SUPPLEMENTAL AGREEMENT
BETWEEN
ARIZONA BOARD OF REGENTS
AND
THE U. S. NUCLEAR REGULATORY COMMISSION

THIS SUPPLEMENTAL AGREEMENT, effective the 31st day of May, 1985 by and between the UNITED STATES OF AMERICA (hereinafter referred to as the "Government"), as represented by the UNITED STATES NUCLEAR REGULATORY COMMISSION (hereinafter referred to as the "Commission"), and ARIZONA BOARD OF REGENTS (hereinafter referred to as the "Contractor"),

WITNESSETH THAT:

WHEREAS, the parties desire to modify Contract No. NRC-04-78-271 as hereinafter provided, and this supplemental agreement is authorized by law, including the Energy Reorganization Act of 1974, as amended, and the Atomic Energy Act of 1954, as amended.

NOW, THEREFORE, said contract is hereby modified as follows:

1. Appendix A, attached to this supplemental agreement and made a part hereof, provides for the research to be performed by the Contractor during the contract period specified therein.

2. In Article II - The Period of Performance, the date "December 31, 1985" is substituted for the date "May 31, 1985."

3.o In Article III - Consideration, the sum"$2,197,566.84" is substituted for the sum "$2,087,937.62."

IN WITNESS WHEREOF, the parties have executed this document.

UNITED STATES OF AMERICA

BY: Paul J. Edgeworth
Paul J. Edgeworth
Contracting Officer
(title)

Nuclear Regulatory Commission

Arizona Board of Regents
University of Arizona
Tucson, Arizona 85721

BY: Floyd A. Swenson
Floyd A. Swenson
Contracting Officer
(title)

I, James T. Wheeler, certify that I am the
(attester)

Assistant Vice President for Research of the Contractor named

under this document; that Floyd A. Swenson
(signatory)

who signed this document on behalf of said Contractor was then

Contracting Officer of said Contractor; that

this document was duly signed for and on behalf of said Contractor by authority of its governing body and is within the scope of its legal powers.

IN WITNESS WHEREOF, I have hereunto affixed my hand and the seal of said Contractor.

James T. Wheeler
James T. Wheeler
Asst. Vice President for Research

(SEAL)

JUL 16 1985

CONTRACTOR: ARIZONA BOARD OF REGENTS

APPENDIX A

For the Contract period June 1, 1980 through December 31, 1985

Article A-1 RESEARCH TO BE PERFORMED BY CONTRACTOR

(a) The unclassified Scope of Work under this contract entitled, "Sealing Rock Masses" is as follows:

REPORTS:

Progress reports shall be submitted quarterly. An annual topical report shall be submitted at the end of each of the three (3) periods of work. A final report shall be submitted upon completion of the contract performance.

June 1, 1980 through May 31, 1981:

1) Laboratory Work

a) Develop a test facility for a variety of plugging materials (including clay and cement) under a variety of rocks and a range of load conditions. This includes building radial and polyaxial permeameters. The budget includes the drilling subcontract for the Subsurface Mass and Energy Transport project and for this project.

b) Use the facility to ascertain sealing performance under ideal conditions (laboratory simulated field conditions) and develop a data bank. The primary tests to be performed are rock permeability, sealant permeability, seal leakage (along the rock-seal interface) long-term seal durability, and seismic response.

2) Field Work

The materials judged best will be used for plugging holes drilled at the field-test facility in cooperation with Simpson, Neuman and Thompson in their research on ground water in fractured crystalline rocks. The performance will be tested by comparing tracer tests and fluid injection tests before and after plugging.

3) Analytical Studies

Rock creep over time will be calculated by two dimensional elastic analysis.

4) The possibility of using facilities at the Nevada Test Site for the studies in other rock typed, will be examined.

June 1, 1981 through May 31, 1982:

Research work to be performed from June 1, 1980 to May 31, 1981 will consist primarily of:

1. Field studies, including detailed comparisons between laboratory and field performance.

2. Laboratory studies (simulated field conditions) to broaden the experimental data basis.

3. Data analysis.

The main emphasis of the work during the year will be on a systematic field testing program. It is expected that the experimental work performed during the previous year will provide a solid factual basis for the final selection of sealing technology, field emplacement techniques, and degree of sealing that can be achieved under "ideal" laboratory conditions. The results obtained during the previous year will include specific data on the permeability of the rock at the location of some of the boreholes to be sealed and tested during this year. These data are essential for the subsequent plugging performance assessment.

The experimental field work will consist of drilling (coring) additional holes in selected rock types, sealing (plugging) with clay and cementitious products, and performance evaluation with pressurized injection and tracer tests. As part of the proposed field work several holes will be plugged and tested for long-term performance. Some of these tests will consist of continued steady pressurization over several months, others of intermittent short-term testing at regular intervals of several months.

Supporting laboratory work for this principal field sequence will include permeability and sealing tests on the cores recovered. This will provide the necessary reference basis for comparing the actual field performance, as it is when affected by at-depth installation procedures, with laboratory performance.

In addition to laboratory tests in direct support of the field work, it is necessary to continue laboratory studies of plugging performance that cannot be done in the field. This includes most importantly the changes in stressfields to which the rock mass can be subjected over long periods of time. Such changes will be simulated in the testing facilities developed during the previous year.

June 1, 1982 through May 31, 1983:

The main emphasis of the proposed research during this year will be on laboratory testing, with some supplementary field work.

The proposed laboratory work will consist largely of a direct continuation of work initiated previously. This will include long-term tests, i.e., direct creep loading and/or internal pressurization of plugged cores in the triaxial frames equipped for long-term testing.

The main emphasis of this last year lab work will be on extending the experimental data basis for various rock types and plugs. This will include testing in both triaxial and polyaxial conditions. At this stage of the project, the experimental work of both types will have been reduced to routine operations. It will therefore be possible to obtain an extensive data basis in a time and cost efficient fashion, by systematic studies of the performance of a variety of sealing products in a variety of rock cores.

Field work will consist of two types: continuation of previously initiated long-term tests in already plugged holes, and performance testing of new installations suggested by the results from previous field measurements or lab measurements performed as part of this contract, or by results or recommendations based on research performed at other institutions.

June 1, 1983 through September 30, 1984:

Research work to be performed from June 1, 1983 to September 30, 1984 will consist primarily of:

1. Field Testing of Borehold Plug Performance
2. Laboratory Testing of Borehold Plug Performance
3. Scouting Work on Discontinuity Sealing

1) Field Testing of Borehole Plug Performance

Field work involves four aspects:

a) Site Selection
b) Field Drilling, Hole and Core Mapping and Testing
c) Plugging
d) Plug Performance Testing

The site selection is nearing completion now for tuff, and one more site, probably granite, will be located. Field drilling is completed for approximately fifty percent. Field testing equipment is seventy percent complete, and field testing has been started. A detailed field testing schedule is given in Table 1. This schedule is fairly tight, considering that it involves field work at different locations. Moreover, for quality assurance reasons, it is highly desirable to run the experiments for a long time, and to duplicate them to the greatest extent possible.

Table 1

Proposed Time Table - Field Testing of Borehole Plugs

Aug. - Dec. '82 :	Oracle Ridge Mine (granite; limestone)
Jan. - April '83 :	Oracle Granite
May - Aug. '83 :	McNary Dam Site (basalt)
Sept. - Dec. '83 :	Tuff Site
Jan. - April '84 :	Second Granite Site
May - July '84 :	Final sequence of field tests (details to be decided - site, especially rock type and plug material to be selected based at least in part on previous results - leave open possibility of retesting an earlier plug)

2) Laboratory Testing of Borehole Plug Performance

The primary purpose of the laboratory plug testing to be performed is to broaden the experimental data base on which one can draw to justify conclusions with regard to expected and achievable hole plugging performance. This includes broadening both in terms of the types of materials tested, the kind of conditions under which they are tested, and establishing the repeatibility and reliability of the results obtained.

During this period, the laboratory borehole plug testing program shall consist of three main aspects:

- continued systematic investigation, i.e. evaluation of the influence of materials and of test parameters on seal performance
- assessment of the influence of "unusual" features on borehole plug performance
- assessment of size effects on seal performance

The first category of experiments clearly is intended to directly enlarge the data basis, with what are now essentially "routine" experiments: variation in rock types, in plug products, in flow pressure gradients, and in external stressfields. An essential objective of these experiments is to assure redundancy in results in order to obtain a maximum possible degree of confidence in the validity of the results and of the experimental procedures. These experiments are a direct continuation of the experiments reported on to date, in progress reports and in topical reports.

Three types of testing included in this category are studies of the influence of dynamic loading (simulated earthquakes) on borehole plug performance, studies of the damaged or disturbed zone about boreholes, and studies of temperature effects (i.e. sealing performance at elevated ambient temperatures).

The second class of experiments is to evaluate the influence of features that might affect plug performance but are not included in the basic testing sequence in order not to have an excessive number of variables in that sequence. Examples of such non-standard features that are considered include the influence of drilling method (plugs in percussion-drilled holes are presently being tested), the influence of allowing a plug to dry for a certain time (two tests presently concluded), the influence of hole wall contamination, the influence of pressure curing, etc. One permeameter presently is reserved for such non-standard experiments. This might be increased to two in the future, on condition that sufficient basic data can be gathered without interference from such more speculative experiments.

3) Scouting Work on Discontinuity Sealing

Sealing of discontinu ties is a fundamental aspect of rock mass sealing. Although considerable experience exists in grouting and rock bolting, two practical sealing methods, the performance of such methods remains highly upredictable, especially in the ranges of relatively low permeability, of most concern near HLW repositories. The importance and complexity of this problem with respect to nuclear waste isolation are such as to warrant a major investigation. Because there is a close link between discontinuity sealing and borehole plugging, especially in terms of experimental equipment, a gradual transition of equipment utilization from one to the other would seem most appropriate.

Two basic types of experiments shall be performed:

- radial permeameter tests on single fracture grouting
- polyaxial block testing on single fracture grouting

These are to be complemented by a series of back-up experiments:

- grouting experiments on controlled-width parallel plate models, primarily to assess the grout properties on an experiment simulating its actual application, and to assess and compare the validity of parallel plate flow equations for highly viscous materials
- aperture studies on discontinuities in rock blocks
- material property determinations of grouts.

4) Summary of Work

The primary work to be performed during the period June 1, 1983 through September 30, 1984 is the in-situ testing of borehole plugs, laboratory testing of borehold plugs, and scouting work on fracture sealing. The borehole plug performance assessment studies will give a broad data basis of experimental laboratory results, backed up by several field experiments. This data will cover three rock types and two plug types (as a minimum), tested under a range of stress and fluid pressure conditions. These experiments will constitute a major addition to the (presently very limited) factual data basis on plug performance. As a consequence, it will provide a considerably improved framework within which to judge the likely performance of in-situ seals. Considering that truly in-situ experiments will not be available for some time (with a very small number of exceptions), and will be small in number,

an experimental, factual framework on which to judge the sealing performance that can be expected should be of considerable value in guiding internal NRC (licensing requirements) discussions and reviews. It will provide input for release risk assessments. The data basis will allow comparisons against DOE data, and provide factual information for meetings with the scientific community, with the public, and with other regulatory agencies. It will provide direct numerical guidelines for performance that can be expected according to requirements in 10 CFR 60.133,142.

The experiments performed to date show that, in the laboratory, cement borehole plugs, installed in unfractured sections of low-permeability rock (granite, basalt), will reduce water flow along a diamond drilled borehole to a level not exceeding by more than one order of magnitude the flow through a geometrically identical section of intact rock. All rock masses have a permeability which is several (often many) orders of magnitude greater than that of an intact, small rock sample. Hence boreholes, if sealed even approximately as effectively as those in the laboratory, will not significantly modify the pre-existing isolation effectiveness of the rock mass.

The second major aspect of the effort is an initial study of fracture grouting. It is highly probable that grouting will be necessary around some sections of a repository. First and foremost is the high probability of grouting during shaft sinking. This is an extremely common practice in shafts where water problems are encountered or expected. It is well-known that such shaft grouting is highly unpredictable (undoubtedly to a considerable extent because of inadequate site investigations, a situation which presumably will not be encountered for HLW repositories) in many aspects: grout quantities, pressures, sealing performance. It is common for grouted shafts to allow visible water inflow (the same holds true for tunnels). While this can be accepted in ordinary mining and construction practice, and can be handled by draining and pumping, such an approach does not seem to be acceptable for HLW repositories.

The proposed fracture sealing study will address what probably is the most important fracture sealing problem: the sealing of discontinuities directly about underground excavations. The biaxial loading frame will allow testing of rock blocks under stress conditions simulating that situation. Similarly to borehole sealing, it is important to develop a factual experimental data basis, of a broad generic type, in order to develop a rational framework for estimating the performance that is achievable in practice. Such a framework will allow a solidly based engineering judgement, before detailed site-specific measurements can be available, about the potential risks of flow parallel to excavations that might remain even after grouting.

October 1, 1984 through May 31, 1985:

Research work to be performed from October 1, 1984 to May 31, 1985 will consist primarily of:

Task 1: Field Work

Subtask A: McNary Dam Site Field Testing

Three four-inch diameter cement plugs with lengths ranging from eight to sixteen inches have been installed at depths ranging from 150 to 200 feet in vertical boreholes in basalt. The contractor shall conduct continuous pressure build-up and fluid build-up tests on these cement plugs for a duration of at least six months, or until as close to the end of the contract period as possible while allowing sufficient time for site demobilization and return of the instrumentation to Tucson, whichever is longer. The tests will be performed in accordance with the procedures described in NUREG/CR-3473, or with minor modifications therefrom. The data (flow through and around the plug, pressure) will be analyzed to determine in-situ performance (equivalent hydraulic conductivity) of the plug system (i.e. plug, plug-rock interface, immediately surrounding rock). The hydraulic conductivity of the field plugs will be compared with that of plugs tested in the lab, installed in the same rock type, and mixed with the same cement and additives. For plugs that perform very poorly in the field, remedial action will be attempted by emplacing additional cement on top of the existing plug.

Subtask B: Oracle Ridge Mine Site Field Testing

One five inch long four-inch diameter cement plug has been installed previously in a nearly horizontal hole connecting two mine drifts, thus allowing access to both ends of the plug. The contracor shall perform continuous constant pressure injection tests and repeated tracer tests (frequency determined by breakthrough time for initial tests) to evaluate the feasibility and effectiveness of sealing horizontal holes with cement plugs. The data shall be analyzed to determine the hydraulic conductivity and porosity of the plug system, and the travel time of water (tracer) through the system.

Subtask C: Cargadero Canyon Site

The contractor shall install four four-inch diameter cement plugs with lengths not less than four inches, at depths between 10 and 40 ft in vertical holes in granite. The contractor shall perform constant pressure injection tests and tracer tests to obtain data (cumulative flow, flowrate, travel time) to assess in-situ sealing performance of cement in granite. The data shall be analyzed to determine in-situ properties of the plug system (e.g. hydraulic conductivity, porosity). The results shall be compared to previously obtained laboratory resutls for cement plugs in granite.

Results Expected from Field Tests

- data: the data obtained from the field tests will provide direct input for repository sealing performance assessments, and will provide a direct comparison for the evaluation of the appropriateness of sealing data used by the applicant in license application performance assessments (effective or equivalent hydraulic conductivity and porosity of the total in-situ sealing system). The data will assist in evaluating whether the sealing data used by the applicant are realistic.

- analysis: field correction factors: comparison of the field results with laboratory results will provide a tool for evaluating to what extent parameters measured on materials (cement) in the laboratory need to be adjusted for field performance assessments.
- repeatability, reliability: a comparison of performance results from identical installations in the same conditions (e.g. three plugs at McNary dam, four at Cargadero Canyon) will provide data on the repeatability of field performance that can be achieved, and hence on the reliability of data.
- identification of plugging problems: it is probable, based on past experience, that not all plugs will perform fully satisfactorily. Identification of problems encountered during plugging is a high priority of this project, because it allows pointing out specific problems that might be encountered during actual repository sealing. Such problems, and their resolution, need to be addressed in a license application, and the adequacy of the resolution proposed by the applicant confirmed by NRC staff during license application review.

Task 2: Laboratory Work

Subtask A: Radial Permeameter Testing

Radial permeameter testing allows sealing performance measurements of borehole plugs under a wide range of stress conditions applied to the plugged rock sample and of injection pressures applied to the plug. The contractor shall conduct radial permeameter tests on cement and bentonite plugs (1" diameter, 1" to 4" long) in granite and basalt rock cylinders (6" diameter, 12" long). Two tests on cement plugs shall utilize stepwise increased and decreased injection pressures from 300 psi to 1500 psi (at room temperatures between 65°F and 73°F). One test on bentonite shall utilize injection pressures from 3 psi to 1500 psi, with the upper limit to be decided

based on initial results, at room temperatures (65°F to 73°F). The rock samples shall be stressed axially and laterally in the 500 psi to 3000 psi stress range. All tests shall be conducted in accordance with procedures summarized in NUREG/CR-3473, unless initial results suggest minor modifications therefrom (e.g. change in outflow collection system, control methods, monitoring procedures). All tests shall be conducted for a minimum of six months, unless premature failure of either plug or rock precludes this, in which case an essentially identical test will be started. One test on a cement plug shall be conducted at temperatures of approximately 45°C and 90° (see subtask C for details).

Subtask B: Size Effects on Borehole Plug Performance

The contractor shall perform constant pressure and/or falling head injection tests on cement plugs ranging in diameter from 1 inch to 9 inches and with length to diameter ratios ranging from 1 to 2. The flow data shall be analyzed to assess whether size affects significantly the performance of cement plugs.

Subtask C: Temperature Effects on Borehole Plug Performance

Using the radial permeameter (see subtask A, and the procedures and reference given there), the contractor shall conduct constant pressure injection tests on a cement plug at temperatures of approximately 45°C and 90°C. The contractor shall conduct flow tets in unconfined rock samples (at 45°C and 90°C) to assess sealing performance under the most severe stress conditions (i.e. internal injection pressures, no external confining pressures). Experiments will be performed at 45°C and at 90°C on cement plugs in steel cylinders to determine cement and cement-steel interface hydraulic conductivities at these temperatures. Data analysis will include comparisons with results at room temperature.

Subtask D: Drilling Damage Studies

The contractor shall submit a final topical report on the influence drilling damage might have on borehole sealing performance.

Subtask E: Dynamic Effects on Cement Plug Performance

The contractor shall submit a final topical report on the influence of dynamic effects (simulated earthquake loading) on the performance of cement borehole plugs.

Subtask F: Scouting Experiments on the Sealing Performance of Fracture Grouting

The contractor shall conduct tests to assess the sealing performance that can be obtained from grouting fractures in rock. Water injection tests shall be performed on the fractures prior to and after grouting. The external (uniaxial) stress on the sample shall be varied from near 0 to 2,000 psi during the pre-grouting tests. The fracture aperture will be determined as a function of normal stress from these tests, and an appropriate stress level selected for application to the sample during grout injection. Grout injection pressure will be applied somewhat less than the externally applied stress, most likely in the range of 200 to 500 psi. The results shall be analyzed to make an assessment of the hydraulic conductivity of the fractures before and after grouting, and to assess the validity of laws predicting fluid (water, grout) penetration along the fractures. Grout distribution along the fracture planes will be observed post-mortem by visual inspection. Data analysis shall provide a preliminary assessment of the predictability of rock discontinuity grouting feasibility and of grouting performance, topics about which very contradictory statements can be found in the literature. This in turn will assist NRC in establishing whether grouting performance data used in license application performance assessments can be provided by the applicant with reasonable assurance that the claimed performance can be met in practice.

Subtask G: Sealing Performance of Bentonite and Crushed-Rock Mixes

The contractor shall perform water injection tests on plugs constructed of crushed basalt and bentonite. A range of bentonite to rock ratios (10% to 50%), extending somewhat beyond the ranges that

have been considered for conceptual shaft and drift plug designs, shall be considered for the initial tests, and more detailed tests shall focus on ranges with the most encouraging initial results. Sizes of crushed rock to be considered shall range from 1/4" to 2". Detailed tests shall be performed on the largest size range that show the best initial results and allow a reasonably uniform plug construction with available equipment. All initial tests are to be performed on plugs installed in steel cylinders. A few concluding tests on mixes with very good performance might be performed on boreholes in rock blocks. Data analysis will include determination of flow characteristics (hydraulic conductivity), even though incomplete saturation complications are expected, and of axial interface strength.

June 1, 1985 through December 31, 1985

The following work is to be performed by this contract extension. The work has been broken into two tasks: Task 1, Field Testing, and Task 2, Laboratory Testing. Task 1 is further divided into subtasks according to the test site location and Task 2 into subtasks according to the test type. Field and laboratory equipment to be used for this research, as well as the tests and testing procedures, and composition of and techniques for the installation and testing of cement and bentonite plugs etc., are those described in the various annual contractor reports from FIN B6627.

Task 1: Field Work

Subtask A: McNary Dam Site

The contractor shall install three additional 4" diameter cement plugs, 8" to 16" long (three similar plugs were installed previously) at depths of 150 feet to 200 feet in vertical boreholes in basalt. The contractor shall conduct pressure build-up and fluid build-up tests (see note below) on these and previously installed cement plugs to obtain data for analysis, to assess in-situ sealing performance.

Subtask B: Oracle Ridge Mine Site

The contractor shall continue monitoring (see note below) of the 5" long, 4" diameter cement plug installed in a nearly horizontal hole. The contractor shall perform constant pressure and variable pressure water injection tests and tracer test to evaluate the feasibility and effectiveness of sealing horizontal holes in the field.

Subtask C: Cargadero Canyon Site

The contractor shall continue monitoring (see note below) the 6" diameter and between 8" and 12" long cement and bentonite plugs installed in vertical boreholes in granite. The contractor shall continue to perform constant and variable pressure water injection tests and tracer tests in order to obtain data to assess in-situ sealing performance in granite. The results shall be compared to previously obtained laboratory cement and bentonite plug performance data to evaluate the effectiveness of field plug installation techniques.

NOTE: All field monitoring for subtasks A, B, and C shall be completed at the conclusion of this contract extension. The contractor shall, before the expiration of the contract, drill out all installed plugs for inspection and detailed examination. The results of the examinination shall be included in the technical report for each subtask.

Task 2: Laboratory Testing

Subtask A: Temperature Effects on Borehole Plug Performance

The contractor shall conduct and complete experiments on plugs emplaced in rock blocks and steel pipe to obtain flow data and strength and swelling data for assessing sealing performance at elevated temperatures. Specifically, the tests will include constant pressure water injection tests (at pressure of 500 psi, 1000 psi and 1500 psi) and variable pressure water injection tests (pressures up to 1000 psi) on 1" diameter, 1" to 2" long plugs of the following:

- 3 to 6 cement plugs for temperatures from ambient up to 250°C (intermediate temperatures, e.g., 60°C, 100°C, 150°C, 200°C shall be included).

- 3 to 6 bentonite plugs for temperatures from ambient up to 250°C (intermediate temperatures, e.g., 60°C, 100°C, 150°C, 200°C shall be included).

- 3 to 6 bentonite - crushed rock mixes (proportions to be determined from work under progress) for temperatures from ambient up to 250°C (intermediate temperatures, e.g., 60°C, 100°C, 150°C, 200°C shall be included).

Subtask B: Laboratory Investigation of the Influence of Installation Procedures on the Sealing Performance of Cementitious and Earthen Borehole Plugs

The contractor shall conduct and complete a systematic laboratory investigation of the installation procedures commonly used in commercial well plugging, e.g., bailer dumping, displacement cementing, and dropping of bentonite pellets. The experiments (constant pressure water injection tests at 500 psi, 1000 psi and 1500 psi, variable pressure water injection tests at pressure up to 1000 psi) shall be conducted for each procedure, and shall involve

plugs ranging in diameter from 1" to 4" with length/diameter ratio equal to one. The data shall be analyzed to assess the significance of the installation procedure on borehole sealing performance.

NOTE: The precise number of plugs will be dictated by the results obtained as the testing progresses.

Subtask C: Size Effects on Borehole Sealing Performance

The contractor shall complete constant pressure water injection tests (at pressures of 100 psi, 250 psi and 500 psi) on cement plugs ranging in diameter from 1" to 9" with a length to diameter ratio of one. The flow data shall be analyzed to assess if size effects influence the sealing performance of cement plugs in the laboratory.

NOTE: The precise number of plugs tested will be determined by the results obtained from the tests.

4.0 REPORTING REQUIREMENTS:

1. The contractor shall submit monthly financial status reports within 15 days of close of each month.

2. The contractor shall submit Quarterly Progress Reports within 30 days of close of FY-Quarters. The Quarterly Progress Reports shall summarize all technical tasks conducted during the corresponding quarters. Significant problems encountered, findings and conclusions pertinent to the objective of the project should be highlighted in the Quarterly Progress Reports. Budgetary and administrative information shall be provided in a separate Quarterly Administrative Report which includes the comparison of actual and projected expenses, and other related administrative activities.

3. The contractor shall submit Technical Reports at the conclusion of research tasks. Technical Reports shall be self-contained, and will be suitable for publication as a NUREG/CR report. Technical Reports should include an Executive Summary that summarizes the research results with regard to the project objectives as defined in the Statement of Work or contract. This is specifically designed to enhance the usability of reports to the licensing staff and the agency as a whole. Determination of topics and reporting schedules shall be made by the NRC project manager and contractor jointly.

4. A copy of all written and oral presentations given at professional meetings and technical papers submitted for publication in technical journals which is related to or funded by this project will be transmitted to the NRC technical project manager.

5. Report Distribution:

   (a) <u>Topical and Quarterly Progress Reports</u>

Technical Project Manager	7 copies
Chief, Earth Sciences Branch, Division of Radiation Protection and Earth Sciences, Office of Nuclear Regulatory Research	1 copy
Chief, Waste Management Branch, Division of Radiation Programs and Earth Sciences, Office of Nuclear Regulatory Research	1 copy
Director, Div. of Waste Management, Office of Nuclear Material Safety and Safeguards	1 copy

Document Control Center, Office of
Nuclear Material Safety and
Safeguards — 1 copy

(b) Monthly Financial and Quarterly Administrative Reports

Technical Project Manager — 1 copy

(c) Microfiche

Microfiche is required of all reports to be published as NUREG or NUREG/CR documents. The specifications for this microfiche are listed on the last page and the distribution is as follows:

Document Management Branch
Division of Technical Information
and Document Control, — 1 master

Document Control Center
Division of Waste Management, Office of
Nuclear Material Safety and Safeguards, — 1 duplicate

QUALITY ASSURANCE:

The contractor shall develop and submit to NRC for review of quality assurance (QA) program plan for work to be performed under the contract or shall indicate that a previously approved, applicable Q.A. program will be applied to the work under this contract.

Any work (i.e., interpretations, analyses, computations, methods, etc.), developed under the contract shall be performed under an adequate quality assurance program. Quality assurance comprises all those planned and

systematic actions necessary to provide adequate confidence that the research has been satisfactorily performed. Quality assurance includes sufficient documentation to assure the reproducibility of the results of the research. That is, the methods and techniques used to collect, reduce, and interpret data produced by research are sufficiently accurate, traceable, and articulate so that other researchers could duplicate the work done and independently evaluate the results.

An adequate QA program should address the following areas as appropriate:

experimental design, and rationale--sample selection, number of samples, sampling frequency, controls;

statistical evaluation of experimental design-assessment of statistical power, of sampling scheme and measurement techniques, including expected accuracy and precision;

sample prepartion-selection of sample type, treatment of samples, sample identification;

measurement techniques used--description of measurement process, description/identification of equipment used;

calibration methods--frequency, techniques, standards, traceability;

date recording--method of recording data, identification of person(s) recording/certifying data;

data reduction--methods and codes(s) (including identification of modifications and updates);

data analysis--description of techniques used, methods of data verification (e.g., spot checking of measurements, calculations, etc.);

records management-identification, location, and retention time of data, analyses, associated records, duplicate data and/or records; and

statistical evaluation--interpretation of data, stating actual accuracy and precision of results achieved.

In addition, if standards tests or calibration procedures are employed (e.g, ASTM standards) these should be cited in the program. Finally, if appropriate to the size and nature of the contract, the work and results should receive exposure in the scientific community through publication of results in referred journals, or through peer reviews, or both.

6.0 MEETINGS AND TRAVEL:

The contractor and subcontractor shall present the technical progress of the project at NRC headquarters at least annually. Any travel to be charged against project funds requires prior approval by the NRC project manager.

7.0 DOE FURNISHED MATERIALS:

None

8.0 NRC FURNISHED MATERIALS

None

9.0 CAPITAL EQUIPMENT:

All capital equipment expenditures require the prior written approval of the NRC Project Manager.

10. SUBCONTRACTS

Subcontracts require the prior written approval of the NRC Contracting Officer.

11. DISPOSAL OF PROPERTIES:

Not applicable

12. TECHNICAL DIRECTION

J. Philip, NRC Project Manager (FTS 301-427-4604) will be responsible for directing this project.

(b) The Principal Investigator expects to devote the following approximate amount(s) of time to the contract work:

Jaak J. K. Daemen: June 1, 1980 through May 31, 1982: 20% of his time during each of the academic years and 100% of his time during each of the summers. June 1, 1982 through May 31, 1983: 10% of his time during the academic year and 50% of his time during the summer. June 1, 1983 through September 30, 1984: 20% of his time during the academic year and 100% of his time during the summer. October 1, 1985 through May 31, 1985: 100% of his time during the academic year. June 1, 1985 through December 31, 1985: 100 percent of his time during the academic year.

ARTICLE A-II WAYS AND MEANS OF PERFORMANCE

(a) Items for which support will be provided as indicated in A-III, below

(1) Salaries and Wages $ 515,889.68

(2) Equipment to be purchased or fabricated by the Contractor $ 252,611.00

June 1, 1980 - May 31, 1981:

In Excess of $1,000.00

Puska Gas and Liquid Permeameter

Universal Poro meter

Precision High-Pressure low-flow pump

Manual Grouting pump (low-pressure, low-volume)

Large-diameter self-feeding diamond saw

Radial permeameters

Polyaxial permeameters (3)

Computer terminal

pH meter

Triaxial Vessel with modified piston

Creep loading frames (3) and long-term pressure maintenance and control system

Universal Flat load Cells(3)

Electronic Balance

Oven with temperature-humidity controls

Multi-channel data recorder

Enerpac handpumps (2)

Mass flow meter meter with batch control

Diamond core drill bits

Accessories and auxiliary equipment

June 1, 1981 - May 31, 1982:

In Excess of $1,000.00

- 6" core barrel
- hole caliper and inclinometer
- accessories for borehole preparation and inspection
- integrated multiple-packer isolation unit with down-hole pressure-temperature-flow recorder
- tracer detector and monitor
- strain monitor and servo-control system
- accessories for laboratory equipment

June 1, 1982 - May 31, 1983:

In Excess of $1,000.00

- multiple-packer unit with built-in tracer detector, monitor and pressure-flow recorder
- lab tracer detector
- acessories for field equipment

June 1, 1983 - September 30, 1984:

In Excess of $1,000.00

Biaxial loading frame
Viscometer
Pressurized consistometer
(with calibration device)
Laboratory vane shear tester
High-precision helium leak detector, or portable gas chromatograph
Trailer-mounted hoist with winch, generator and air compressor
Sampling pump for deep wells
Borehole TV CAMERA (with recorder)

October 1, 1984 - May 31, 1985:

In Excess of $1,000.00

Plug-testing short-stub packers
(2 @ $2,500 each)
Straddle packer
pH meter with electrodes
Injection/collection systems for
Cargodera canyon field tests
(4 @ 1,250 each)
Radial permeameter control consoles
4 @ $1,400 each)
Automatic data gathering system for
Cargodera Canyon field tests
Air injection permeability measuring
system
Hydraulic accumulators (3 @ $500 each)
Radial permeameter (9" diameter ID)
Gas-over-water pumps (3 @ $2000/each)
Viscosimeter
Borehole TV camera

(3) Travel

(i) Domestic $ 64,600.00

(ii) Foreign $ -0-

(4) Other direct costs including staff benefits

(5) Indirect costs based on a predetermined rate of 44 percent applicable to direct costs excluding equipment

(b) Items, if any, significant to the performance of this contract, but excluded from computation of Support Cost and from consideration in proportioning costs: None

(c) Time or effort of Principal Investigator(s) including indirect costs and fringe benefits contributed by Contractor but excluded from computation of Support Cost and from consideration in proportioning costs: None

Article A-III

The total estimated cost of items under A-II(a) above for the contract period stated in this Appendix A is **$2,197,566.84** the Commission will pay 100 percent of the actual costs of these items incurred during the contract period stated in this Appendix A, subject to the provisions of Article III and Article B-XXVIII. The estimated NRC Support Cost for the contract period stated in this Appendix A is **$2,197,566.84.**

The estimated NRC Support Cost is funded as follows:

(a) Estimated unexpended balance from prior period(s) $ -0-

(b) New funds for the current period $ 109,629.22

(c) The new funds being added in A-III(b) constitute the basis for advance payments provided under Article B-X.

MICROFORM SPECIFICATIONS FOR WASTE MANAGEMENT CONTRACTS

Microfiche used for submittal purposes shall conform to the following specifications:

1. Microfiche containing source documentation shall conform to the NMA Type 1 format (ANSI/NMA MS.5) consisting of 98 frames arranged in 7 rows and 14 columns.

2. The reduction ratio shall be 24:1 for all microfiche.

3. The microfiche shall be standard 148 mm x 105 mm.

4. The microfiche shall be one silver-halide master and one diazo placed in individual acid free envelopes.

5. Diazo duplicates may be either blue/black or black.

6. The microfiche shall be titled in the following manner:

FIN No.	Title of Report	Date
Contract No.		
Nureg/CR No.		
Fiche No.		

   Fiche number refers to 1 of 2, 2 of 2, etc. information.

7. Title information shall be eye readable on a clear background.

8. The submittal of microfiche containing proprietary material shall be coordinated with the Document Management Branch, Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, DC 20555, to set format and procedures for submittal.

9. Foldouts, if any, shall be segmented and filmed in logical order.

10. The first frame shall be blank, and the second frame shall contain the resolution target (NBS 1010A).

11. Questions on microfiche specifications should be submitted in writing to:

    Document Management Branch, Division of Information and Document Control, U. S. Nuclear Regulatory Commission, Washington, DC 20555