.1 **OECD Piping Failure Data Exchange Project (OPDE)**

$0K
$23K

Objective: To participate in the international OECD Piping Failure Data Exchange project on behalf of the Canadian nuclear industry. The OPDE was established to encourage multilateral cooperation in the collection and analysis of data relating to piping failures in nuclear power plants. CNSC staff will use the data collected during this project for: ageing management, including tracking of piping pressure boundary integrity; degradation evaluation in support of in-service inspection applications; pipe leak and rupture frequency estimation in support of various probabilistic safety assessment tasks; leak-before-break evaluations; risk impact; trend-and-pattern evaluations, etc.

Scope of Work: The OPDE Project will cover piping components of the main safety systems (e.g., ASME Code Class 1, 2 and 3). It will also cover non-safety-piping systems that if leaking could lead to common cause-initiating events such as internal flooding of vital plant areas. The OPDE Project will exchange piping failure data including non-through wall cracks, leaking through-wall cracks, pinhole leaks, leaks, ruptures and severances (pipe breaks caused by external impact). The non-through wall indications interpreted as structurally significant and/or exceeding design code allowable for wall thickness (typically 10%) shall be included.

R145.1 **Verification of Process Zone Model for Assessing Delayed Hydride Cracking of CANDU Pressure Tube**

$0K
$96K

Objective: To provide expert opinion on the process zone model, with respect to the theoretical and engineering soundness of the methodology, to assist the CNSC in deciding on its acceptability for use on Zr-2.5%Nb CANDU pressure tubes.

Scope of Work: Based on, (but not limited to) the information provided, as well as knowledge and experience with structural integrity analysis methods and with the zirconium alloy and its application in CANDU power reactors, provide an independent, expert, assessment of the validity of the process zone methodology as an engineering procedure to evaluate flaws for DHC initiation in CANDU Zr-2.5%Nb pressure tubes.

R146.1 **Development of Draft Regulatory Guides for Nuclear Security Regulations**

$9K
$14K

Objective: To provide guidance to licensees and service lines in covering the implementation of and compliance with the Nuclear Security Regulations and to assist licensees in augmenting their security programs consistent with the Nuclear Security Regulations requirements.

Scope of Work: To develop the basics for four regulatory guidance documents which will be use by licensees and CNSC service lines subject to the Nuclear Safety and Control Act, General Nuclear Safety and Control Regulations and associated regulations.

R147.1 **Saskatchewan Uranium Miner's Study - Preparation of Cohort**

(4.598.2)
$23K
$4K

Objective: To provide an additional 18 years of mortality follow-up since the conduct of the original study (total mortality follow-up of miners now from 1950 to 1998), improved exposure estimates and analysis of the Eldorado uranium miners' cohort to determine the relationship between radon exposure and lung cancer.

Scope of Work: To prepare the Beaverlodge Study Cohort, including correction of identified errors and updating of radiation exposure histories, completing and filling the application for the mortality match with Statistics Canada.

R147.2 **Saskatchewan Uranium Miner's Study**

$40K
$20K

Objective: To estimate the risk of cancer death as a result of uranium mining and disseminating these findings.

Scope of Work: Link the Eldorado Nuclear cohort to the Canadian Mortality Database for the years 1950 to present.

R147.5 **Un-Duplicate the Eldorado Cohort – Part 1 of the Saskatchewan Uranium Miners' Cohort Study**

$0K

$37K

Objective: To obtain scientifically sound estimates for the risk of lung cancer as result of radon exposure as well as refining our understanding of the occupational health risks of uranium mining. The risk estimates are important and may assist in the setting of new uranium mining standards/regulations by the CNSC and other regulatory agencies.

Scope of Work: Identify and resolve duplicate records in the nominal roll and consolidate the work history file of the Eldorado cohort following the internal linkage of the nominal roll by Statistics Canada; provide the National Dose Registry (NDR) non-Eldorado work history exposures and estimate exposures when no NDR duplicates are found; and manually resolve possible doubtful linkages of the miner cohort with the Canadian Mortality Database (CMDB).

R147.6 **Finalization of the Nominal Roll and Work Histories for Part 1 of the Saskatchewan Uranium Miners' Cohort Study**

$5K

$9K

Objective: To provide an additional 18 years of mortality follow-up since the conduct of the original study (total mortality follow-up of miners now from 1950 to 1998), improved exposure estimates and analysis of the Eldorado uranium miners' cohort to determine the relationship between radon exposure and lung cancer.

Scope of Work: Assist, the contractor in R147.1, in finalizing the nominal role of the Eldorado miners' cohort, correcting errors in the work history files and entering the corrected information into a Microsoft Access, or mainframe database. This involves reviewing old employee files and entering corrected information into a database.

R147.7 **Preliminary Meeting for the Analysis Phase of the Saskatchewan Uranium Miner's Study**

$0K

$2K

Objective: To discuss an analysis plan/proposal and the responsibilities of the principal investigator responsible for the analysis of the updated Eldorado Uranium Miners' Cohort and to discuss progress on the data linkage of the Eldorado Cohort to the Canadian Mortality Database.

Scope of Work: Travel to CNSC Head Office, Ottawa to meet with the CNSC Project Manager of the Saskatchewan Uranium Miners' Cohort Study. Provide scientific and technical advice associated with the updated Eldorado Uranium Miners' Cohort while attending two meetings.

R148.1 **Comparison and Validation of Several Methods that Determine Neutron**
(6.579.1) **Dose Equivalent**
$27K **Objective**: To obtain independent verification of the calculated neutron dose
$17K equivalent determined by empirical formulae using the MCNP source code.
Scope of Work: Neutron production and neutron dose equivalent will be assessed using: published empirical formulae; Monte Carlo Simulation; and direct measurement. The MCNP code V4.00.0 will be used to calculate the neutron dose equivalents. The calculations and measurements will be carried out for a myriad of bunkers at various medical facilities.

R156.1 **Information on the Health Effects from Ambient Levels of Tritium in the**
$12K **Environment**
$2K **Objective**: To produce an information document on the health effects of ambient tritium in order to assist CNSC with the dissemination of objective scientific, technical and regulatory information to the public.
Scope of Work: The contractor will prepare a 10 to 20 page document, written for a public audience, which presents the current knowledge on the physical and chemical characteristics of tritium in oxide and elemental forms and its behaviour in the environment. The document will also contain data on ambient concentrations of tritium, and the current knowledge on the health effects of exposure to tritiated water and tritium gas. In addition, the contractor will incorporate comments made by the CNSC's Communication Division on the first draft and produce a simplified question-and-answer document.

R159.1 **Training Programs for Nuclear Operations Personnel**
$0K **Objective:** To audit or evaluate the present selection criteria and training
$54K programs used by licensees for the position of Senior Health Physicist at a nuclear power plant. The results will be used by the CNSC to develop a standard that could be used as a basis for certification to ensure that persons filling these positions are qualified to carry out their responsibilities as required by the Nuclear Safety Control Act and Canadian Nuclear Safety Regulations.
Scope of Work: Development of a detailed evaluation approach and methodology. Auditing/evaluating the two sites specified in order to collect and analyze the necessary information and facts. Make recommendations for improving the certification process.

R161.1 **Uranium Concentrations in Port Hope Soils, Vegetation and Soil Organisms**

$20K
$26K

Objective: The main objective of CNSC activities related to environmental protection is to ensure that licensed facilities and their operations do not cause adverse impacts on the environment. The objective of this project is: to develop an improved protocol for the long-term monitoring of uranium in soil; to derive site-specific parameters for uranium distribution in Port Hope soils to verify the reliability of model predictions for uranium accumulation in soil due to the Cameco's facility releases; to derive site-specific parameters for uranium bioavailability to locally grown vegetation to verify/refine the estimates of DRLs and radiation doses to critical receptors; and to derive site-specific uranium screening level concentrations for soil organisms.

Scope of Work: Existing methodology for sampling of soil and vegetation will be revised to obtain site-specific parameters for uranium mobility in Port Hope soils and uranium bioavailability to soil organisms and locally grown vegetation. Samples of soil and vegetation will be collected simultaneously to characterize site-specific soil characteristics and determine uranium concentrations in soils, vegetation and soil organisms.

R170.1 **Power Reactor Regulatory Standards Development**

$20K
$11K

Objective: To identify all national and international standards that are useful or applicable to the regulation of Canadian nuclear power plants; to support the completion of all key regulatory policies and standards by March 2003; to support the issuance of guides for public comment by March 2003; and to provide a clear operational document framework and direction for continuing development of future operational regulatory policies and standards for the Directorate of Reactor Regulation.

Scope of Work: The identification of specific regulatory activities related to nuclear power plants where standards and guides are needed; and the identification, listing and procurement of relevant existing national and international standards, guides other relevant publications.

R171.1 **Doses to Transport Workers - Phase 2**
(8.577.2)
$47K
$47K

Objective: To develop criteria or recommendations that can be used for establishing a radiation protection program, and information that can be used for assessing improvements and optimization of these programs. This phase will update the data on doses of ionizing radiation received by transport workers.

Scope of Work: Phase 2 will involve measurements of doses of ionizing radiations received by a selected population of transport workers over a defined period of time, collecting records of doses from transport companies having such records and estimating the number of packages, types and categories and shipments made and the information on the packages.

R177.1 **Paleothermometry of Canadian Shield Groundwaters**
(5.553.1)
$0K
$14K

Objective: To determine the paleoclimatic conditions under which deep shield groundwaters were recharged by measuring the noble gas concentrations in samples collected from selected mine sites on the shield. The results from this study will enable the CNSC to better understand the origin of deep groundwaters on the shield and the safety implications for potential candidate sites for radioactive waste disposal facilities.

Scope of Work: This project will involve field work and laboratory analyses. Ground water samples will be collected from flowing underground boreholes at selected mines on the Canadian shield. Noble gas concentrations in these samples will be analyzed using a specially modified quadrupole mass spectrometer at the AECL Chalk River Laboratories. The measured concentrations will be used to calculate the paleotemperature of the atmosphere at the time of recharge.

R178.5 **Feasibility Study for Part II of Saskatchewan Uranium Miners' Cohort Study**
$0K
$40K

Objective: To obtain scientifically sound estimates for the risk of lung cancer as result of radon exposure as well as refining our understanding of the occupational health risks of uranium mining. The risk estimates are important and may assist in the setting of new uranium mining standards/regulations by the CNSC and other regulatory agencies.

Scope of Work: To conduct a feasibility study that identifies the scope, implementation process, projected timeframe, power of the study, and cost for a proposed cohort study of Saskatchewan uranium mine workers to assess their cancer risks from exposures in the present day mine sites (1975 on).

R188.1 **CNSC's Participation in DECOVALEX III (Contribution)**
(5.167.2) **Objective**: The continuation of a multi-disciplinary interactive and
$39K cooperative research effort designed to increase the understanding of various
$43K thermohydromechanical (T-H-M) processes of importance for radionuclide release and transport from a repository to the biosphere and how they can be described by mathematical models.
Scope of Work: DECOVALEX III is focusing on four specific tasks (projects): 1. FEBEX in-situ T-H-M experiment; 2.Yucca mountain Drift Scale Test; 3. Benchmark test problems for treatment of coupled T-H-M processes in performance assessment; and 4. Forum for discussion and documentation on treatment of coupled T-H-M processes in performance assessment. The objectives of these tasks are: to increase the basic understanding of T-H-M coupled processes in fractured rocks and buffer materials; to investigate the predictive capabilities of different codes to field experiments and to perform verification of codes; to exchange experimental data, and improve the understanding of the constitutive behaviour of rock masses and buffer materials; to perform T-H-M calculations in a performance assessment context; and to review the state-of-the-art in coupled T-H-M issues in performance assessment.
Note: DECOVALEX is the acronym for the International cooperative project for the **DE**velopment of **CO**upled models and their **VA**lidation against **Ex**periments in nuclear waste isolation.

R191.1 **Independent Expert Panel Review of Canadian Best-Estimate and**
$45K **Uncertainty Analysis Methodology for CANDU Reactors**
$20K **Objective**: To assist CNSC staff in formulating a position on the adequacy of the application of the best-estimate and uncertainty analysis methodology and provide input to a regulatory guide on best-estimate methods.
Scope of Work: To form an independent expert panel which will provide independent technical advice on the new best-estimate and uncertainty analysis methodology, which is being used for safety analysis. The individual panel members will be required to review the package of documents dealing with: the technical basis of the best-estimate and uncertainty analysis methodology as described in industry guidelines and related documentation; the prototype application to a large break LOCA in a Bruce B unit; the application to the Darlington large LOCA analysis; and the application to the CANFLEX large LOCA analysis.

R197.1 **Proposal to Investigate the Possibility of Improving Tritium Management**
$14K **at SRB Technologies (Canada) Inc.**
$0K **Objective**: To determine the applicability of state-of-the-art techniques in tritium management to the operation at SRBT.
Scope of Work: To review the existing tritium management practices at SRBT; assess the effectiveness of the current tritium management practices in maintaining low emissions and work place doses; and identify where practical and cost effective improvements in tritium management techniques and interception technology could be applied.

R202.1 **International Regulatory Practices in Fuel Design Qualification**
$0K **Objective:** Assist the CNSC in developing a fuel design review plan adapted
$45K to Canadian regulatory environment, which builds on international standards and best national experiences.
Scope of Work: Perform a comparative study of the international practices with regards to regulatory review and approval processes for new fuel design and provide recommendations for a new fuel design review process.

R203.1 **Independent Expert Panel Review on Reactor Physics Uncertainties**
$23K **Objective**: To assist CNSC staff in formulating a position on the adequacy of
$68K reactor physics IST codes best estimate predictions and associated uncertainties for applications in large LOCA analysis; to assist in the resolution of related closure criteria in certain specific ongoing licensing actions, such as GAI 95G04 and 99G02; and to help determine specific regulatory and licensing actions related to restoration and consolidation of safety margins in LOCA analysis.
Scope of Work: To form an independent expert panel which will provide independent technical advice on the Canadian Nuclear Industry position papers on specified key reactor physics parameters. The Panellists are to examine the sufficiency and conclusiveness of the evidence provided in the industry position papers and supporting documentation to confirm the basis for the parameters presented (bias and standard deviation), or to recommend alternative values. Specifically excluded from the review are issues relating to the level at which the uncertainties should be applied. The review and assessment will be focused on the range of uncertainties in predictions of the following main parameters by the Canadian Nuclear Industry reactor physics codes WIMS/DRAGON/RFSP: coolant-density-change induced reactivity; fuel-temperature-change induced reactivity; and effective delayed neutron fraction.

R206.1 **Background Radionuclide Concentrations in Major Environmental Compartments of Natural Canadian Terrestrial Ecosystems**

$0K
$50K

Objective: To develop an integrated sampling methodology for terrestrial ecosystems; to derive site-specific parameters for radionuclide distribution in various types of natural soils; to derive site-specific parameters for radionuclide bioavailability to dominant plant species and local vegetation communities; and to derive site-specific parameters for radionuclide bioavailability to soil invertebrates and other terrestrial organisms.

Scope of Work: To collect and examine data on background concentrations of naturally occurring and man-made radionuclides in main components of natural terrestrial ecosystems (including soil, vegetation, soil organisms, etc.) from existing documentation (historical and current) and through field investigation.

R215.1 **Workshops on the Remediation of Legacy Uranium Mines in Canada**

$0K
$19K

Objective: To bring together a broader group of potential stakeholders including other regulators (e.g. Environment Canada, Fisheries and Oceans Canada, Natural Resources Canada, and possibly provincial regulators) who may have an interest/involvement in remedial work at legacy uranium mines in order to: provide further insight into requirements under the NSCA and regulations, and put the issues faced at a licensee's site into broader context; encourage a positive dialogue between the CNSC and federal and provincial departments responsible for legacy uranium mine sites; and provide CNSC staff with a better understanding of the technical, public and other issues related to legacy mine sites across Canada and specific to individual sites.

Scope of Work: To organize and facilitate the 2nd Workshop on Remediation of Idle Uranium Mines in Canada, including the distribution of workshop information; coordination of participant submissions; and production/distribution of workshop proceedings.

R219.1 **Identification of Vital Areas for AECL's Chalk River Laboratories**

$0K
$76K

Security related project.

R220.1 **Update of Existing Design Basis Threat**

$0K
$50K

Security related project.

Appendix E:
Projects Planned for Fiscal Year 2002-2003
Scope of Work

R105.2 **Loss of Reactivity Control Analysis Methodology – Phase 2**

$30K **Scope of Work:** The contractor shall perform an independent set of transient and steady state calculations, for a CANDU-6 core using a state of the art solution method, such as the nodal method and NESTLE code with HELIOS/ZENITH generated cross-sections and DRAGON generated incremental cross-sections. The contractor will assess the sensitivity of neutronic trip setpoints to the treatment of spatial effects and use of three-dimensional neutron kinetics methods. The contractor will identify areas of potential improvements, and make recommendations with respect to the treatment of spatial effects and the current use of point kinetics method in safety analyses of loss of reactivity control and loss of flow events.

R109.2 **International Steam Generator Tube Integrity Program (ISG TIP-3)**

$84K **Scope of Work**: The research program included under this project is directed to the development of experimental data and predictive correlations and models needed for the independent evaluation of the integrity of ageing steam generator tubes. The areas addressed by the research program include assessment of the procedures and equipment used for in-service inspection of steam generator tubes, and recommendations for improved reliability and accuracy of in-service inspection; evaluations and improvement of correlations and models for evaluating integrity and leakage of degraded steam generator tubes; and evaluation and improvement of correlations and models for predicting degradation generation and progression in steam generator tubes as a function of aging and under the appropriate environmental conditions. The above data, correlations and models will be validated by testing of realistic mock-ups and service degraded tubes.

R127.1 **Development of a Knowledge Management System**

$52K **Scope of Work**: The contractor will identify CNSC staff needs and available knowledge bases, suggest a possible knowledge management process and tools and prepare a plan for its possible implementation.

R138.1 **Safety Analysis Review Guides for Non-Power Reactors**

$54K **Scope of Work:** It is proposed to expand the scope of the existing guide to cover applications to other research reactors such as NRU, McMaster & SLOWPOKE reactors.

R170.2 **Power Reactor Regulatory Standards Development – Phase 2**
$82K **Scope of Work:** Review and categorise all identified standards, with emphasis on national, international & CANDU reactor type, to determine their usability as a CNSC standard or guide as is, with minor modifications, with major modifications; develop a process to produce official CNSC standards or guides for those categorised as useable as is or with minor modifications; modify those standards identified above in order to produce CNSC standards or guides.

R178.1 **Technical Review Panel for the Saskatchewan Uranium Miner's Cohort (SUMC) Study**
$20K **Scope of Work:** The Technical Review Panel will provide the independent scientific peer review of the results of R178.5 Feasibility Study for Part II of Saskatchewan Uranium Miners' Cohort Study and will provide required suggestions in order to make the study robust. The Technical Review Panel will be required to travel to the study working group meetings in Saskatoon, give a presentation of their peer review, and provide ongoing technical advice to the study working group throughout the duration of the project.

R178.3 **Study Working Group for the Saskatchewan Uranium Miner's Cohort (SUMC) Study**
$9K **Scope of Work:** The SUMC Study working group shall meet in Saskatoon in order to discuss and plan the overall SUMC project.

R198.2 **Fuel Experimental Program Review – Phase 2**
$57K **Scope of Work:** Within the remaining activities of the industry's fuel experimental program, the contractor will be asked to review a number of documents describing results obtained and methodology used. These documents will include recommendations regarding test specifications and selection of test site, experimental design and Test matrix, test reports, analysis to support experimental design and test results, separate effect test identification and analysis. The contractor will also be required to participate in some industry/CNSC meetings including an OPG sponsored workshop to review results of the experiments.

R200.1 **Validation of Fuel Computer Codes Used in Safety Analysis**
$53K **Scope of Work:** Review validation documents associated with the fuel codes ELESTRES-IST 1.0, ELOCA-IST 2.1 and SOURCE-IST 2.0. This will include an assessment of: how well the overall validation and qualification methodology adopted meets international standards; the completeness of the validation documentation; the completeness of the validation matrices; the methodology that was used to assess agreement between code calculation and experimental results; the methodology used for data qualification; the

completeness of the experimental data and identification of any gaps; the methodology used for sensitivity assessment; identified modelling errors or inadequacies; the applicability of these codes to the new bundle designs being considered by the industry; and the applicability of ELOCA-IST 2.1 and SOURCE-IST 2.0 to LLOCA in the prompt-critical regime.

R201.1 **Adequacy of Intra-Bundle Power Profile Treatment in Large LOCA Analysis**
$59K
Scope of Work: The contractor shall perform a review and assessment of the adequacy of hot pin enthalpy calculations in the current licensees' LOCA methodology. The assessment will be based on independent calculations and sensitivity studies using a global-local methodology where the time-dependent boundary conditions from NESTLE NM calculations are provided to a transport kinetics method, such as EVENT, for kinetics calculations at the pin level. The sensitivity studies will cover the effect of radial gradient of coolant density and pressure tube creep and sag. Some programming work to develop the coupling interfaces between NESTLE and EVENT will also need to be performed.

R205.1 **Toxicity of Uranium and Molybdenum to Aquatic Organisms in Water Representative of Canadian Freshwater Environments**
$40K
Scope of Work: Perform high quality uranium and molybdenum toxicity tests for freshwater fish, zooplankton, algae and a benthic invertebrate for regulatory purposes. Both acute and chronic toxicity tests are to be performed using sensitive life-stages in both soft water and hard water representative of Canadian freshwater environments. The contractor will perform the tests using Environment Canada protocols meeting strict scientific quality assurance/quality control standards. The LC50/EC50s and LC25/EC25s are to be calculated and reported. Uranium and molybdenum concentrations are to be measured at the start and finish of the tests and key parameters such as pH, hardness, temperature and oxygen concentration must be measured and controlled. Experimental procedures and all results will be reported in detail.

R210.1 **Participation in the CNSC Working Group on External Dosimetry**
$9K
Scope of Work: For the 2002-2003 FY, work will involve contribution to the drafting of regulatory guidance document C-134 (Guide on Neutron Dosimetry in Canada) and contribution to the dispositioning of comments on other regulatory documents that have or will have been submitted to CDS and have been through the public consultation process.

R211.1 **CNSC Working Group on Internal Dosimetry**
$20K
Scope of Work: In order to support regulatory decision-making in the area of licensing internal dosimetry services, the Working Group will advance the development of two regulatory documents. It will draft a regulatory guide on uranium bioassay and dose assessment, and disposition comments following

the public consultation period. It will also review and comment on the revision to regulatory standard S-106, Technical and Quality Assurance Standard for Dosimetry Services in Canada. In order to support regulatory decision-making in the area of assessing the internal dosimetry component of licensees' radiation protection programs, the Working Group will advance the development of three regulatory documents. It will review and finalize the draft of G-147, Radiobioassay Protocols for Responding to Abnormal Intakes of Radionuclides, advance drafting of C-100 Rev. 1, Guide for Tritium Bioassay and of C-150, General Bioassay Guide.

R212.1 **Comprehensive Review of the Effectiveness Waste Rock Management and**
$31K **Decommissioning Practices**

Scope of Work: Perform and document a critical review of existing decommissioned waste rock piles in Canada and around the world, focusing on the decommissioning criteria and objectives, the decommissioning options considered, the adequacy of monitoring programs and the analysis of observed versus predicted performance. To set the stage for the case studies, the project will also include a review of the recent developments in the understanding of short and long term environmental problems associated with waste rock; the contaminant transfer mechanisms; the adequacy of existing environmental impact prediction models and the different field characterization and monitoring tools. Potential sources of information include open literature, mining company reports, and personal communications with regulators and industry.

R213.1 **Implementation of Geographic Information System (GIS) - Idle Mines,**
$26K **Elliot Lake**

Scope of Work: In consultation with the Project Officer for the Elliot Lake Idle Mines, the Project Manager and other CNSC staff as appropriate, the contractor will design the structure of the ARCVIEW Project of the five idle mine sites (how the monitoring data and other related information will be presented and manipulated). The contractor will identify and then acquire or access the source(s) of the information that will be incorporated (base maps at various scales, site layouts, monitoring data tables (eg from ENVISTA), etc.). With the assistance of the appropriate CNSC staff (to supplement staff's knowledge and expertise with GIS and data management) and using CNSC computing resources, the contractor will extract the information from the sources and produce the themes in ARCVIEW and the interfaces with external analysis software.

R214.1 **Assessment of Radiation Doses Arising from Civilian or Military Vehicle**
$60K **Use of Radium Luminous Devices in Operating or Static Display Vehicles**

Scope of Work: To document the scope and distribution of radium luminous devices in a wide variety of operational aircraft, static displays, and in

museums and collections. It is not expected that the consultant would visit all collections, but would propose an inspection plan that would statistically represent the significance of these devices in Canada. From this data, and from supporting data collected from Transport Canada and other sources, the consultant would be able to sub-group this information by: vehicle type, aircraft type, number of devices, year of manufacture, and other related groupings, and given occupational exposure averages for flight crews, museum staff or other segments, calculate annual radiation exposures expected by different segments of the general public that may come in contact with these devices.

R217.1 **Guidelines for Safety Assessments Using Best-Estimate and Uncertainty**
$55K **Analysis for Power and Research Reactors**

Scope of Work: To consolidate all preceding CNSC works pertinent to the application of a best-estimate and uncertainty methodology for licensing submissions; consider international practices for regulatory use of the methodology; identify and resolve issues for regulatory use; and prepare a guidance report.

R221.1 **Information on Technologies Available for the Reduction of Tritium**
$23K **Emissions**

Scope of Work: Prepare two reports, one on the various technologies available to reduce tritium emissions from tritium processing facilities; the other, on good work practices for effective management of tritium and emission monitoring. In addition, the contractor will provide CNSC staff with advice, guidance and answer questions relating to reduction of tritium releases, effective tritium management and tritium in general.

R223.1 **Presentation of Results of the Independent Review of New Brunswick**
$6K **Power's Cable Qualification Tests**

Scope of Work: The CNSC had hired Canadian Nuclear Utilities Service (CNUS) to perform an independent review of the cable qualification tests carried out by New Brunswick Power (Point Lepreau) and determine whether the results of the testing program are based on acceptable good practice and on reasonable simulation of potentially expected conditions and aging mechanisms. The contractor will present the results of report to CANDU-6 licensees and CNSC staff. This will provide the licensees with an opportunity to provide feedback to the CNSC on the CNUS findings.