Department of Energy
National Nuclear Security Administration
Washington, DC 20585

OCT 31 2002

The Honorable John T. Conway
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N.W.
Suite 700
Washington, D.C. 20004

Dear Mr. Chairman:

The Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 97-2, *Criticality Safety*, requires quarterly status reports. Enclosed is the Department of Energy's quarterly status report for the fourth quarter of Fiscal Year 2002.

The Implementation Plan contains 30 milestones, all of which have been completed. Although all commitments have been met, stability of funding for the Nuclear Criticality Safety Program (NCSP) has been an ongoing concern. With the Secretary's decision for Defense Program to fully fund and manage the NCSP for Fiscal Year 2003 and beyond, stability of funding should be achieved.

The NCSP continues to sustain progress in all of the program task areas as reflected in the body of the enclosed report. In addition, we have completed the following Technical Report # 29, *Criticality Safety*, commitment that was made in a Secretarial letter to you on May 30, 2001:

> The Nuclear Criticality Safety Program Management Team will work with the Criticality Safety Coordinating Team (Federal criticality safety professionals at the Field Offices) to monitor reportable and non-reportable criticality safety deficiencies throughout the next year and issue a report to the Deputy Administrator for Defense Programs documenting its conclusions and recommendations.

Dr. Jerry McKamy reviewed all criticality safety related occurrence reports for the past year along with graded reporting criteria procedures that are implemented at the sites. In conjunction with Dr. McKamy's analysis of criticality safety reportable occurrences, the Criticality Safety Support Group (CSSG) participated in a review of existing criticality safety reporting criteria in Department of Energy Order 232.1, *Occurrence Reporting and Processing of Operations Information*, and developed a consensus set of reporting criteria. The CSSG forwarded a memorandum to the NCSP Manager, documenting these activities along with the proposed reporting criteria. I have since forwarded the proposed criteria to the Office of Environment, Safety and Health to assure consideration in the Department of Energy Order 232.1 revision process.

If you have any questions, please contact me directly or have your staff contact Mike Thompson at 301-903-5648.

Sincerely,

David H. Crandall
Assistant Deputy Administrator
for Research, Development, and Simulation
Defense Programs

Enclosure

cc (w/encl):
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QUARTERLY STATUS OF THE IMPLEMENTATION PLAN FOR DEFENSE NUCLEAR FACILITIES SAFETY BOARD RECOMMENDATION 97-2 FOURTH QUARTER OF FISCAL YEAR 2002

The Department of Energy (DOE) began implementing Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 97-2 in January 1998 by formally establishing the Nuclear Criticality Safety Program (NCSP). Each of the seven NCSP Tasks (Integral Experiments, Benchmarking, Analytical Methods Development and Code Maintenance, Nuclear Data, Training and Qualification, Information Preservation and Dissemination, and Applicable Ranges of Bounding Curves and Data) is dependent upon the others for a successful program. The NCSP is being conducted according to the new Five-Year NCSP Plan which was finalized in September 2002.

The Criticality Safety Support Group (CSSG) is performing its chartered functions in support of the NCSP Manager's implementation of the NCSP according to the new Five Year Plan. During the fourth quarter of Fiscal Year (FY) 2002, the CSSG met in Washington to validate planned FY 2003 work prior to budget execution and to discuss other important criticality safety issues. CSSG efforts in developing a consensus criticality safety interpretation of the DOE 10 CFR 830 Guides were discussed with Dr. Crandall, and the CSSG interpretation document was forwarded to the Assistant Secretary for Environment, Safety and Health for concurrence on October 9, 2002. The CSSG also discussed the upcoming criticality safety related meetings scheduled to be held in conjunction with the Winter American Nuclear Society Meeting in Washington, D.C., in November 2002. Aside from the technical meetings, two other important meetings are scheduled. A workshop for authorization basis and criticality safety experts to discuss the 10 CFR 830 implementation is scheduled for November 16, and the NCSP meeting is scheduled for November 22. Finally, selected members of the CSSG met with Commissioner Nils Diaz of the Nuclear Regulatory Commission to discuss areas of mutual interest regarding criticality safety and to thank him for his willingness to participate in the November NCSP meeting in Washington. The Chairman of the DNFSB has also accepted an invitation to this meeting to share his views on criticality safety. It is expected that this will be a very interesting and productive meeting.

Because all 30 of the Recommendation 97-2 milestones are completed, this report will focus on the status of activities for each of the seven NCSP elements. Accomplishments and key issues in each of the program task areas which arose during the period are contained in the following sections of the report.

Integral Experiments

The following is a summary of experimental activities conducted at the Los Alamos Critical Experiments Facility (LACEF) during the fourth quarter of FY 2002:

Experiments were conducted on four of the five LACEF assemblies during this quarter in support of the NCSP. In addition to performing these experiments, one criticality safety course was also

conducted. Two significant events occurred this quarter: (1) DOE approved the new Documented Safety Analysis (DSA) at Technical Area (TA)-18 and the associated safety basis implementation plan, and (2) the ^{237}Np experiment achieved initial criticality. These both represent major multi-year effort milestones for TA-18.

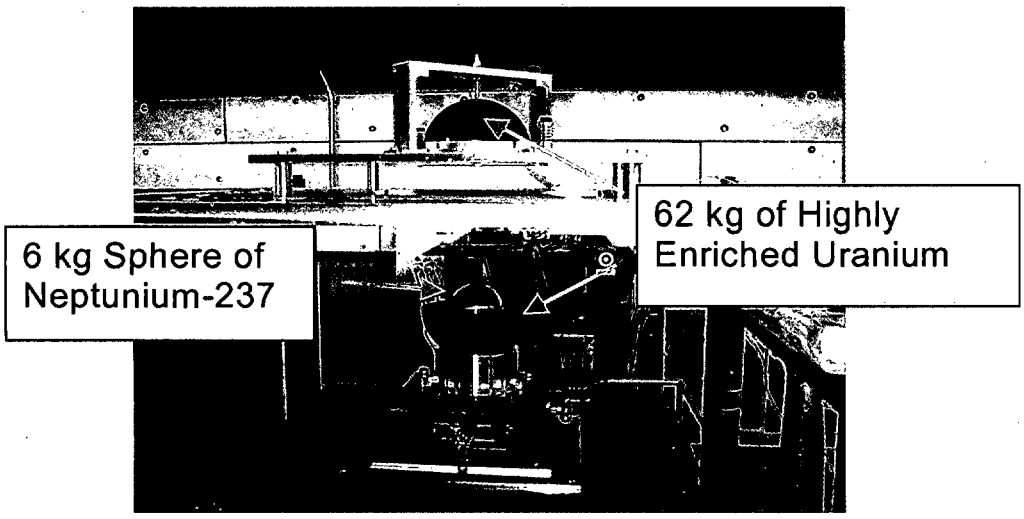
Flattop: Following Flattop's return to operational status on June 19, 2002, nine LACEF crew members have re-established their qualification to operate the assembly. Flattop was operated four times during this quarter primarily for operator requalification, but also on one occasion for the criticality safety class.

Comet/Zeus: The Zeus critical experiment on the Comet critical assembly machine was restacked during this quarter using iron as the interstitial material. It is anticipated that this new configuration will go critical during the first quarter of FY 2003. Due to a CASA 2 electrical upgrade, only three Comet/Zeus operations were performed during this quarter.

SHEBA: SHEBA remains inoperable as a result of failure of the cover gas system; however, all corrective actions and restart actions are nearing completion. A readiness assessment for SHEBA's restart will be conducted in November. In addition, changes necessary to allow SHEBA to operate in the burst mode are being prepared. Approval of the new DSA provides a clear path for restarting SHEBA and authorizing burst mode operations.

Godiva IV: The Godiva IV assembly remains operational. Multiple Godiva operations were performed this quarter in support of benchmarking neutron transport computer codes at Los Alamos. Two new LACEF crew members also received their qualification to operate the Godiva critical assembly during this quarter.

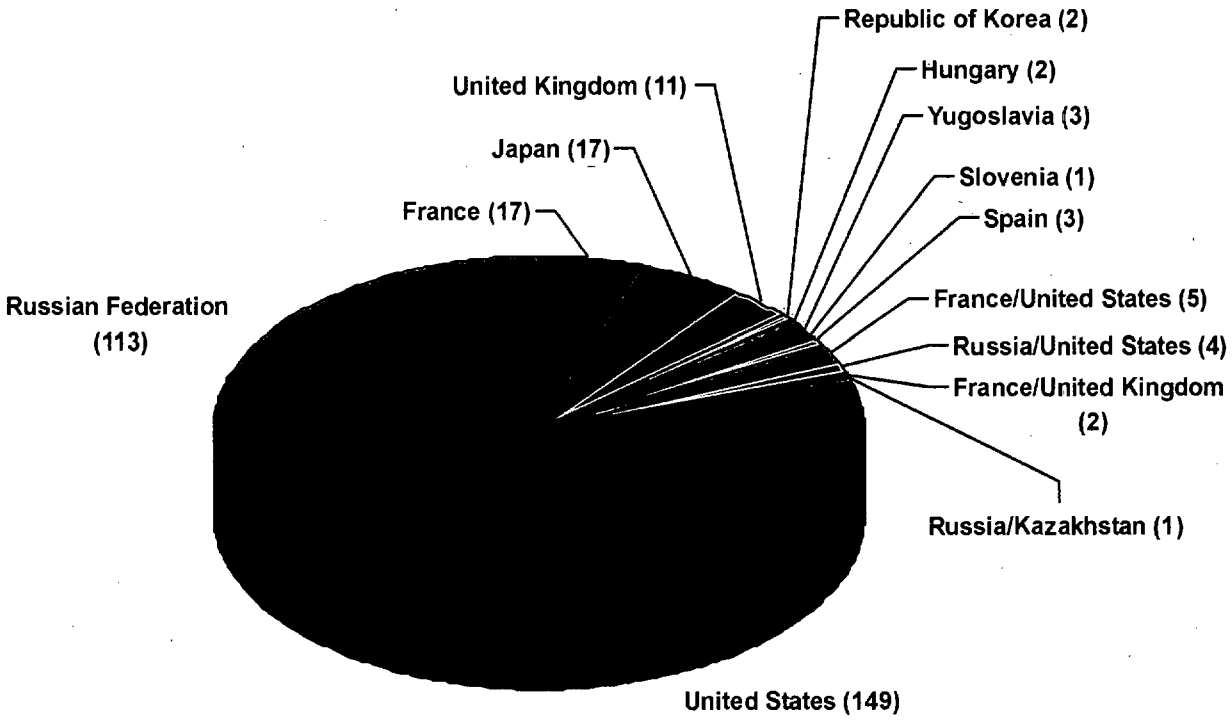
Planet: The majority of LACEF's effort during this quarter went toward completing a critical mass experiment with ^{237}Np. Criticality was achieved on September 26, 2002, at approximately 1:00 PM. Completing the initial critical on this experiment represents a major accomplishment for LACEF, TA-18, and Los Alamos as this experiment has been in the making for nearly twelve years. This experiment is the number six priority NCSP experiment.



Benchmarking

Participants of the International Criticality Safety Benchmark Evaluation Project (ICSBEP) focused primarily on resolution of action items from the 2002 ICSBEP Working Group Meeting and on the 2002 publication during the fourth quarter of FY 2002. Work also continued on upgrades to the ICSBEP Database, DICE.

The September 2002 Edition of the "International Handbook of Evaluated Criticality Safety Benchmark Experiments" and the new version of DICE were published, as scheduled, during the month of September. Included in this version of the handbook are 23 newly approved evaluations and major revisions to two previously approved evaluations. The handbook now contains 330 evaluations that span over 26,000 pages and provide 2,881 critical configurations that can be used by criticality safety analysts for validation of their analytical methods. The contribution from each country, in terms of the number of evaluations is shown below.



Of the 23 newly approved evaluations, 15 were from the United States [Argonne National Laboratory (3), Idaho National Engineering and Environmental Laboratory (3), Los Alamos National Laboratory (5), Lawrence Livermore National Laboratory (1), Westinghouse Safety Management Solutions (2), and Y-12 (1)]. A previously published evaluation of the ZEUS assembly was revised by Los Alamos to include a third configuration. Three of the newly approved evaluations were specifically requested by the criticality safety user community. These evaluations include integral benchmark data for either tungsten or tantalum. Contributions for outside the United States included data for thorium, mixed oxide (MOX) rods in mixed plutonium

/uranium nitrate solution, highly enriched uranium plates, low enriched transportation and storage arrays, and 10 percent enriched uranium solution reflected by borated concrete.

FY 2002 funding for most ICSBEP participants was expended early during the fourth quarter so progress on new evaluations was limited. However, a student at the Idaho National Engineering and Environmental Laboratory completed one new evaluation and made significant progress on a second evaluation. Students working on the project at Argonne National Laboratory were also able to nearly complete a new Zero Power Reactor evaluation.

Finally, a report on the status of the ICSBEP was made to the Organization for Economic Cooperation and Development (OECD)/Nuclear Energy Agency (NEA), Nuclear Science Committee, Working Party on Nuclear Criticality Safety.

Analytical Methods Development and Code Maintenance

Oak Ridge National Laboratory (ORNL)

The staff at ORNL continue to maintain the SCALE/KENO software and assist the nuclear criticality safety community in the use of this software. Assistance included preparation for the SCALE/KENO workshop to be conducted at ORNL in October, as well as direct assistance to code users in the performance of their analyses.

Work continued on the testing and documentation of new software for inclusion in the SCALE Version 5.0 release in 2003. Supplemental funding from the Office of Environmental Management (EM) to accelerate this process has been requested. The EM decision is still under consideration.

In terms of code development, a number of modifications and updates were performed on the KENO V.a, KENO VI, XSDRNPM and NITAWL modules. A major programming effort was involved in reconfiguring the dynamic computer core storage allocation schemes in these codes.

Los Alamos National Laboratory (LANL)

The staff at LANL continue to maintain the MCNP software and assist the nuclear criticality safety community in the use of this software. During this reporting period, development of MCNP Version 5 was completed. This new version has been entirely upgraded to standard Fortran-90 with MPI and OpenMP, and has been tested on a wide variety of computer platforms (Sun, SGI, HP, IBM, PC/Windows, Linux). There are a number of new and important features in the new version, including mesh tallies, photon Doppler broadening, image tallies for radiography, and an extended random number package. Release to the Radiation Safety Information Computational Center (RSICC) is targeted for November 2002.

Work has continued on investigating Monte Carlo k-effective calculations, including convergence behavior, statistical tests for stationarity, effects of correlation on confidence intervals, and

estimation of the dominance ratio. Four papers on these topics have been submitted for publication. Of particular importance are the theories developed in the following three areas:

(1) Conventional wisdom based on MacMillan's work in the 1960s has been that criticality calculations of problems with high dominance ratios would significantly underestimate confidence intervals on k-effective. It has now been proven that correlation, not the high dominance ratio, causes the underprediction and that the effect is independent of the dominance ratio.

(2) A technique for detecting stationarity of eigenvalue calculations has been developed using the Shannon entropy of the fission source distribution. This is a novel approach and has been shown to be very effective.

(3) A method for calculating the reactor dominance ratio in Monte Carlo calculations has been developed, based on modeling the calculations as an autoregressive process. No previous methods for Monte Carlo estimation of the dominance ratio were known. This is potentially very important, since the dominance ratio is a fundamental physical property which is key to reactor stability analysis.

The theory developed for this work has been supported by extensive numerical calculations. These new methods will be incorporated into MCNP Version 5 over the next year, providing some unique Monte Carlo analysis techniques.

Argonne National Laboratory (ANL)

Staff at ANL continued to maintain VIM software and develop improved methods of cross section processing and quality assurance. ANL is now using software (*xsplots*) that performs a complete check of a newly produced library of cross sections (about 100 megabytes of data) in hours. *Xsplots* performs detailed point-by-point comparison of VIM fission, capture, elastic scattering, and total cross sections with a reference library (e.g., an MCNP library), highlights significant differences, and produces plots of both libraries in the energy ranges near the significant differences. The plots are then examined for evidence of cross section processing problems or other problems in the VIM library or the reference library. This is a very powerful tool for cross section verification.

After performing several of these exhaustive and detailed comparisons, the cross section processing codes were modified to correct most of the minor problems that were observed, checked in accordance with ANL software Quality Assurance procedures, and placed into production use. Additional benchmark calculations using various VIM libraries and using MCNP have been begun that will confirm the validity of the new library.

Monte Carlo results from the OECD/NEA Expert Group on Source Convergence in Criticality Safety Analysis benchmark set are being analyzed further and a report is being prepared. A

special session on this subject, organized by ANL, will be held at the American Nuclear Society Winter Meeting in Washington, D.C., this November, and includes eight papers on the four benchmark problems and their analyses.

Nuclear Data

ORNL

The second replacement electron gun was installed in the Oak Ridge Electron Linear Accelerator (ORELA) during this quarter. Also, an electrical power outage to the facility resulted in a loss of the ORELA system vacuum. Currently, ORELA is being brought back up under a procedure that includes a series of intermediate tests. The measurements with the enriched potassium sample will continue when ORELA becomes operational.

The fluorine evaluation is being enhanced with measurements for the total cross section. Preliminary versions of the ^{233}U, silicon, and chlorine data have been made available to the criticality safety community through RSICC for data testing. Work continues on the generation of covariance data for the unresolved resonance region (URR). Modifications to the ^{238}U nuclear data are being evaluated that will contribute to the international effort to address deficiencies in this data. The resonance parameters in the energy region from 10 to 20 keV are being tested. A journal article on the new silicon evaluations has been accepted by the Physical Review.

Enhancements continue to be made to the SAMMY program. An interim version of SAMMY, correcting some of the earlier release's difficulties related to portability, has been released via RSICC. In the URR, the capability has been provided to use different resonance parameters in different energy regions. URR results can now be reported in Evaluated Nuclear Data File (ENDF) format. In both the resolved resonance region and the URR, covariance matrices can now be reported in a concise format which has been proposed to the Cross Section Evaluation Working Group (CSEWG) for inclusion in the ENDF.

Several presentations on the NCSP Nuclear Data work will be made at the PHYSOR 2002 meeting in October. Plans are being made for ORNL participation in the Nuclear Data Advisory Group (NDAG) and CSEWG meetings at Brookhaven National Laboratory in November.

LANL

The new ^{233}U neutron ENDF evaluation is nearing completion. Results above about one keV have been merged onto recent improvements at lower energies from ORNL. There are many aspects to this analysis: systematic accumulation of all relevant experimental data; re-normalization of the neutron data to modern standards - where appropriate; interpretation of the experimental results in terms of nuclear theory to allow interpolation and extrapolation of the data into unmeasured regions; and finally, assemblage of the experimental and theoretical results into a formal ENDF evaluated nuclear data file that can be processed for use in simulations in Criticality Safety

programs. Compared to another recent piece of work on ^{233}U from Japan, the new evaluation contains a number of improvements. Particularly important is the fission cross section for criticality calculations. Thorough and proper use has been made of current/modern standards related to the fission cross sections. This new ^{233}U evaluation will be described at CSEWG, and at our NDAG meeting in November.

Regarding ENDF formats, they have proven very useful for allowing the exchange of data between different evaluation groups and for insuring the stability of the nuclear data processing codes used to provide libraries for applied calculations. The CSEWG is currently considering various proposals for changes to these formats for the upcoming ENDF-7 system. They have been working intensively with the authors of processing codes to try to determine what proposed changes might be practical and what changes might really be necessary for improved performance over the next few years. Discussions to date seem to indicate that some of the proposals would have such severe impact on some of the processing code systems as to disable them for a long period after the introduction of the changes. In some other cases, the proposed changes do not really seem to be necessary. This subject is to be discussed at the next two CSEWG meetings.

Regarding Unresolved-Range Probability Tables, in the new probability table treatment for MCNP there is a feature for treating the problem of temperature correlation. If a neutron track moves from one region to another region containing the same resonance material at a different temperature, the cross section used to continue the track in the second region should be correlated to the one used in the first. A new sampling scheme has been developed for the PURR module of NJOY to alleviate this problem, and it is now being tested.

Argonne National Laboratory

Validation calculations were performed for a series of benchmark assemblies in conjunction with the inter-comparison effort for the VIM and MCNP libraries (see ANL section of Analytical Methods Development and Code Maintenance, above). In particular, ANL, in collaboration with LANL, has reviewed the effects of processing the probability tables for the URR. Questions regarding the sensitivity of the results to these data are being further investigated.

Training and Qualification

This program element includes three sub-elements: (1) hands-on criticality safety training at LANL; (2) training development; and, (3) criticality safety qualification program activities.

Hands-on criticality safety training continued at LANL during the fourth quarter of FY 2002. Seventeen persons attended a 3-Day Course for uncleared individuals that was conducted July 23-25, 2002.

Regarding training development, two Nuclear Criticality Safety Engineer Training (NCSET) modules on the criticality safety of plutonium separations have been completed and are in place

on the NCSP web site. These modules have had some potentially sensitive material removed to allow unlimited access. However, DOE personnel can access unabridged versions by following instructions in the modules.

Work on the second of two NCSET modules on hand calculations continues under the direction of the criticality safety group at LANL with the help of Joe Thomas. This module will deal with the more advanced methods that were introduced in the first hand calculation methods module.

The planned module on the development, selection, and use of cross section sets in criticality safety turned out to be a module on cross section resonance processing theory. This module will be simplified and rewritten for inclusion in the NCSET collection, and the intended module on selection and use of cross section sets will be written next quarter.

The NCSET module on the preparation of criticality safety evaluations is approximately one-half complete. Depending on other project commitments, work is expected to continue on this module next quarter.

There is no new information on qualification activities to report at this time.

Information Preservation and Dissemination

This program element currently contains two sub-elements: (1) the Criticality Safety Information Resource Center (CSIRC); and (2) NCSP web page development.

Regarding the CSIRC Program, scanning of the ANL log books and loading records continues. No progress was made on scanning the potentially contaminated material since the retired technician who was doing the scanning left for an extended period. An outside contractor, Cover to Cover, continued work and during this quarter scanned the records from ZPR Assemblies 10 and 11. Work will continue next quarter when FY 2003 funding is received.

The NCSP web site at Lawrence Livermore National Laboratory is being maintained and improved under technical direction of the NCSP manager. This web page provides technical information for the criticality safety community and serves as a hyperlink to other web sites that are important to the NCSP. During the fourth quarterly of FY 2002, web site improvements included:

(1) Added eleven new users to the web site registration database;

(2) Updated Web server software to "Apache 1.3.26" to fix buffer overflow computer security vulnerabilities as mandated by DOE cyber security policy;

(3) Added NCSET training module 10 and module 11 and announced their availability in the web page;

(4) Created the web pages documenting the June 2002 Hollywood Florida End-users meeting and the view graphs used in that meeting;

(5) Investigated the feasibility in implementing a pass word system for accessing selected data bases; and

(6) Worked on implementing a new version of Hanford Database onto the NCSP web site.

Applicable Ranges of Bounding Curves and Data

During the fourth quarter of Fiscal Year 2002, three of the five technical program tasks were actively addressed. Emphasis continued on moving software into production status prior to the further development of guidance on its use and/or the performance of sensitivity/uncertainty studies. The Applicable Ranges of Bounding Curves and Data (AROBCAD) work level was reduced due to limited funding. Anticipated supplemental funding from EM to address specific applications has been delayed.

Software development for performing material/geometric optimization for determining bounding curves and data has ceased following the incorporation of the SMORES module into the frozen version of SCALE Version 5.0 that is awaiting completion and issuance through RSICC. An advanced geometric optimization methodology was reported as an operational prototypic software that is under development at the University of California, Berkeley. Follow-on support of that work by AROBCAD has been delayed until FY 2003.

User manuals for SEN1 and SEN3, as well as the new methods to compute the sensitivity of k-effective to the group cross section resonance processing with BONAMI and NITAWL-II, are still in preparation. Plans are being developed to apply AROBCAD methodology in the analysis of DOE/EM applications requiring near-term results.

A new method for examining the "coverage" of sensitivities by critical experiment benchmarks for a safety application calculation has been conceived and a prototype example examined for boron absorbers. The concept was developed as part of the AROBCAD task but it was applied to a United States Nuclear Regulatory Commission funded analysis. Preliminary work was performed on the Savannah River Site gadolinium-plutonium glass log project with the small amount of supplemental EM funding that was received in September. This work is anticipated to be completed during the first quarter of FY 2003.

The revised SEN1 and SEN3 control modules, including the use of the CENTRM point transport code for resonance processing and the definition of multiple unit cells in a model, are continuing to be folded into SCALE 5.0. Revisions include the improvement of memory management in both sequences. Also, further revisions are being made on the CANDE module in preparation for inclusion in SCALE Version 5.0. Guidance on the use of CANDE and SAMS is in preparation.